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# *Energy as a spatio-temporal project & the Rhine Basin urbanisation*

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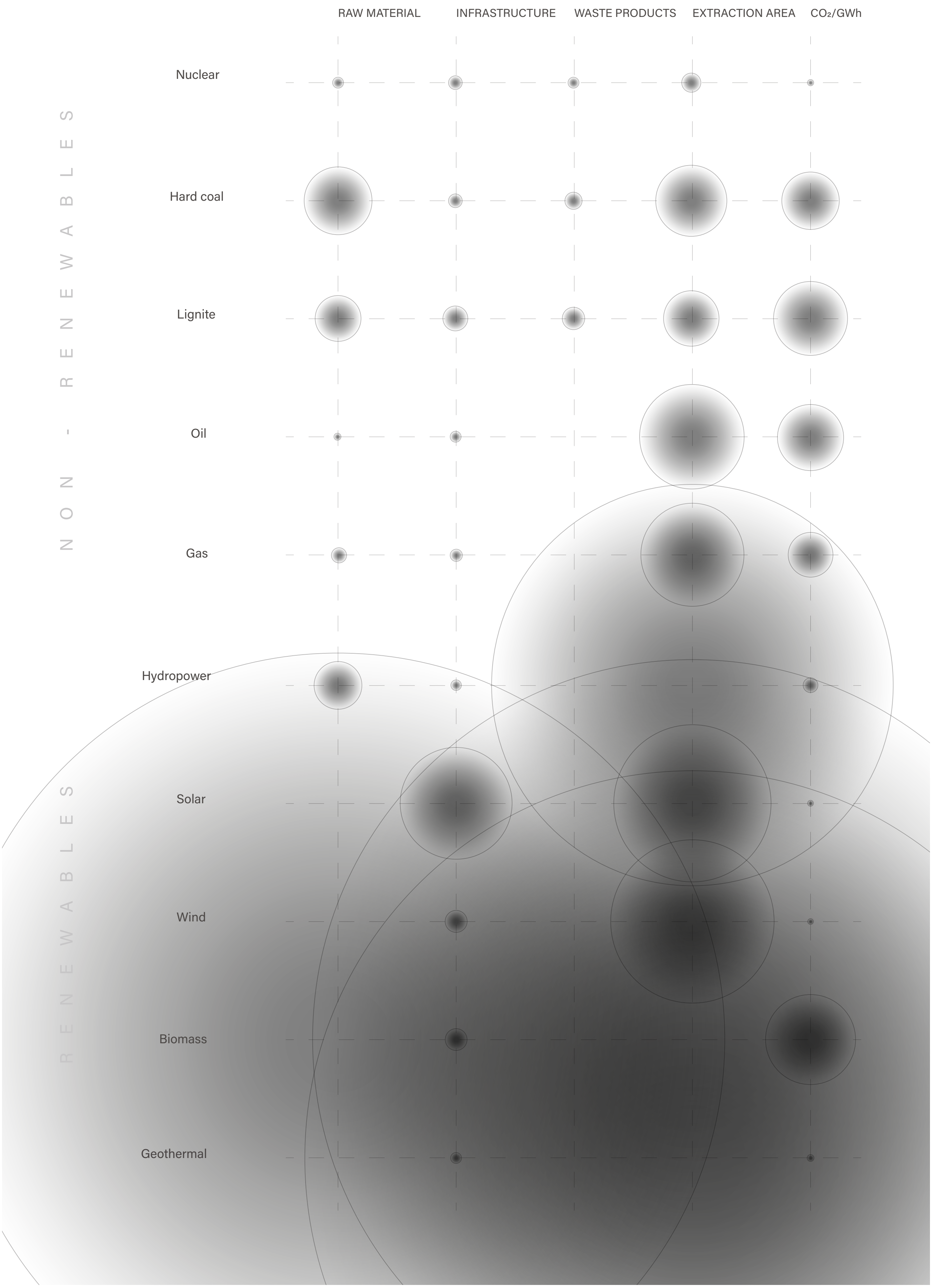
Looming crises demand viable territorial responses for their interdependent challenges. Approaching energy as a spatio-temporal project can reorient spatial planning and urban design to organise such responses. The current context of quickened 'energy transition' requires the investigation of the scaling-up of renewable energy so that the coming decades can compose socio-ecologically just alternatives in renewed urbanisation paradigms towards the 22nd century. Accordingly, the project proposes a conceptual tool and methodology for the transitional territories of operational energy landscapes in the Rhine Basin. First, it maps the evidence of non-renewable energy, then anticipates and assesses the 'energy transition' in its current and future landscapes, informing its territorial design. The project surpasses current dichotomies between the urban and rural, conservation and intervention, and nature and society, developing hybrid landscapes where technologies for mitigation, restoration and sustainability are grounded in the temporalities of the habitats for humans and more-than-humans. In other words, a reorganisation of the links between energy, food, and work into ecological frameworks. Moreover, it works as a platform that contributes with speculative spatial thinking to refresh the concept of sustainability, problematising the geopolitical project for the planet into a geological age of climate instability.

Figure 1: Spatial footprint in hectares for the equivalent of the electricity demand of 1 million homes, or around 3387 GWh. Data: Sijmons, 2014; IEA, 2019



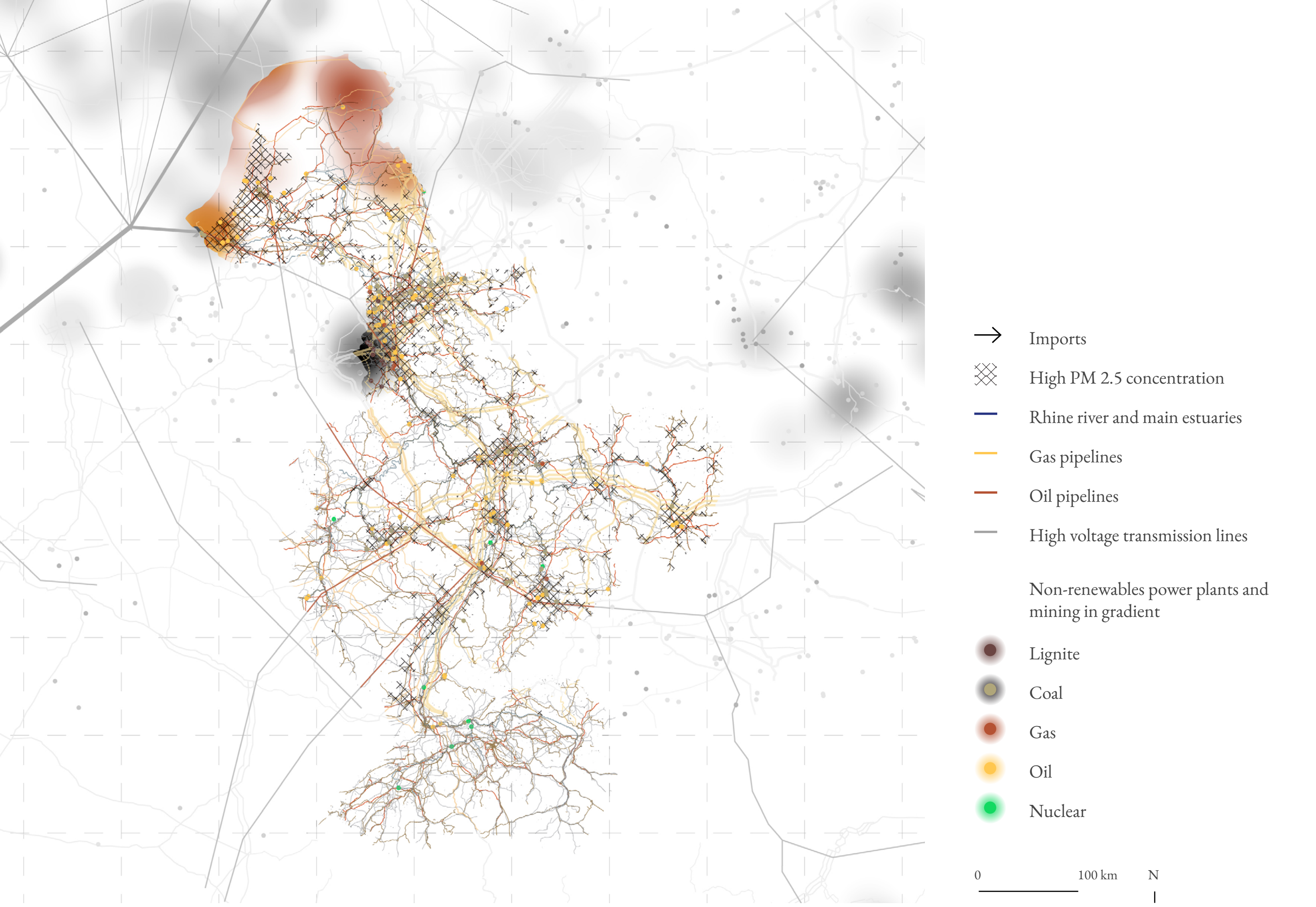



Figure 2: Rhine Basin as an operational landscape

## *INTRODUCTION*

### *Context*

The Great Navigations inaugurated the period known as "the long 16th century". They kick-started Extractivism (and the capitalist world-ecology) through European powers colonising other continents' natures - mainly people's labour and land resources. (Moore, 2015) After many waves of exploitation of natures and exhaustion of frontiers, non-renewable sources have globally become the best EROI (energy return on investment) and, subsequently, the backbone of every activity. (Illich, 1983) The Industrial Revolution of the 18th century, and especially the Great Acceleration in the middle of the 20th century, fueled the modern era to the new possibility of energy-intensive life and exponential growth. In a bit more than a century, the process that operationalised the Earth and provoked a sharp increase in production also feedbacks in the forms of climate change and biosphere degradation (Steffen et al., 2015), with burning fossil fuels for the generation of energy being one of the most significant contributors. (EEA, 2020)

The exponential growth of a globalised industrial society and the amount of exploitation led to concerns about the planet's liveability for future generations since the 70s when the scientific community sounded the alarm, and an environmental movement began to gain momentum. The 1973 and 1979 energy crises were the first global demonstration of the link between energy landscapes, a planetary society, and the Earth's depletion. (Mair et al., 2020)

Nowadays, the predicted supply shortage and the climatic consequences are becoming too latent and dangerous/unprofitable for the smooth functioning of (Neo) Extractivism. (Acosta, 2013) The triad of energy, economy and environmental conditions is forming a scenario where spatial planning and urban design can be relevant in composing an alternative spatial project as the energy landscapes of the renewables era require and make possible different spatial configurations. (Ghosn, 2009) Further than applying more 'sustainable' practices, a different plan for the role of urbanism is necessary to avoid reshaping the perpetuation of unjust geographies of power. What is the agency of territorial design and spatial planning in conceiving and composing a viable design for the Earth's habitats, productivity, and logistics?

### *Energy as a spatio-temporal project*

Energy has a spatial project to operationalise its processes and support consumer society. The shift from a nomadic to an agricultural society created the possibility for settlement. The second shift from agricultural to industrial gave rise to networks that are called a process of "planetary urbanisation". (Brenner, 2013) The modern era is the reorganisation of the territory around the avail-

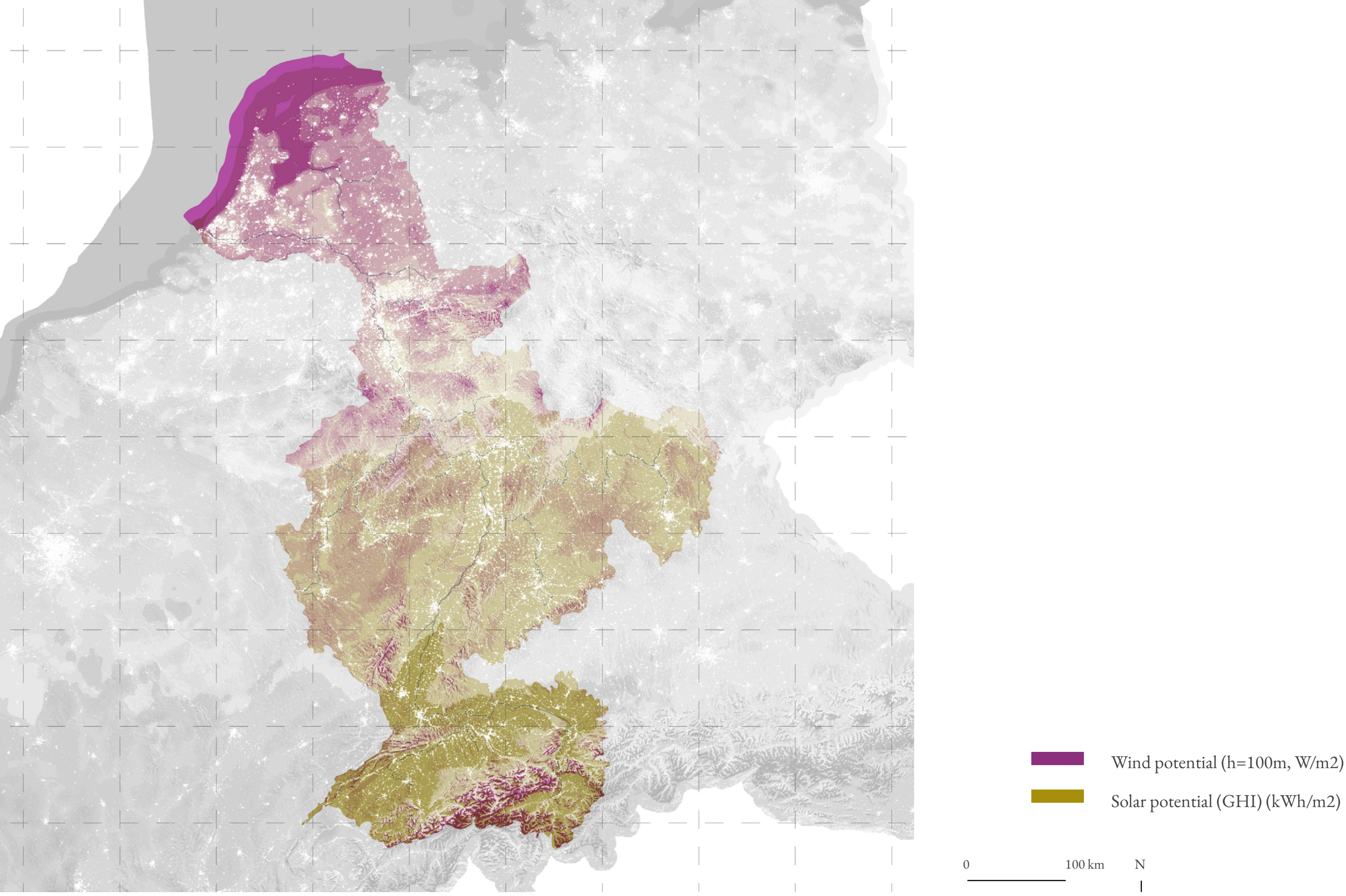



Figure 3: Wind and solar renewable energy potential

ability of abundant (non-renewable) energy established by a new horizon of possibility for production. (Iturbe, 2019)

The phasing-down (yet very active) of non-renewables is territorialised in extended urbanisation with nodes of production in a dense web of connection to mining territories. Conversely, the spatial challenge of renewable energy is that of another kind of urbanisation, highlighting different spatial challenges, especially in the energy landscapes of conversion. (Bruckner et al., 2012) The comparisons (Figure 1) make clear the spatial footprint for the processes in non-renewables and renewables.

It is possible to map energy landscapes of extraction in mining materials to build renewable technologies, mostly silicon, aluminium, and glass for the solar cells and panels and steel for the wind turbines and its column. Vast landscapes of grasslands, intensive and extensive agriculture and forestry are becoming operationalised to receive renewable energy production technologies - or serving as the primary material. This situation shapes a radically different landscape than the previous mode of energy. The overlapping and alignment of new spatial demands with existing structures will take different forms.

## *METHODOLOGY*

### *Methodological framework*

The project follows a methodology that identifies the evidence of energy transition and energy landscapes to inform the next steps. The unpacking of transdisciplinary literature review and research of various data sets informed the fundamental understanding of energy as a spatial project, especially in scaling renewable energy technologies - like grid adaptation, solar panels, wind turbines, batteries, CCS (Carbon Capture and Storage) plants and others.

The framework is organised into three parts: Inheritance, Anticipation and Projection. The composition of sets of cartographies on the Rhine Basin forms a spatial analysis of the non-renewable forms of energy landscapes summarised in the drawings presented in the “Inheritance” section. Following the investigation of the crises of the fossil-fuel era, the “Anticipation” section maps and points to the current state of ‘energy transition’ as one incapable of addressing the looming planetary issues of climate change and biosphere degradation when its focus is on technological transition and decarbonisation of the economy. In a state of climatic instability, exhaustion of old energy supplies and ecological depletion, the need for social and ecological just alternatives shows that energy as a spatial project must already be a concern of today’s urbanism.

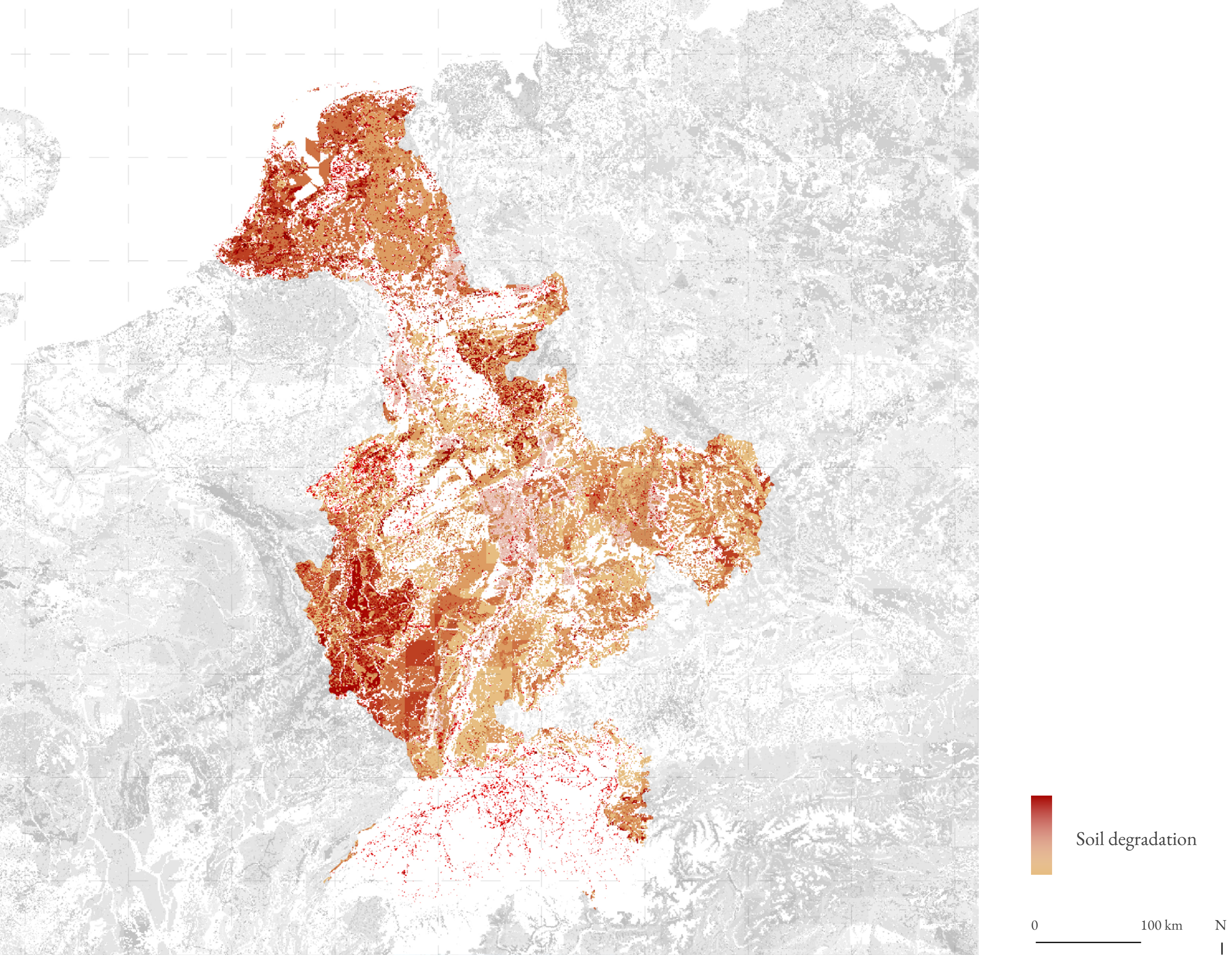



Figure 4: Subsurface: Soil degradation

Those two movements serve as the first synthesis, identifying the operational landscapes as the typological territory of the coming interventions, as these are set to be crucial for the next energy temporality. It also shows that these landscapes could host its transitional territory potential for new hybrids of energy and ecological systems, human and more-than-human production and inhabitation. In that context, how can energy landscapes mediate a socio-ecologically just urbanisation for future modes of energy production in the Rhine Basin?

The "Projection" section gathers speculative design proposals for the territory of the Rhine Basin and territorial typologies of the future operational landscapes of energy. In this section, "Cartography" overlays different kinds of infrastructures from the "Inheritance" and "Anticipation" temporalities to conceive and compose a Rhine scale "Energy-Ecology Network". This project implements the renewable energy mode, understanding its transitional essence and building new urban networks along the European continent. The elements and landscapes that form this "Energy-Ecology Network" are refined in the following chapter of "Terraforming", which uses typological transects to unpack the configurations and relations in these crucial landscapes. Moreover, it weighs into the tense debate of the international political game over energy sources. The proposal works as a platform that contributes to grounding a practico-philosophical rethinking of the planet and its urbanisation and a refreshed understanding of 'sustainability' into a geological age of climate instability.

Concomitantly, it highlights that the back and forth between the European continent, Rhine basin, regional and even local scales are part of a planetary perspective that crosses scales. The planetary is not only spatial; it also informs temporalities - highlighted and converging in the years 2030, 2050 and 2100. Apart from their specificities and scientific, ecological, societal and economic predictions that combine in them, they form a set of short, medium and long-term speculative framing needed for this terraforming - as analysis and project. It is essential to build on a new temporality that considers the long duration of the Earth and turns technological conditions into historical conditions for the fitting position of the human agency in planetary systems. This nexus makes it possible to think of energy as a spatio-temporal project. In the Rhine Basin, it becomes a project for transitioning infrastructure, a kind of infrastructural landscape design. This method and proposal suggest that this understanding can build more socio-ecologically just paradigms of urbanisation. In this case, triggered by the infrastructural character of energy landscapes.

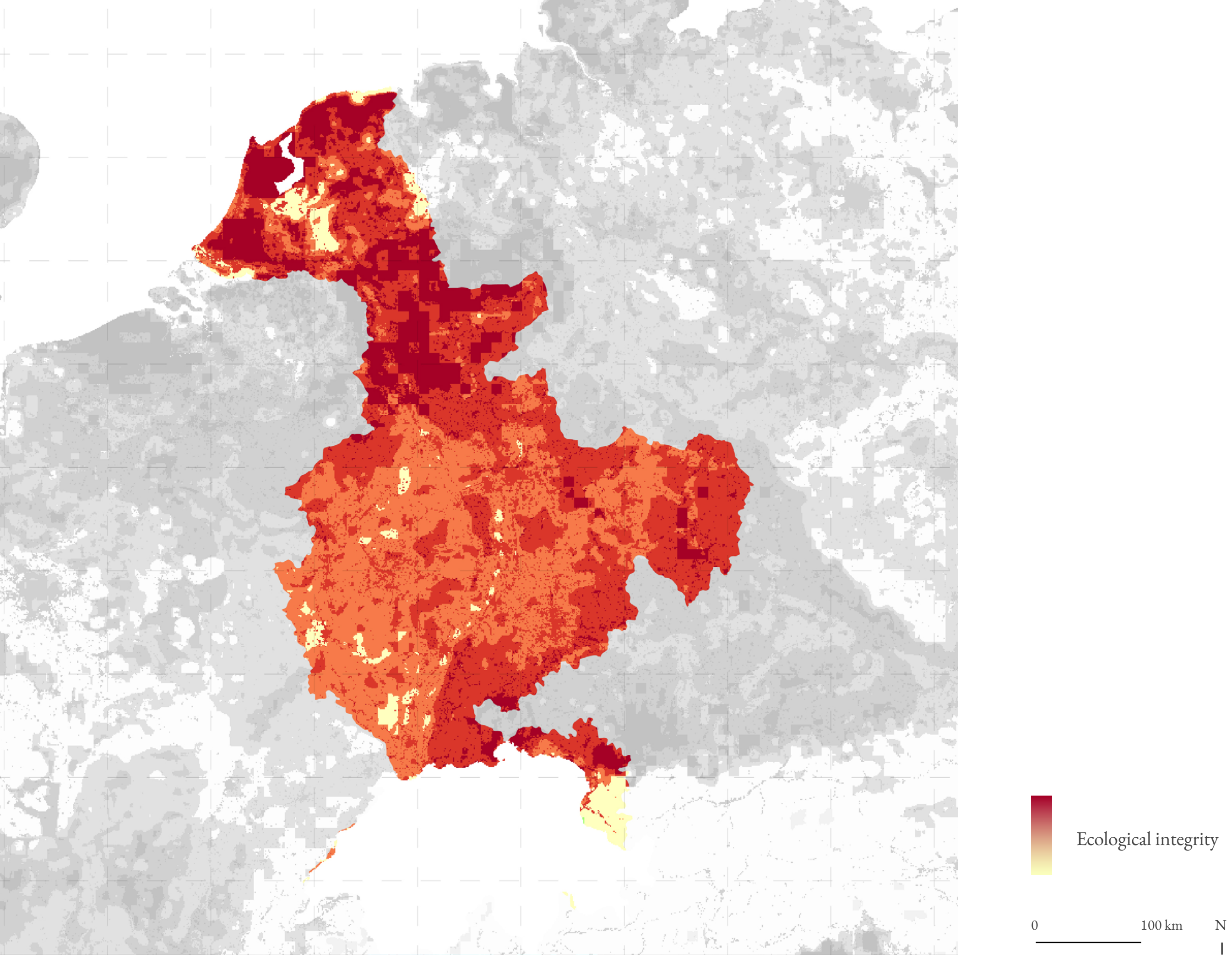



Figure 5: Surface: Land fragmentation

*EXPERIMENT/RESEARCH*

*Inheritance: Rhine Basin as operational landscape*

Focusing on the Rhine Basin's energy landscapes is to map the sociospatial and environmental transformations that unfold in the wide-range fabric of urbanisation. "Inheritance" investigates urbanisation from the perspective of the zones outside agglomeration and how those spaces are structured to support cities' material and commodity demands. The energy landscapes of non-renewables form a network of operational landscapes. (Brenner & Katsikis, 2020). The map (Figure 2) identifies energy landscapes of extraction, transport, conversion and distribution that compose and support metropolitan regions with its networks: the energy distribution grid, gas pipelines, oil traffic, road and water logistics, including the Rhine River, where not only water converges to it but many elements of the energy apparatus. It also shows nodes: fossil fuel mining, power plants and the dumping of its 'externalities', here presented mainly as atmospheric pollution.

Through the various configurations of these operational landscapes, the Rhine Basin constitutes one of the bases for Europe's material economy and commodity flows. However, as operationalisation processes intensify in the constant search for profit, the capacities of natural systems to support them are gradually exhausted. They need to be compensated through recurring investment and eventual capital intensification. While it is considered one of the best-managed basins in the world, with restoration projects successfully restoring biodiversity and improving water quality in the past years, it should broaden its perspective further than its rivers to see the whole landscape that its waters make possible.

In this scenario, the issue for energy landscapes is not only to find solutions for the energy issues, which will lead to considering the biophysical limit to energy generation, proposing decarbonisation and a European Green Deal that misses the opportunity to rethink the ways those territories are formed and inhabited. It is essential to think with the "externalities" (Ghosn, 2020) of the current energy-intensive modes of inhabitation and propose an alternative geopolitical project out of a renewed perspective on what 'sustainability' means, in this case, demonstrated through and for energy landscapes. Building in the now the new temporality of energy seizes the opportunity to deal with the transition as another possible urbanisation. In that direction, Ghosn (2009) poses a very pertinent question: what are the social, political and spatial implications of future modes of energy, and how can design practices partake in shaping a more just urbanisation?

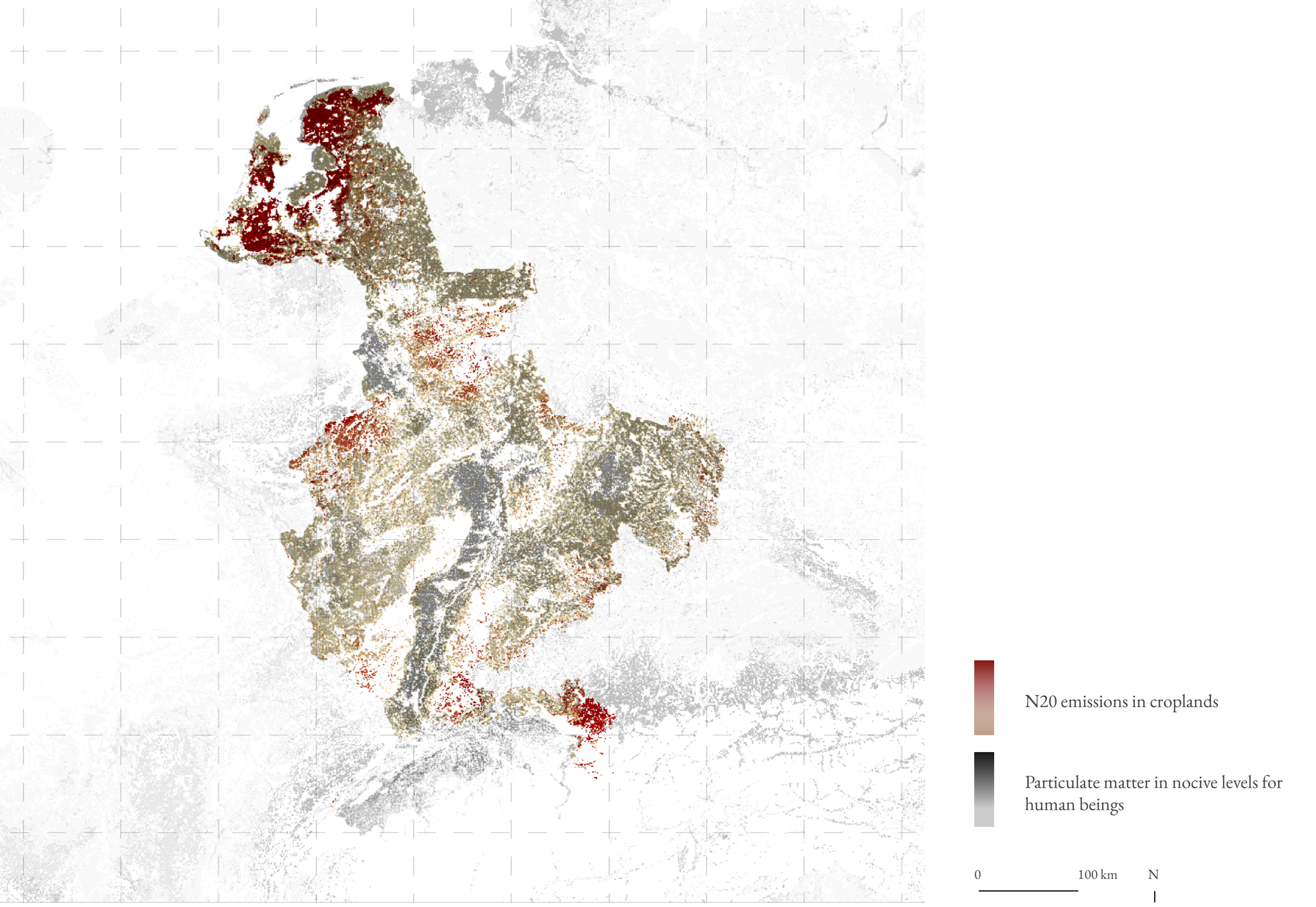



Figure 6: Atmosphere: "Externalities" dump

*Anticipation: Future operational landscapes of energy in the Rhine basin*

"Anticipation" foresees conditions of the 'energy transition' under the brief organised by the last decades of the thinking and geopolitics on "sustainable development". It focuses on the energy mode of renewables and its contribution to mitigating the climatic inheritances of the previous mode of energy, backing up a pace of development for some centuries.

The methodology follows the same pattern as the previous section. With the European Green Deal as policy and the IPCC and EC (European Commission) reports as technical limits, it is possible to anticipate the spatial effects of the decarbonisation of many industries and the scaling-up of renewable energy landscapes. As the energy sector is set to "cannibalise" other landscapes, it must receive a comprehensive analysis of its territorial consequences in its search for "cheap natures" to exploit. In the current geopolitical trend, by 2050, the 'energy transition' will demand a reevaluation of its spatial project.

Given the inheritance and the anticipation of the "energy transition", a consistent move towards renewables will see more and more land being taken for energy production. In metropolitan regions, adapting the built-up area is essential: photovoltaic on roofs, wind turbines, and geothermal installation where possible will assist local energy needs. However, the greater network that sustains all the other activities and keeps the provision of energy for the agglomeration zones through renewable energy is still to become mature. It is expected that the contemporary 'energy transition' will operate precisely this change and awaken the new temporality of energy, heavily based on solar and wind sources of energy production. That movement will tilt the balance towards other uses of the available land, changing the dynamics of operational landscapes in the Rhine basin.

The map (Figure 3) shows the renewables' potential outside agglomeration zones, focusing on wind and solar energy. These technologies are being invested in large-scale energy production, competing with fossil fuel energy. According to the European Commission, in 2020, renewables overtook fossil fuels as the number one power source in the EU for the first time, generating 38% of electricity, compared to 37% for fossil fuels. It aligns with the goal behind the European Green Deal, which is to become a climate-neutral continent by 2050.

However, the scale-up of the renewable era of energy production does not come alone. The looming climate and biosphere collapses will bring together many other complex consequences - that will be felt socially and economically. For the moment, there is a significant concern about the rapid loss of biodiversity, in which the population abundance of wildlife (including mammals, birds, reptiles, amphibians and fish) has been decreasing by more than half in less than 50 years. This scenario is

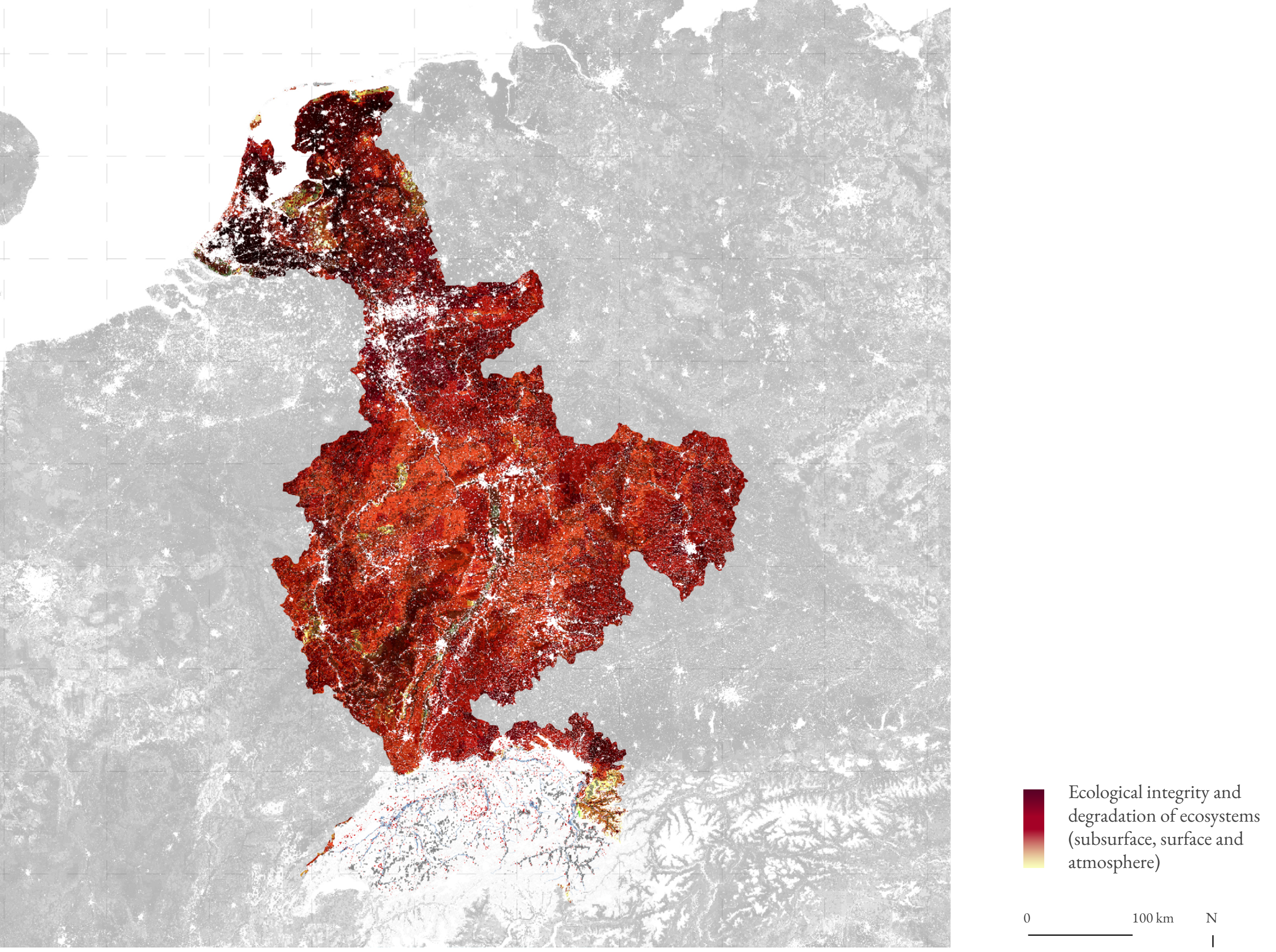



Figure 7: Low ecological integrity and high degradation of ecosystems (subsurface, surface and atmosphere)

well-known for the Rhine Basin and spreads over the landscapes that the next mode of energy is set to operationalise. A vertical mapping of the subsurface, surface and atmospheric conditions was composed to understand the current situation of the landscapes these energy production technologies will encounter.

For the subsurface, the case is of overall soil degradation. Intensive practices and the use of harmful substances that prioritise crop yield to the detriment of soil health in croplands damage organic content, affecting its health and turning soil into sand. In turn, it causes disturbance to crop yield, water scarcity, loss of soil biodiversity, climate change in the lack of carbon retention and other consequences that can be measured in productivity levels that are in decline in most of the lands of the Rhine Basin. The map (Figure 4) brings together data from biomass productivity in grasslands, forestry and croplands, the richness of organisms in the soil, the potential for carbon storage, the soil organic carbon levels and the trend in above-ground vegetation biomass productivity.

At the surface level, landscape fragmentation results from a paradigm of urbanisation with little concern for ecological integrity. The map (Figure 5) bundles trophic function, connectivity and natural dynamics in the landscape, reflecting the extent to which anthropogenic defaunation, fragmentation of the landscape, and the continued extraction of natural resources have disturbed ecosystems. (Fernández, Torres, Wolf, Quintero, & Pereira, 2020) An exception to overall low integrity is the Natura 2000 sites, illustrating the potential of those areas to compose a backbone supporting efforts to increase ecological connectivity across European landscapes if connected in comprehensive spatial planning. A network of infrastructural spaces, as new hybrids of conservation and intervention, would become a new paradigm for urbanisation that account for more-than-human life in its course.

Lastly, the atmosphere continues to be depleted not only by energetic landscapes but in many forms of industrial production. The map (Figure 6) adds particulate matter to GHG emissions from croplands to provide an instant of overall harmful exhaustion of human productivity in the air.

The map (Figure 7) bundles the indexes of a mapping of conditions in the subsurface, surface and atmosphere. Taken together, it portrays the low ecological integrity and high degradation of ecosystems in every landscape outside agglomeration zones. It exposes that the overall geopolitical “sustainability” project is unfitting to respond, perpetuating damages in its mitigation efforts. Precisely, transcending the situated responses, this narrative's argument is to invest in a territorial response to global processes.

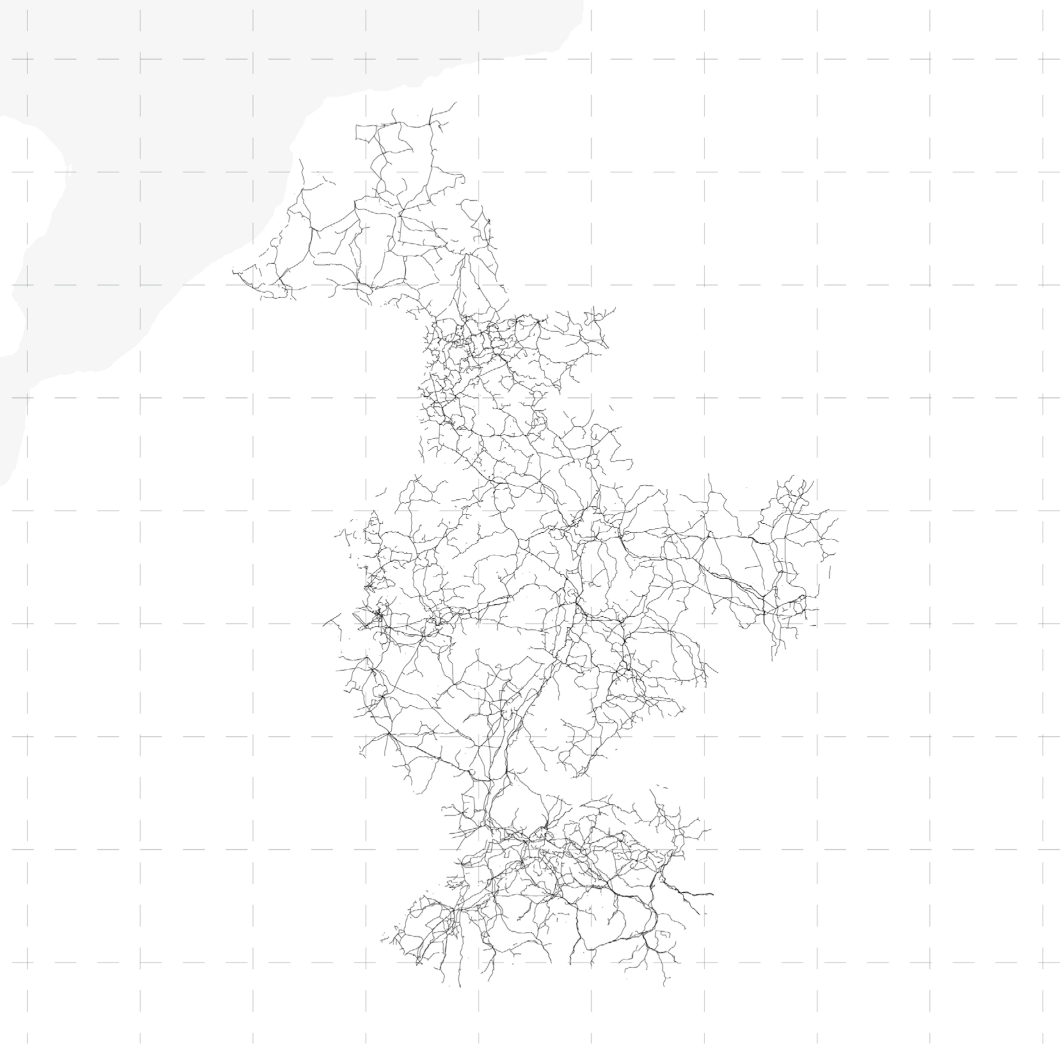



Figure 8: High-voltage transmission lines over the Rhine Basin

*RESULTS*

*Projection: Cartography*

At this moment, it is possible to turn from analysis and anticipation to projection. Working with the landscapes highlighted by the "Inheritance" and "Anticipation" sections, "Projection" proposes an alternative way of understanding territorial and regional integration with trans-scalar infrastructural landscape design and management proposals for the future operational landscapes of Europe.

The spread of the high-voltage electricity grid (Figure 8) is the first inheritance of some infrastructures that created convenient territorial conditions and can be well used in the future. Power is usually transmitted through overhead powerlines, supported by transmission towers, generating a vast network of connected lines crossing almost all the territory of the Rhine Basin. Because of its danger to human life, it creates a human avoidance zone under and buffered by its lines. The region of these transmission lines usually overlaps with the future operational landscapes of energy because they do not penetrate denser areas of human inhabitation. This condition highlights the potential of those areas for renewable energy technologies to link to the grid and alter the management of adjacent areas through its deployment.

This map (Figure 9) shows the areas recognised as the main locations for the project grounding the 'energy transition' to renewables: the future operational landscapes of renewable energy production. Its vastness draws attention to its potential to become a "third landscape" where an alternative urban model can be validated.

As a crucial addition to finding the best locations for this network, the map (Figure 10) draws the main ecological corridors that connect high ecological integrity conservation patches are identified. (Fernández et al., 2020) With this contribution, the "Energy-Ecology Network" (Figure 11) takes shape.

The network is proposed around the high-voltage transmission lines following the proposed ecological corridors shown on the previous map. The initial buffer is 5km wide - considered a minimum to preserve an effective ecological corridor for many species (Beier, 2019) - and expands as it touches or connects conservation patches to keep landscape continuity.

Regarding energy, the potential of this area is enormous. The electricity generated in this area can fulfil the energy demand much further than the local context, distributing the electricity across the inherited grid. The close distance from the grid avoids losses and triggers the grid's renovation towards adaptation to renewable energy technologies (its retrofitting, renovation, and actualisation). From an ecological perspective, the connectivity in space strengthens the restoration of ecological functions around large areas of intensively used, fragmented and impoverished wildlife land. The connectivity also boosts the overall

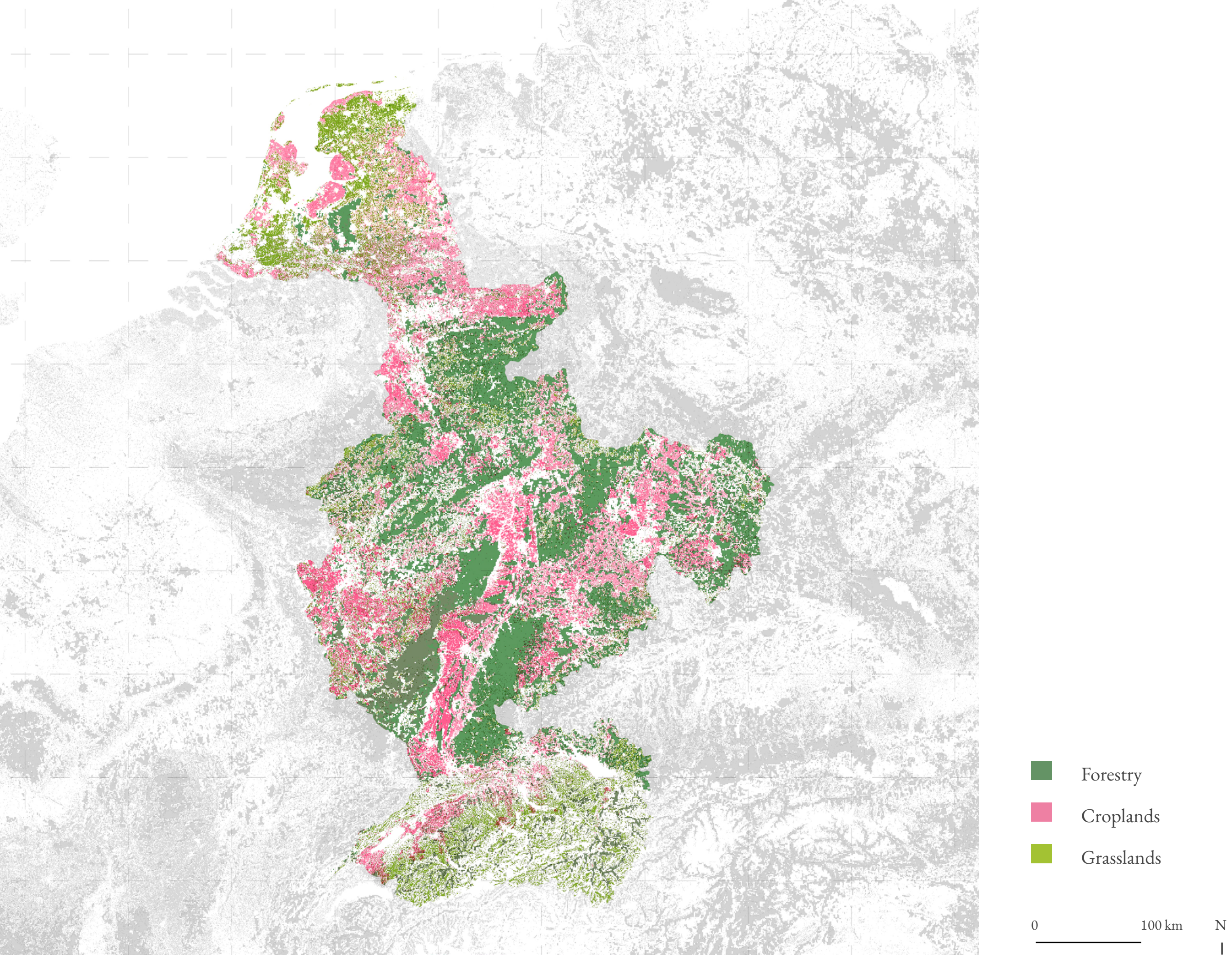



Figure 9: Future operational landscapes of energy

biodiversity resilience, making the movement of species and the genetic exchange possible as it provides habitats for fauna & flora. From an urban planning perspective, the current 'energy transition' is the moment to approach this 'new' space as the organiser of a new kind of urban network of energy generation and distribution, ecological connection and restoration and alternative human productivity and creativity - testing a reorientation of energy, food, and work into ecological frameworks in the operational landscapes of energy.

Several objectives are combined while deploying renewable energy technologies: (1) it connects higher ecological integrity zones to strengthen the basin's local and continuous ecological resilience. (2) It aims at maintaining or restoring the connected landscape with an alternative energetic-ecological management. (3) It creates the possibility of designing the ecotone between landscapes for energy, ecological purposes, and other land uses. (4) It addresses the long-term goal of restoring and conserving European biodiversity, functioning as a spatio-temporal "stepping stone".

Looking at the urbanisation paradigm it mediates: (1) It reuses the inherited pattern to propose a corridor that tests a new urbanisation paradigm. (2) It builds a conceptual tool, introducing transitional landscapes that surpass current dichotomies between the urban vs rural, conservation vs intervention, nature vs economy and society. (3) It composes a "third landscape" as a platform for an alternative understanding of productivity, composing hybrid landscapes for humans and more-than-humans. (4) It is an expanding project. It grounds a spatial planning process to deal with current or future energy transitions. Altogether, it becomes an alternative urbanisation pattern for European territorial and regional integration.

The following section will use typological transects to add resolution and speculate on the character of a region and its transition when approaching typical structures like highways, agglomeration zones, and others, bringing together several actions for the future operational landscapes of the energy transition.

*Projection: the temporalities of energy*

The graph (Figure 12) draws a cross chronology between environmental, energetic and biodiversity policies, directives, plans and key dates - historical and projected - from the rise of environmental concerns around the 1970s until the end of the current century.

It does so by tracking the exponential carbon emissions and loss of biodiversity acting as actors in the history of energy policies, directives and important actions. It portrays only a fraction of the interweaving relationship between energy and its relation to the web of life (Moore, 2018)

2030 is the closest deadline for predictions regarding the depletion of ecosystems and crossing planetary boundaries. It is characterised as a time towards an effort


Figure 10: Main ecological corridors that connect high ecological integrity conservation patches (Fernández et al., 2020)

to mitigate the consequences of centuries of Extractivism. For example, The EU Biodiversity Strategy 2030 aims to recover European ecological systems, and Trans-European Networks will be implemented around that date. Other policies for clean air, circular economy, the last round of the Common Agriculture Policy, and significant steps to decarbonise industries are due to that date.

2050 is viewed as a deadline for new systems to be fully operational. For example, the EU Biodiversity Strategy envisions "restored, resilient, and adequately protected" ecosystems. Cities like Rotterdam aim to be "net-zero". Fossil fuels are phased-out in many European countries, like Germany. By the time of the COP24, the European Commission prepared a zero-emissions strategy for the EU. In line with this request, the European Commission published the EU's vision for a "prosperous, modern, competitive and climate-neutral economy by 2050."

2100 already speculates for the transition to another technological possibility. It envisions that in a scaling-up of post-extractive forms of energy generation, the "Energy-Ecology Network" can get rid of its renewable energy structures and deliver a restored and connected landscape for Europe, becoming a new backbone for European urbanisation. The temporality for 2100 is a project to set the scene for the next century's urbanisation. Hopefully, in this urbanisation paradigm, the distinctions between technology, politics, economics, and ecology will be less clear, being all of these at once in different ways. (Bratton, 2021) To envision that, the terraforming project can start now in the future operational landscapes of energy.

*Projection: The terraforming of future operational landscapes of energy*

Terraforming is something that humanity does as it inhabits the Earth, and it adapts and is adapted to its conditions. It is also important to realise that "the response to anthropogenic climate change will need to be equally anthropogenic." (Bratton, 2019) In other words, the response to, for example, more parks, forests and different city and more-than-city landscapes is to reorient urbanisation towards a different paradigm, building other landscapes that compose a viable Earth for living beings. However, how would it look like, be governed, what is in there, and who can access them? The understanding of that continuous transitional process asks for the nuance not to design a solution but to speculate on an intentioned terraforming, with a design that mediates other ways of seeing the world.

The 'energy transition' theme is a hinge for projects that discuss the composition of hybrid habitats. Following that line of thought, the project invests in expanding the idea of NETs (Negative Emission Technologies) to include more than the biological or industrial modes towards a larger framework for NET as an intelligence of inhabitation. Biological NET is something a tree does in its bio-

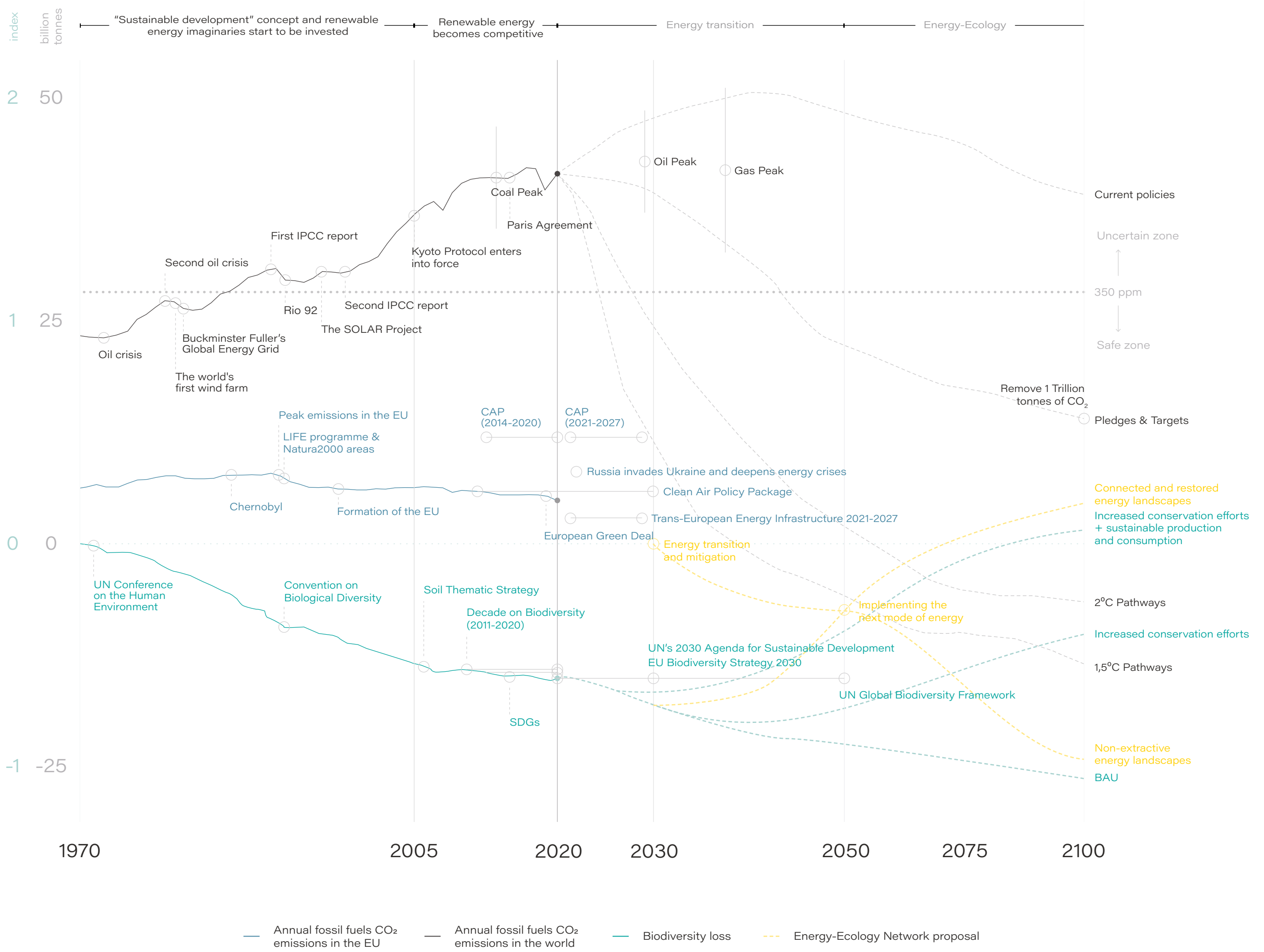



Figure 12: Cross-chronology between environmental, energetic and biodiversity policies, directives, plans and key dates

logical technological apparatus. Industrial NET has also become something humans do by building CCS plants to suck carbon back to deep geological strata. Urbanisation processes as negative emission technology mean the kind of terraforming that reorient sociospatial and environmental transformations unfolding in the operational landscapes of energy to recast the intense focus of climate action from metropolitan regions to include the wide range of urbanisation, especially the areas of forestry, croplands and grasslands.

For that reason, the last "Projection" part focuses on the configurations and elements of how each typology of energy landscape can behave in an instant of each energy temporality (2030, 2050, 2100). Forestry, croplands and grasslands receive the alternative paradigm of the Energy-Ecology Network and speculate on the interactions with many elements in its landscapes, testing its gradients when encountering uses like highways, railways and agglomeration zones of different number of inhabitants. Typological transects unpack the configurations and relations in these crucial landscapes through a longitudinal section of 5km, the initial buffer zone along the high-voltage transmission lines. It aims to demonstrate the composition of a new paradigm in time and space, demonstrating what must be interrupted, continued or made anew.

*Woodland and forestry*

The abundance of trees characterises forest land use and is an essential ally in addressing climate change and biosphere degradation. The separation of areas for no entrance and some sort of human 'retirement' from intervening in these zones must be reorganised as a process of urbanisation and not only regarded as conservation. The "Energy-Ecology" concept can provide a way to implement efficient ways to deal with forests welcoming practices for lower intervention or energy technologies that have lower disturbance to ecosystems than the actual use.

The typological transect of a forestry landscape (Figure 13) portrays the current condition, with the elements mostly found in the territory of the Rhine basin. The subsequent illustrations show the speculation until a new temporality of energy landscapes, with a zoom on one specific situation.

It is important to highlight the Natura2000 areas, mostly in forestry landscapes. Through the decades, the most important is to connect them to provide migratory paths for biodiversity to adapt to climate change consequences. Additionally, renewable energy technologies can organise hybrid landscapes to connect those areas inside the expanded buffer zone of high-voltage transmission lines. Every other land use patch must be directed for 'rewilding' through renewable energy technologies. For example, by 2030 (Figure 14), high-den-

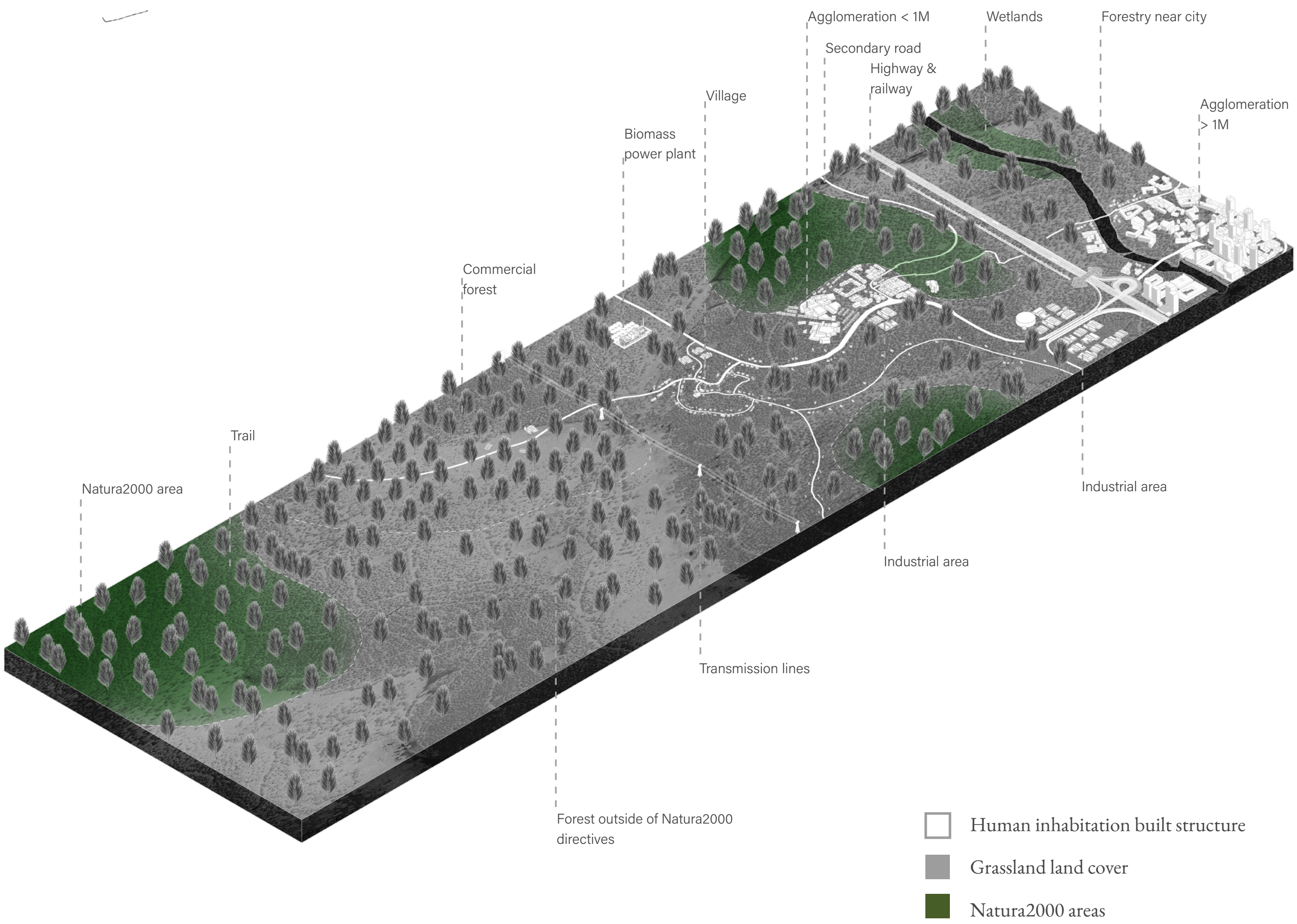



Figure 13: Transect for the territorial typology of forestry landscape in the Rhine Basin

sity of photovoltaic panels will be installed in a previous cropland area. By 2050 ((Figure 15), the same area will decrease its density of energy technologies and redirect more area for lower intervention. Multiplied in many regions, this action will create a hybrid of 'ecological corridor', recreational park and energy generation. By 2100 (Figure 16), as another 'energy transition' (hopefully to non-extractive technologies) is being realised, renewable technologies will give way to a fully realised forestry network that prioritises more-than-human habitats but does not exclude controlled human visitation.

*Croplands*

The speculative design of this typology (Figure 17) envisions new paradigms in response to energetic demand, climatic response and definition of ecological areas for expansion. Three relevant dimensions of present-day agricultural landscapes are land cover, land management and landscape structure. (Verburg et al., 2013) The Energy-Ecology Network is a novel landscape structure for croplands, balancing new values of energy and ecological provisioning. Its land cover is varied and not taken into consideration in the resolution of this study, being relevant when encountering local situations. The land management aspect is, however, highly important. How the vegetation, soil, and water are treated in agricultural practices yields highly different spatial outcomes, with higher productivity or degradation.

To better understand the significant spatial heterogeneity of agricultural landscapes across the Rhine Basin and to propose changes in landscape functions and values, it is necessary to understand some forms of management that produce a certain quality in the landscape. Also, to understand with which elements the Energy-Ecology Network is being implemented. Instead of addressing a location, this method explores the variety of agricultural landscapes to recognisable elements that could be relevant for policy-making at the interregional scale. The developed typology comprises a diversity in composition, spatial structure and management intensities. This form of representation serves as an assessment to assist and visualise landscapes' influence on environmental change.

Among many types of croplands, medium and large-scale intensive arable lands are a common sight around the Rhine Basin. In that case, models of regenerative agriculture must become the new norm for restoring degraded soil and fostering natural processes' recovery and resilience. It would act to revert the common association of intensive arable land with intensive feed crops that degrade the soil with high amounts of nitrogen input and GHG emissions. In that case, agrivoltaics can be combined with farming, especially in vineyards regions, optimising crop yield and quality with renewable energy production. (Figure 18)

A particular situation is of croplands that stand in between forestry patches. In the run-up to 2050 (Figure 19),

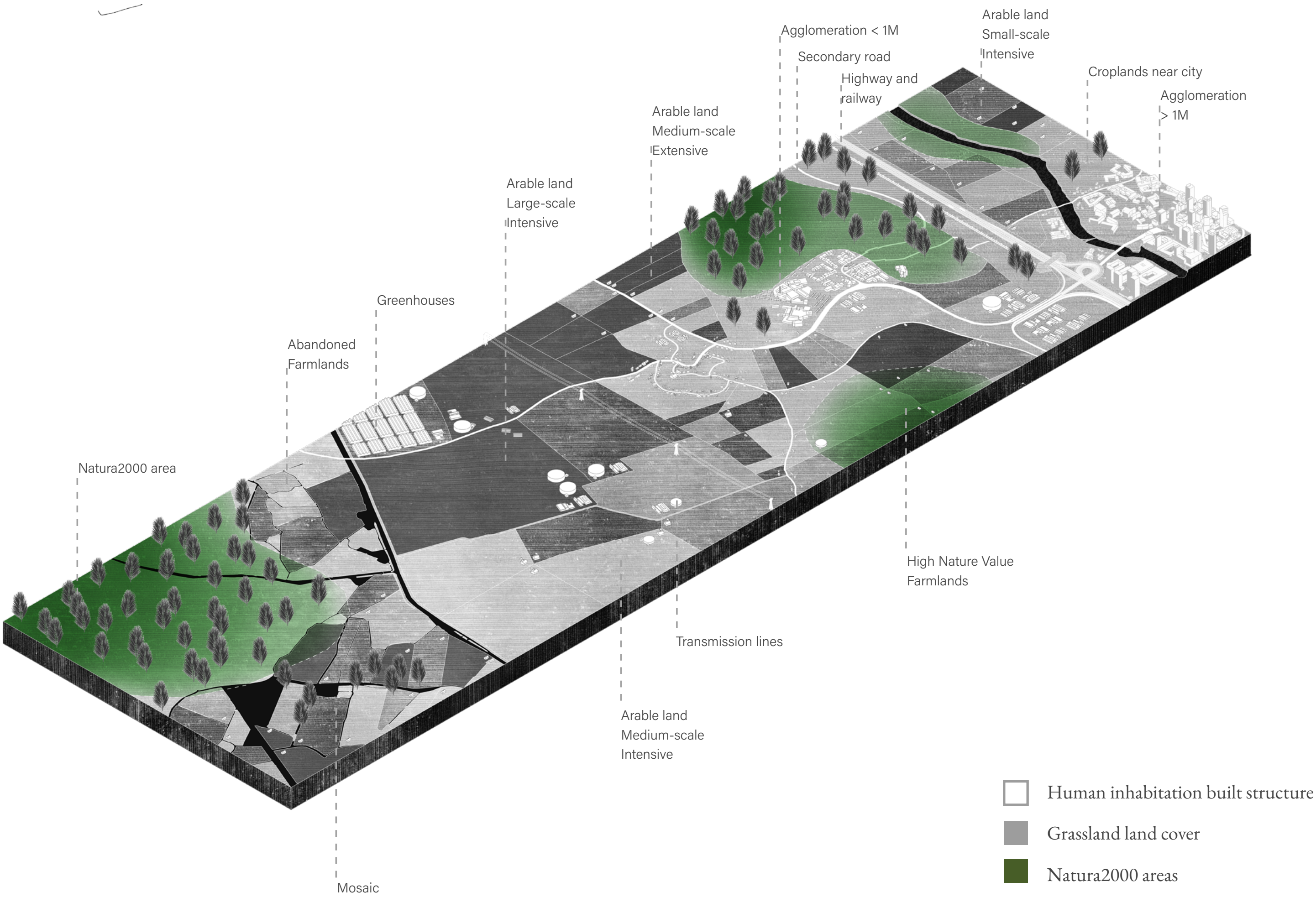



Figure 17: Transect for the territorial typology of croplands in the Rhine Basin

these are designed to include renewable energy production. At the same that it is implemented, it raises the possibility of designing its ecotone according to the different needs of an area. Ecotones could be designed for recreation and become a continuous park shared by humans and more-than-humans. Renewable energy is produced like never before, but at the same time, an 'ecological corridor' appears following the transmission lines.

*Grasslands, heathland and shrublands*

The temperate grassland biome comprises large open areas of grasses and shrubs, where trees can be present but are infrequent. There are many grasslands in the Rhine Basin boundaries, and here they are gathered as an ecosystem. Its further particularities should be designed in other resolutions according to local circumstances.

The ecosystem recognised as grasslands (Figure 21) holds an essential part of Europe's biodiversity. Its conditions are ideal for a rich diversity of species and are especially important for birds and invertebrates, providing vital breeding grounds. In relation to human habitats, they are the source of a wide range of public goods and services, ranging from meat and dairy products to recreational and tourism opportunities. In addition, they act as carbon 'sinks' and are a vital asset in reducing levels of GHG in the atmosphere. Fulfilling all those functions, they are a crucial part of the Energy-Ecology Network, being the most flexible.

It is vital to mention the links between agricultural and grassland habitats. In the Rhine basin, it is hard to find a grassland ecosystem that has not been modified and, to a significant extent, has been created and maintained by agricultural activities. These grasslands are maintained through farmers' grazing or cutting regimes, including a large amount of increased farmland abandonment, which is predicted to continue in Europe over millions of hectares (mostly of low-productive land) in the next decades. This scene allows these areas to transition with alternative management policies to provide energy as it recovers landscapes with higher-value nature. As the balance tilts towards increased biodiversity, many benefits are also enjoyed by humans; for example, the reduction of fire risk through the browsing and grazing activity of large herbivores.

There are many examples of grasslands near cities. These are areas that are usually taken for housing expansion or formed by the abandonment of previously inhabitation use - dwelling or industrial. The urbanisation of these zones, as an expansion of the city, can receive an alternative proposal in the Energy-Ecology Network. It is here proposed to focus on high levels of educational, cultural and recreational use among renewable energy technologies. For example, housing and other urban functions among industrial carbon capture and storage technologies, batteries, photovoltaic panels considering spatial quality, new models of wind turbines and geothermal stations. It is a learning space for the nearby city to learn about energy intertwined with a new way of inhabiting the Earth.

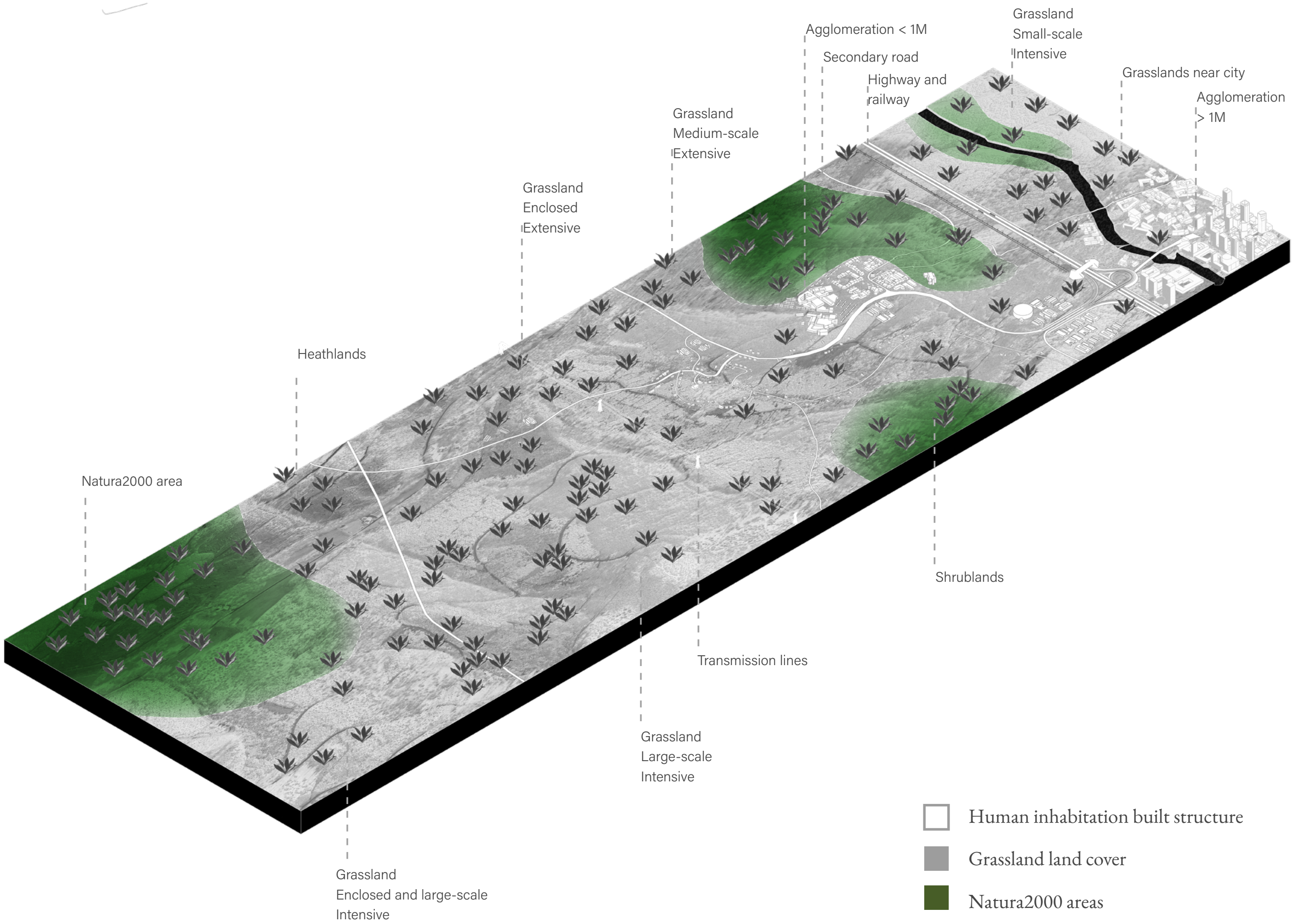



Figure 21: Transect for the territorial typology of grasslands in the Rhine Basin

*CONCLUSIONS*

The project concludes by providing a couple of assumptions to understand the convergence of the social, climatic, energetic, and ecological crises with the urbanisation of the Rhine Basin territory. First, it demonstrates that the relation to energy carries human habitats through every new paradigm of spatial possibilities. The concept of 'energy transitions' underscores the infrastructures that organise every new urbanisation paradigm. Second, the investigation indicates that croplands, grasslands and forestry are the future operational landscapes of energy. These are the next frontier for the scaling-up of renewable energy technologies. Third, the project's main outcome is to prove that energy landscapes can mediate socio-ecologically just urbanisation for future modes of energy production in the Rhine basin and Europe. Fourth, "Energy-Ecology" is a conceptual and methodological tool for introducing transitional landscapes that surpass current dichotomies between the urban vs rural, conservation vs intervention, nature vs economy and society. It invests in grounding a perspective that overcomes the human-centredness of Earth's inhabitation. It demonstrates the necessary "retreat" in space and "retirement" in time for the project of a viable planetarity on Earth. Lastly, the territory of the Rhine Basin transcends the vertical subsurface-surface-atmosphere continuum and the horizontal administrative boundaries of countries. It is the limit of an ecosystem bound by water, an element that forms the basis for living conditions on the planet. In that perspective, the "Energy-Ecology Network" proposes a more comprehensive Trans-European Network along the current energy grid with multifunctional corridors where renewable energy technologies are balanced with connection and restoration of landscapes. The project shows it is possible to communicate across disciplines and amplify intellectual experimentation through geospatial intelligence and visual-spatial narrative.

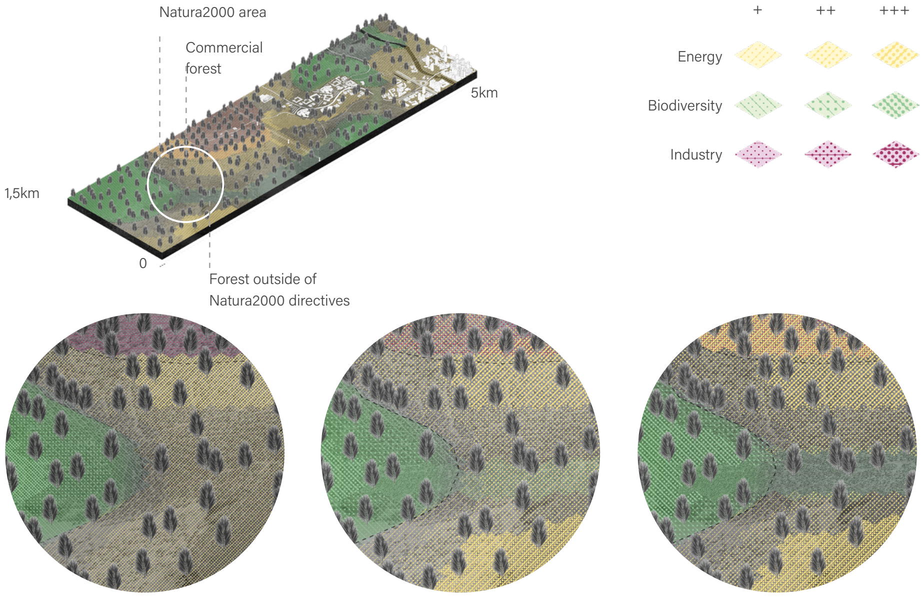
The design of the "Energy-Ecology Network" proposes a kind of "architecture of the territory". (Topalovic, 2016) It is a fitting engagement for spatial design methodologies, broadening the understanding of territory from the purely technical or administrative domain. This perspective creates the space for the design of different nature-based solutions (NbS) as intermediaries envisioning beyond the adaptation to the increasing climatic instability and becoming "stepping-stones" - in time and space - of new territorial conditions. It becomes part of a more applicable instrument for the city and more-than-city design, where societal and ecological visions are contemplated in the present temporality of 'energy transition'. From the perspective of the International Union for Conservation of Nature (IUCN), NbS must address several types of societal challenges in an integrative manner and not be isolated for a single goal, so it involves collaboration and coordination of mul-


Figure 25: "Energy-Ecology Network" in the Rhine basin with proposed expansion towards the European continent

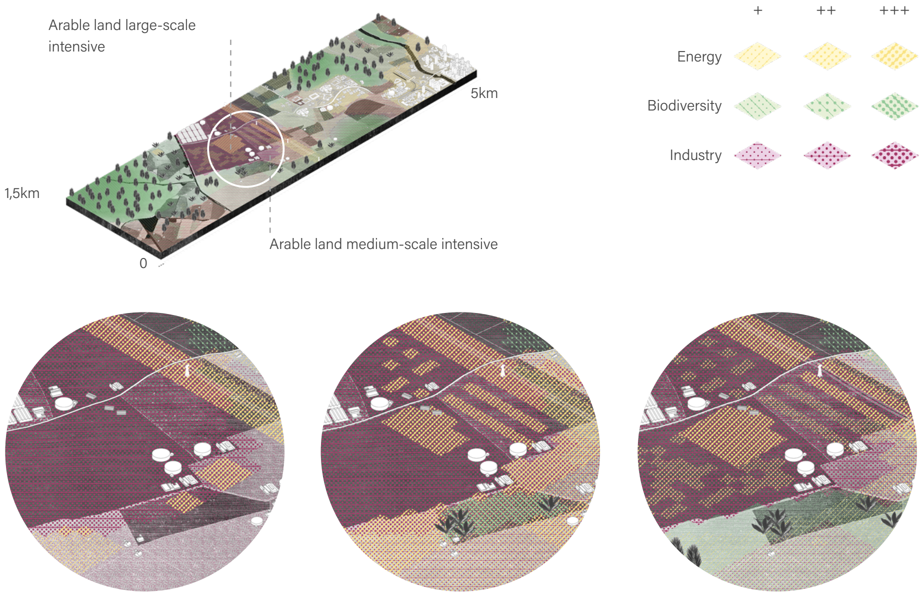
tiple stakeholders while building synergies across sectors. The next temporality of energy as a spatio-temporal project is included in a broader context of a planetary condition where the distinctions between technology, politics, economics, and ecology will be less clear, being all of these at once in different ways. (Bratton, 2021) Considering the design of NbS that attends this perspective contributes to a future urbanity when the dichotomies between the organic and non-organic, natural and artificial will be progressively surpassed, and hybrid habitats can be realised. Moreover, it shows that the territorial approach makes way for the project to be understood as an instrument for European integration. This project proposal could serve as a background for developing cross-sectoral and cross-governance policy instruments and grounding a framework for rethinking European networks beyond the typical infrastructures, becoming an alternative way of understanding territorial and regional integration.

The challenge of a Trans-European Nature Network and a Trans-European Energy Network (if revised for decarbonised technologies, like renewable energy) can be linked through a broadened view of NbS as instruments for negative emission technologies as landscapes. It expands the goal of the transition to renewable energy to contemplate climate and ecosystem mitigation, adaptation and restoration in its operational landscapes of energy. It is possible to conceive and compose landscapes of solar and wind energy, batteries and transmission powerlines while implementing regenerative forms of land management that also address food provision, water regulation, soil protection and restoration and the fostering of fauna & flora habitats, inaugurating a new condition of urbanisation in the Rhine Basin.

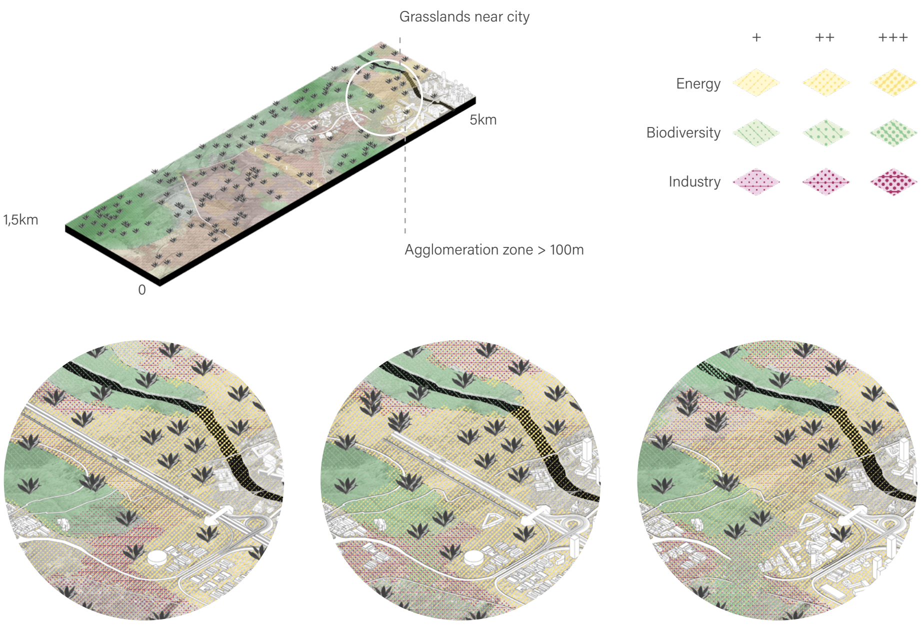
Finally, from a conceptual perspective, it offers a critique of current sustainability debates, engaging with post-capitalism and post-environmentalism questions with a grounded yet speculative narrative of 'energy transition' futures across the Rhine Basin. It does so by exemplifying the power of design to act as a catalyst for interdisciplinary knowledge integration through a combination of analytical and creative tools, with an emphasis on bringing together geospatial analysis with research-by-design tools and workflows. Speculative territorial design can be used as a platform to discuss, investigate and reorient urban theory and spatial planning as a philosophical, technological and geopolitical force.




Figures 14 to 16: 2030, 2050, 2100 respectively




Figures 18 to 20: 2030, 2050, 2100 respectively




Figures 22to 24: 2030, 2050, 2100 respectively

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