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temporalities of
energy landscapes in the Rhine basin

energy as a spatio-temporal project

master thesis graduation report

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Master thesis
P5 Report

Energy as a spatio-temporal project:
temporalities of energy landscapesin the Rhine basin

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energy as a spatio-temporal project

temporalities of energy landscapes in the Rhine basin

The relation to energy is what carries humanity through every new spatial possibility. The context of the European Green Deal that triggers decarbonisation of many industries and faster energy transition to the latest technologies of renewable energy production is only one among many past and future transitions. All in all, it brings different conditions of possibility to think of energy as a spatio-temporal project. The relevance of space is brought forward when the scaling-up is also a spreading around, highlighting the potential not only in the agglomeration zones but mainly in its interdependence with operational landscapes. These areas must be invested with a renewed understanding of the distribution of renewable energy technologies in landscapes, realising its potential for socio-ecological connectivity and becoming a new backbone of urbanisation that can mediate alternatives for the state of climatic instability. In this direction, the Rhine basin is the location to investigate the relation of energy landscapes in the fossil-fuel age, anticipate the potentials and limitations of the 'energy transition' and speculate on the current and future energy modes. The project draws from territorial analyses, energy policy and technical documents and ecological perspectives to build a conceptual tool, introducing transitional landscapes that surpass current dichotomies between the urban and rural, conservation and industry, nature and economy and society. It develops a platform for common grounds where energy landscapes become temporal and spatial "stepping-stones" towards connecting and restoring landscapes towards just coexistence between natural processes, habitats for humans and fauna & flora amongst current and future modes of energy production. Eventually, it could serve as a background for developing policy instruments for rethinking European integration and networks beyond the typical infrastructures in Europe, becoming an alternative way of understanding territorial and regional integration.

Keywords: temporalities, energy transition, energy landscapes, operational landscapes, urban networks, ecology, Rhine basin, Europe

about

"Energy as a spatio-temporal project: temporalities of energy landscapes in the Rhine basin" focuses on the translation of multidisciplinary scientific knowledge (primarily ecology, environmental sciences and energy) into spatial design, planning and strategy. The "Energy-Ecology Network" is an alternative understanding of territorial and regional integration composing renewable energy corridors connecting higher ecological integrity landscapes for a socio-ecologically just energy transition into regenerative, restorative and sustainable practices in the current and future operational landscapes of energy. Ultimately, it forms a new "energy-ecology" backbone for the urbanisation of Europe. As strategy, it proposes a conceptual tool and methodology for the landscapes of energy transition to act as spatial and temporal "stepping-stone" through hybrid land uses and for new balances of habitats for non-humans and humans. Moreover, it could be seen as assisting policy instrument for rethinking European integration and networks.

context

The project problematises the scaling-up of renewable energy in the Rhine basin, seizing the current context of energy transition to address new paradigms for urbanisation. The European Green Deal triggers a faster energy transition to the renewable technologies of energy production and decarbonisation of many industries. However, it still falls short of the spatial and ecological understanding of its challenges. The project bridges a gap between the design and policies over energy technologies, climate reports and speculations, and ecological principles in a broader proposal for energy as a spatio-temporal project that tackles planetary urgencies, like climate change and biosphere degradation, mediated by its landscapes.

framework

For the future operational landscapes of renewable energy production. It builds on an ecological turn that sees beyond sustainable economic development, which retains the same inequalities of colonial approach to natural processes and forms of production of value in appropriation and extractivism. It proposes a socio-technical transition to just sustainability models with strategic approach to land management in the current energy transition. It does so by providing new quantitive and qualitative models to the provision of habitats for human and non-human life in the productive landscapes of renewable energy.

propositions

The relation to energy is what carries humanity through every new paradigm of spatial possibilities.

Croplands, grasslands and forestry are the future operational landscapes of energy.

Energy landscapes can mediate a socio-ecologically just urbanisation for future modes of energy production in the Rhine basin and for Europe.

"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.

The "Energy-Ecology Network" is a Trans-European Network along the current energy grid to propose multifunctional corridors where renewable energy technologies are balanced with connection and restoration of landscapes.

The Energy-Ecology Network in the Rhine basin with proposed expansion towards other territories outside the Rhine basin. The grey tones maps the Natura2000 patches in Europe.

High voltage transmission lines
Croplands
Forests
Grasslands
Conservation areas (Natura2000 and Emerald)
Ecological hotspot
Proposed ecological corridors
Railways and highways

0 100 km N

basis

"Nonetheless, all worlds eventually come to an end, and this end can be indexed by the inability or inadequacy) of an existing world configuration to absorb frictions within it." (Reed, 2021)

"This delicate threshold (to grapple with the unknown) can be described as a constitutive inter-worldly friction between the probable and the possible, namely: the site of meta-relations between an actualized world and an unactualized otherworld." (Reed, 2021)

How do we begin to think referential frameworks for an unconcretized otherworld (an affirmative labour, for which inductive modes of knowing are inadequate because there are no memories available from a world that has yet to be inhabited)? (Reed, 2021)

"What future would make the past worth it? Perhaps the future of planetary intelligence is now as existentially entwined with a radically different career for composition, foresight and order-giving as its advent was from the cascading centuries of pilotless destruction. Taking this new existential condition seriously demands a radically different sort of philosophy."
(Bratton, 2021)

My motivation is an investigation on the value given to the work performed by human and non-human entities and how it spatialises unjust productive logics across the inhabitation of the planet. Concomitantly, to understand historical processes and how they inform today's imaginaries and influence long-term/future plans or the urbanism of today. Following this drive led me to the topic of energy, with the plans, policies, concepts and vocabulary around the announced epoch of "energy transition" getting my attention.

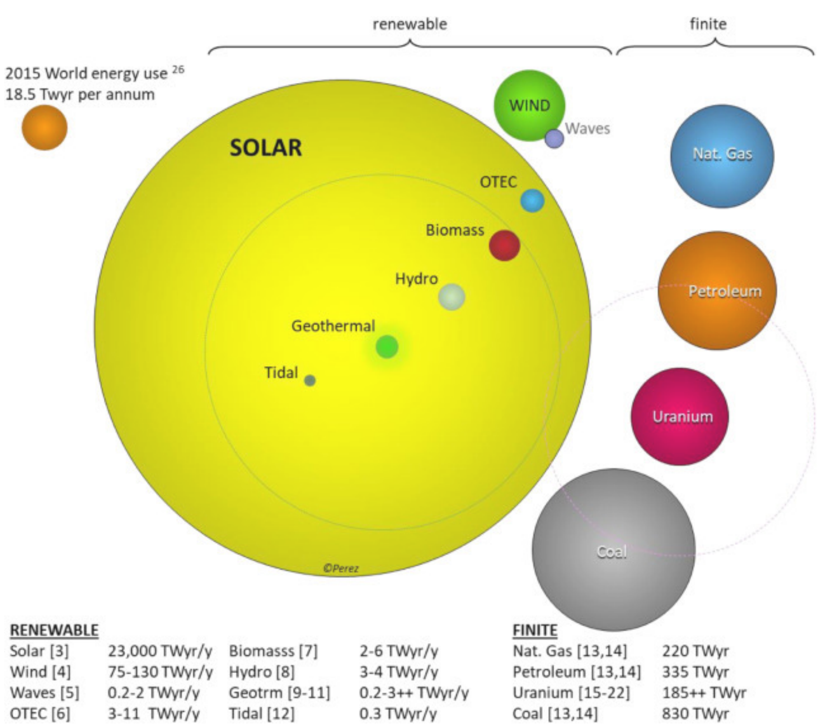
To structure the narrative, I found inspiration in an essay called "The End of a World and its Pedagogies", written by Patricia Reed, an artist, writer and designer. She builds an argument about the efforts of composing new worlds at the fringe of a dying one. The topic of energy is inevitably intricate with current climate change and biosphere degradation, overstepping core planetary boundaries and damaging Earth's life-supporting systems. The task of building worlds worth living in is pressing, so Reed's proposed structure served as fitting point of departure for this thesis.

The territory of the Rhine basin is chosen for it 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. It is also a heavily urbanised region, where the watershed and energy ties are historical, being the target of many envisioned futures. This set of location and narrative organises this project-book as follows:

The first part focuses on the **inheritance** of the spatial consequences of non-renewables, mainly fossil fuels. It researches the socio-ecological damage and the energy crises that occur under its over-productive logic up until today. Still taking inspiration from Reed's perspective, she calls this investegation the "negative labour", which is the effort to articulate the frame that sustains the logics (of capitalism) irrelevant so that it is possible to learn the inadaptation from this world. This necessary inadaptation is something that the buzz around the "energy transition" is working on, even if it is clouded by what sustains the actual frames of reference.

The project continues with the effort to **anticipate** the scaling-up of the renewables, promised to be fully operational by 2050. It projects the potentials and limitations of this rising era under the scope of "sustainable development" and its shortcomings. This effort is part of what Reed calls "affirmative labour", which takes the form of building an observatory to speculate on scenarios for future energy modes, focusing mainly on the processes that viabilise socio-ecological energy landscapes envisioning non-extractive energy production. This belvedere makes it possible to observe and distinguish the "externalities" inherited in many ecosystems along with the cunning and industry of the human inhabitation of the Earth.

Lastly, in the **projection** there is an active intention to design with the externalities, as the studio Design Earth poses. The inherited and anticipated pieces become elements for the planet's terraforming once again, however, for the coexistence of energy and ecology, connecting and restoring landscapes and developing a different paradigm over productive landscapes.



Available energy supply comparison by sources.
Image 1: Perez, M., & Perez, R., 2022

Energy landscapes

First of all, it is important to understand the locations of this project. Energy landscapes are all the areas where anthropogenic-induced energetic exchanges happen. Building on a categorisation provided by the IPCC (2014), energy has five types of landscapes: extraction, transportation, conversion, distribution and consumption.

Primary energy or extraction landscapes
Primary energy consists of energy carriers, a substance containing energy that can be converted to heat or used for any other energy-consuming purpose. The most common energy carrier is electricity, the most versatile form of energy available. In today's process, by large, the work of natural processes is treated as commodities that are captured directly from natural resources in mining sites. Examples are coal, oil, gas, nuclear, geothermal, solar, wind, hydroelectric, biofuel, wave and tidal energy. Suppose a depletion of resources must be prevented; in that case, a transition should be made to renewables, as they can last indefinitely, whereby non-renewables consist of a limited supply which cannot easily be replaced. (See figure on the side).

Transportation landscapes
In some cases, the transfer between primary and secondary energy occurs in the same location. When not, it needs to be transported. Trains, trucks and ships are used, but also pipelines crossing continental distances guarantee the supply for the conversion landscapes.

Secondary energy or conversion landscapes
Before the energy is used, it needs to be transformed for the desired use. Secondary energy describes transformed energy when natural resources can not suffice. For example, crude oil cannot be used directly in cars or boilers, as it consists of a highly variable mixture of hydrocarbon molecules. It needs to be transformed into a usable product. In the building sector, secondary commodities are usually found in the form of electricity. An example is the electricity and heat produced by burning fossil fuels in power plants. Under the current mode of energy, those sites are the ones where the pollution is concentrated, depleting not only the local ecosystem but the planetary climate.

Distribution landscapes
These are the transformers and transmission lines that form a mesh throughout the world, mainly distributing the energy converted into electricity for nearly any activity in the modern world. Roads, railways and ship routes are also part of it, as it brings refined fuel to be stored for further consumption.

Consumption landscapes
These are mostly industry, mobility, housing, agriculture and others. Those landscapes function by using the electricity and heat that comes to fuel their activities.

Extraction

Extraction of lignite in the Ruhr region.

Transport

Engineering works along the Rhine river adapted to it to a more controlled and efficient transportation route. In the map, the red line superposes the geological meanders of the river.

Conversion

Non-renewable and renewable energy technologies of conversion are portrayed in the photo.

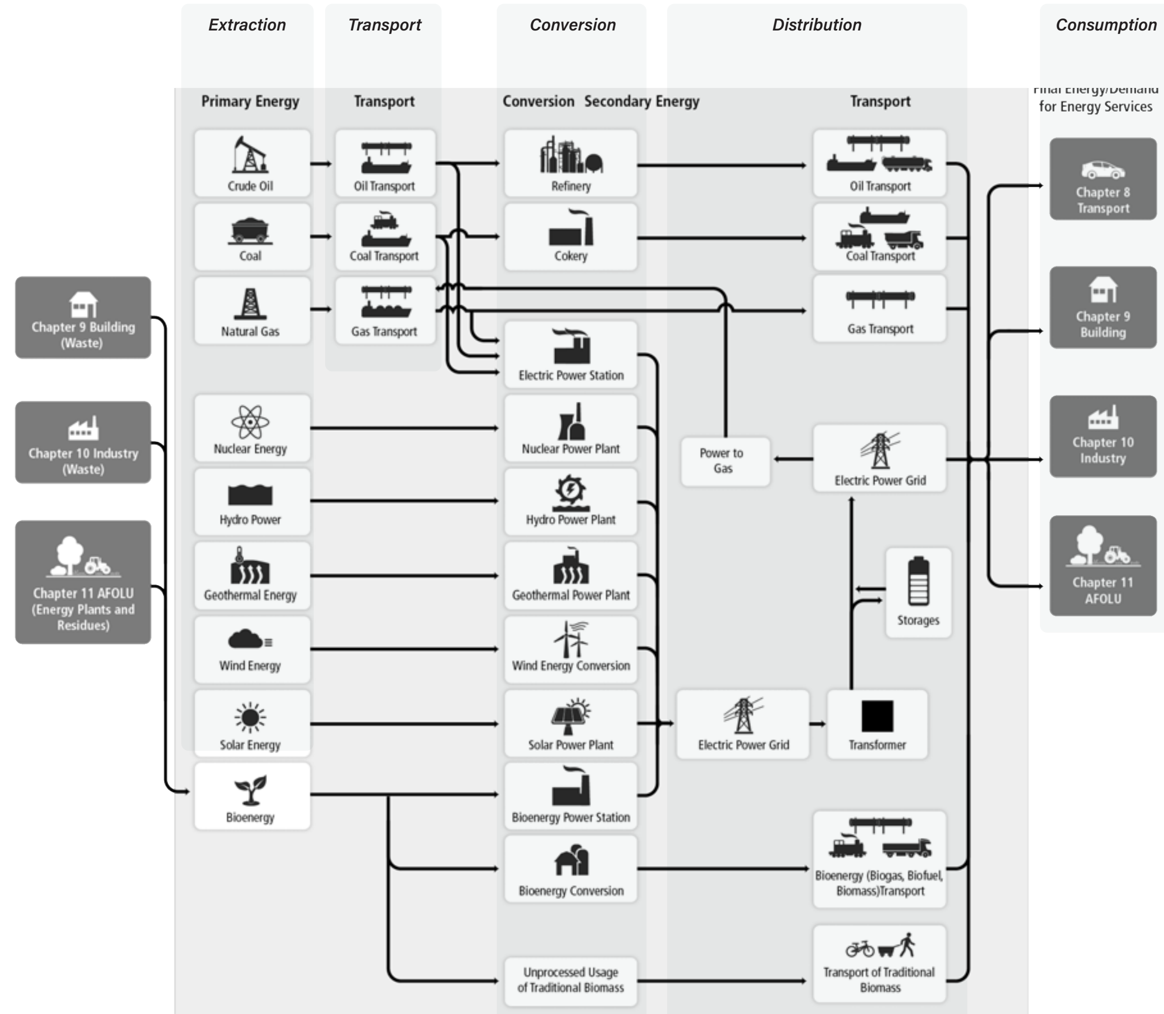
Distribution

High-voltage transmission lines distribute the generated electricity around the Earth.

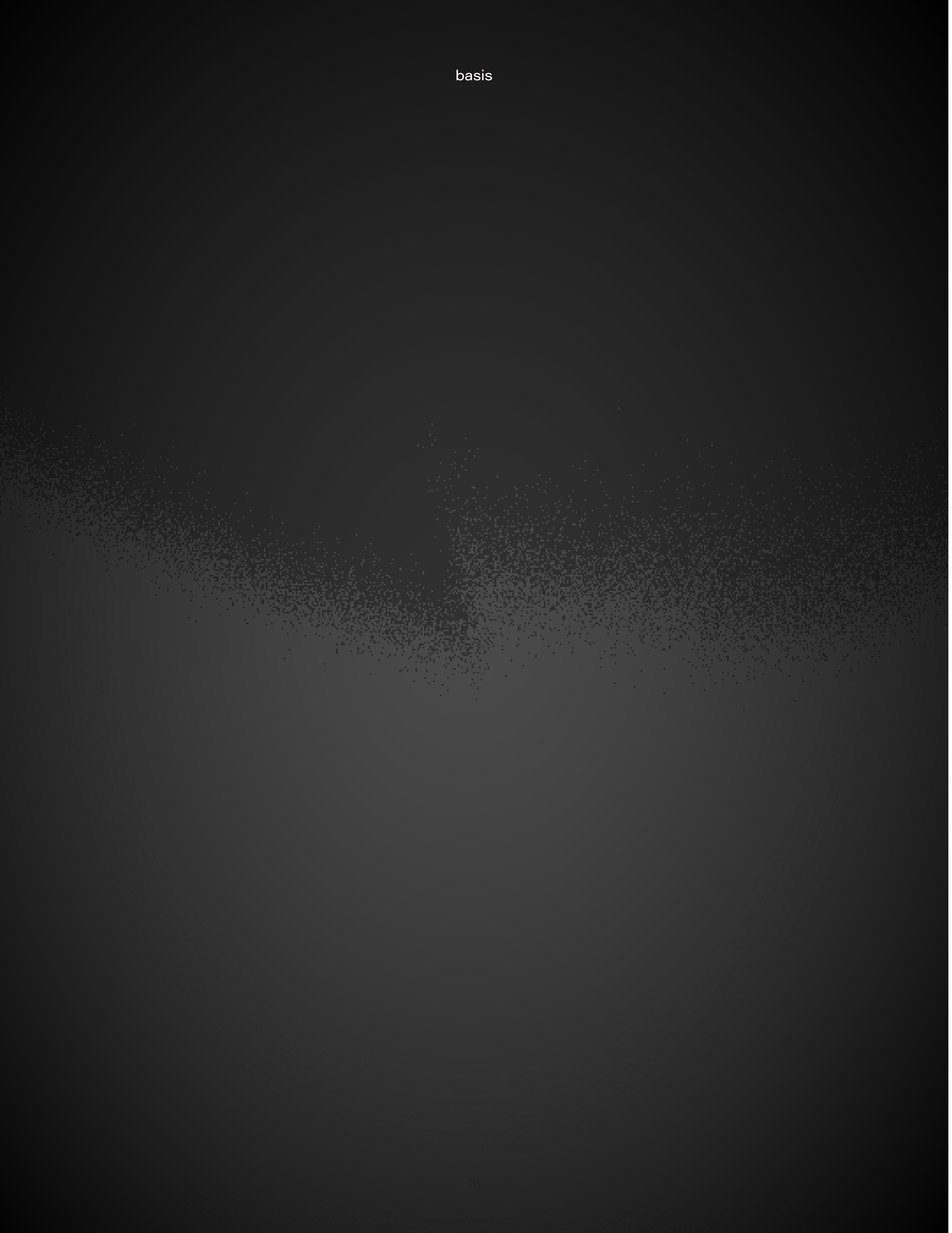
Consumption

The photo shows the city of Frankfurt, however, any agglomeration zone could be portrayed here.

An example of the energy landscapes for the region of the lower Rhine.
Image 2 to 6, from top-down

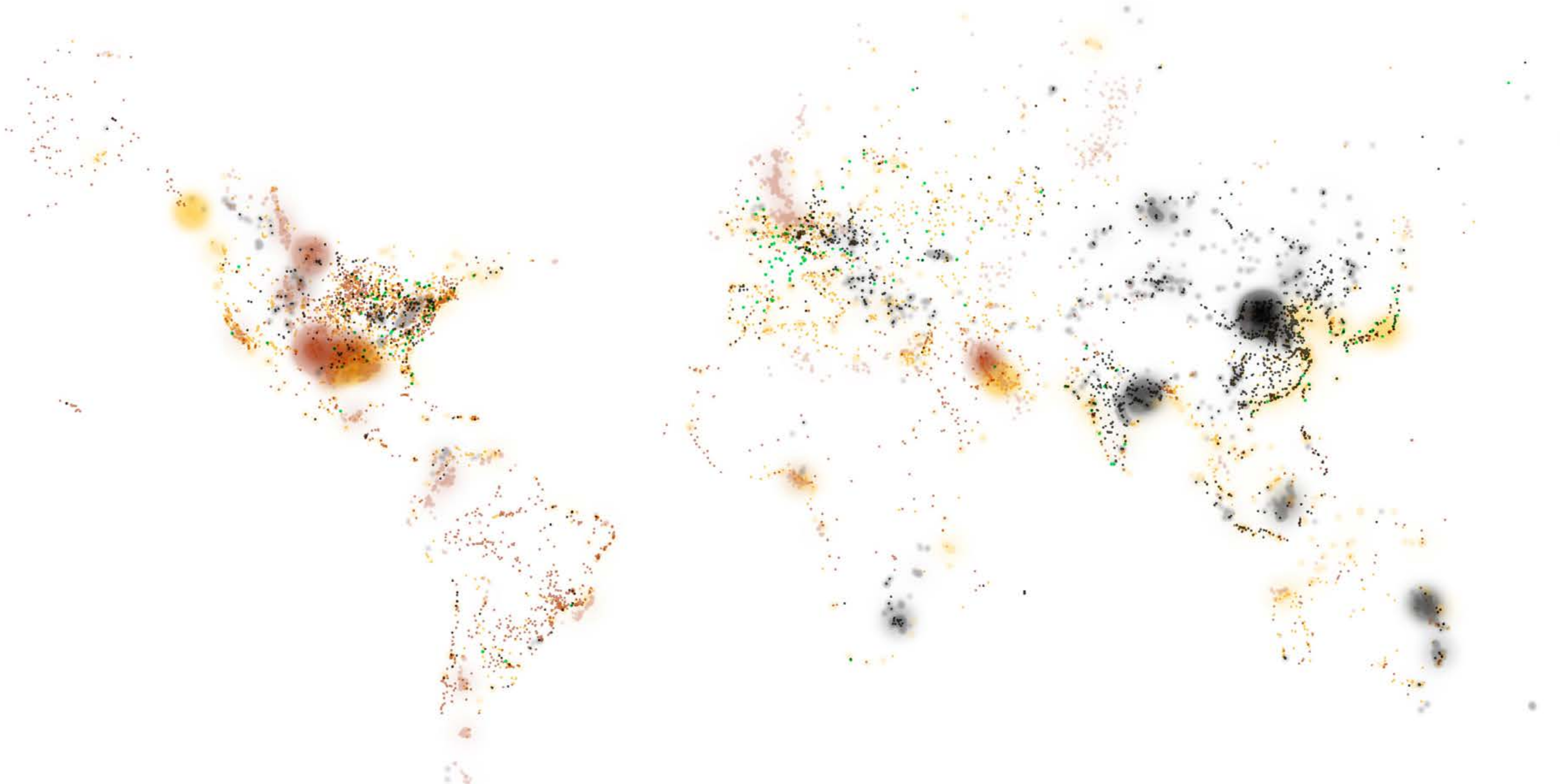


The diagram above summarizes the ways of the available large scale technologies to generate electricity that power the globe.
Data: IPCC

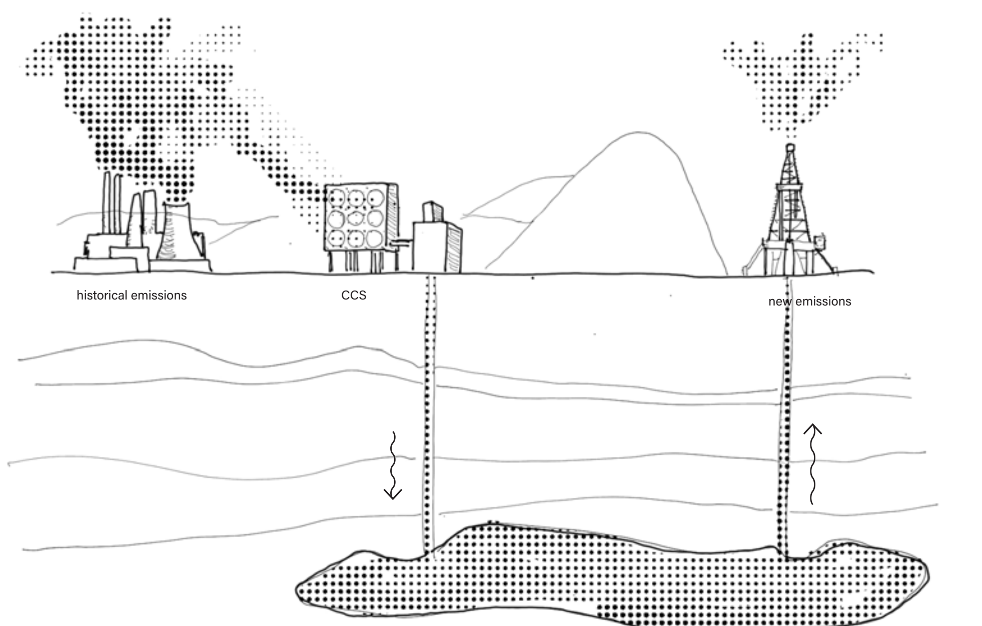


Problem *statement*

A global system that makes natures work



Non-renewable landscapes of energy
Data: Global Energy Observatory et al., 2019; Global Energy Monitor, 2022



Non-renewable sources have globally been the backbone of every activity. (Illich, 1983) Since industrialisation, and especially after the Great Acceleration in the middle of the 20th century, this condition 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 current world-ecology[1] drives the condition mentioned above. It rides on the myth that everything is made of energy and encompasses every landscape as a symbol of the age of production, measured in input and output. (Illich, 1983) This productive and accumulative imaginary sees everything in terms of devices that work, from machines to humans and natural processes. This notion and its social construct benefit some groups by reproducing imaginaries that reinforce a position of separation of (and within) "Society" from "Nature". (Moore, 2015) In all, this logic hides an accumulative relation behind a veil of sustainable development - even when the basis of this world is collapsing. Though tools and instruments address parts of issues and compose a mitigation strategy, there is a difficulty to find effective means for intervening in the behaviours and practices that engender the patterns of the current world-ecology.

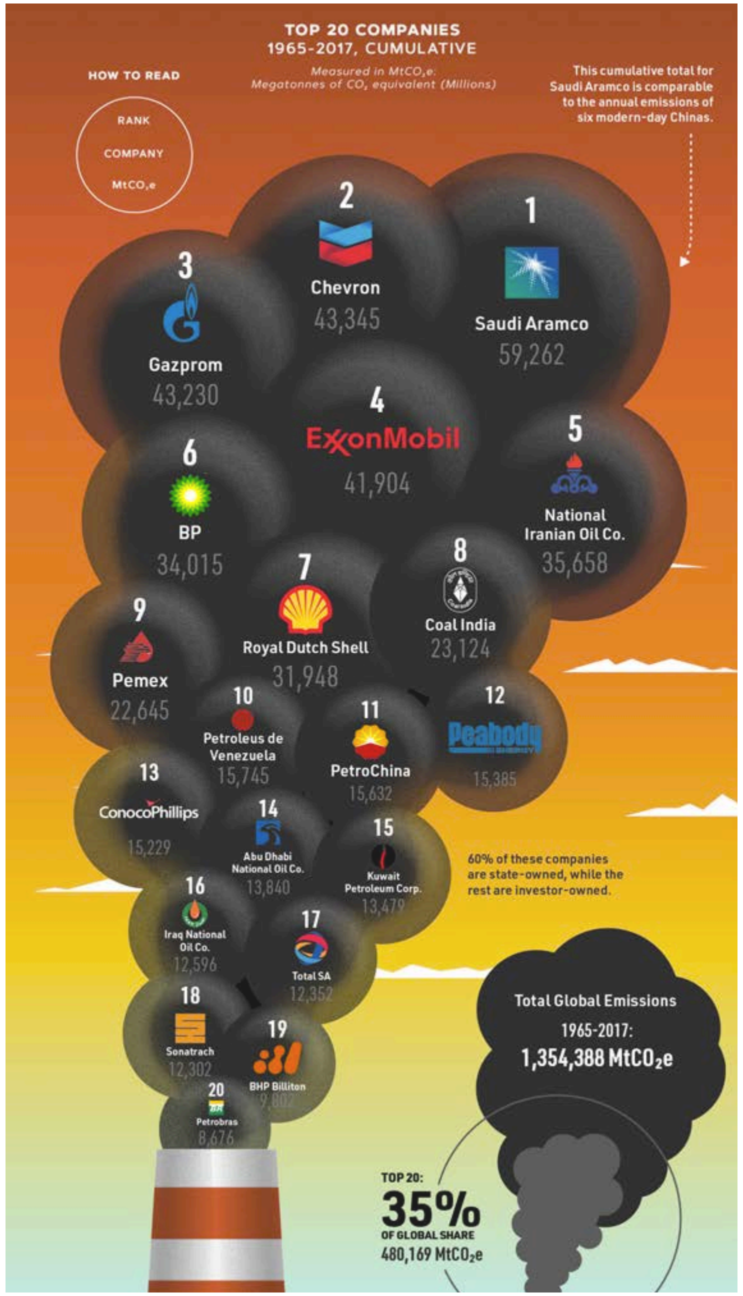
The exponential growth of a planetary industrial society and the amount of exploitation led to concerns about the planet's liveability for future generations since the 70s, when the scientific community sounded the alarm and an environmental movement began to gain momentum. The 1973 and 1979 energy crises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

Nowadays, the predicted supply shortage and the climatic consequences are becoming too latent and dangerous for its smooth functioning. The triad of energy, economy and environmental conditions is forming a scenario again for spatial planning and urban design to weigh in, making an alternative spatial project as the energy landscapes of the renewables era require and make possible different spatial configurations. (Ghosn, 2009) When landscapes of energy are physical manifestations of extraction, production, distribution and consumption under a damaging productive logic, a completely different plan to question what is functional and needed is urgent. (Bratton, 2019)

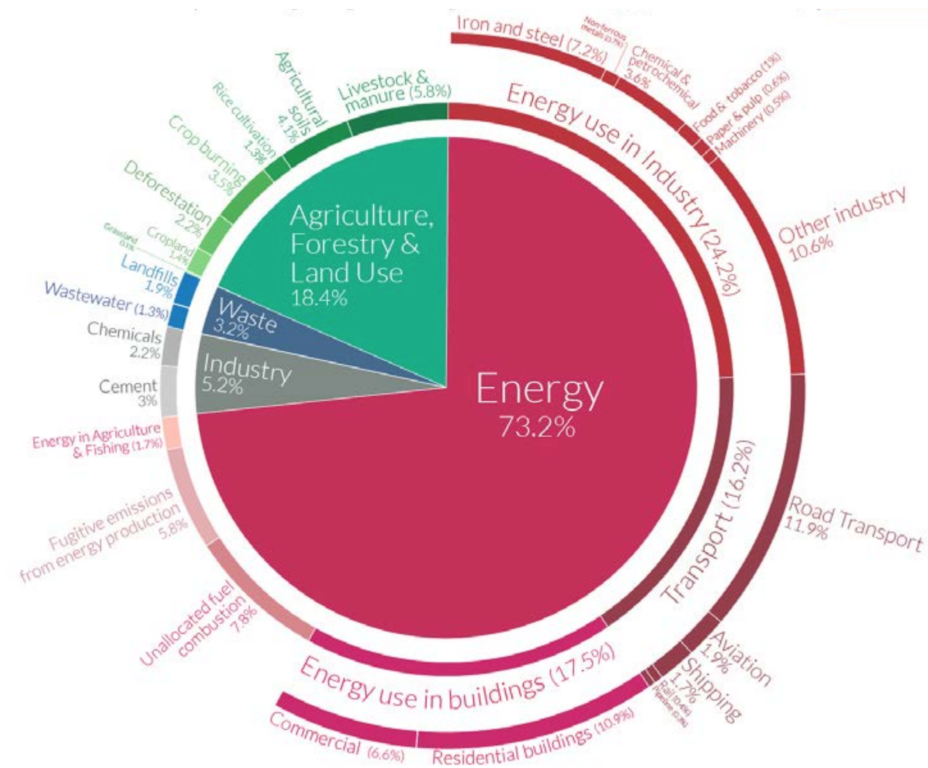
This interweaving of the current conditions requires a careful examination of the role of urbanism in shaping the perpetuation of uneven geographies of power. At the same time, a position of care must address the trend that energy technologies have to be used as instruments to recast the totality of the space within exploitative and extractive productive urbanisation. The current 'energy crisis' and the latent 'energy transition', buzzwords in newspapers and reports, conceal an underlying issue: this current regime proposes no viable alternatives for life on this planet. (Fisher, 2009)

1.
Enmeshed cycles of capital, power, and nature in modern capitalist imaginaries and system that degrade key spheres of life (Moore, 2015)

(left)
The rationale of net-zero
Source: Author, 2022.

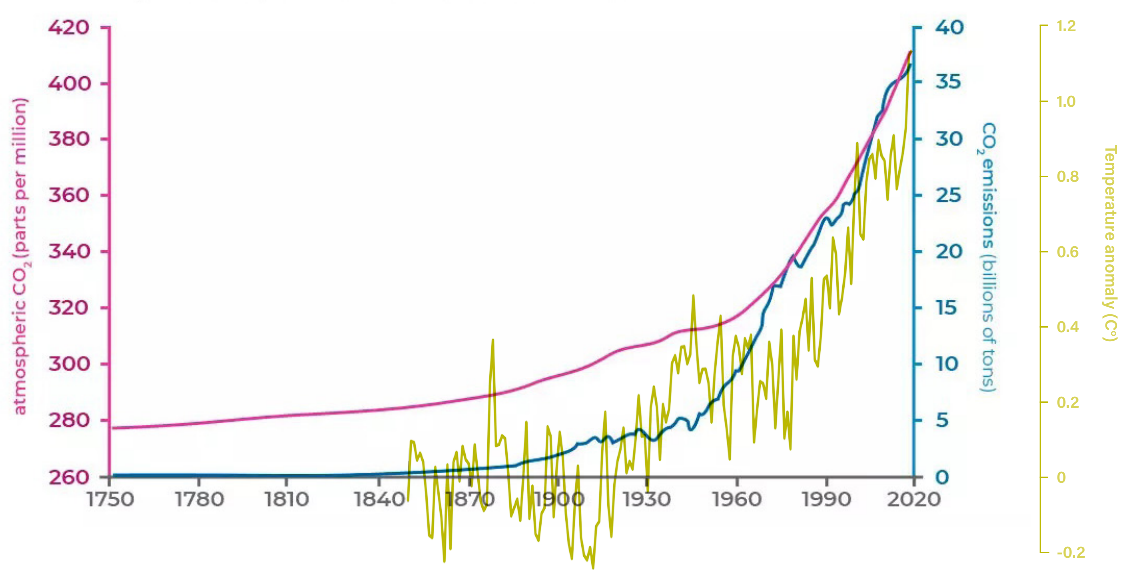


“Energy is ultimately a root cause of the exceedance of many planetary boundaries.” (EEA, 2020)



(above)
The companies responsible for the most global carbon emissions. The illustration show that just 20 companies are responsible to contribute over a third of all carbon emissions since 1965. A switch to low-carbon technologies is crucial.
Image 7: Visual Capitalist, 2021

The diagram on the right shows how the energy sector is responsible for almost 3/4 of emissions that cross planetary boundaries like the climate.
Image 8: Our world in data, 2016



2.
In an effort to understand the phenomena, the planetary boundaries is a concept and framework developed by Earth-sciences scientists to identify and provide insight into the environmental tipping points of Earth's life-supporting systems so that it is possible to develop responsible projects addressing the maintenance and restoration of Earth's systems.

CO2 in the atmosphere, annual emissions and temperature anomaly
Data: NOAA, ETHZ, Our World in Data, Hawkins et al., 2017

Non-renewable mode of energy and planetary-scale systems degradation

The historical and current use of non-renewables, namely fossil energy and nuclear energy, feedbacks in far-reaching environmental consequences. The degradation and pollution of landscapes are primarily local. However, the emission of GHG (greenhouse gases) from depleting reserves and mining operations, transportation of the extracted material, conversion of its embedded energy into electricity and heating, its distribution through pipelines and transmission lines and the consumption, mostly for the energy sector, have worldwide consequences.

It is no news anymore about the "unequivocal" (IPCC, 2021) warming of the planet, a consequence of one of the highest GHG levels, which is now almost 50% higher than pre-industrial levels. The highest concentration in almost a million years and probably in the last 2 million years (Global Carbon Atlas, 2018). Equally unprecedented is the speed at which GHG has accumulated in the atmosphere during the Industrial Era at about ten times faster than any time in the past 66 million years of the Earth's history. It is also "extremely likely (95–100% probability) that human influence was the dominant cause of global warming between 1951 and 2010." (IPCC, 2021) It is reasonable to argue that the mode of energy and its political, economic and spatial project set the scene for this operation. (Iturbe, 2019)

The planetary boundaries[2] framework points to the fact that "biosphere integrity" and "climate change" are core planetary boundaries through which other systems operate. The current energy mode is much related to these two categories as it alters and exploits landscapes for its demands from extraction to consumption, which uses the biosphere as a resource and the climate as a dump. The current fossil-fueled mode of energy, also understood by the previous visuals, highlights how crucial the decarbonisation of the energy landscapes is, raising claims for an energy transition towards renewable energy, which has lower emissions through the life cycle of its technologies.

As scientists sound their alarms, economists join the choir with predictions that fundamental shifts in the political economy agenda must be done until 2030 to prevent 'social collapse', a consequence of the spread of automation, artificial intelligence and the end of human participation in some tasks leading to less job opportunities. However, one clarification about the looming collapses is important, as Benjamin Bratton argues, "[t]hey are not the same kind of 'collapse', but they loom because of similar failures to comprehend and compose viable planetary systems." (2019) The intricate of modes of energy and urbanisation have a new opportunity to act in the project of scaling-up of the new renewable era.

> *"The climate system is a manifestation of the amount, distribution, and net balance of energy at Earth's surface. The total amount of energy sets the overall conditions for life. [...] Biosphere integrity is [...] defined as the totality of all ecosystems (terrestrial, freshwater, and marine) on Earth and their biota. These ecosystems and biota play a critical role in determining the state of the Earth system, regulating its material and energy flows and its responses to abrupt and gradual change." (Steffen et al. 2015)*

“The frequent calls for “us” to recognize “our” responsibility for the environment avoids the real questions of responsibility, the real causes of pollution and degradation. The slogan of “sustainability” hides rather than reveals that unpleasant fact.” (Marcuse, 2006)

Imaginaries like that for what is possible for the “energy transition” mask real fundamental changes that need to be envisioned and drive interventions.
Source: Author, 2022.

The myopic pathways of current sustainability

In 1987, the United Nations’ World Commission on Environment and Development (also known as the Brundtland Commission), in its report Our Common Future, suggested that development was acceptable. However, it must be a kind of ‘sustainable development’ that would meet the needs of the poor while not increasing environmental problems. That statement acknowledges part of the problem and is continuously proven to be an impossible goal.

Since then, ‘sustainable development’, something regarded as desirable in environmental terms, has reached other fields. The vocabulary that comes with it has found its place in the economy and environment, ranging from efficient regions to net-zero policies. In this shape, it is undercutting real reform by suggesting that its actions are for universal benefit. The focus is on an urgent and fast cutting of emissions that, under the current world-ecology, promises to be sustaining those in power with new technologies but few social transformation, and still degrading more natures. The meaning of sustainability, “the capability to be upheld or defended”, requires careful examination if it is used meaningfully in the sciences that deal with urban areas.

In 2019, for the European context, the European Union launched its “Green Deal”, aiming to make Europe carbon neutral by 2050. An essential dimension of it is the concept of “just transition”, that is, a transition to a carbon-neutral economy that is fair and “inclusive to all”, “leaving no one behind”, as the document states. The document also recognises that the level of the current ambition is “insufficient[3]” and that the coming instability and ecological transition will reshape geopolitics. This acknowledgement is crucial, but it is necessary to problematise the sustainability that already, for some decades, could not provide appropriate actions.

The spatial effects of ‘sustainable development’ acting as a goal under the neoliberal globalisation and the new economy end up amplifying the current conditions of conflicting interests and unequal distribution of power even if it meets environmental goals. (Soja, 2009; Marcuse, 2006) Its perspective is not a fitting analytical framework for understanding the interlinked nature of coercion in market work, coercion in non-market work, and the origin of environmental crises. (Mair, Druckman and Jackson, 2020) As Marcuse argues, perhaps “sustainability” should be considered only a constraint for developing the current paradigm of accumulation. It could also be argued that the current positioning of sustainability is very fitting for mitigation proposals, as it does not address core issues of the current state of over-productive, extractive and growth-based capitalism.

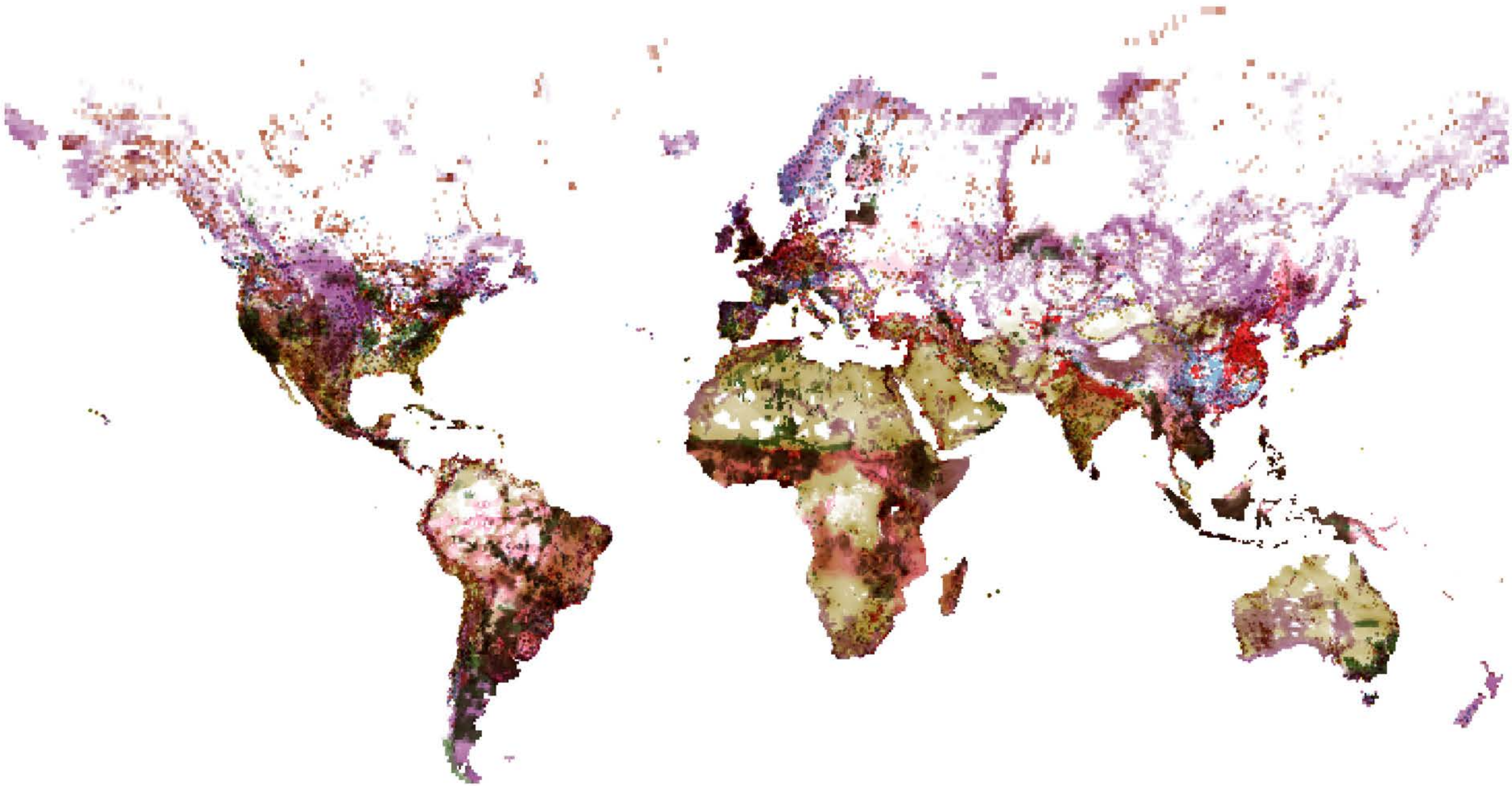
In this scenario, another project would be needed to balance environmental goals with social and spatial justice[4] in its urbanisation proposals. The complications are not in the technologies employed to cut emissions but rather in the crossing of frontiers searching for cheap natures[5] to exploit. Under the non-renewable regimes, it was characterised by nodal sites of extraction, conversion and consumption. Now, at least for the conversion landscapes, this changes completely. If before, it mainly exploited the subsurface and the atmosphere; now, the surface waits to be the next frontier, and spatial practices are one of the main actors.

3.
United Nations Environment Emissions Gap Report, 2019

4.
“The notion of ‘spatial justice’ offers a useful framework for considering the geographic dimensions of social inequality in cities and regions (Soja, 2010, Soja, 2009). One of the first mentions of ‘territorial’ issues within social justice can be found in Harvey (1973), with Pirie (1983) putting forward an explicit argument about the need for moving beyond such regional framings towards ‘an alternative conception of space itself’ (p. 471). Indeed, as Harvey (1996) observes, concerns about justice ‘intertwine with the question of how to understand foundational geographical concepts’ (p. 5). This suggests that a spatial justice approach involves not only revealing and describing geographical inequalities, but also critically evaluating such inequalities in terms of wider forms of (in)justice and their effect on human well-being.” (Bouzarovski & Simcock, 2017)

5.
Moore presents ‘natures’ as frontiers that the capitalist appetite devastates when extracting its work-value, always looking for a ‘cheap’ nature to compensate for the loss of profit when the last frontier cannot keep up with previous levels of production. (Patel & Moore, 2018)

Energy as a spatial project



Potential renewable landscapes of energy
Data: Socioeconomic Data and Applications Center (SEDAC)

Energy has a spatial project to operationalise its processes and support our 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 now being called a process of "planetary urbanisation". (Brenner, 2013) The modern era is the reorganisation of the territory around the availability of abundant energy established by a new horizon of possibility for production. (Iturbe, 2019)

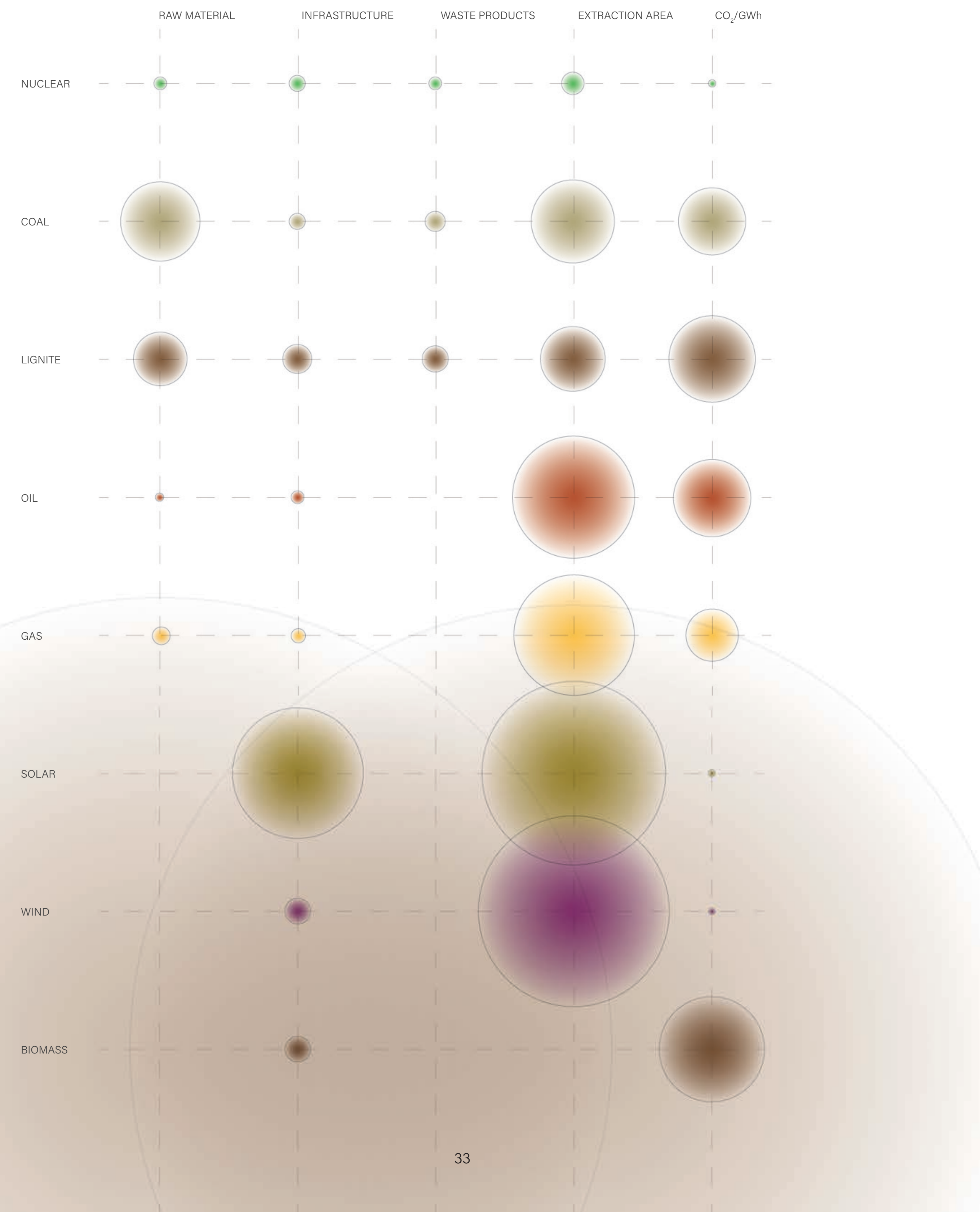
The planetary map of the last spread shows the range of landscapes that the renewables as a mode of energy operationalise. It is possible to map energy landscapes of extraction in mining materials to build renewable technologies, mostly silicon, aluminium, glass for the solar cells and panels and steel for the wind turbines and its column. Vast landscapes of grasslands, intensive and extensive agriculture and forestry are becoming operationalised to receive energy production technology - or serving as the primary material for such technology. This shapes a radically different landscape than the previous mode of energy.

The phasing-down (yet very active) mode of energy of non-renewables is territorialised in extended urbanisation with nodes of production in a dense web of connection to mining consumption territories. In a hurry to be the majority of conversion landscapes by 2050, the dawn of the renewable era raises questions about the grid and the sprawling of these infrastructures being treated as the panacea for environmental struggles. There must be caution in the transition to this new regime.

> "If unaccompanied by reflection on the 'needs' upon which the current regime thrives, may usher in few social benefits and little if any political and economic transformation, and merely pay lip service to the sustainability discourse in architecture: 'Zero-energy building would fit neatly between coffee without caffeine and war without warfare'. " (Ghosn, 2009)

The spatial challenge of renewable energy is not necessarily requiring more space but requires other kinds of spaces, especially in the energy landscapes of conversion. (IPCC, 2012) The overlapping and alignment of new spatial demands with existing structures will take different forms. The comparisons on the side make clear the spatial footprint for the processes in non-renewables and renewables, demanding more space.

> *"Energy needs space. It exploits a space as a resource, a site of production, a transportation channel, an environment for consumption, and a place for capital accumulation." (Ghosn, 2009)*



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

Energy against Ecology

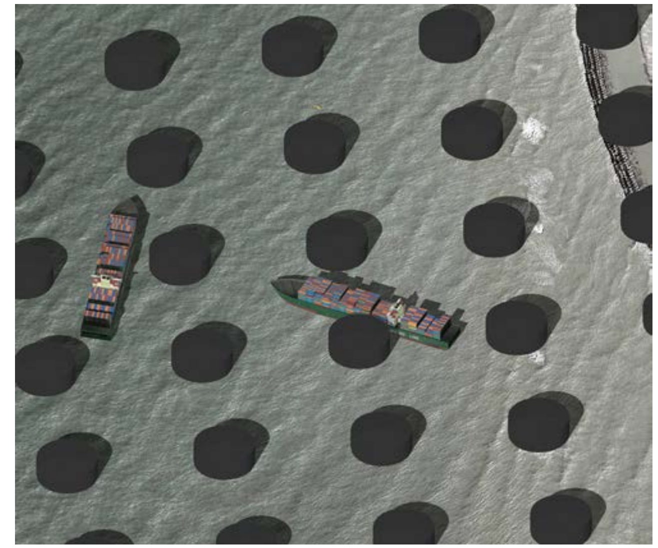
"Energy against ecology" has a double meaning. The overall process of energy (from the extraction to consumption, its technologies and the infrastructures it needs and makes possible to be created) has been largely opposed to ecological principles, as its implementation takes an enormous toll on the environment in each of its landscapes. On the other side, the other meaning is to put energy systems against the light of ecology and begin to acknowledge its damages to ecosystems. This can come to enlighten the approaches to the production of energy today and in the future to account for its process within - not only its limits but its - ecological frameworks.

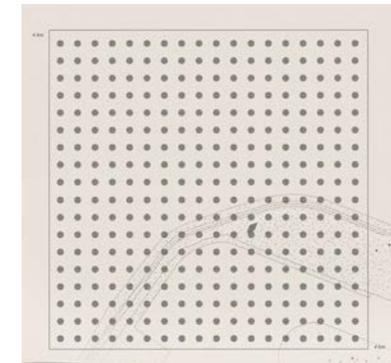
Energy is rarely directly addressed by architects and urban thinkers but instead treated as a given condition of a world, enabling it to be perceived as something ecologically neutral. At this moment, it is essential to remember that energy is ubiquitous. If it has to start somewhere, it is most acknowledgeable to humans to observe that it is from solar radiation that photosynthetic bacteria, algae and plants take sunlight and, with water and air and soil, turn it into other kinds of matter. The embodied energy passes to other metabolisms of other organisms. The end of an energy cycle becomes the beginning of another. Bathsheba Demuth writes that an "ecosystem is the aggregate of many species' habits of transformation, their ways of moving energy from its origin in the sun across space and condensing it over time. To be alive is to take place in a chain of conversions." This may sound philosophical or even spiritual; however, it could not be more material. It shows how energy has commonly been grasped as removed and removable from its natural context. Added to it is the blind-eye, despite the territorialising tendency of energy extraction and industrialisation, to any sense of relationship between energy and land. Its entropies treated as "externalities" are just a consequence of being seen as detached from an ecological context.

"An ecological perspective provides a very different vantage point from which energy can be seen as shared, as a characteristic of life and movement that subtends all our sociopolitical and economic systems." (Iturbe, 2021)

Across the political spectrum and throughout transformations of contemporary thought, an energetic condition has shaped a way of life, yielding not only theories of time but also theories of space. Every new form of inhabitation responds to a new energetic condition for civilisation, an always expansive disposition, whether dense or sparse. The infrastructural space that aligns with the energetic possibilities is one that adds to the current fragmentation and degradation experienced in the landscapes of highly urbanised areas like the Rhine basin. Even if today, in many post-industrial cities, the "externalities" have been moved to the hinterland, the expansion or the construction of all sorts of infrastructures keep the pattern that contributes to the ecological situation.

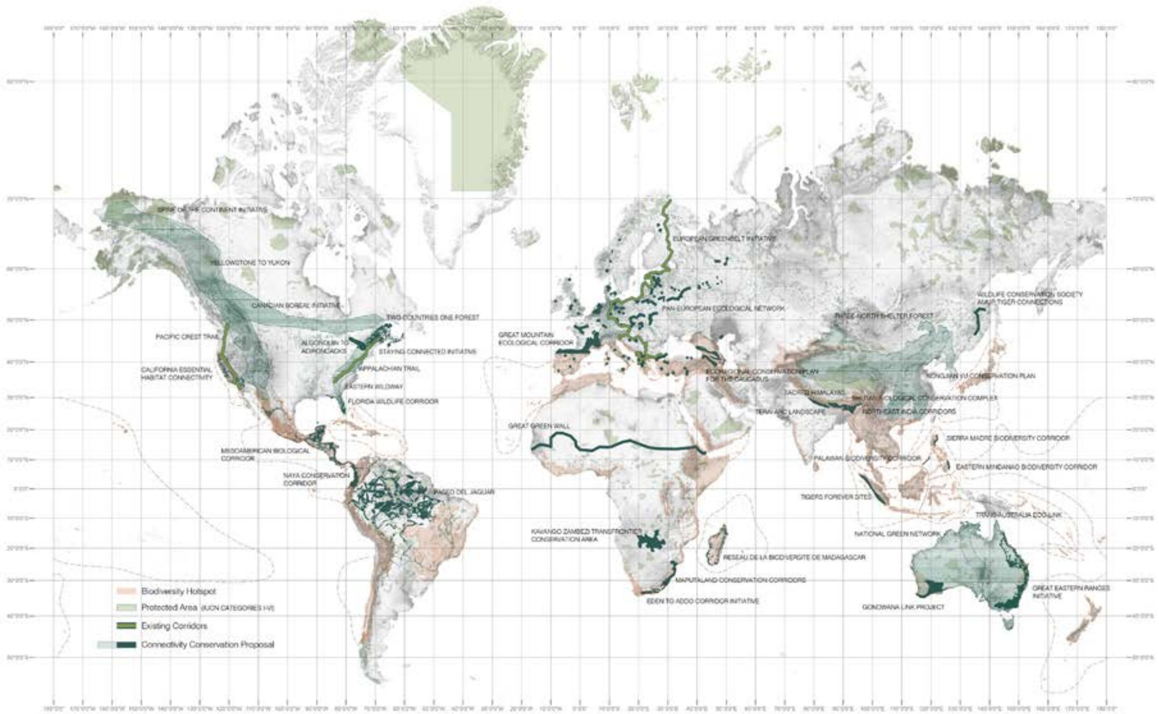
Iturbe also suggests that "in order to disturb carbon modernity in a fundamental way, it will be necessary to see a broader ecological and energetic picture." That feeds on a speculation: what if a new temporality and spatial project of energy could reconnect and restore these landscapes in ways that do not close those areas to a monofunctional conservational use or an overly industrialised area but propose completely new urbanisation paradigms?

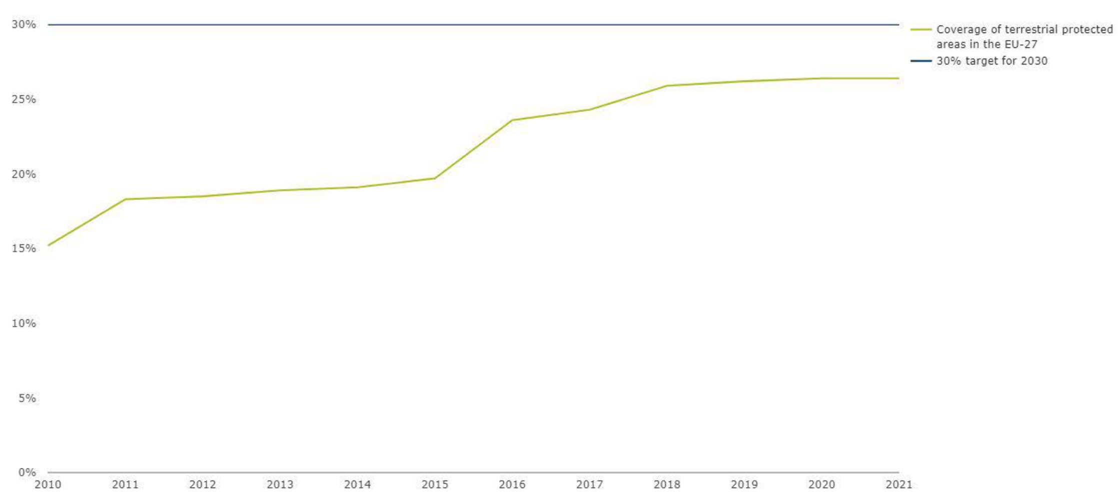




Project "328 silos" is a critic on the "sustainable development" narrative under the Maasvlakte 2 development, in the Port of Rotterdam. It takes a portion of the land and imagines if it was possible to capture the carbon emissions of the area, turning it back into solid state and keeping it in the area where it was released into the atmosphere.
Source: Author, 2021.

"Yet energy is not only electricity and power for machines. It is not simply the means by which the economy is built. Energy is a property of matter manifested in the ability to work, move, grow. Energy undergirds the form that individual organisms and ecological relationships take, giving everything on Earth its particular contours. Energy moves and, as it does, all life exists in a perpetual state of transformation, taking on specific form in moments and then dissolving only to define a threshold - between species, systems, or spaces." (Iturbe, 2021)





Restore and reconnect

Some proposals are already beginning to invest in the idea of reconnecting landscapes by identifying the hotspots of biodiversity to be kept and through many new forms of management to those areas. The effort to connect fragmented patches of conservation is seen worldwide, as the map on the left shows. The destruction and fragmentation of natural ecosystems are fundamental causes of the global biodiversity crisis. Those projects converge on two correlating fronts: addressing biodiversity loss together with ecological restoration. It means that, in spatial terms, land degradation and land fragmentation are tackled.

The human toll on Earth has disrupted the functional capacity of many ecosystems, so a common aim is to address climate change mitigation and adaptation by restoring functional and self-sustaining ecosystems.

At the same time, it is vital to then connect those areas. "Connectivity is important to preserve the ecological integrity of ecosystems and is regularly used for planning and conservation purposes at local and regional scales, however, large-scale connectivity is insufficiently provided in planning and monitoring strategies, especially given rapid climate change." Restoring landscape connectivity can be achieved by restoring natural habitat patches and riparian corridors in intensive agricultural areas or constructing wildlife passes over roads and railways to increase ecological permeability. Landscape connectivity is crucial now that species are increasingly turning to migration to adapt to climate change and other environmental pressures. The need to both maintain and restore ecological connectivity is critical to the conservation of biological diversity, which provides irreplaceable functions and services, such as the provision of fresh water, food, climate regulation and pollination, just to name a few.

Besides restoration and connection, other proposals also consider the overall quality of the fauna and flora habitats and their relation to human participation.

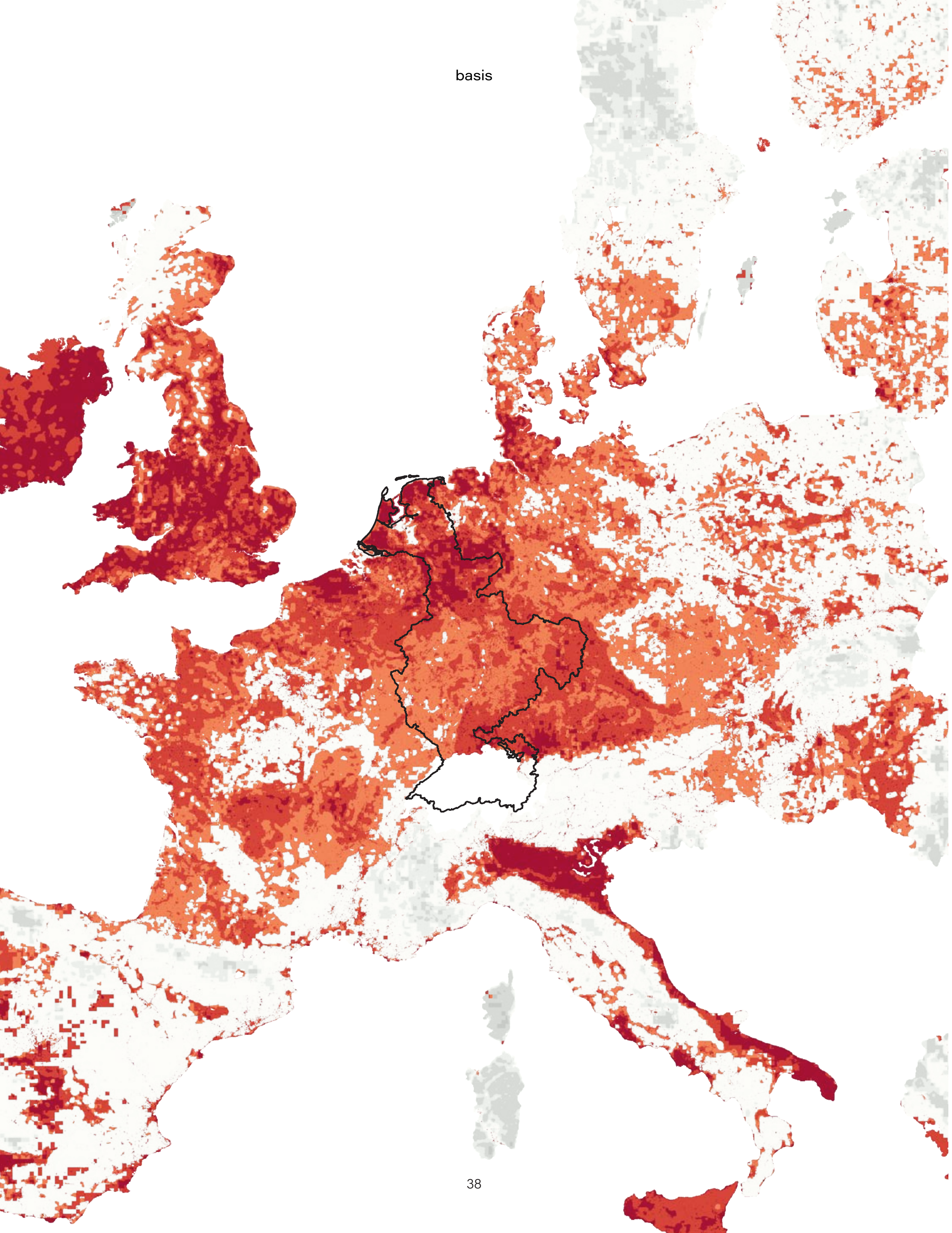
Edward O. Wilson's "Half-Earth" hypothesis states that in order for the Earth to continue to thrive, human modes of inhabitation need to set aside at least half of its space as, in essence, a kind of park. That proposal has been developed by the "World Park Project". It plans to create continuous and restored habitats to protect endangered species on a planetary scale, but the areas also include human recreation.

Those two projects show a view of a kind of ecological approach that aims to find alternative ways to compose humane approaches to the biosphere. It shows that even fenced off Protected Areas need a rather multifunctional approach that actively engages people in its composition and new configurations. Ones that first need to work on the damages of the previous forms of management but are still possible to be restored, connected and habited in the coexistence of humans, fauna and flora.

Inside the EU, a target was set to achieve legal-bound protection of a minimum of 30% of EU land, as set out in the EU Biodiversity Strategy for 2030. In 2021, protected areas covered 26.4% of EU land, with 18.5% designated as Natura 2000 sites and 7.9% having other national designations. Further expansion of these terrestrial protected areas will be needed, but they are not a guarantee that the composition of biodiversity habitats is achieved. For that, EEA suggests that "effective management requires building a coherent and well-connected network of protected areas with clearly defined conservation objectives and measures."

(top left)
Global landscape connectivity projects
Image 9: Atlas of the end of the world, 2017

(bottom left)
Percentage of terrestrial protected areas in the EU-27
Image 10: EEA, 2022

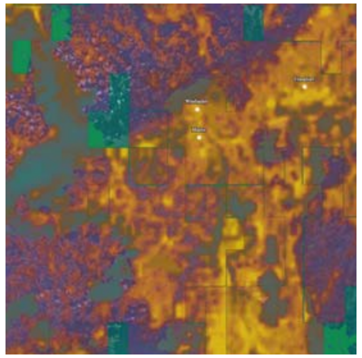


Energy: crisis, transition, imaginaries

In summary, the "energy crisis" is not only about the declining security of supply but mostly about what still remains in the phase-down of fossil fuels. The development of an extended operationalisation of the landscape through an intricate mode of energy and urbanisation also brought ecological degradation. Mobility networks, power plants, transmission lines and towers in a grid, highly agglomerated zones of inhabitation, extensive and intensive croplands, and forests focused on biomass production for different uses; all of them contribute to the state shown on the map at the side. "Ecological integrity" is measured from three major components of "wildness": trophic function, connectivity, and natural dynamics. "This indicator aims to reflect the extent to which anthropogenic defaunation, fragmentation of the landscape and the continued extraction of natural resources, have altered the natural state of ecosystems." (Fernández et al., 2020)

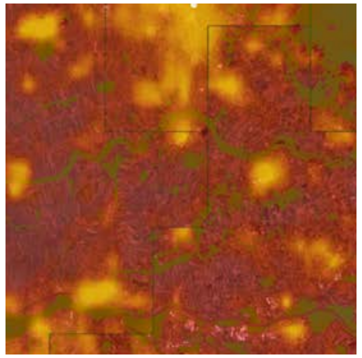
Secondly, the current effort of "energy transition" and its scaling-up of renewables will be, as has been already pointed out, an era of mitigation of the previous externalities that damaged the global climate and depleted the biosphere integrity. It will have its pros, with a high chance of decarbonising the economy in significant steps. However, it will be insufficient to avoid the causes that inaugurated the Anthropocene, the era in which human activity becomes a geological force. It might slow the consequences of the previous mode of energy to the atmosphere and the climate, but at the same, it will push new frontiers in landscapes. It is most likely that by 2050, it will demand a reevaluation of its spatial project - also due to the realised potential and limitations of the technologies that it trusted.

The anticipation of the scaling-up of the renewable era paints the scenario for the third part of this project. Flooding and drought, soil degradation, lower biodiversity and exhausted ecosystems are still the inheritance not only of fossil fuels but also of a renewable era that, even if it shows concerns, under large-scale "sustainable development", it will be unfitting to address anything other than a 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 regeneration as a spatial energy project must already be a concern of today's urbanism.



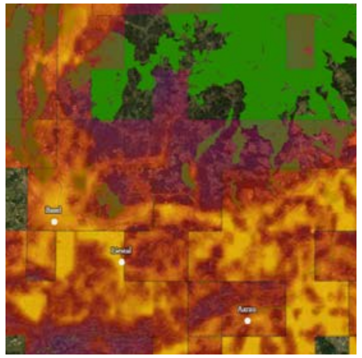
DELTA RHINE

93% under human pressure
Rainfed agriculture



LOWER RHINE

100% under human pressure
Rainfed agriculture

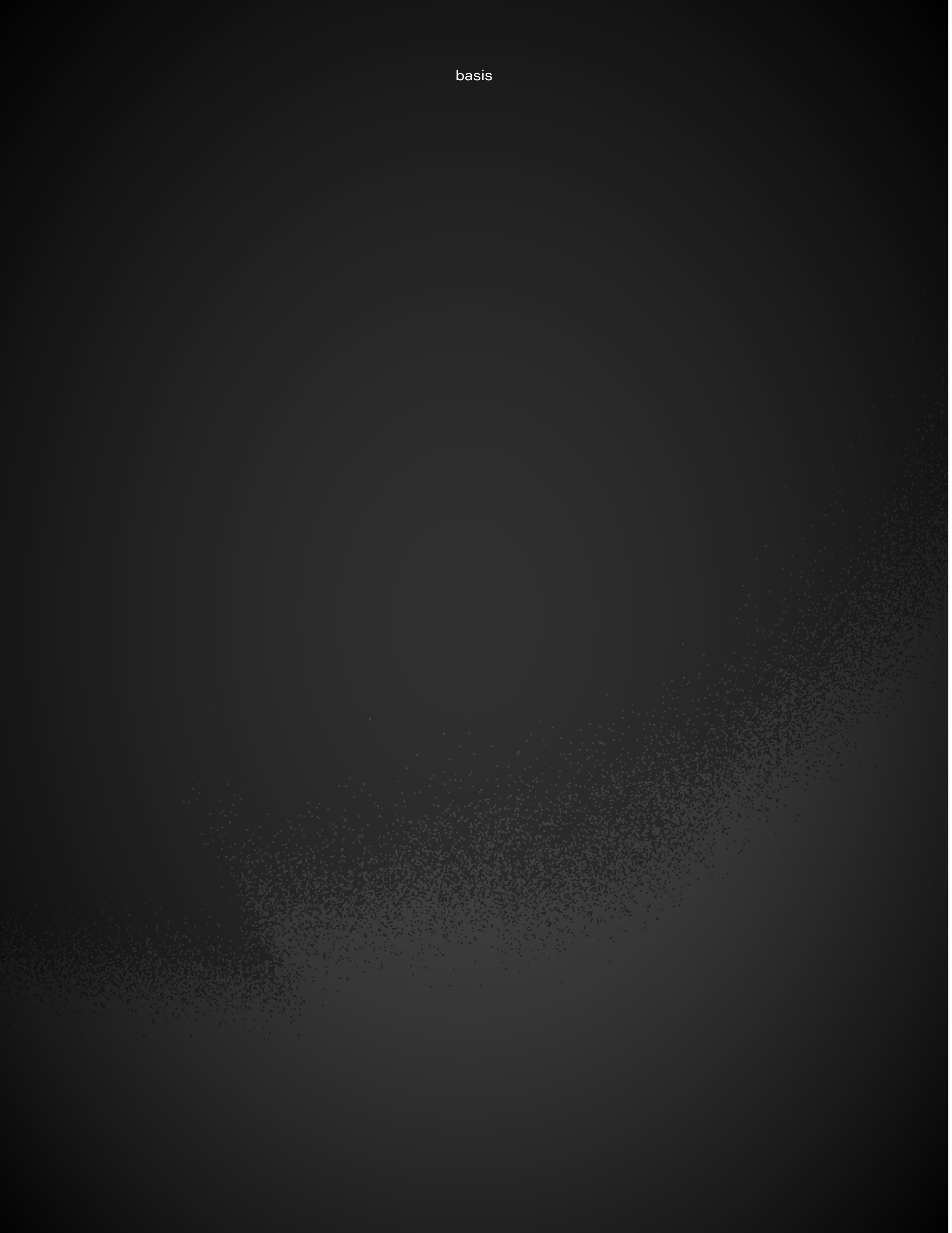


UPPER RHINE

81% under human pressure
Rainfed agriculture

(Above) Screenshots of current conditions in three areas of the Rhine basin under the parameters of the Half-Earth Project.
Image 11-13: Half-Earth Project Map, 2022

(Left) Ecological integrity, with the Rhine basin highlighted
Source: By author with data from Fernández et al., 2020



Context

The Rhine basin through the lens of energy landscapes

A river basin is the portion of land drained by its tributaries towards a large river. It encompasses all of the land surface dissected and drained by many streams and creeks that flow downhill into one another. River basins are crucial for the maintenance of planetary-scale systems. They are considered a subsystem in the Earth life-supporting systems and can influence the balance of the whole biosphere and climate in the planet. (Steffen et al, 2015) The Rhine basin is located in the west side of the european continent, expanding for 185.000 km2 across more than seven countries. It has acted as a backbone of electricity supply systems since the dawn of the 20th century, having a pivotal position in the gradual development of a European electricity system. (Lagedijk, 2015)

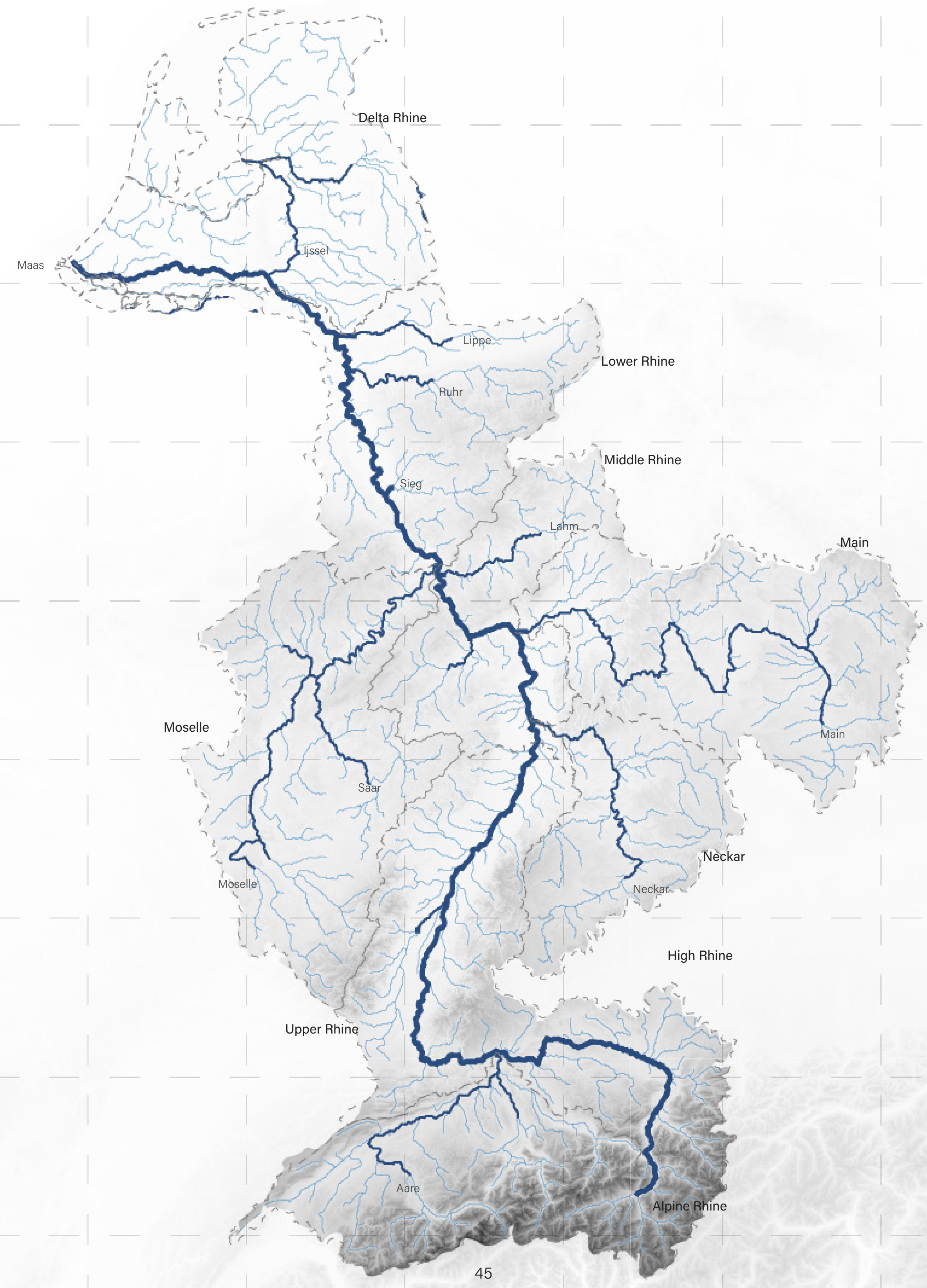
World basins
Data: GRDC, 2020

The Rhine river basin covers parts of Switzerland, Austria, Liechtenstein, France, Luxembourg, Germany and the Netherlands. The main tributaries of the Rhine are the Neckar, Main, Mosel, Lahn, Ruhr Saar, Lippe, Ijssel and Sieg. The river basin can be subdivided in five sections using geographical and geological features (Preusser, 2008), which also set different types of productive landscapes.

The river originates in the Alps, the Alpine section of the river has a high hydropower potential. Next is the Upper Rhine, where around Basel, the floodplain is used for agriculture up to Mainz. Several cities exist along the Rhine branch in this section. Third is the Middle Rhine between Mainz en Bonn, which is hilly. In this section, the Rhine flows through a narrow gorge. Next is the Lower Rhine, which sees a cluster of energy landscapes of extraction and conversion responsible for high amounts of energy being produced, GHG pollution and land degradation. From here, the flood prone area widens until it becomes a river delta in the Netherlands (Hooijer et al., 2004).

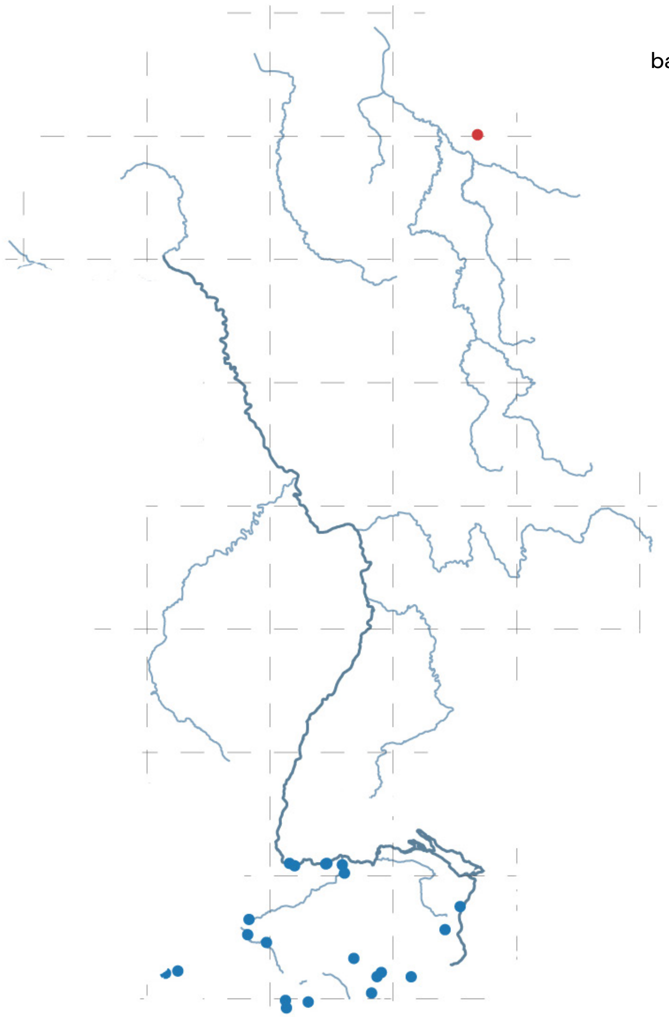
About 50% of the basin is used for agriculture, and 15% for urban or suburban uses. The remainder is forest and otherwise fallow lands (Eberle et al., 2005). The Rhine river is extensively used for inland shipping (Jonkeren et al., 2007; CCNR, 2009) and connects one of the world's largest seaports in Rotterdam to the hinterland European markets. Its waters provide for industrial, domestic, and agricultural landscapes. (Grabs, 1997) The Rhine basin is one of the most heavily industrialised areas in the world. It has 60 million inhabitants, of which more than 10 million live in flood prone areas that are protected by dikes. (IKSR, 2021)

Energy landscapes have always been strongly linked to river basins, using water for navigation of inputs, cooling or even as primary material for energy production, like the hydropowers. Now, with the renewables and consequences of climate change and biosphere degradation, its relation to energy is becoming more indirect. However, depending on how the spatial project of energy is treated, it can be part of the restoration of ecosystems that exist due to its relation to the watershed, like the productive landscapes of croplands.

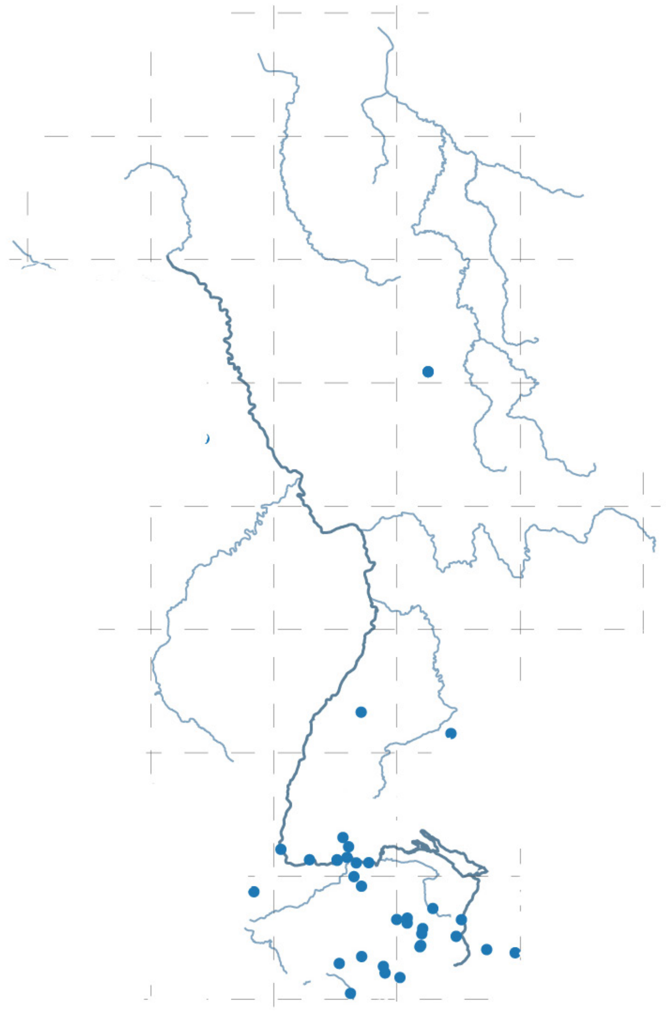


Rhine river
Main estuaries
Watershed
Sub-basins

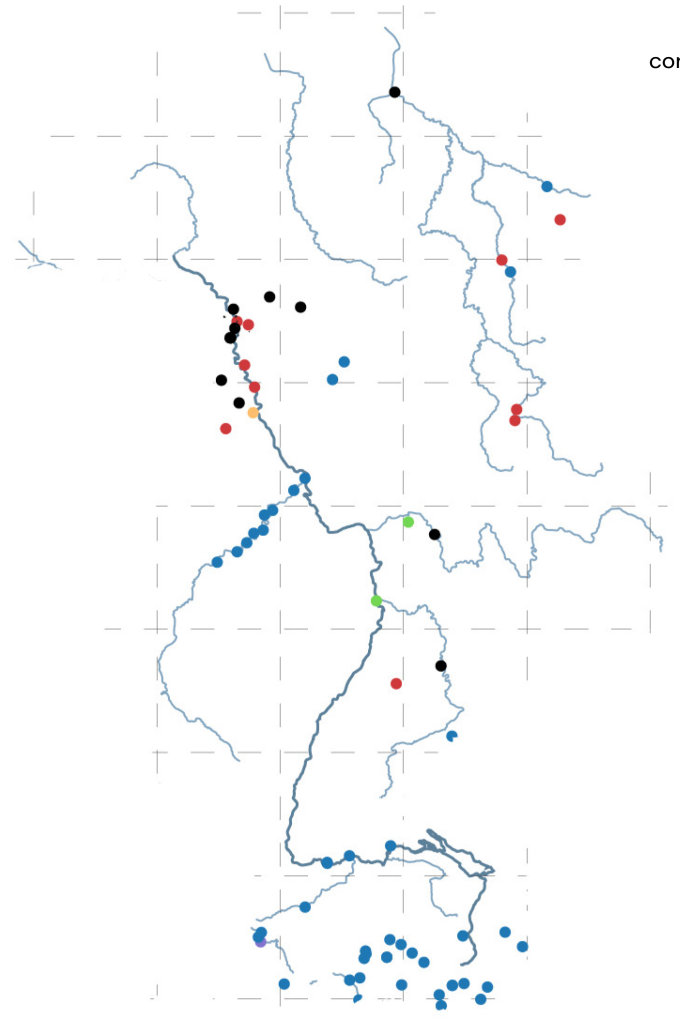
0 100km N



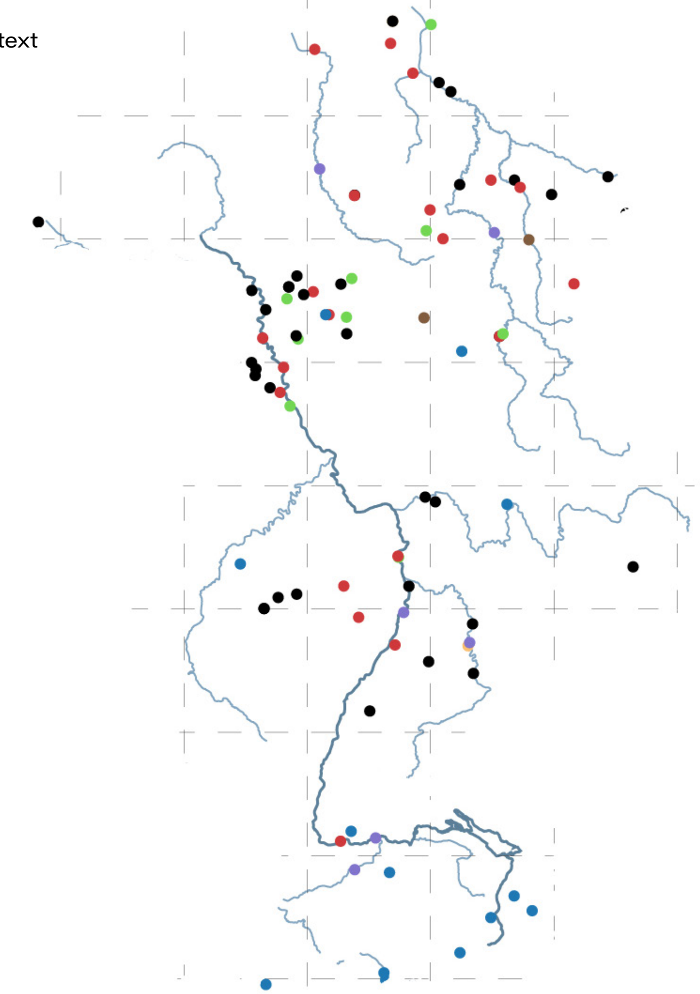
From the Great Acceleration until the I World War
1850-1914



The period of World Wars
1914-1945



The Post-War period until the UN Conference on sustainability
1945-1973



From the UN Conference until Rio 92
1973-1992

The sequence of maps above illustrate the kind of technology installed along each temporality since the increase of fossil-fuels use in the wake of the Great Acceleration. Even though data availability and completeness is a limitation[6], it is interesting to see the development of the energy production along with its locations. Historically speaking, the development of the electricity system has been very international, and the Rhine was a major part of that.

The first map and period above starts in the last decade of the nineteenth century and lasts until 1914. After the rapid industrialization and growing populations of the 2nd half of the 19th and 1st half of the 20th century, the Rhine was in effect an open sewer, 'seasoned' with a deadly brew of toxics set free by the chemical production of acids, alkalis, fertilizers, explosives and dyes. Most of the electricity generated in the area came from hydropowers located in the Upper Rhine region. The mechanisation of the river yields not only transportation gains, but also energetic.

6.
Because not all countries publicly report their power sector data along with the commissioning year. It it is not feasible to assemble 100 percent power plant coverage. It is particularly difficult to identify the smaller, distributed power plants, a category that includes smaller renewables and diesel generators.

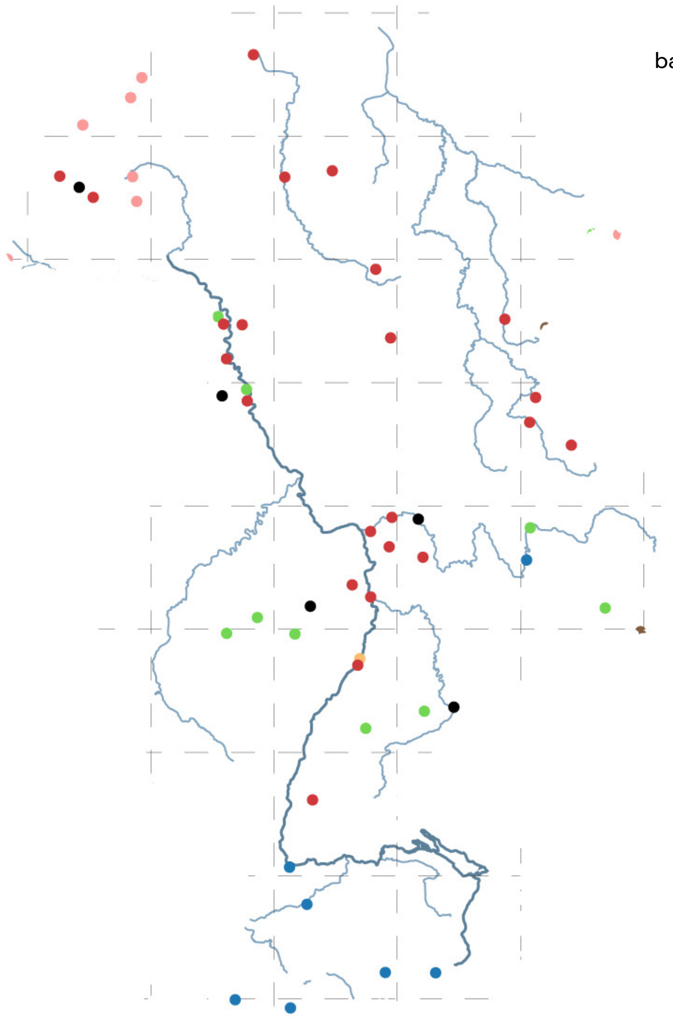
Hydro

As expected, the interwar periods sees nations having a inward looking, due to its nationalistic policies. However, paralell to that, and witnessing to what Iturbe mentioned, energy breaches through it and an imaginary on an European network appears on the scene for some years.

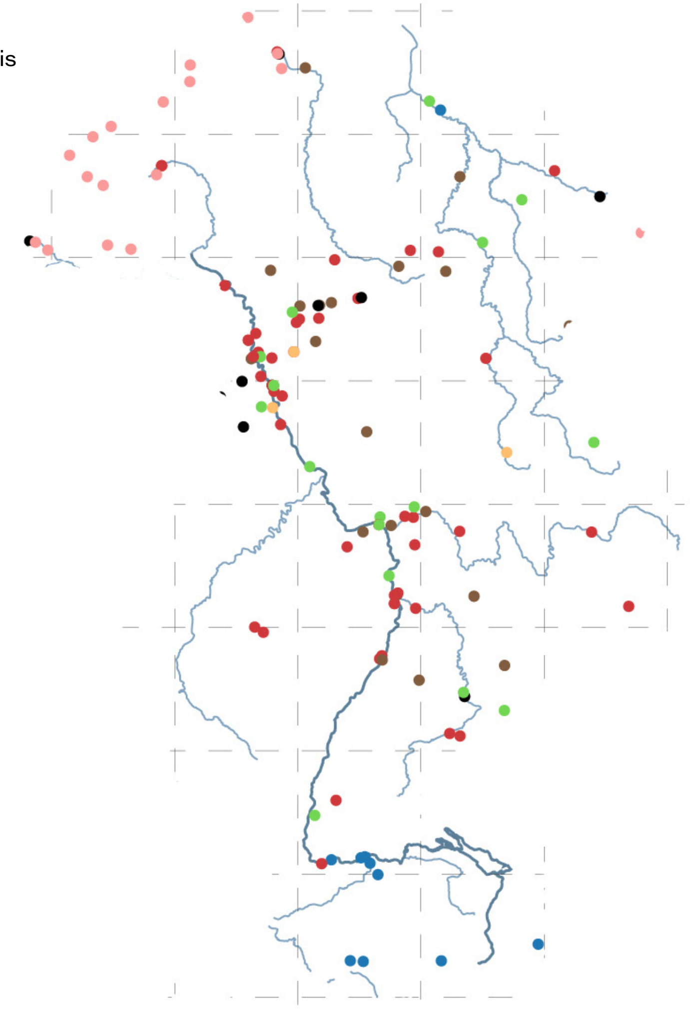
The Post-War years sees the European cooperation in the field of electricity becoming institutionalized. The reliance on fossil-fuels strongly reach the Ruhr area, with many coal, gas and oil power plants being constructed in the region - along with mining fields. Industries were drawn to the Rhine basin's natural resources, which included vast coal resources. Around the turn of the century, the chemical industry followed in the slipstream of mining and metallurgical firms, leading to ever-increasing water and energy demands. Then, the region's resources were key to energy production companies, employing its power plants and transmission lines. If the history of water and city is a fact, it is only because of the close link between water and energy supporting the inhabitation

Biomass
Coal
Gas
Oil
Waste

Nuclear



From Rio 92 and Kyoto Protocol to the new millenium
1992-2000



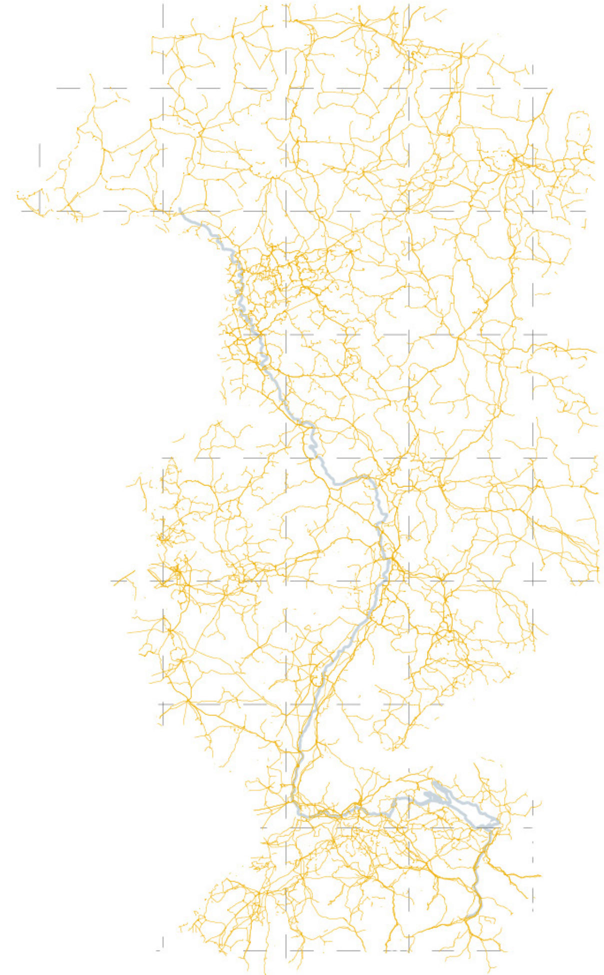
Last two decades
2000-2020

clusters throughout every mode of energy - foraging, agriculture but especially fossil-fueled. The fast increase in ecosystem degradation raise concerns internationally about the sustainability of those extractive practises.

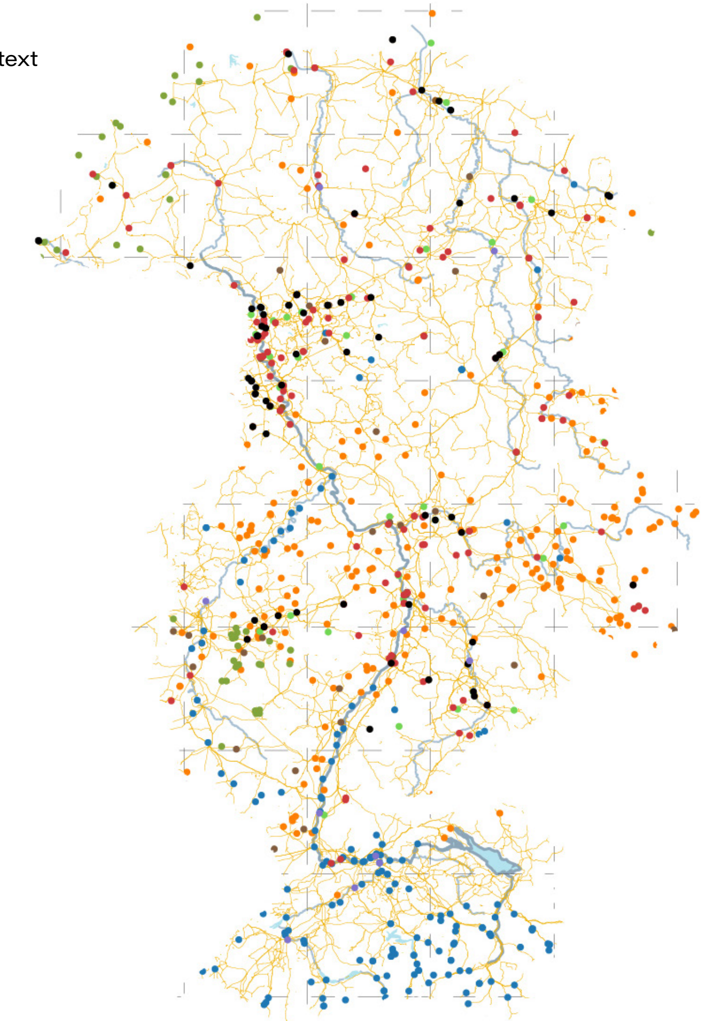
Initially the Rhine's flow was used to generate hydroelectricity and the transportation of coal, but in later decades also to cool nuclear power plants. "Electricity companies from that region, like RWE, now own power plants and transmission lines in various countries. They used the region's resources as a stepping stone towards becoming European players. Key parts of the current-day European grid are also based on the Rhine's resources. Electricity systems grew as industries matured along the Rhine, as the exploitation of water and coal resources intertwined with the development of the metallurgic and chemical sectors." (Lagedijk, 2015)

The Rhine basin today has a pivotal role in the construction and operation of the European power grid.

Solar
Wind



High-voltage transmission lines



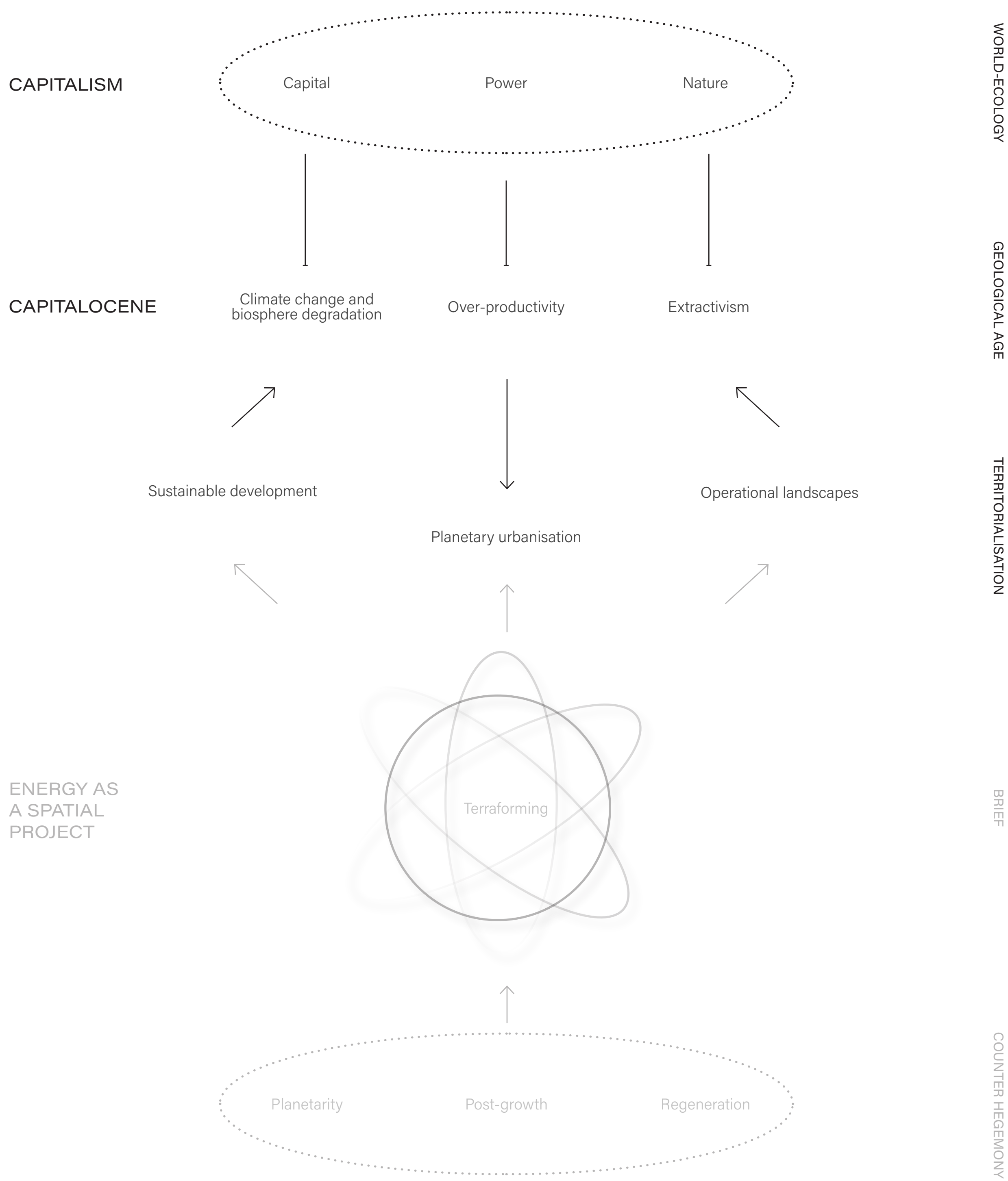
The state of the energy grid and its power plants by 2018

Almost 80% of total electricity that feeds around 500 million people is generated from nuclear and fossil-fuel-powered plants and the grid is controlled by control rooms in the Rhine basin (Lagedijk, 2015).

Not only energy production but energy distribution is operationalized in the Rhine basin. Rhine cooperation is often assumed to be a precursor to European integration, and although there are certainly several synergies, there is little systematic evidence for this (Scott 1989; Knippenberg 2004).

Data: Global Energy Observatory et al., 2019; Global Energy Monitor, 2022

Methodology



Theoretical framework

The theoretical framework illustrates current hegemonic conditions that generally run global dynamics and the relationships between theories and their territorialisation. These theories arise from various fields of knowledge and are viewed from an urban design and spatial planning perspective shaping the Rhine basin region.

The top side of the diagram illustrates the functioning of the current world-ecology[7] that is known under the name of capitalism. This world-ecology breeds and is now sustained by the current geological era of fast direction in crossing planetary boundaries, like climate change and biosphere degradation. This is done via the accumulative, extractive and over-productive logic being pervasive in the work of humans and non-humans. Lastly, Moore presents 'natures' as frontiers that the capitalist appetite devastates when extracting its work-value, always looking for a 'cheap' nature to compensate for the loss of profit when the last frontier cannot keep up with previous levels of production. (Patel & Moore, 2018)

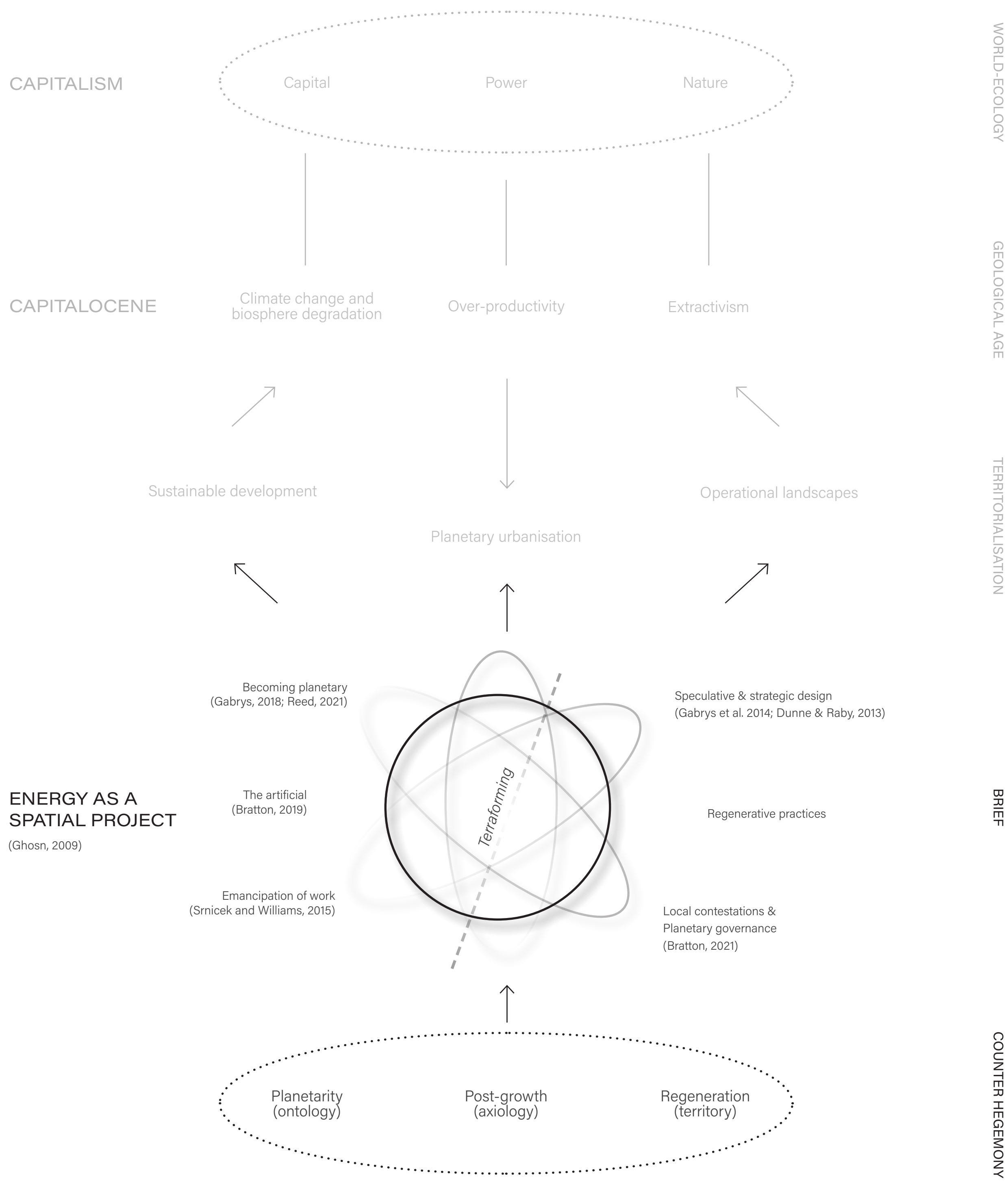
The territorialisation of this hegemony can be seen by the frames of the concept of "planetary urbanisation." (Brenner & Schmid, 2012) It provides a frame to understand the changing geographies and pace of urbanisation and the planetary interconnected network of material and financial accumulation. Within this context, the spatial extension of large-scale land-use systems devoted to resource extraction, energy, and water and waste management; the transformation of vast "rural" areas through the expansion of large-scale industrial agriculture, land grabbing and territorial enclosure; and the commodification of "wilderness" spaces, including the atmosphere itself are put to serve the profit imperatives of a planetary formation of capitalist urbanisation. (Brenner and Schmid, 2015) Within this frame, the concept of Operational Landscapes[8] (Brenner & Katsikis, 2020) questions the role that spaces beyond the agglomeration zones play in urbanisation processes. It is also important to mention the territorialisation of 'sustainable development' acting under the neoliberal globalisation and the new economy that ends up amplifying the current conditions of conflicting interests and unequal distribution of power even if it meets environmental goals. (Soja, 2009; Marcuse, 2006)

Through the spatial perspective, the current situation and the coming scenario (phasing out, also the phasing in, the abandoned plants) is the first step to not get lost in "Nature x Society" chasms but understand that humanity's mark on the planet via urbanisation is, in fact, part of a sequence of "chemistry, abstraction and phase change, pattern and then collapse, and other things besides" in which energy is a crucial backbone. Only by "recognizing our own cognition and industry; not as immaterial but as manifestations of a material world acting upon itself in (regular intelligent) patterns" can we embrace "an ontological turn of a different sort", one that is very material and spatial. (Bratton, 2019)

In this context, decarbonisation and energy transition is not solely a question of technology, but also a theoretical question for urbanism, one that questions current modes of energy as unfitting cultural and material foundations for the prerogative of addressing climate change and restoration and regeneration of the biosphere. In that light, this thesis will treat energy landscapes as a spatial and technological condition in its own temporalities, having implications on society and nature through its vision on the value of work and its rewards. "Terraforming" is then the project assembling an alternative paradigm and proposal to build other futures. (Bratton, 2019; Srnicek and Williams, 2015)

7. Enmeshed cycles of capital, power, and nature in modern capitalist imaginaries and system that degrade key spheres of life (Moore, 2015)

8. An investigation on urbanisation from the perspective of the zones outside agglomeration; which are commonly unrepresented in maps over the urban age. It focuses on the sociospatial and environmental transformations that unfolds in the wide-range fabric of urbanisation; and most importantly, how those spaces are being restructured to support the material and commodity needs of major cities.



Conceptual framework

The term 'Terraforming' first appeared in science fiction and is now used in Earth sciences to describe the process of modifying a planet, moon or other celestial body in order to be suitable for human life. This could involve modifying it to a more habitable atmosphere, temperature or ecology for humans. A first expansion of the term comes with the acknowledgement of climate change and the transgression of planetary boundaries that poses the challenge to terraform this very planet, which means to ensure that the planet will be capable of supporting 'Earth-like' life. The spatial project of future modes of energy poses the challenge of shaping an alternative basis for a viable planetarity. (Bratton, 2019)

TERRAFORMING
Terraforming is something that humanity does as it inhabits the Earth. The terraforming[9] is then assembling an alternative brief that sets other futures in the today. It is a position of care reflected by the articulation of feminist theories that offers a framework with which to understand the interlinked nature of work and the origin of environmental crises from an ontological view[10].

The term 'Terraforming' first appeared in science fiction and is now used in Earth sciences to describe the process of modifying a planet to ensure that the planet will be capable of supporting 'Earth-like' life. Our relation to the environment as we know has a material limit, and the transition is doomed to be unfitting. Given the planet's current conditions, this is something to be done on Earth itself. Looking at the territory, the following decades position the urgency to fundamentally transform the modes of urbanisation, from form to organisation. The "Terraforming" here assembles the fundamentals, or "referential frameworks", as mentioned in the very beginning, from perspectives of planetarity, post-growth and regeneration and proposes alternative configurations and compositions to energy landscapes.

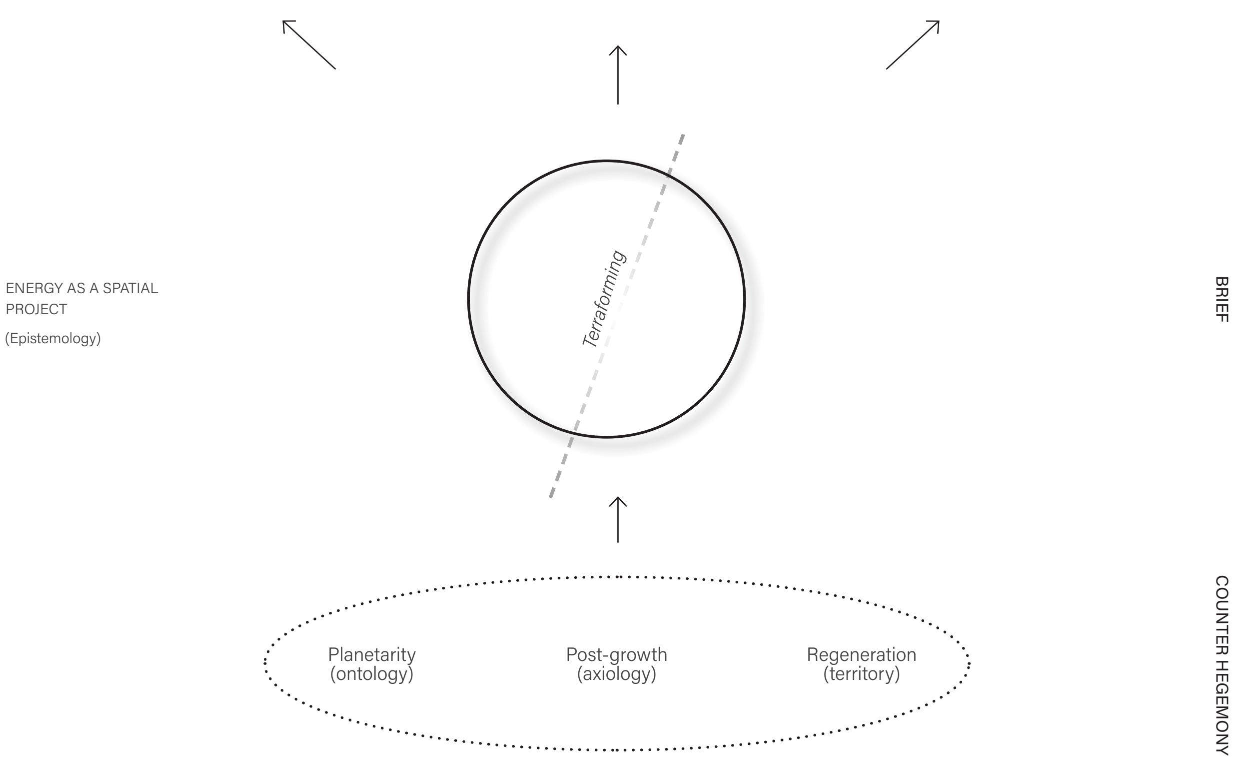
PLANETARITY
In 1997, Spivak, a critical theorist and postcolonial intellectual, introduced the term 'planetarity' in one of her writings to advocate forms of life that could not be discerned in the globalisation discourse. She uses the term to describe a space for living (and not an abstract model, like the "globe"). In this context, 'planetarity' can be understood as the inhabitable translation of planetary thought, and it is then not a theme or discourse but an alternative structural condition. Planetarity is closer to an ontological aspect that flows to the social dimension. It is an alternative frame of reference to start thinking about, orienting ideas and activities that look for social transformation through positions of care organising values of interdependence and coexistence. It means the commitment to constant opening to alternative cosmologies that informs other planetary relations between biotic and abiotic entities, shifting away from the current position of separation and pretentiousness.[11]

It also means a demystification and disenchantment in our relation to the planet. In making clear that the human species is unfinished, partial, fragmented, and internally contradicted by its hypocrisies, it provides different entries into that incompleteness. Planetarity includes the presumption, as stated, that going forward, the distinctions between geotechnology, geopolitics, geoeconomics, and geoecology will be less clear and less distinct. The kinds of institutions and frameworks that get built will be ones that may look like a technology, they may look like politics, they may look like economics, and they may be all of these at once in different ways. (Bratton, 2021) Building this new condition in a state of climate instability is part of a new paradigm that finds its actions also in the frames of regenerative practices.

9.
"The Terraforming" is also the title of three-year think-thank organised by Benjamin Bratton at the Strelka University, Moscow, Russia.

10.
"Using a feminist framework we can locate productivity as a part of the oppressive force of growth based capitalism, and outline the ways it is implicated in patriarchal as well as capitalist forces of oppression." (Mair, Druckman, Jackson, 2020)

11.
"The dualism of mind-body, self-nature, human-animal, normalcy-exception, risk-safety is a universalist dogma that emerged out of a specific time and place (namely the Western Enlightenment). This dogma is so entrenched that to engage in 'alternative' theorising, which reflects on how we co-produce knowledge in relation to a multiplicity of beings, is labelled as naïve, superstitious, or worse—'pre-modern' magic (Bennett 2010)." (Bellacasa, 2012)



REGENERATION

In light of the previous ontological turn, it is not to revive ideas of return to "nature", but to envision "living ecologies" that are more pleasant and intelligent modes of inhabitation. It means understanding and joining Earth's natural processes and recognising our own cognition and industry in being part of it, as Benjamin Bratton puts it. (2019) Taking into consideration a constant understanding of the planetary geochemistry and its existing capabilities of living systems to participate in those dynamics for ecological restoration, it does not exclude that nature-based, mitigation, restoration, rehabilitation, and resilience are tools inside a trans-scalar structuration of a precise and needed operation to find balance in humane's modes of inhabitation within planetary cycles and systems. In its constant negotiation, the precise and needed operation will not undergo under the current hegemonic cosmology and its practices. It is why a post-growth mentality is necessary.

POST-GROWTH

The key to creating a post-growth world lies in addressing the issue of labour productivity growth. Labour productivity growth is implicated in violating biophysical limits, the degradation of work, the generation of inequality, and the devaluing of work. Tackling it through energy as a spatial project can enable the transition to a world of less environmental damage and stronger social bonds. (Mair, S; Druckman, A; Jackson, T., 2020) History can locate the transition to fossil fuels and its dense energy capacities as a key dynamic in the transition from a low to a high productivity economy, leading to new possibilities of growth and development in industry, housing and mobility. From a more epistemological perspective, "political ecology makes the critique that management strategies often disregard the value of common property arrangements and local and indigenous livelihoods, knowledge, expertise, and regenerative practises that highlight the importance of supporting knowledge and world-views that foster community and multispecies relations based on interdependence and mutuality (Osborne et al, 2021). This perspective opens up the task of "ecosystem restoration as moving towards a regenerative and equitable system that integrates social and ecological functions, creating the enabling conditions for a thriving, abundant future not only for society but for all life." (Osborne et al, 2021) These two quotes show how each one (planetarity, regeneration and post-growth) builds on each other.

As of now, we can only think of society in terms of growth and development. It is necessary to build on the front to value the work of human and non-human entities. Then, Terraforming becomes the brief for a renewed take on energy landscapes, in the 21st century, as a spatial project to come up again, with new forms of inhabitation that follow a new set of energetic conditions.

Analytical

What is the inheritance left by the non-renewable modes of energy to the territory of the Rhine basin understood from its sub-surface to the atmosphere?

What are the geopolitical challenges in the history of the Rhine basin and its exchange of energy?

What are the potentials and limitations of the “energy transition” to the current landscape disposition of the Rhine basin?

What are the social, political and spatial implications of the next mode of energy of the renewables?

Propositive

How to set a common vision and project of regional planning approach responding to the need of social and ecological transitions that faces environmental instability?

How to design a trajectory based on actions that are both desirable, low in resources and scalable for the territory of the Rhine basin?

How to identify the potential locations of tension between energy and other productive landscapes? And how to find a balance between the fitting action and local possibilities and contestations in this overlap of land-uses?

How can design help to mediate among different cross-border interests, governance arrangements, and thus assist transboundary collaboration based on a non-extractive understanding of productivity?

How to translate care and welcome other planetarities within the possibilities and transition of energy landscapes from fossil to renewable and in the future revaluation of the “energy transition”?

Research question

How can energy landscapes mediate a socio-ecologically just urbanisation for future modes of energy production in the Rhine basin?

Research question

How can energy landscapes mediate a socio-ecologically just urbanisation for future modes of energy production in the Rhine basin?

Research aims

The aim is to propose an architecture of the territory that can address socio-ecological and just urbanisation from the "energy transition" to the renewable era of energy landscapes. It is then organised in three parts:

(I) Inheritance: To investigate historical development of energy in a planetary-scale but specially in the context of the Rhine basin in order to understand its ties to the current condition of climate change, biosphere degradation and operational landscapes.

(II) Anticipation: To anticipate the territorialisation of the next mode of renewable energy by analysing its potentials and limitations highlighting the tensions in productive landscapes by the overlapping of current and new structures.

(III) Projection: To speculate on the future operational landscapes of energy production as the territory for the composition of new relations and balances between industry and biodiversity, between human and fauna and flora habitats.

Methods

(1) Literature review: Gather knowledge from within and also outside spatial practice and translate their contribution to the spatial project of energy landscapes.

(2) Visual documentation: The collection and production of photography, cinematography and drawings that represent the local conditions and society.

(3) Adaptive cycle: Conceptual model to understand the structure and processes of complex systems. Main relevant adaptive cycles for the place and topic are identified and the related times of change addressed.

(4) Monograph series: In line with the methodology of the studio, the construction of maps and other forms of visualisation to investigate the territory according to themes of "accumulation" and then the envisioned proposal to intervene in the mapped conditions.

(5) Backcasting: The anticipation of probable realities based on the envisioned change against current trends and the potential tensions in time and in the land.

(6) Typological study: Selection of relevant sites that can be the object of strategic urban design pathways and interventions.

(7) Speculative process: Speculation as a lens through which to look at the problem to make it more evident. Design better-formulated questions or a brief for further intervention. Find the best format and design a narration that comprehensively describes the specificity of a defined problem.

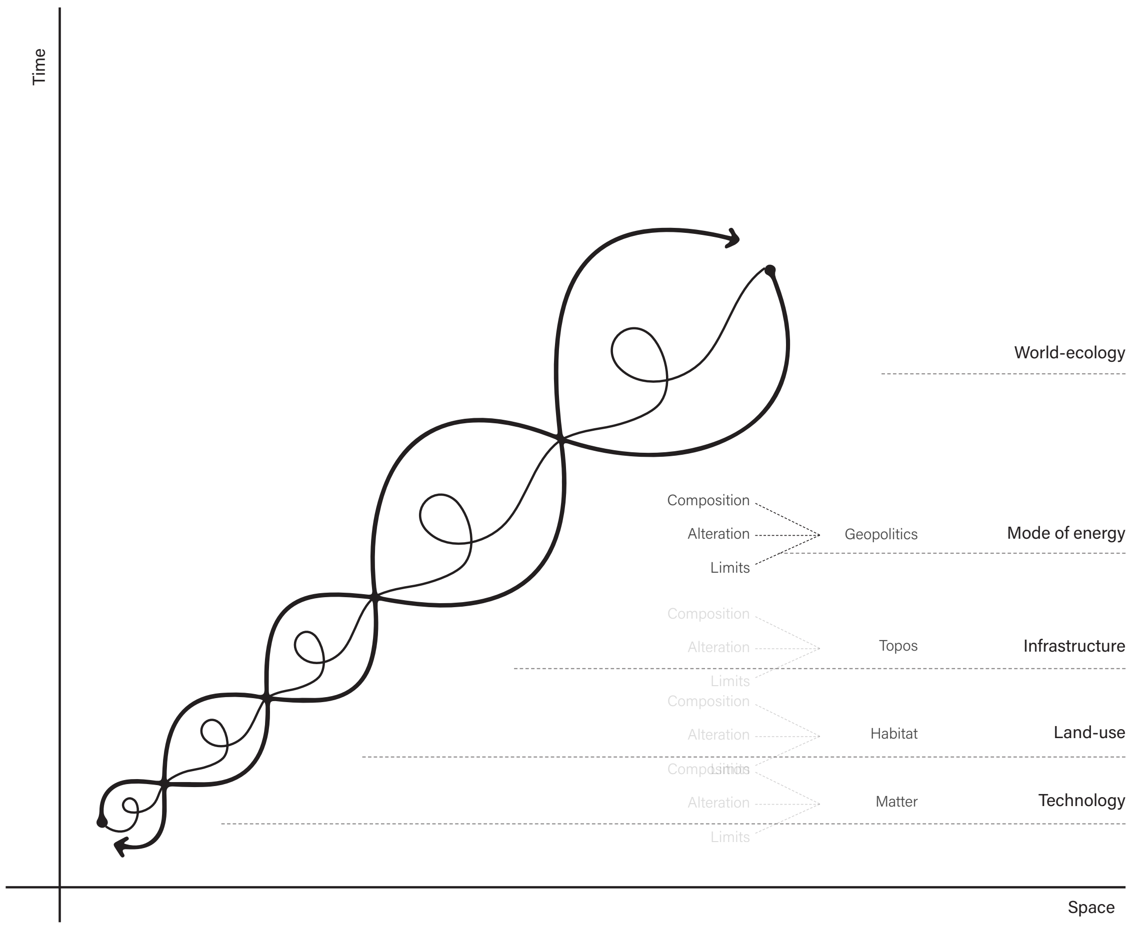
Prospected outcomes

The envisioned outcome of the thesis is to form a narrative, with scientific and societal contribution, that can invest in alternative pedagogies following the "energy transition" as a socio-ecological transition towards a new paradigm that propose spaces of coexistence between human industry and biodiversity productivity and habitats. Each part of the narrative has its values:

(I) Inheritance: Comprehend and visualise historical processes that led to the looming condition of societal and climatic collapse in a near-future.

(II) Anticipation: Anticipate and criticise the territorialisation of the next mode of energy in the renewable technologies as it follows frameworks of "sustainable development".

(III) Projection: To localise, imagine and compose appealing and sensible future scenarios that can influence the pathways being taken today regarding the phase-down and the rising of new energy landscapes towards ecological restoration of depleted ecosystems in many scales.



Analytical framework

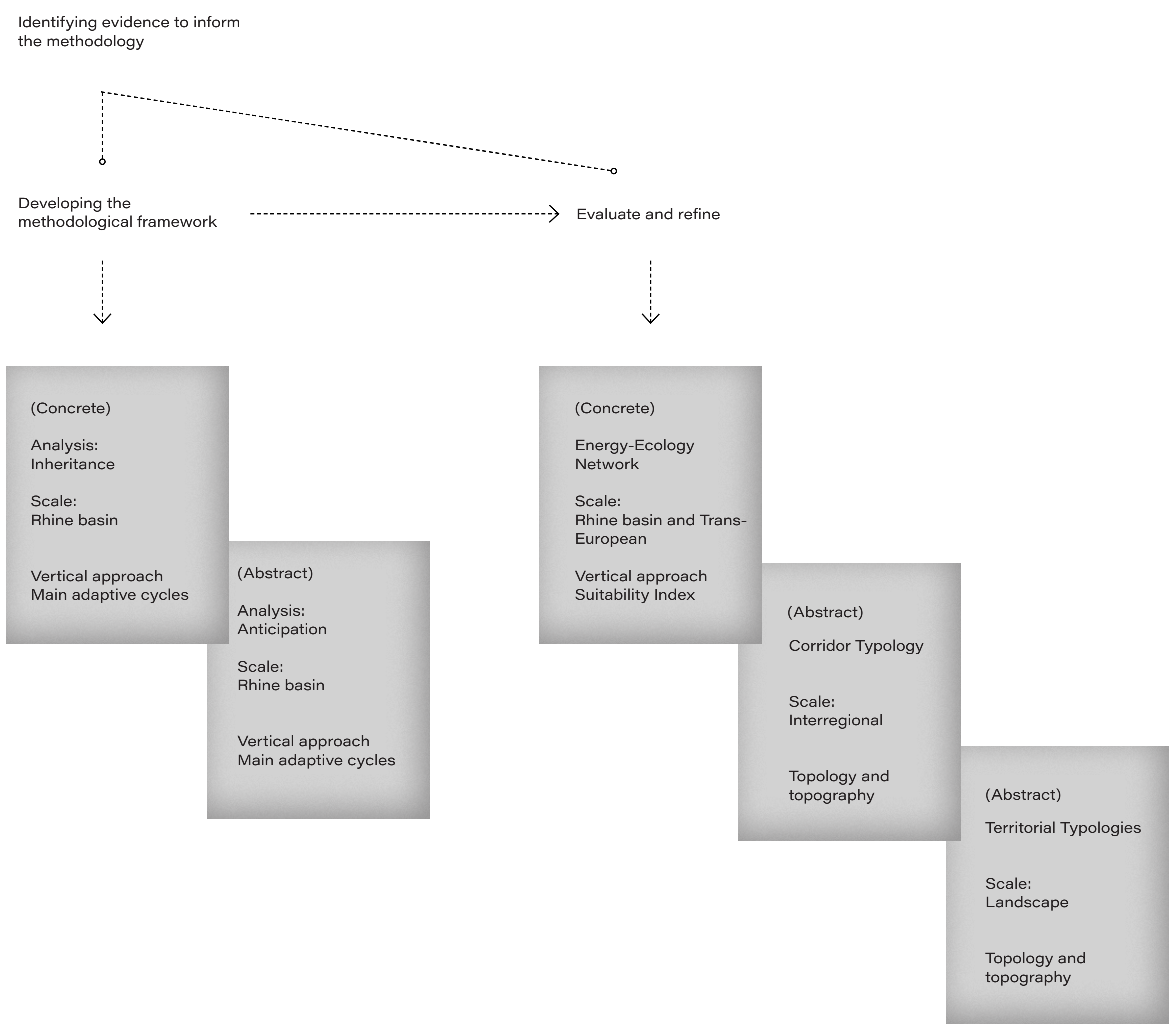
The project follows two main analytical frameworks. One for the "Inheritance" and "Anticipation" sections and another for the "Projection" phase.

First, it follows lines of inquiry that align with the main adaptive cycles and related times of change. In that sense, the main adaptive cycles relevant to the place and topic are identified and the related times of change addressed. This way, the whole Rhine basin is investigated. That is an effort to unpack and examine the non-renewables and the search to identify possible territorial typologies for further action.

To visualise it, it relies upon the composition of cartographies; they are three for each line of inquiry: (1) composition is about the material layer and understands its qualities in a map; (2) alteration understands the relations between subsurface-surface-atmosphere and energy systems; (3) lastly, it shows a process that is reaching its limit and the urgency to act. This is done twice. First, for the non-renewable mode of energy and its accumulation project. Then for the rising renewables mode of energy, in anticipation of its potentials and limitations.

Cartography is a way of mapping that composes lenses to view contingencies in the territory. To highlight elements, to portray their resonances or disparities. Here it is closer to the ancient practice of "chorography" and maybe of a "chronicle". It is closer to an artistic way of mapping territory in its temporal and spatial qualities.

In reference to the process-work of the "Atlas for the end of the world", the drawings are a form of composing an 'ecological cartography' of the Rhine basin and its relationship to operational landscapes of energy, which is the curatorial 'bias' of this project. Further than the issue of portraying a three-dimensional world in a two-dimensional platform, "mapping's future - what we are here calling ecological cartography — lies not in static two-dimensional images but in the temporal flow of the fourth", which is a challenge for any cartographies that aim to analyse the temporalities of energy landscapes. In essence, the cartographies show not only a current condition but also elements that can carry along a new temporality of the terraforming act. The analytical framework makes it possible to identify a longer-term meta-design project as it stares backwards but also highlights elements that would address that a viable twenty-second century becomes possible.



Methodological framework

The project follows a simple methodology identifying the evidence of energy landscapes to inform the next steps.

The interdisciplinary search on literature review and research of various data sets informed the key understanding of energy as a spatial project, especially in the context of a renewable energy mode, which demands much more physical space in the scale-up of its technologies across the Rhine basin.

In developing the framework to act upon the findings, 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, evidence pointed to the current state of "energy transition" as one incapable of addressing the looming planetary issues of climate change and biosphere degradation; showing that perhaps the next mode of energy could address it properly. This is laid out in a series of cartographies on the Rhine basin anticipating the renewable forms of energy landscapes summarised in the "Anticipation" section.

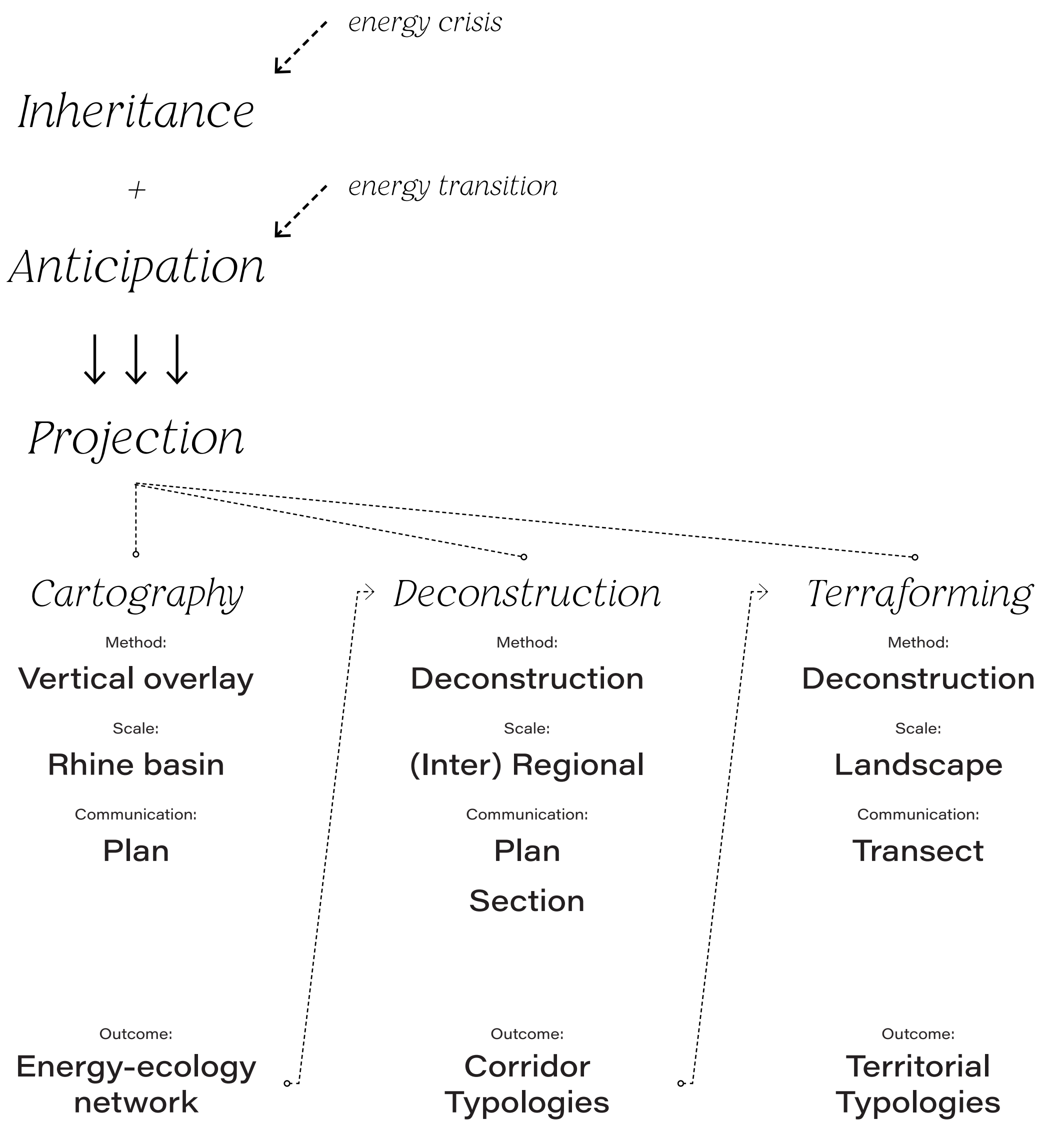
Those two movements serve as the first synthesis, identifying the operational landscapes as the typological territory of the coming interventions, as these are set to be crucial for the next energy temporality. Not only that, but it also shows that these landscapes could be the transitional territory for a new coexistence and balance between the provision of energy and ecological systems. Fulfilling the necessity to provide more basis to construct the bridge to propose inside ecological frameworks, a consultation with experts in the fields of biodiversity conservation and ecosystem dynamics was done. The contribution of their studies and sets of maps were crucial for the "Projection" section of this thesis. The first part of this section, "Cartography" overlays different kinds of infrastructures from the "Inheritance" and "Anticipation" reflections and takeaways and, adding the ecological perspective, builds a Rhine scale energy-ecology network that implements the renewable mode of energy, understanding its transitional essence and building connections between fragmented conservation areas as its alternative balance of energy production provides restoration of ecosystems and habitats for humans and biodiversity.

The elements and landscapes that form this energy-ecology network are refined in the following chapters of "Deconstruction" and "Terraforming". The former provides many territorial typologies of regions between conservation patches with its characteristics and balances. The topology and topography of the infrastructural elements are arranged in ways that demonstrate the forms and relations in the landscape transition of the corridor until a new temporality of energy. This is done through plans and sections for each relevant time frame. The latter shows the transition of the future operational landscapes of energy production that form these corridors and uses typological transects to unpack the configurations and relations in these crucial landscapes.

All in all, it understands that transition is always happening and proposes to make the most of each period and energetic conditions for a terraforming that supports Earth-like life. It is worth mentioning that this method could be repeated for future modes of energy, according to the need for designated areas for the human or the fauna and flora types of habitats and uses.

This highlights that not only the back and forth between the planetary, European, Rhine basin, regional and even local scales are invested with the proposals, but also time scales are identified. Being 2030, 2050 and 2100. Apart from their specificities and scientific, ecological, societal and economic predictions that converge in them, they form a set of short, medium and long-term speculative framing needed for this terraforming.

'Energy as a spatio-temporal: temporalities of energy landscapes in the Rhine basin" is a project for transitioning infrastructure, a kind of infrastructural landscape design. The suggestion of this method and proposal is that this understanding can "unlock" more socio-ecological structures in this case, demonstrated through/for energy landscapes.



Design workflow

The investigation and anticipation, when overlapped with current territorial conditions found in the Rhine basin, highlight tensions between the inheritance of the accumulation project in the non-renewables and the potentials of the scaling-up of the renewables promising to reach its peak by mid-century. Different from scientific modelling, this is a type of projective future that belongs to the design field. It follows a method developed by Ian McHarg called the "suitability index". This cartographic method provides systems of infrastructural sites along the whole watershed that highlight the energetic conditions to interrupt, continue, or be proposed as new. These "territorial typologies" inform a constellation of sites that deserve a deeper look.

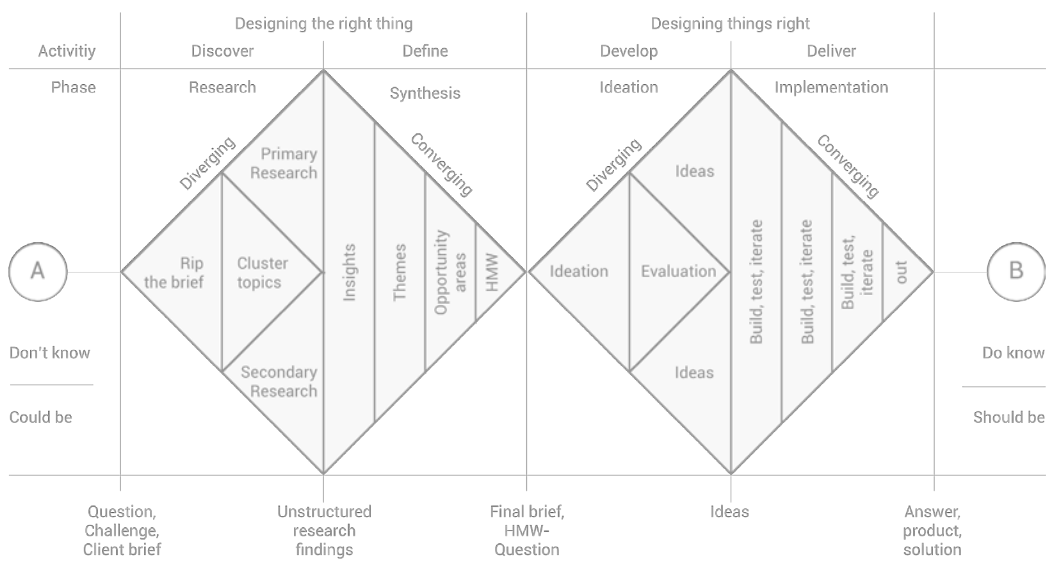
It is important to remember that the time of this project is not only to announce other processes and values; it is to investigate ways for spatial planning and urban design to assist the construction in space and time of this other world with a different set of values. Socio-ecological just urbanisation is one which values the work of natures in different sets of values. However, this is something that, given the many modes of urbanisation and its consequences so far, we (as humans and especially as spatial planners and designers) are still to learn.

In the 1960s, Ian McHarg provided a way to understand the land and find a method to translate its qualities and better integration with the human environment to the spatial planning of sites. He developed parameters for a "suitability analysis" meant to be a"rational" and "explicit" method that any other person following the same rationale can reach the same results. Employing its value system, this method answers many questions, including a problem of evaluation similar to the investigation between the "Inheritance" and "Anticipation" sections. To find, through cartography, which lands are more relevant for the scale-up of renewable energy technologies, be it for their high or low suitability. The basic proposition understands the stratification of places in the sum of historical, physical, and biological processes; that these are dynamic and constitute social values, then each area has intrinsic suitability for certain land uses and finally, that certain areas lend themselves to multiple coexisting land uses. The Rhine basin has been investigated through its productive aspirations, from the perspective of energy landscapes and its interaction with other forms of productive landscapes.

The cartographic overlay provides the infrastructural elements to be brought to the "Projection" of the new energy-ecology network.

"The maps in this study are more like mosaics than posters - for a good reason. They result from asking the land to display discrete attributes that, when superimposed, reveal great complexity. But this is the real complexity of opportunity and constraint. Yet it may appear anarchic, but only because we have become accustomed to the dreary consistency of zoning, because we are unused to perceiving the real variabilities in the environment, and responding to this in our plans."

The Energy-Ecology Network is then demonstrated by designing ways to translate it to regional corridors and to typologies found in the landscapes of the scale-up of the renewable mode of energy. This to provide frameworks that address the climate and biodiversity crises with restoration projects in many scales of implementation.



Double Diamond Design Thinking Process.
Image 14: Nessler, 2021

On the speculative

The presented conceptual framework must be informed by a less 'solution-driven' kind of methodology and more attentive to the complex problem of intricate systems, so (urban) design can propose fitting perspectives. This means an alternative approach to the common design process. It is, in majority, assisted by a well-known "double diamond" approach of discover-define-develop-deliver, where the diagram below reflects the cyclic nature of divergence and convergence in the design process. In summary, to diverge means to open up and explore more options, to converge to close and select some more promising directions - even though no process is so clear and linear. The focus is on the idea that eventually some problem is going to be solved. So far, in general, this diagram works both in terms of methodology and planning of the design process.

Alternatively, Dan Hill, in his book "Dark Matter and Trojan Horses: A Strategic Design Vocabulary" states that "design has failed to make the case for its core value, which is addressing genuinely meaningful, genuinely knotty problems by convincingly articulating and delivering alternative ways of being. [...] Yet although it can solve problems, design should be about much more than this. Indeed, the problem-solving ability is perhaps the least important aspect, coming as it does at the end of a potentially more valuable exploratory process or approach." Today, with systemic issues like the planetary boundaries approach proposed, the design methodology must reinvent itself and avoid the trap of trying to 'fix' so-called "wicked problems". [11] In that sense, it is necessary to focus better on the left part of the diagram.

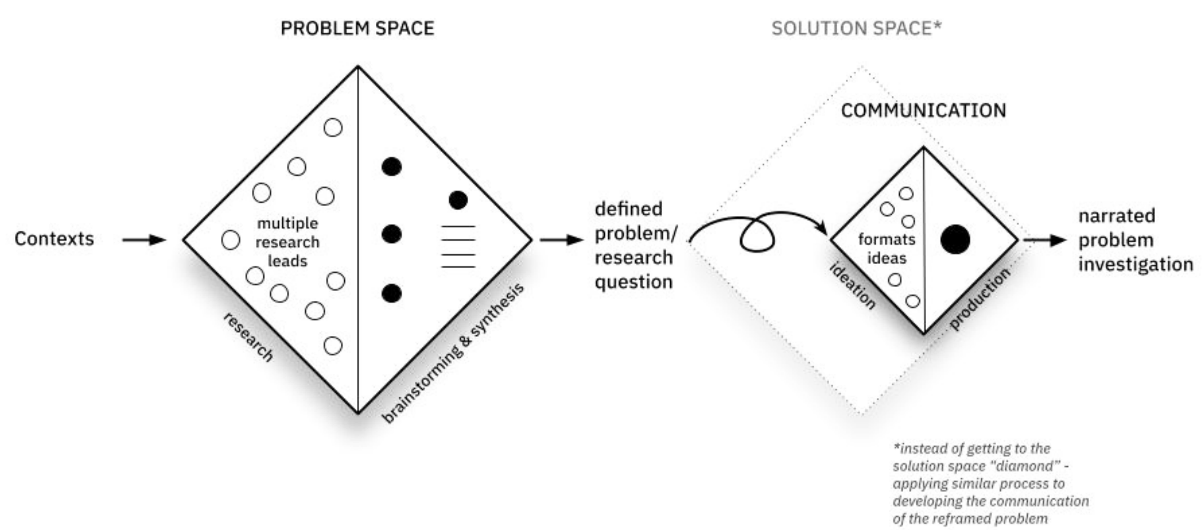
In the age of complexity it is maddening to try to catch all available information, so the skill of speculation comes as even more important to be trained. "For the social sciences, the 'speculative' is being taken up as a practico-theoretical approach to reconceptualising problems and seeking more imaginative propositions. In other words, speculation acts as a means for asking more inventive questions." (Gabrys et al. 2014) Benjamin Bratton argues that "Speculative design must focus on what is so deeply functional as to be unlikely." (2019) The task of design can be powerful when providing images from futures that are hard to imagine due to the current conditions of possibility and the complex nature of problems. The speculation is perhaps the best tool that can probably be used to find different angles to view the problems. Often the speculative is perceived as a complete freedom from any constraints and envisioning any possibilities, that is why grounding the work with profound research is crucial. Not only that, it is important to remember that the focus of speculative design and, therefore, speculative research is not about predicting or designing the future directly. It is about creating the visions that help debate the preferable directions of the present.

Understanding its pertinence to the topic of energy, Hein (2018) states that "Urban and architectural design professionals are well-positioned to imagine life beyond oil—to imagine alternative energy practises, to transform existing cities, and to design meaningful new urban forms and practises." In conclusion, we need to make sense of the built environment and its representation's relevance in the construction of power systems. In the case of fossil fuels, this industry has created the space and networks, influencing culture to adapt it to its necessary efficiencies and in a way that embodies robust, heavy, long-term materialities. Nowadays, even if fading at some points, this industry continues to largely shape societies' value systems, imaginaries, and decision-making. "All of this makes it particularly difficult for societies to overcome oil dependency and promote new energy practices.
The first step in reimagining the future is truly seeing the extent of oil's effect on our everyday landscapes and understanding the ways in which collective mindscapes shape the physical environment." (Hein, 2018) Even if she is advocating for a transition out of fossil fuels, it is also possible to already localise this challenge for the renewable energy mode. This highlights the scope of design to be attentive to more research and communication-based work, so the urban design can not only produce different spaces but also problematise it as it goes.

As conclusion for the approach suggested by the methodology, Dan Hill (2012) summarises it clearly

11. "A wicked problem is a social or cultural problem that's difficult or impossible to solve—normally because of its complex and interconnected nature. Wicked problems lack clarity in both their aims and solutions, and are subject to real-world constraints which hinder risk-free attempts to find a solution."

when saying that "much existing design practice falls neatly within an analytical context of problem-solving, broadly speaking, yet the idea that policy and governance can be convincing through mere presentation of fact supported by clear analysis is also being directly challenged. In-depth analytical approaches can no longer stretch across these interconnected and bound-less problems, where synthesis is perhaps more relevant than analysis." Synthesis gives us the power to combine things that did not seem to belong to one another. Moreover, that capability is largely amplified when the step from the conventional design process to the speculative is made. The diagram below illustrates the idea of "upstream speculation", reworking the double-diamond diagram not to find the solution for the problem but to find the best solution for its communication format.



Upstream speculation diagram.
Image 15: Besplemennova, 2020

Problem statement, frameworks and process

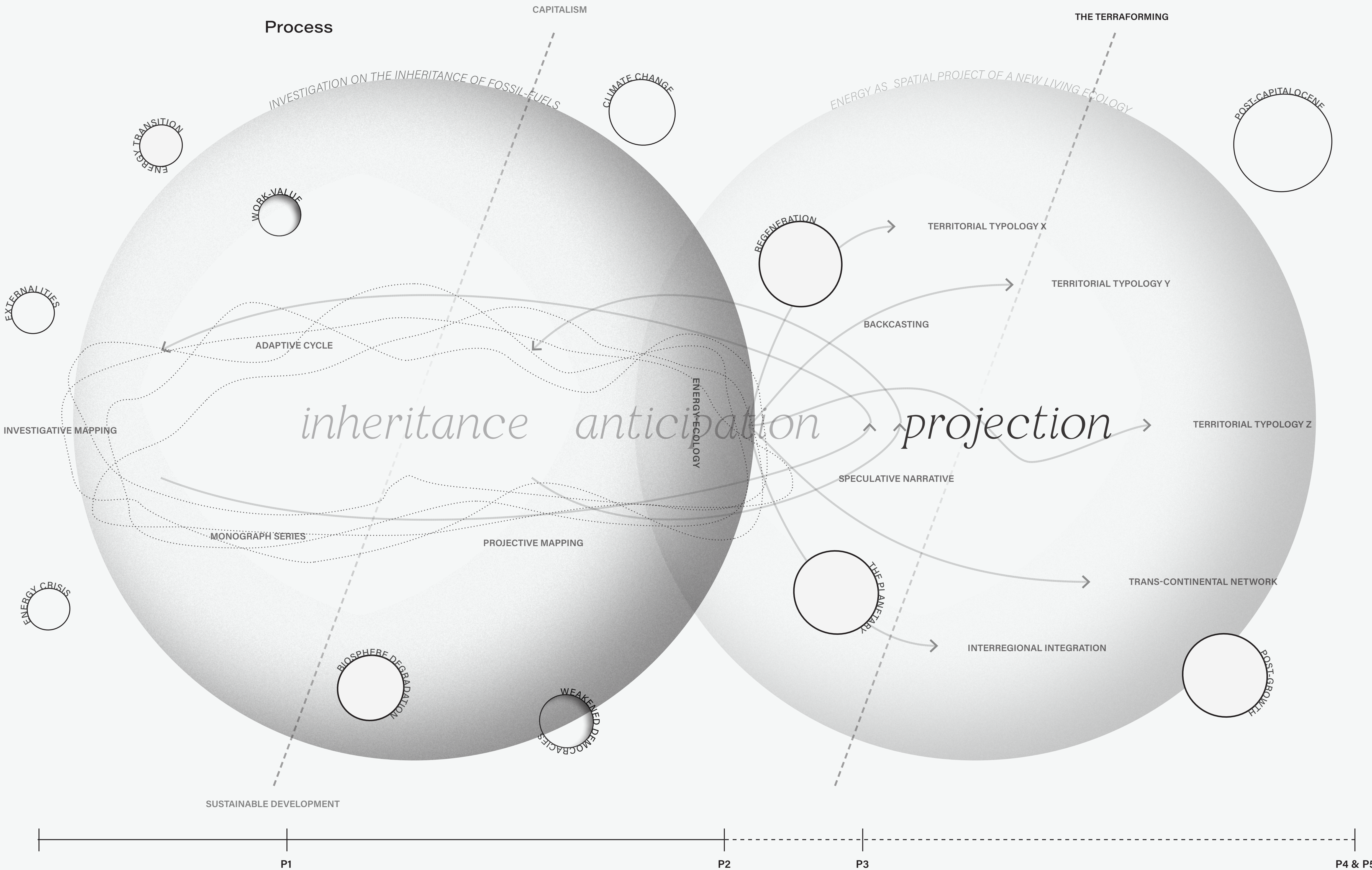
The main focus of the thesis is an interest in investigating the more significant role of work and its intricate in society, economy, environment and landscape. This is depicted in investigating the modern history of energy landscapes, exploiting many natures, human and non-human. In the same logic, the "energy transition" aims to function as a fix, even when totalising a "solution" mentality has proven inefficient in addressing complex problems. On the ground, the low-emission technologies still embody many externalities and will generate a competition for land, which in the Rhine is promising to clash with agriculture, forestry and grasslands. Adding yet another layer of productivity growth to the already productive landscape that is the other side of urbanisation, not the agglomeration but the operational, might exploit new frontiers and aggravate ecological conditions.

Summarising the spatial challenge in the narrative, the "energy crisis" is mostly about what comes as an inheritance in the phase-down of fossil fuels with all their damage. It has developed an extended operationalisation of the landscape in its intricate of mode of energy and urbanisation. Secondly, the current effort of "energy transition" in the scaling-up of renewables will be an era of mitigation. It will have its pros, but at the same, it will push new frontiers in the land. Then, in a state of climatic instability, exhaustion of old energy supplies and ecological depletion, the need for social and ecological regeneration as an energy spatial project must already be a concern of the urbanism of today. Energy landscapes are positioned as a hinge to articulate new futures breeding out of the spatial design of an energy-ecology network.

I argue that, in parallel, it is a theoretical and conceptual effort because of the transformative role of energy in society. The energy-intensive life must be reevaluated. The composed concept of "terraforming" comes along as an alternative set of values to understand the dynamics of the built environment and the spatial practice. The project aims to grapple with the spatial project of energy needed for volatile futures - not because they are in the future but because we need more than apocalyptic views or socio-technological scenarios. (Mair, Druckman and Jackson, 2020)

"What future would make the past worth it? Perhaps the future of planetary intelligence is now as existentially entwined with a radically different career for composition, foresight and order-giving as its advent was from the cascading centuries of pilotless destruction. Taking this new existential condition seriously demands a radically different sort of philosophy." (Bratton, 2021)

Process

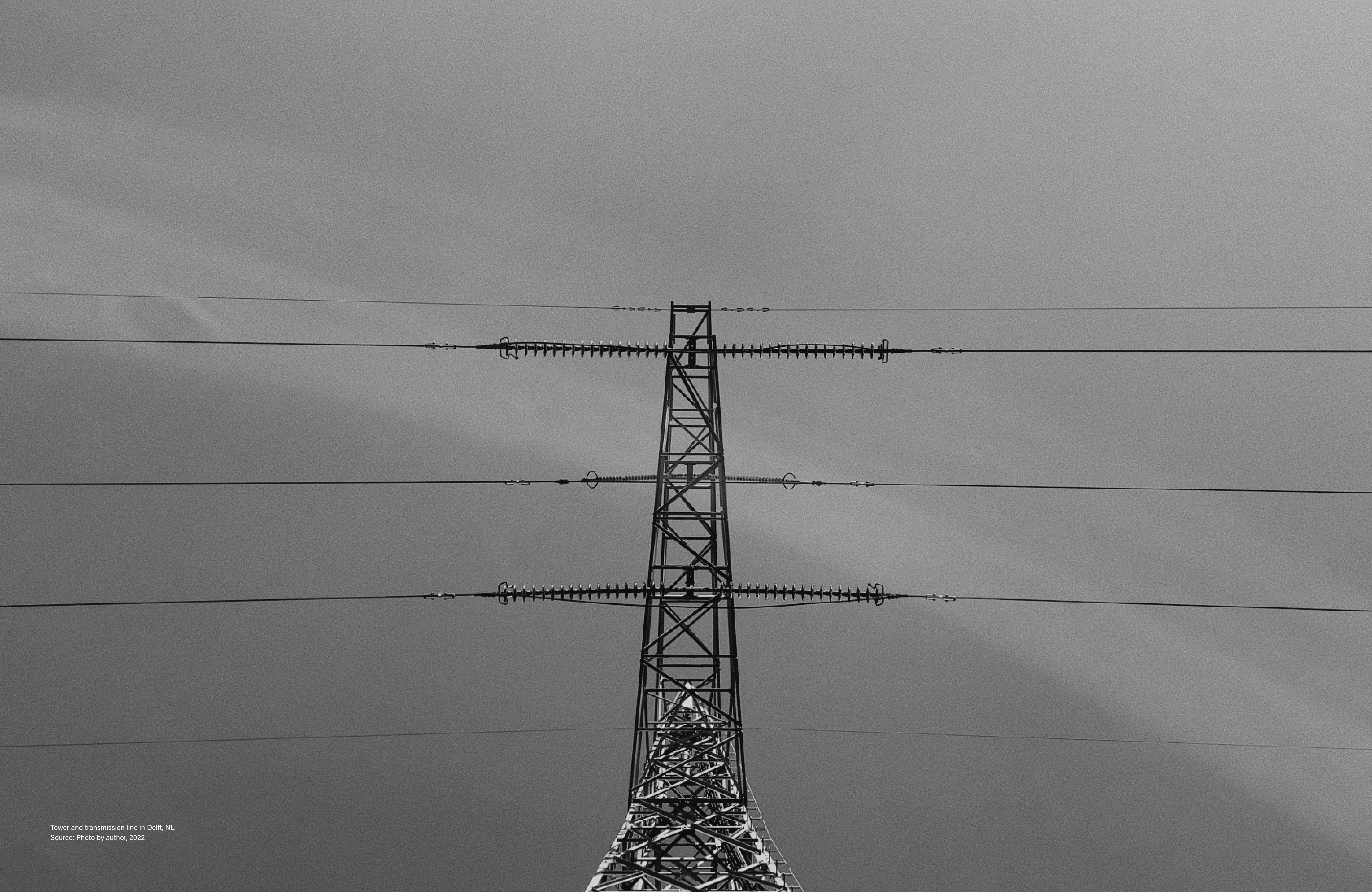


CAPITALISM
THE TERRAFORMING
INVESTIGATION ON THE INHERITANCE OF FOSSIL-FUELS
ENERGY AS SPATIAL PROJECT OF A NEW LIVING ECOLOGY
CLIMATE CHANGE
POST-CAPITALOCENE
ENERGY TRANSITION
WORK-VALUE
EXTERNALITIES
REGENERATION
TERRITORIAL TYPOLOGY X
TERRITORIAL TYPOLOGY Y
BACKCASTING
ADAPTIVE CYCLE
ENERGY-ECOLOGY
INVESTIGATIVE MAPPING
inheritance
anticipation
projection
TERRITORIAL TYPOLOGY Z
SPECULATIVE NARRATIVE
MONOGRAPH SERIES
PROJECTIVE MAPPING
TRANS-CONTINENTAL NETWORK
ENERGY CRISIS
THE PLANETARY
INTERREGIONAL INTEGRATION
BIOSPHERE DEGRADATION
WEAKENED DEMOCRACIES
POST-GROWTH
SUSTAINABLE DEVELOPMENT
P1
P2
P3
P4 & P5

1

inheritance

Facilities in the Maasvlakte, the Port of Rotterdam
Source: Photo by author, 2021



Tower and transmission line in Delft, NL
Source: Photo by author, 2022

Clear boundaries in the landscape, 6,3362498° E 50,0308021° N
Source: Google Earth, 2022

Matter

Focus: Technologies
Relation to energy: Material (ton/W)
Entropy: Emissions

Topos

Focus: Infrastructure
Relation to energy: Volumes (ton/W)
Entropy: Land degradation

Habitat

Focus: Land-use
Relation to energy: Spatial footprint (W/m^2)
Entropy: Area

Geopolitics

Focus: Mode of energy
Relation to energy: Scarcity
Entropy: Productivity paradigm

Energy crisis and the project of accumulation

“Inheritance” is an investigation of the contribution of energy to the near-approaching climate and social collapse. It focuses on the mode of energy of the non-renewables and its contribution to the damage in local and planetary ecosystems. The contribution of this energy mode to the smooth running of the current project of accumulation[12] is vital. It made it possible to decouple the energy generation from the consumption of energy, thus, creating landscapes of production that feel external to the landscapes of whimsicality. This feedbacks the development of the imaginary that sees “Nature” and “Society” as unrelated entities. Modernity is possible due to the operationalisation of that mentality, having energy as the backbone of its existence.

This exploitation did not come without externalities, now backfiring more acutely in the form of climate change and biosphere degradation. The change in land-uses, perforating deep-Earth and throwing the waste of that energy into the biosphere and atmosphere, exceeding GHG and particulate matters, keep on sustaining the exceeding of planetary boundaries.

“Inheritance” maps how did we get here.

12. “The current epoch is one of accumulation: not only of capital (primitive or otherwise) but also of raw, often unruly material; from plastic in the ocean and carbon in the atmosphere to people, buildings and cities. Of anxiety, and of a recognition of the difficulty of finding effective means for intervening in the behaviors and practices that engender these patterns.” (Nick Axel et al, 2019)

AS17-148-22727 or "Blue Marble"
Image 16: NASA, 1972

World as the globe

Until the late 17th century, the supply areas, these urban 'hinterlands', remained relatively geographically contiguous and confined at a regional scale (Harvey, 1996). However, consecutive waves of industrial and post-industrial capitalist urbanisation, combined with the pressures from the growth of agglomerations and their expanding metabolic needs, gradually exploded these boundaries (Billen et al. 2012). "As a result, contemporary agglomerations appear largely detached from their surrounding hinterlands. They are rather thought to share a wide network of extensive, fragmented, global hinterlands." (Ibanez and Katsikis, 2014).

At this moment, the theory of 'planetary urbanisation' makes the case that, by the beginning of the 21st century, almost all the human occupation of Earth is shaped by globalised, capitalist urbanisation processes. (Katsikis, 2018) Aiming back at our focus, landscapes of energy, which intrinsically cross operational and agglomeration zones, are central to the feedback loop of development since its rise in EROI made possible the industrialisation of the planet in a relatively sparse configuration. The map below reveals the agglomeration zones (also understood as energy landscapes of consumption) together with the current landscapes of extraction and conversion of energy. These are the operational landscapes of energy, which sum to the extensive productive land of agriculture, grazing, forestry and transportation networks (which could also be considered energy landscapes of distribution).

This forms the material basis for the globalised network and its waves of capitalist intensification that exploit natural systems' geological work (in short and long temporalities). The before mentioned local biosphere degradation and global climate change are part of the loop that feeds itself by exploitation, then scarcity, then new frontier for capital intensification and nourishing business opportunities as it shares the entropies of its operation in imaginaries that are captured, in for example images like the Blue Marble, and a narrative of humankind inhabiting a shared a global village with its humans in control of a "garden" where everything is open to consumption. At its best, it gave legitimacy to the operationalisation over nature in society, and now its logics of accumulation and scarcity are increasingly becoming palpable as a threat.

Composition

The map relates the capacity of the power plants in the Rhine basin with the air pollution in their local region. Centuries of planetary energy conversion have left their entropies in many ecosystems; one very representative is the atmosphere. Mapping the accumulation of GHG emissions (and other particulate matter) in the air can help to visualise and act upon this world-ecology as cleaner air could also mean more just urbanisation, depending on the proposed landscapes of this future reality.

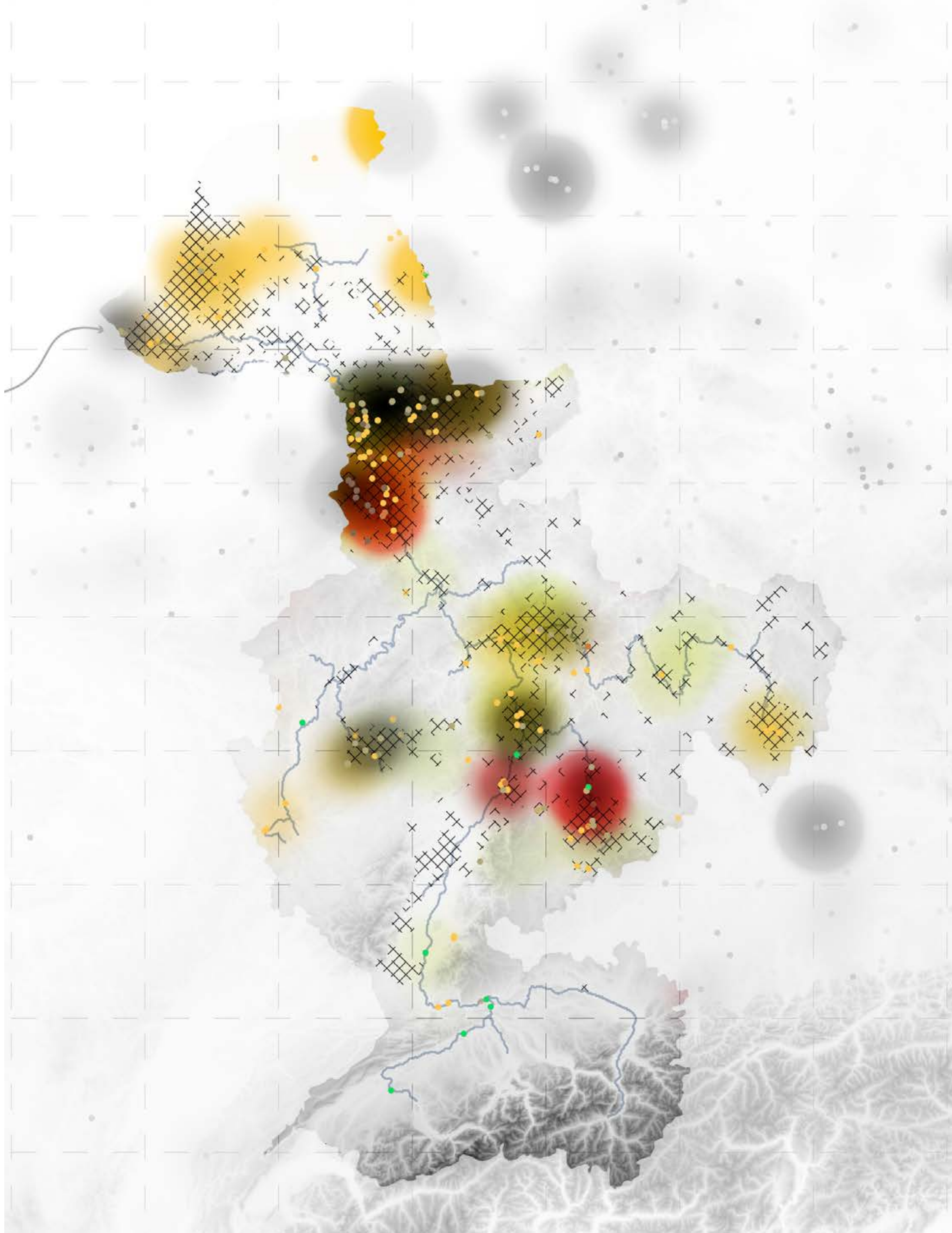
In the atmosphere, matter is not static but reacts and transforms. In the end, trapping heat in the atmosphere and contributing from urban heat islands to climate change.

The cartography is a 'snapshot' map of an ever-moving element, and it shows a pattern that has not only the densest urbanisation areas as indirect air polluters but mostly the clusters of energy conversion landscapes.

Imports
High PM 2.5 concentration
Rhine river and main estuaries

Non-renewables power plants and capacity in gradient
Lignite
Coal
Gas
Oil
Nuclear

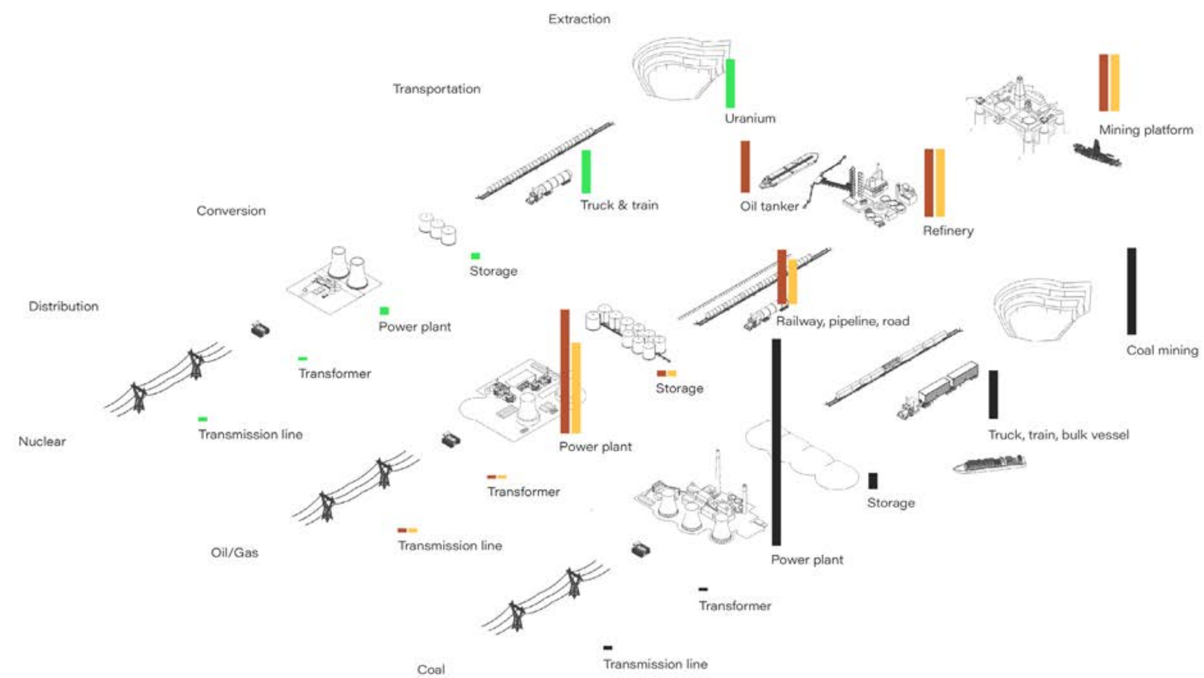
0 100km N



Alteration

The network and forms of historical non-renewable energy landscapes are shown from the extraction until the distribution, correlated with its emissions in each process.

It makes clear that most of the emissions are in conversion landscapes.



Emissions in comparison per landscape

- Coal
- Gas
- Oil
- Nuclear

0 100km N

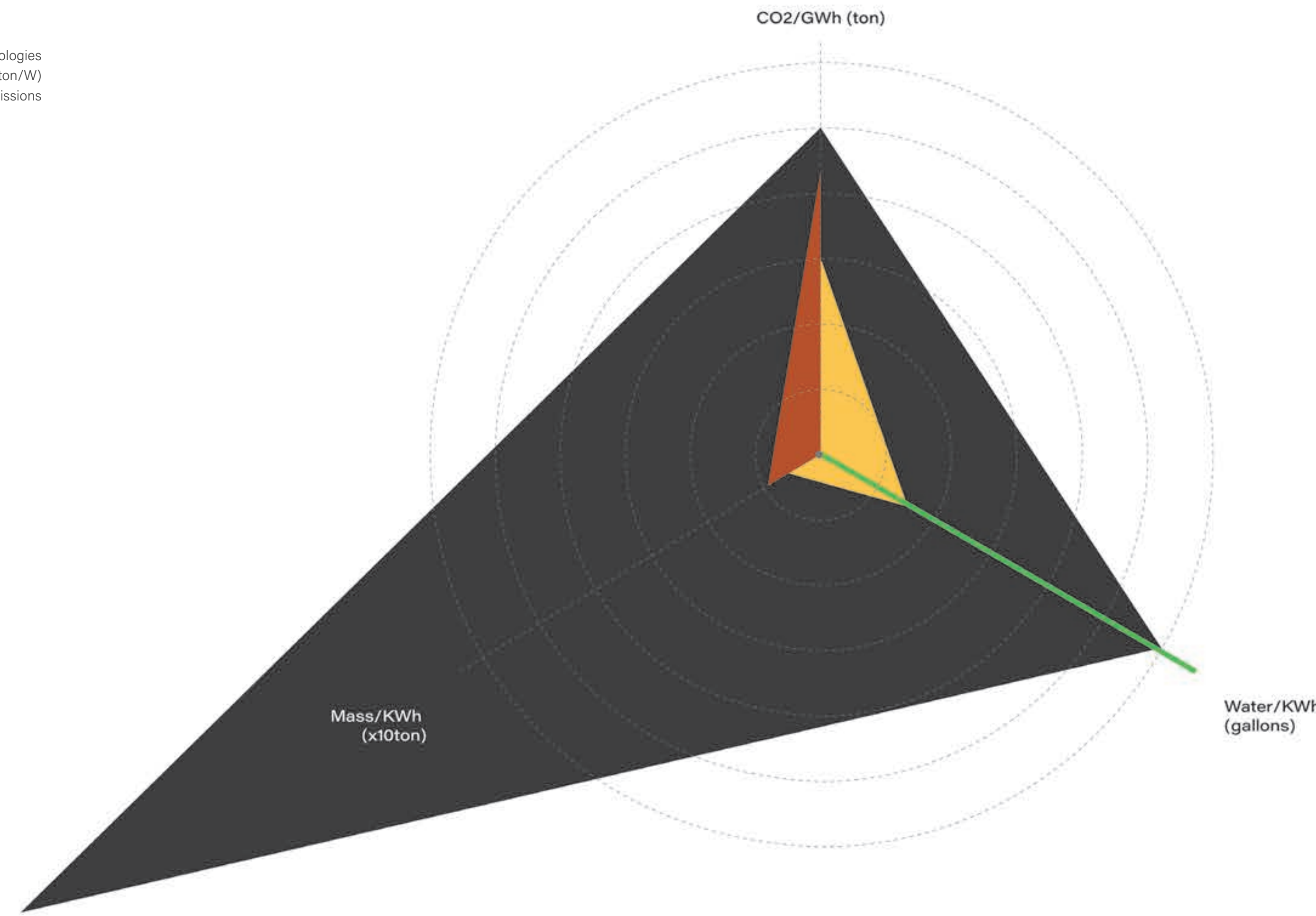
matter

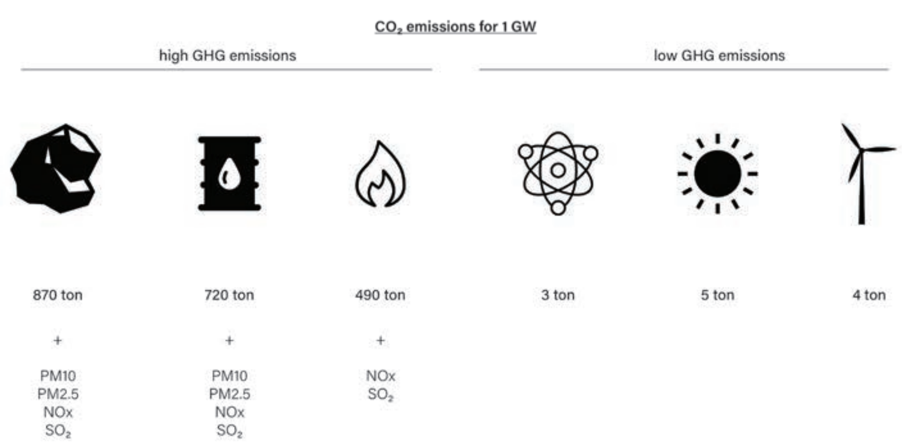
Focus: Technologies
Relation to energy: Material (ton/W)
Entropy: Emissions

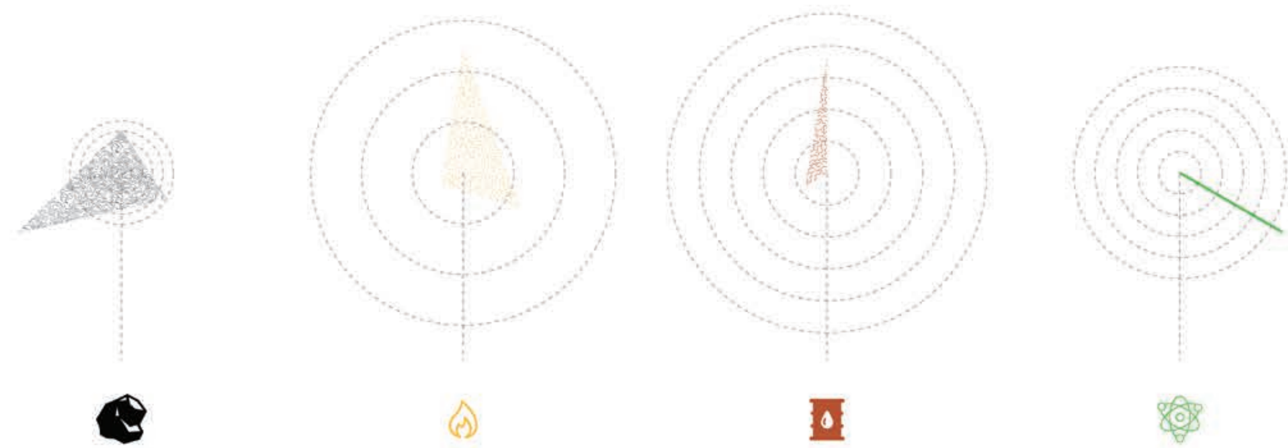
Limit

A correlation is made between material, emission and energy produced in the top scheme on the page on the right and between material and emission in each sub-region of the Rhine basin.

In between the percentages, it represents the consequence of the continuation of a project that enriches a kind of humanity that in turn exhausts natures and the whole balance of ecosystems.







- Coal
- Gas
- Oil

0 100km N

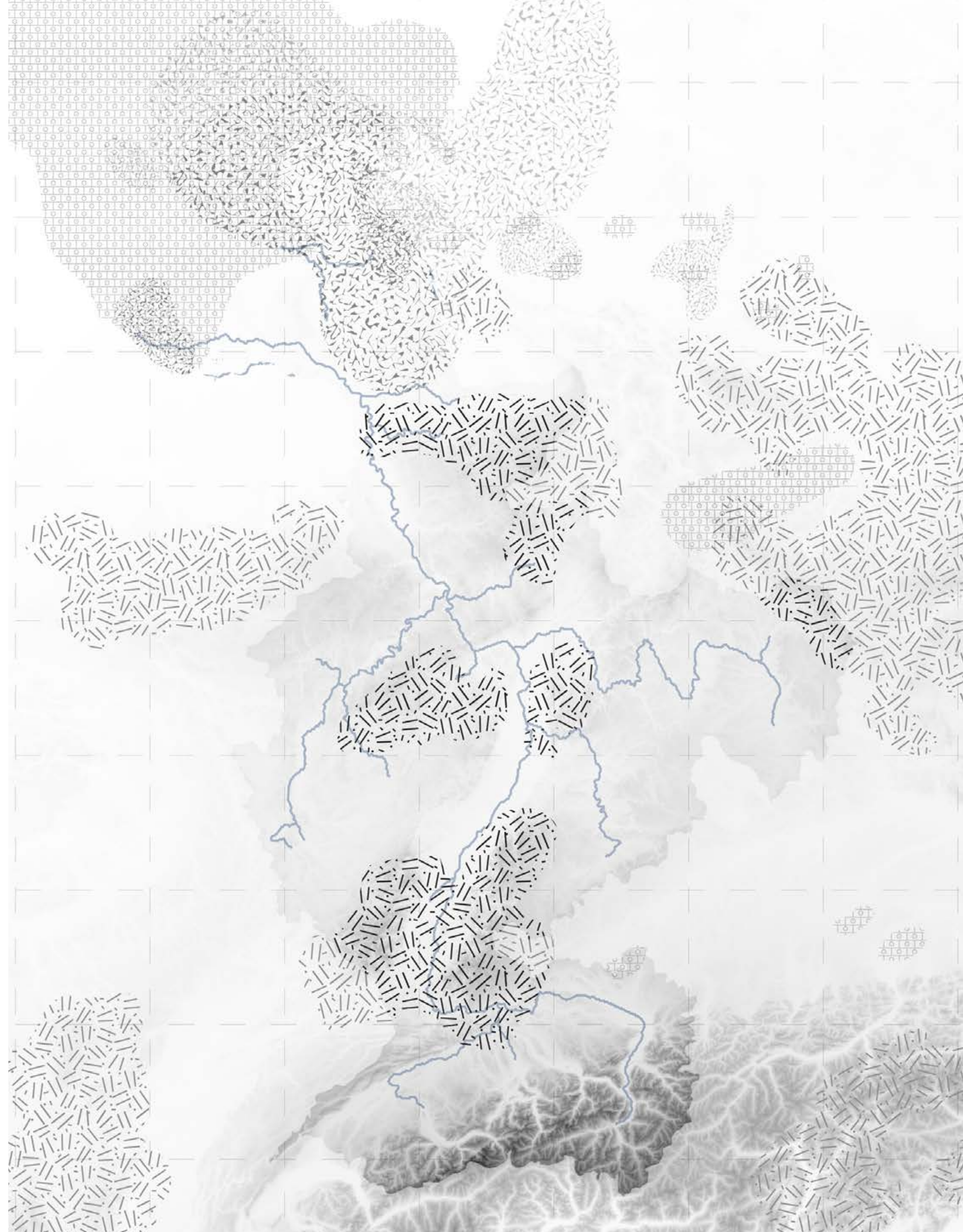
(each ring represents 200 units)

Composition

The geological layer composes the fuel for the Great Acceleration and fossil capitalism. It has been able to generate enormous productivity growth because fossil fuels have a high energy return on energy invested (EROI). EROI is a measure of energy quality. It is a ratio of energy outputs to energy inputs. Fossil fuels have been able to drive productivity growth because relatively few resources need to be invested in getting large amounts of energy out of them. (Mair, Druckman and Jackson, 2020) However, this investment does not come without externalities from the sub-surface to the atmosphere.

Data: Google Earth, 2022

Image 17: Lignite mining at the Ruhr region



Coal
Oil reserves
Gas reserves
Rhine river and main estuaries

0 100km N

Focus: Infrastructure
Relation to energy: Volumes (ton/W)
Entropy: Land degradation

Alteration

Not only the topos is extracted, but its material is also distributed. The operational landscape of the basin is highly manipulated. The map shows the distribution networks of these energetic geological strata and primary and converted energy in the subsurface, ground or the atmosphere.

Underground, the extracted material runs through pipelines for oil and gas. This material is distributed on land and on water in webs that reach the whole globe. The Port of Rotterdam, at the discharge of the Rhine River to the North Sea, is "the absolute leader in the throughput and storage of crude oil. The 95 to 100 million tonnes of crude oil annually entering Rotterdam are almost entirely destined for refineries in the port itself and in the Netherlands, Belgium and Germany." (Port of Rotterdam, 2022) A little bit further up the Rhine river, in the Lower Rhine region, it is possible to see an intensification of these webs, unquestionably related to the cluster of power plants in the region.

Lastly, the electricity is distributed in a highly connected web of transmission lines after the conversion of primary energy into secondary. Lagendijk (2015) points out that this started to take form towards the end of the 1920s when authorities shifted the focal point towards constructing transmission lines within their respective borders. In response to these nationalistic tendencies, engineers started suggesting schemes for a European electricity system.

Energy landscapes of extraction according to capacity/production

- Coal
- Gas
- Oil
- Electricity distribution grid
- Rhine river and main estuaries

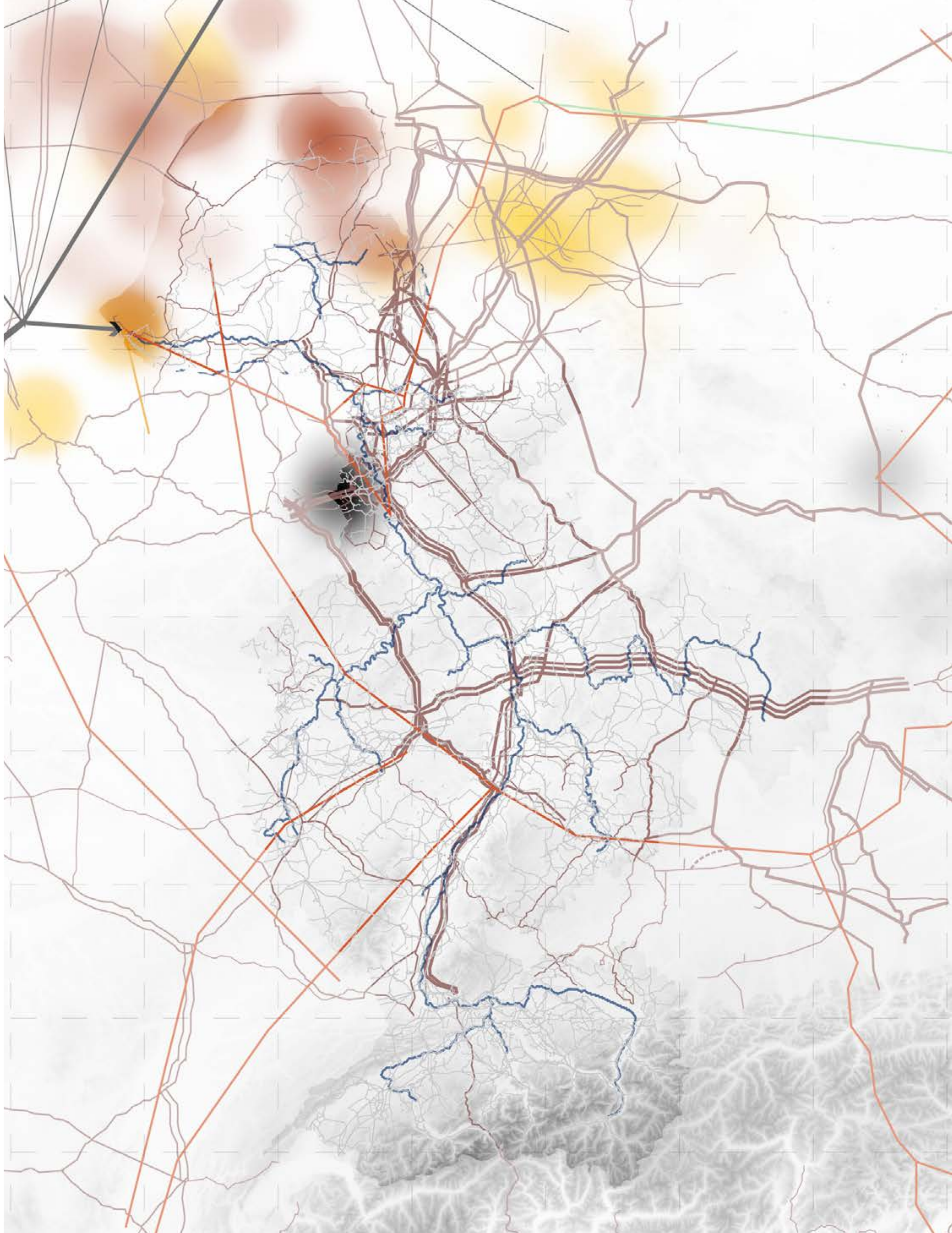
Oil pipelines

- Operating
- Proposed
- Projected

Oil traffic (million tonnes)

- 35-70
- 105-140
- 210-800
- Gas pipelines

0 100km N

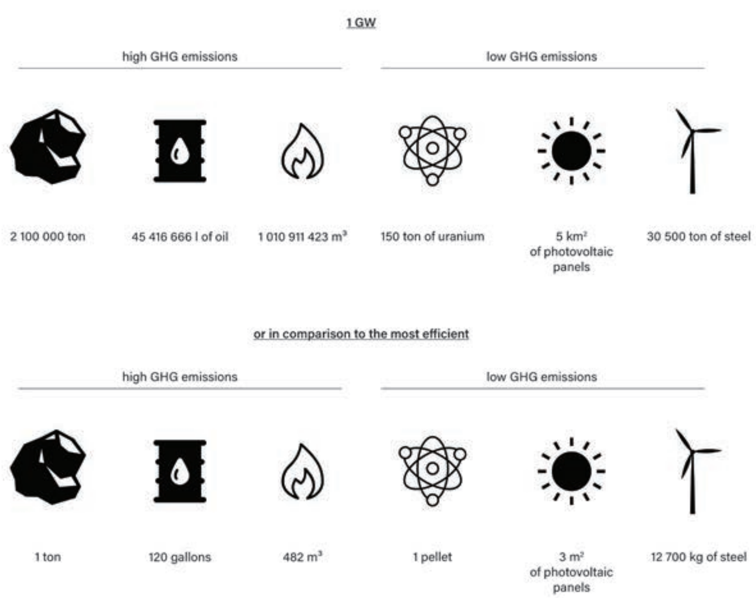


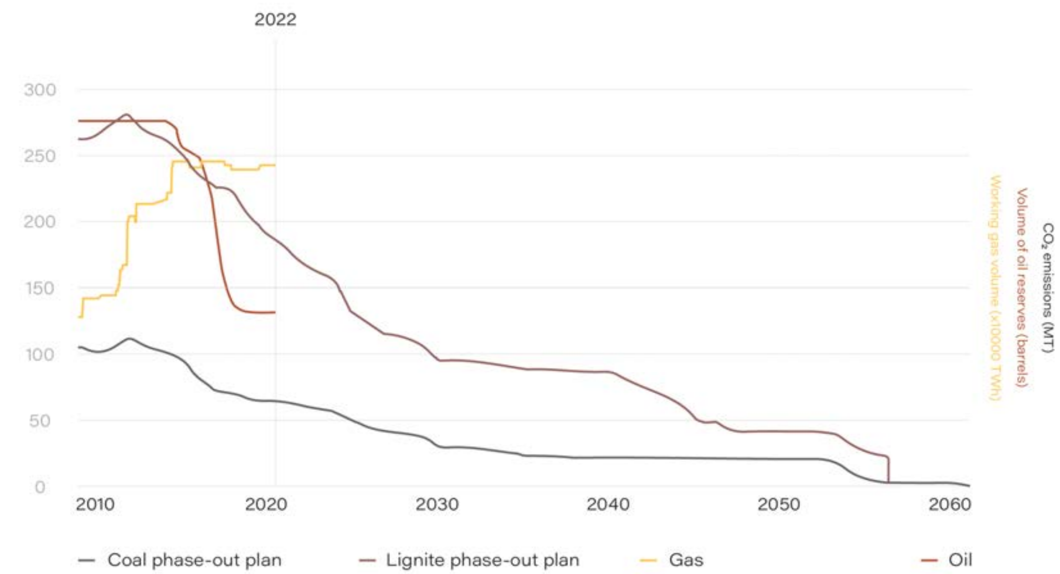
Limit

The limit of the non-renewables is the complete depletion of its primary forms of energy. In that sense, the graph shows Germany's historical and future situation, with the estimated volume of material still left to be explored. The scheme below compares and gives an idea of what is more efficient in a relation of volume needed to generate 1GW.

Germany is an example for the whole region. Looking at the historical development of exploration of the topos in the region, Lagendijk (2015) states that electricity companies, like RWE, now own power plants and transmission lines in various countries. They used the region's resources as a stepping stone toward becoming European players. Critical parts of the current-day European grid are also based on the Rhine's resources. Electricity systems grew as industries matured along the Rhine, as the exploitation of water and coal resources intertwined with the development of the metallurgic and chemical sectors.

This practice of extracting the work of nature, generated for billions of years, needs to be rethought in the opportunity now for a renewable era in order to redistribute value and avoid exploitative practices, leading to other (or deepening) climate and social collapses.





0
100km
N

Focus: Land-use
Relation to energy: Spatial footprint (W/m²)
Entropy: Area

Composition

The habitat layer is the mapping of everything that is considered an energy landscape. The map on the right focuses on the energy landscapes of consumption, well-known as cities.

Landscapes of energy fall into a categorisation called "operational landscapes". Even though agricultural productivity expands across the watershed and is the most significant example in hectares of the process of operationalisation across the basin, and non-renewable energy landscapes do not take up much land for its conversion process, they have a large ecological toll when considering the networks it needs and the other it makes possible.

Even though more than ever in a self-referential whimsicality, the high-density cities and metropolitan regions - the agglomeration zones of "concentrated urbanisation" - historically growing very much attached to the river is not the only element that defines the urbanisation characteristics of the Rhine basin. The agglomeration zones (in high and low densities) form less than a third of the area of the whole Rhine basin. It is instead an extended territorial system of pervasive operationalisation of natural systems that forms an assemblage of "operational landscapes." (Katsikis, 2020) Landscapes of energy, circulation and agricultural production are the main actors.

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 is facing new challenges with the ecological footprint backfiring in the land and in the atmosphere coupling with the "energy transition".

■ High density agglomeration
■ Low density agglomeration

0 100km N

Focus: Land-use
Relation to energy: Spatial footprint (W/m²)
Entropy: Area

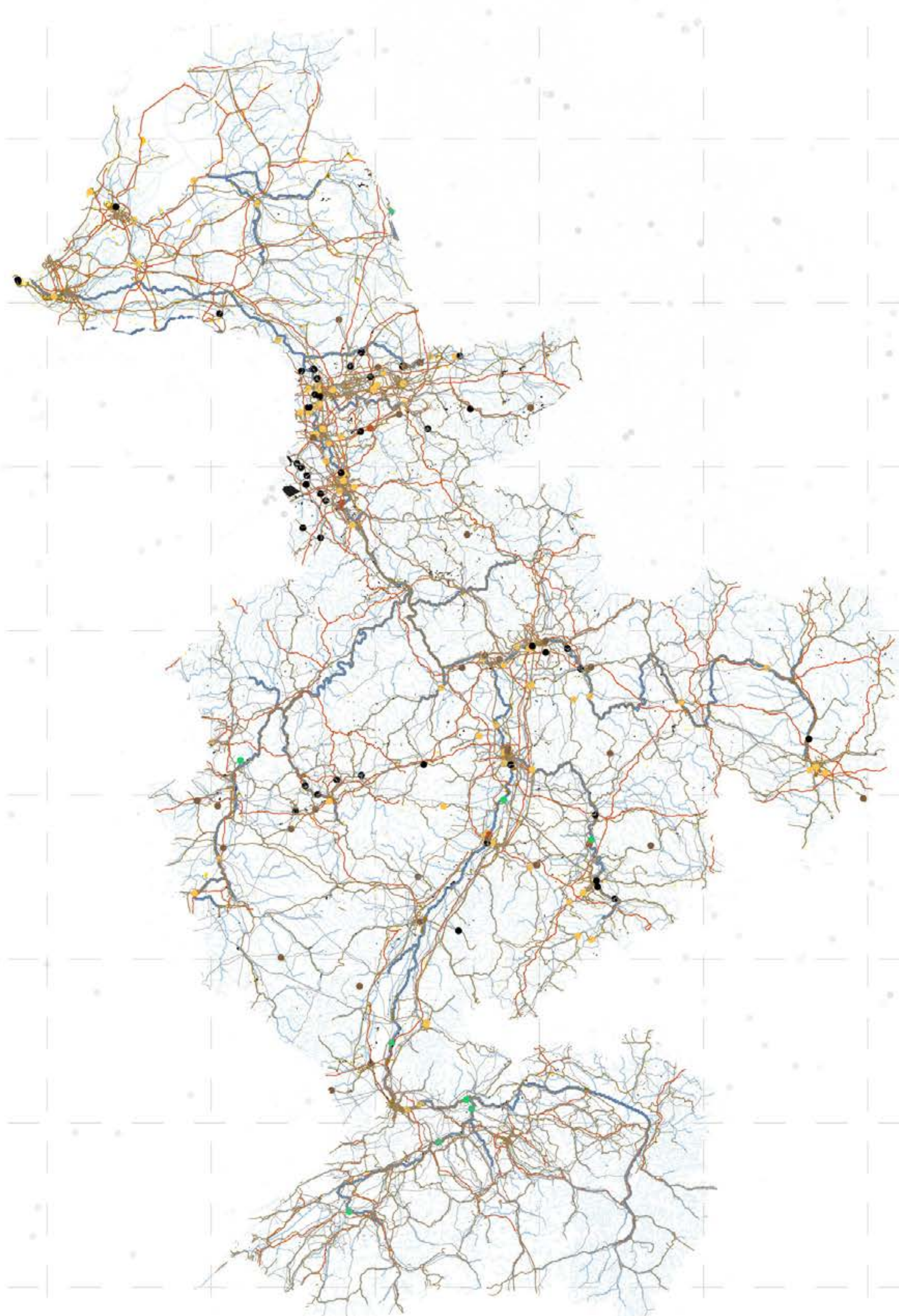
Alteration

The habitat layer is the mapping of everything that is considered an energy landscape. The map on the right shows the other side of the consumption of energy: the operational landscapes of energy during the non-renewable energy modes. In relation to the previous layers, that start to reveal the basic dimensions where a multitude of operational landscapes of extraction, production (of energy and crops) and circulation of primary commodities shapes in the Rhine basin.

Energy consumption by sector per country part of the Rhine basin.
Image 18-22: IEA, 2020

- Rhine river and main estuaries
- Railways
- Roads
- Coal
- Gas
- Oil

0 100km N

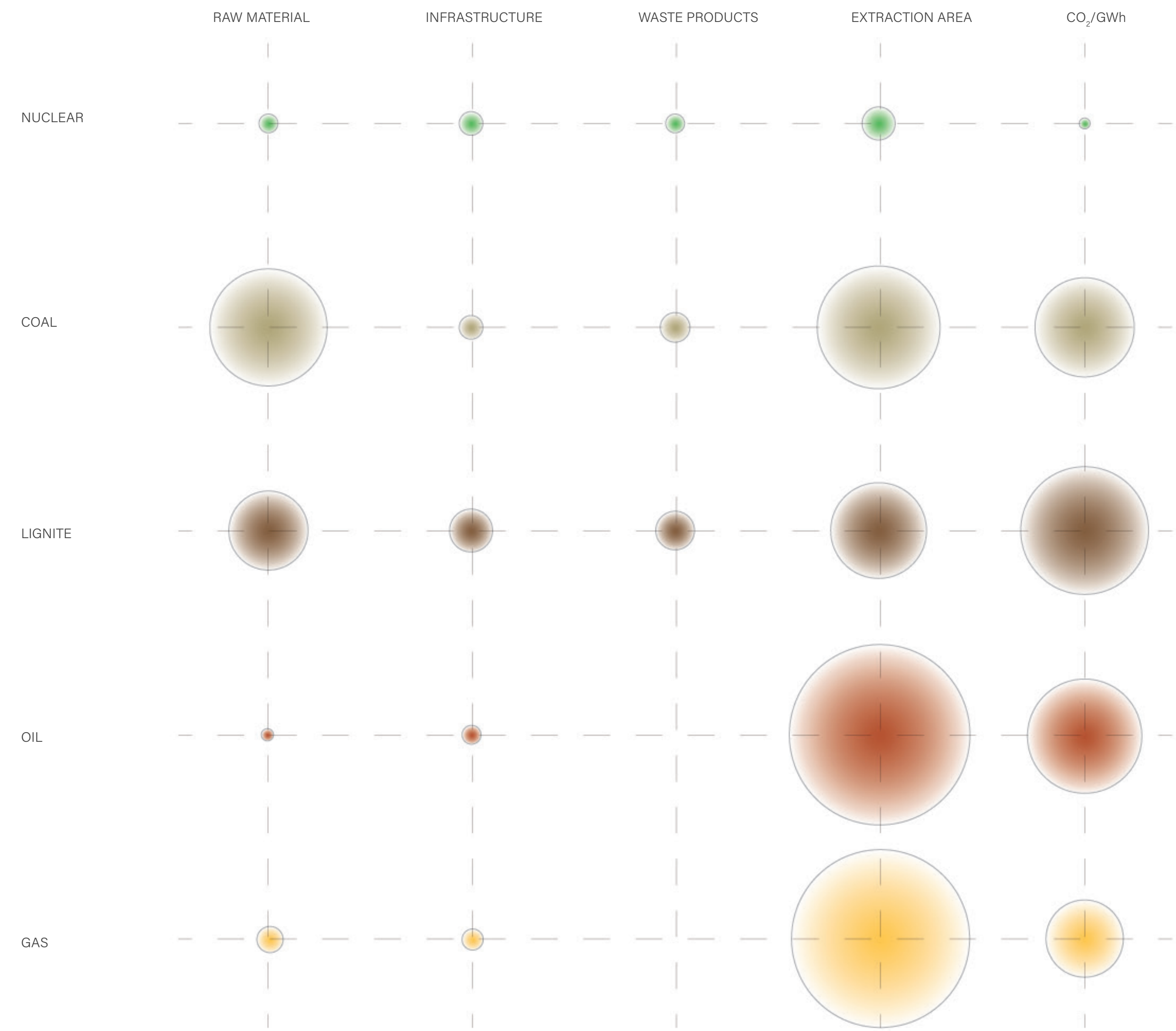


Limit

The spatial footprints of the whole chain of energy generation are organised in comparison with one another and with the total GHG emissions. Nuclear energy is by far the most efficient and less-polluting form of energy, leaving the question of whether it can be used during the current energy transition phase.

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 now being called a process of planetary urbanisation. (Brenner, 2013) The modern era is the reorganisation of the territory around the availability of abundant energy established by a new horizon of possibility for production. (Iturbe, 2019)

In summary, the "energy crisis" is not only about the declining security of supply but mostly about what still remains in the phase-down of fossil fuels. The inheritance is the increased connectivity in its developed and extended operationalisation of the landscape through an intricate of mode of energy and urbanisation, but it is also its ecological degradation. Mobility networks, power plants, transmission lines and towers in a grid, highly agglomerated zones of inhabitation, extensive and intensive croplands, and forests focused on producing biomass for different uses.



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

Focus: Mode of energy
Relation to energy: Scarcity
Entropy: Productivity paradigm

Composition

"...this is why the Green Deal, as a growth strategy remains our compass..."

With these words, Frans Timmermans, executive vice-president of the European Commission in charge of The European Green Deal, speaks at the European Council in 10-11 December 2020, in Brussels.

"...we will reduce emissions by at least 55% by 2030, and today's agreement puts us on a clear path towards climate neutrality in 2050. It gives certainty to investors, to businesses, to public authorities and to citizens. It future-proofs our union."

With these words, Ursula Von Der Leyen, President of the European Commission, continued the speech.

Growth, neutrality and future-proof is a vocabulary dripping on the same kind of productivity logic that got the planet on a fast-track towards climate and social collapses. This logic is organised by capitalism and is marked by production for the market rather than for use (Wood, 2002). In this way, capitalist production separates work for 'production' from work for 'reproduction'. This separation is unique to capitalism (Federici, 2014). The separation of productive and reproductive work enables a distinction to be made between market work termed 'valuable' and work carried out by nature and in the household, which is not considered valuable. This plan is interested in decarbonisation through 'sustainable development' because that maintains the business opportunities and the management of those already in power.

Landscapes of extraction

Landscapes of conversion

Atmospheric pollution

Summary

Lignite
Coal
Gas
Oil
Nuclear

Focus: Mode of energy
Relation to energy: Scarcity
Entropy: Productivity paradigm

Alteration

Another dimension of the decarbonisation of the economy is the new arrangements for energy collaboration. Currently, France is exporting more of its energy production to Germany as it phases-out coal power plants. Russia is pushing plans to build pipelines from its gas plants into continental Europe - halted by its war on Ukraine. Still, coal and gas are 20% of all energy production in the EU. In this long-term project, energy sharing becomes more political as energy supplies become more limited. Economically, this can cause inflation because every aspect of life is dependent on electricity. We are experiencing it now with the energy crisis. Even though the current energy crisis is a sum of more specific factors like the pandemic and a "bad" season for renewables, the current energy crisis shows infrastructural problems for the "energy transition" and the European integration.

Coal
Gas
Oil
Electricity

Data: Eurostat, 2019

0 100km N

Limit

The chronology of fossil fuel energy in the Rhine basin is marked by productivity growth, just like the entire planet. Labour productivity growth has historically had a symbiotic relationship with capitalist markets and fossil-energy. (Mair, Druckman and Jackson, 2020) History can locate the transition to fossil fuels and its dense energy capacities as a critical dynamic in the transition from a low to a high productivity economy, leading to new possibilities for growth and development in industry, housing and mobility.

The graph on the side highlights many moments of concern over the ecological consequence of energy. Nevertheless, it did not change the growth of GHG emissions. Now, the decarbonisation and phasing-out of fossil-fuel in the same exploitative paradigm will harm other natures. The envisioned decline on EROI (Energy return on investment) values makes plausible to imagine that in the near future, it could reach such low levels that the energy sector effectively "cannibalises" other sectors (Sers and Victor, 2018). All in all, a reduction in overall productivity levels is likely to be forced upon humanity (Elkomy et al., 2019). Following these predictions, post-growth imaginaries are being drawn in philosophy, economy and sociological studies; this project aims to take it to the spatial energy project.

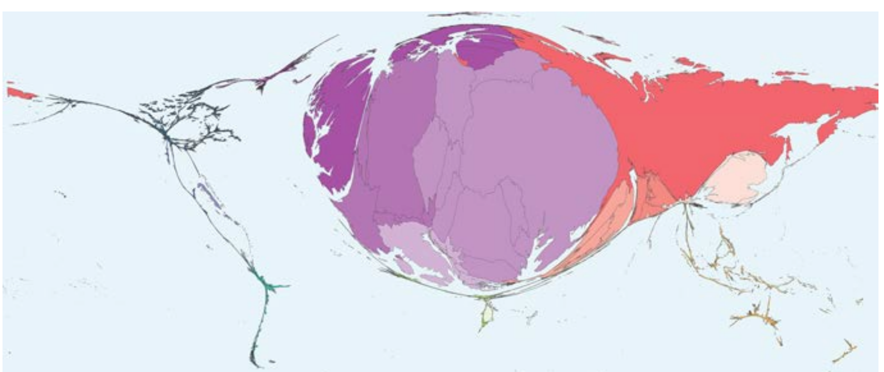
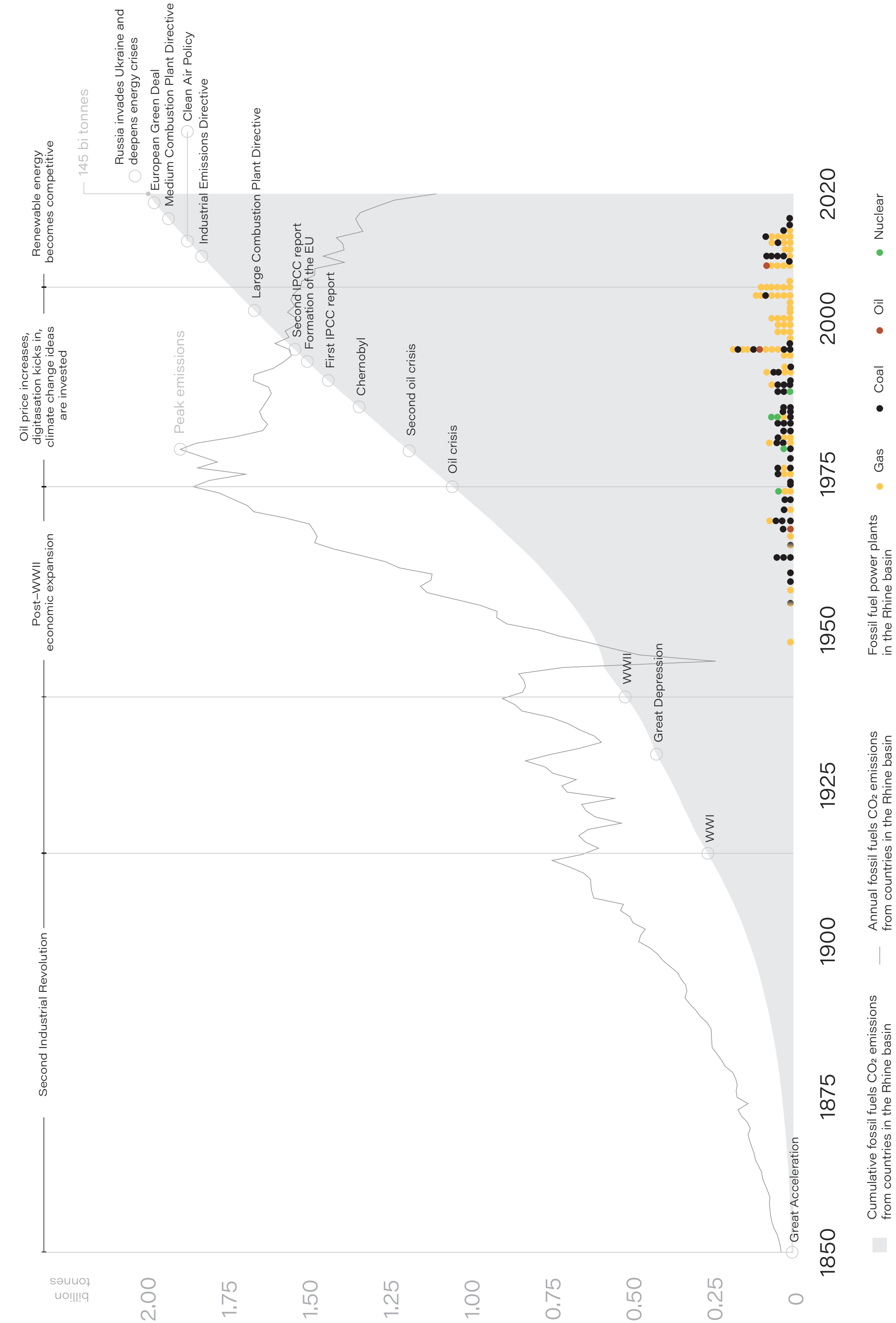


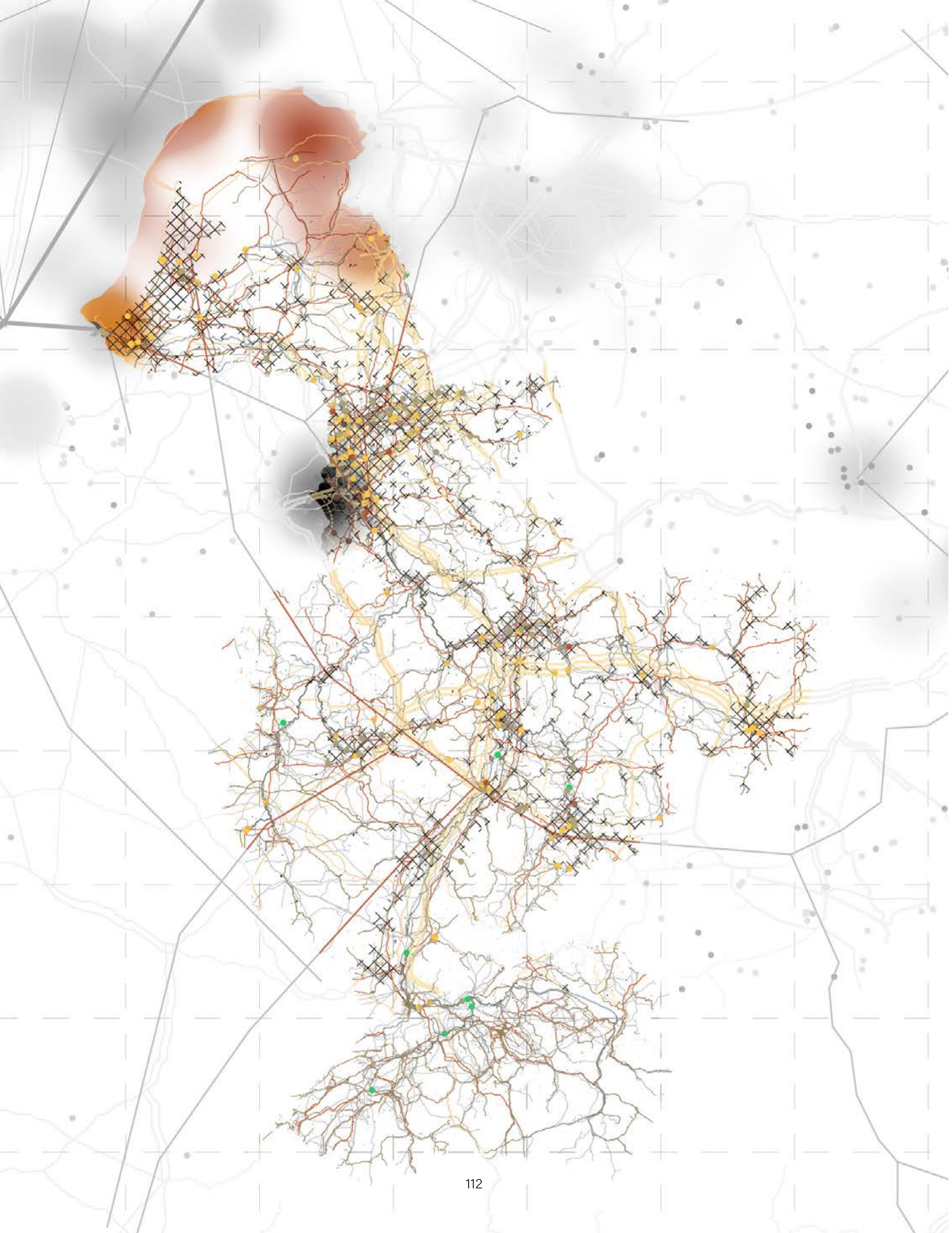
Image 23: Carbon Dioxide Emissions Decline between 1990-2015 is major in Europe

Coal
Gas
Oil

Data: McKinsey, 2022; Ritchie, 2020; Statista, 2021



Reflection



Rhine basin as operational landscape

The current condition of the Rhine basin as an 'operational landscape' can be seen as the inheritance from the globalised world made possible by fossil-fuels. The 'operational landscape' is intrinsically part of the urbanisation process, which was possible to see by the maps on each part of what constitutes the energy landscapes of the non-renewables supporting the other landscapes of whimsicality in a still relatively high EROI. What the UN reports and many others consider the "urban age" is upon us because this interdependence proved successfully operationalised.

The "Inheritance" section helps to identify the current operational landscapes of energy of the Rhine basin from the perspective of the zones outside agglomeration; which are commonly unrepresented in maps over the urban age, and how those spaces have been structured to support the material and commodity needs of major cities, industrial zones and perhaps even the Rhine River, as an area that became so much industrialised that not only water converges to it but many elements of the energy apparatus.

Therefore, it could be said that what defines this extended European system of integration is not so much the cities and metropolitan regions - the agglomeration zones of "concentrated urbanisation" - but rather the broader and historically pervasive operationalisation of natural systems to serve energetic purposes: an assemblage of "operational landscapes." (Katsikis, 2020) Landscapes of energy, circulation and agricultural production. Through the various configurations of these operational landscapes, the Rhine Basin constitutes one of the bases for the material economy and commodity flows of Europe. But as operationalisation processes intensify in the constant search for profit, the capacities of natural systems to support them are gradually exhausted and 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, but to see the whole landscape that its waters make possible. One example is in the Delta Rhine, where the Port of Rotterdam had a recent expansion, the Maasvlakte II. At the mouth of the river the port hosts ever-expanding functions of logistics and energy production. This landscape requires constant drainage to sustain navigational depth across the waterways as power plants deplete its externalities in the atmosphere. In the upper Rhine, the region of Dusseldorf is well-known to swallow villages in order to expand its mining of lignite. Landscapes are operationalised for its exploitation and depletion, taking the work of natural processes for granted.

In this scenario, the question is not 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 European urbanisation. It is essential to think with the "externalities" of our previous/current energy-intensive modes of inhabitation and fathom the nuances of what is to come in more hopeful socio-ecological structures, in this case, demonstrated through/for energy landscapes. Building in the now the new temporality of energy seizes the opportunity to deal with the transition as another possible urbanisation. It could use the latest energy technologies as a tool for territorial restoration and connection of ecosystems. It could provide habitats for humans and non-humans alike. 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?

2

anticipation

A4 highway, The Netherlands, 2021
Collage by author.

Sheep among solar panels
Image 24

Visualising the city below water
Photo by author.

Unacessible "Box full of environmental measures" in the Port of Rotterdam
Photo by author.

Matter

Focus: Technologies
Relation to energy: Material (externalities/W)
Entropy: End of cycle

Topos

Focus: Infrastructure
Relation to energy: Potential (ton/W)
Entropy: Land tensions

Habitat

Focus: Land-use
Relation to energy: Spatial footprint (W/m^2)
Entropy: Competition

Geopolitics

Focus: Mode of energy
Relation to energy: Instability
Entropy: Productivity paradigm

Energy transition and the project of mitigation

“Anticipation” is the investigation of the spatial configuration of the “energy transition” under the brief organised by “sustainable development”. It focuses on the energy mode of the 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 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. The spatial challenge of renewable energy not only requires more space but also exploits other areas, especially in the energy landscapes of conversion. (IPCC, 2012) 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. By 2050, the “energy transition” will demand a reevaluation of its spatial project.

“Anticipation” visualises the limitations of the brief and anticipates near-future conditions.

First image that appears in Google on "energy transition"
Image 25

World of sustainable development

The world of sustainable development as a base for spatial projects is a widely accepted framework. The world of sustainable development will still lead to new possibilities of growth, which under the neoliberal globalisation ends up amplifying current inequalities even if it meets environmental goals, as has been already mentioned before. (Soja, 2009; Marcuse, 2006) Moreover, the European Green Deal sees Europe as a leader. This is questionable in light of history and how European "leadership" started the planetary exploitation of Natures. In these conditions, the EU is set to export its externalities; using energy again as means for renovated domineering in the midst of local environmentally clean practices. It is also worth mentioning that the impact of centuries of colonisation cannot be exported or diluted in discourses on individual ethical positions; in a sense, putting forward the sense that "everyone" should play their part and bear with the consequences of climate change when it is not obviously equally caused and its consequences are also not the same everywhere. Taking the responsibility away from the territory that historically is one of the most responsible for the overstepping of planetary boundaries.

The "sustainability" narrative around the energy topic focuses on policies of decarbonisation, clean air and net-zero energy, transforming ecological crisis into a market opportunity. Since its appearance around the 1960s, sustainability has not done much for the environment it aims to protect and it will possibly be able to mitigate but not to avoid the inauguration of unprecedented climatic instability in the decades to come.

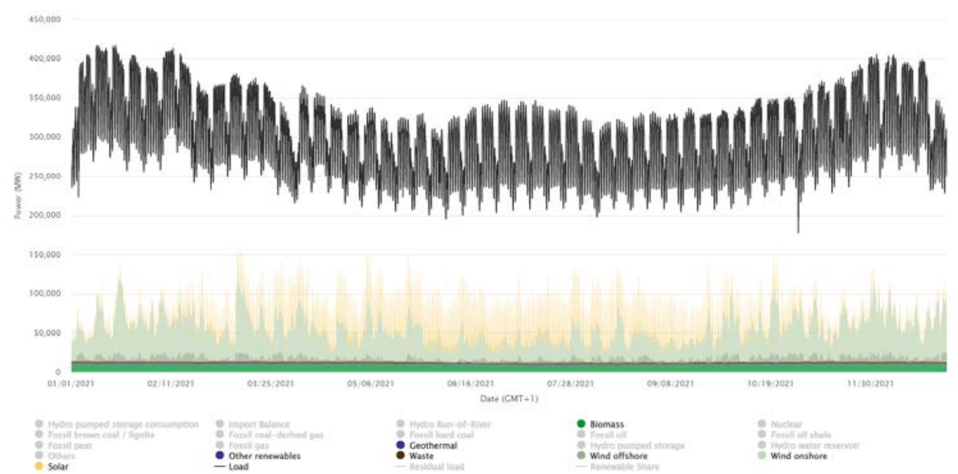
"Not being able to put yourself in the middle is a big problem for ecological thinking."
(Morton, 2018)

Focus: Technologies
Relation to energy: Material (externalities/W)
Entropy: End of cycle

Composition

The project of decarbonisation aims to clear the air from GHG emissions and the renewable technologies of energy generation are a necessary ally. The map composes the current scenario of renewable energy in the Rhine basin, and its spread all over the watershed.

This scenario will only expand, as, at the moment, renewables are not yet the main source of energy in Europe; as it shows in the graph below.



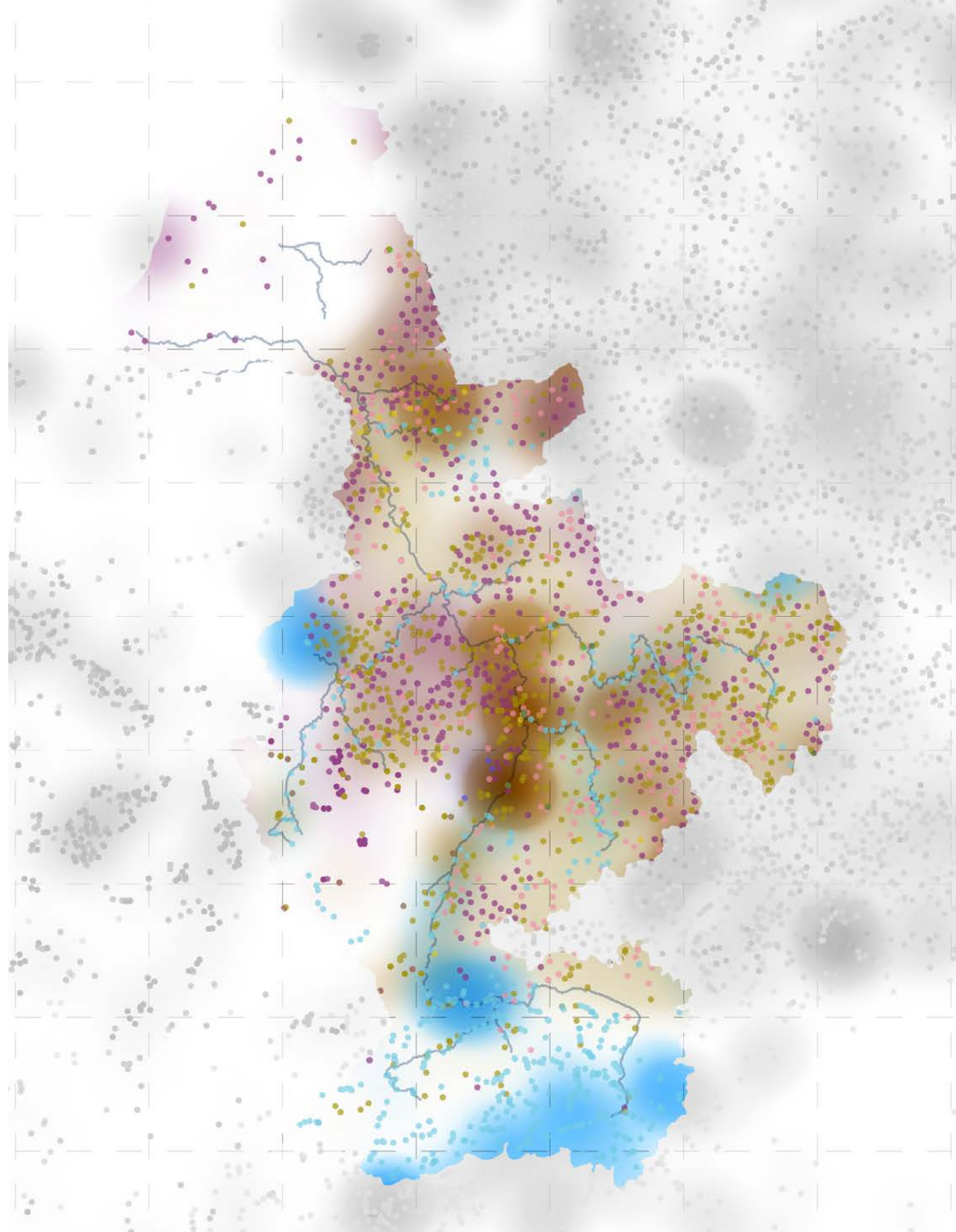
Net electricity generation in europe in 2021
Image 26

Rhine river and main estuaries

Renewables with capacity in gradient

- Wind
- Solar
- Biomass
- Geothermal
- Hydropower
- Bioenergy
- Waste

0 100km N



Focus: Technologies
Relation to energy: Material (externalities/W)
Entropy: End of cycle

Alteration

The scheme portrays the mainstream and easier to scale technologies of renewable generation of energy. Each one does not come without externalities; there are also emissions and mining operations when building the "clean" instruments of energy conversion.

Going 100% renewable power means a lot of dirty mining. There are also emissions in the manufacturing, transport to site and installation which are irrelevant when compared to non-renewables.

5 km² of photovoltaic panels

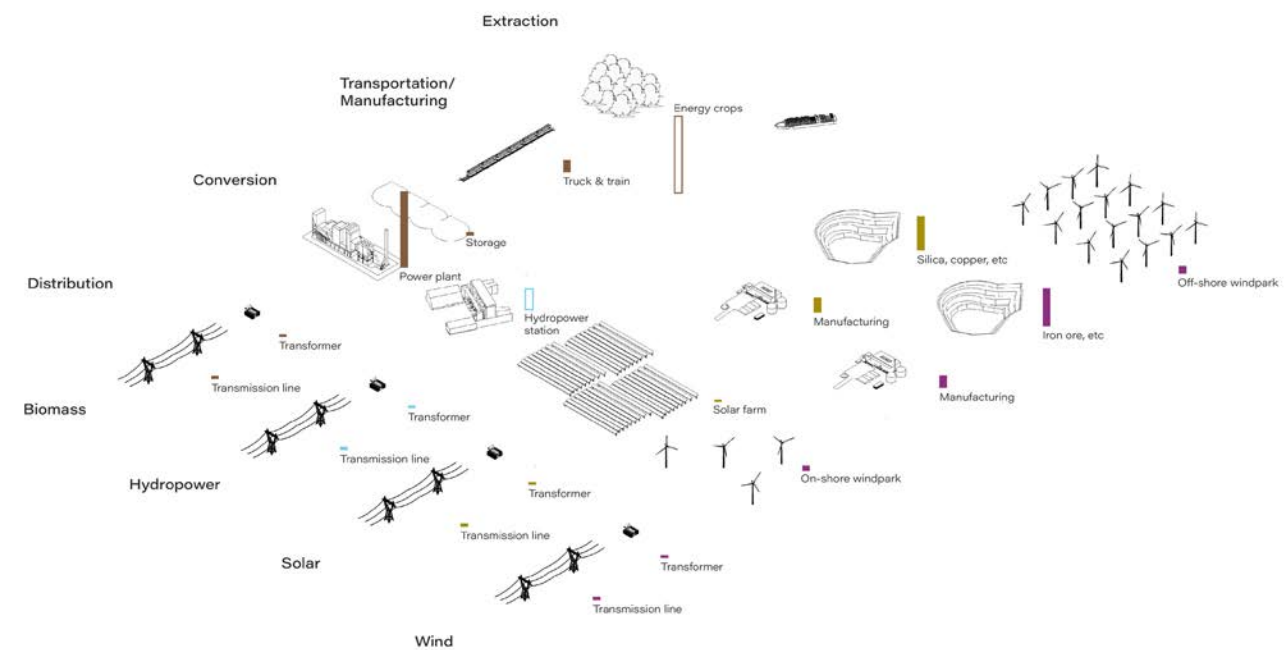
30 500 ton of steel

Material necessary to build the technologies to generate 1 GW of electricity.

Emissions in comparison per landscape

- Wind
- Solar
- Biomass
- Hydropower

0 100km N



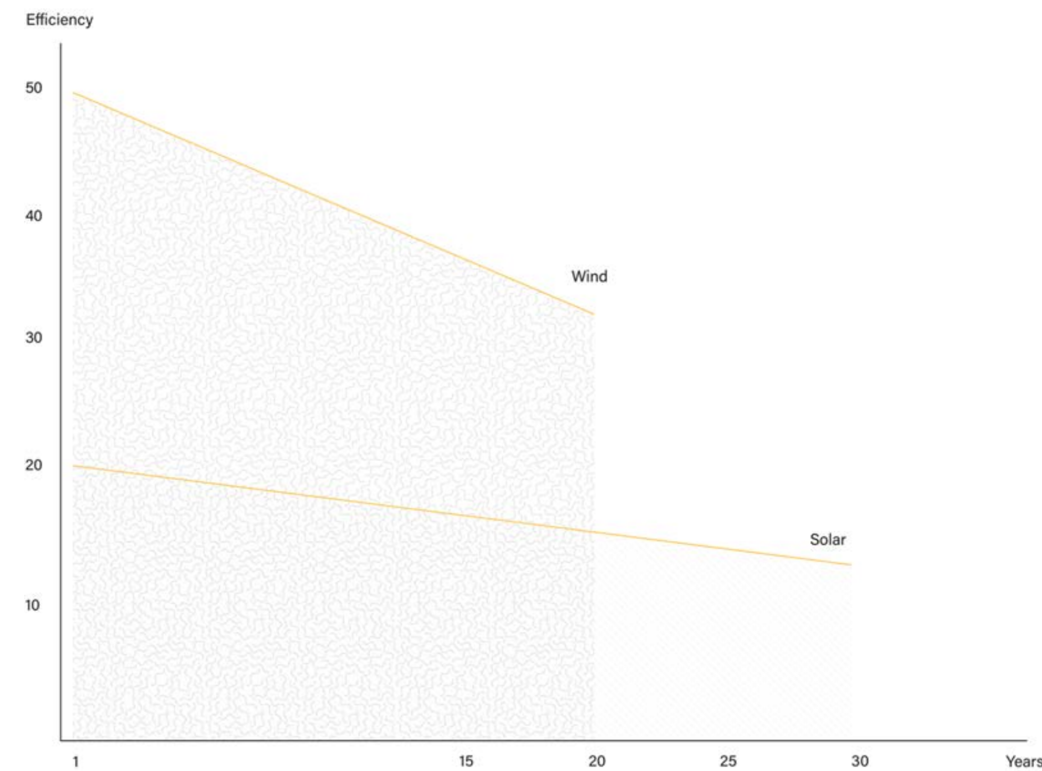
Limit

Even when emissions are not the biggest of the problems anymore, other factors weigh in. The technologies for the conversion of energy into electricity also have an end-of-life cycle. A circular economy must scale-up with the deployment of these technologies.

Regarding wind energy, according to a study made in 2017 by the Cambridge University, turbine blades are set to account for 43 million tonnes of waste by 2050. And most blades end up in landfills, due to current difficulties to recycle. Danish company Vestas is developing a process to chemically extract the epoxy resin plastic in order to use it in new blades. The combination of many materials like glass and carbon fibre makes it hard to decompose the blades.

Regarding solar panels, it is not easier as the breakdown of the elements that compose it must be separated also chemically. At the moment, the easiest option is to repurpose the use of an aged solar panel in a location with lower electricity needs. However, the recycling of end-of-cycle solar panels has the potential to unlock an enormous stock of raw materials in the near future. According to a report by the International Renewable Energy Agency (IRENA), materials like indium and gallium present in old photovoltaic panels will be worth around 15 billion dollars in recoverable resources by the year 2050.

This limit poses the need to develop a circular economy along with the energy transition that understands the constant transition of energy modes, making it possible to repurpose matter for other uses and avoid a new cycle of extraction.



0 100km N

ANTICIPATION

Composition

The map shows the locations with higher potential of available primary energy that support the conversion landscapes of energy for the solar and wind. It also shows the areas that are suitable to grow energy crops to be used for combustion in biomass power plants.

Even though there is potential for the whole region, the Delta Rhine is most suitable for wind energy and the regions of the Upper Rhine, Neckar, Main, Moselle and Alpine are most suitable for solar energy in general. Geothermal potential can be found along the Upper Rhine stream and in the intersection of the Lower Rhine with the whole region of the Delta.

High geothermal suitability
Marginal land for biomass production
Wind potential (h=100m, W/m2)
Solar potential (GHI) (kWh/m2)
Rhine river and main estuaries

0 100km N

Focus: Infrastructure
Relation to energy: Potential (ton/W)
Entropy: New tensions

Alteration

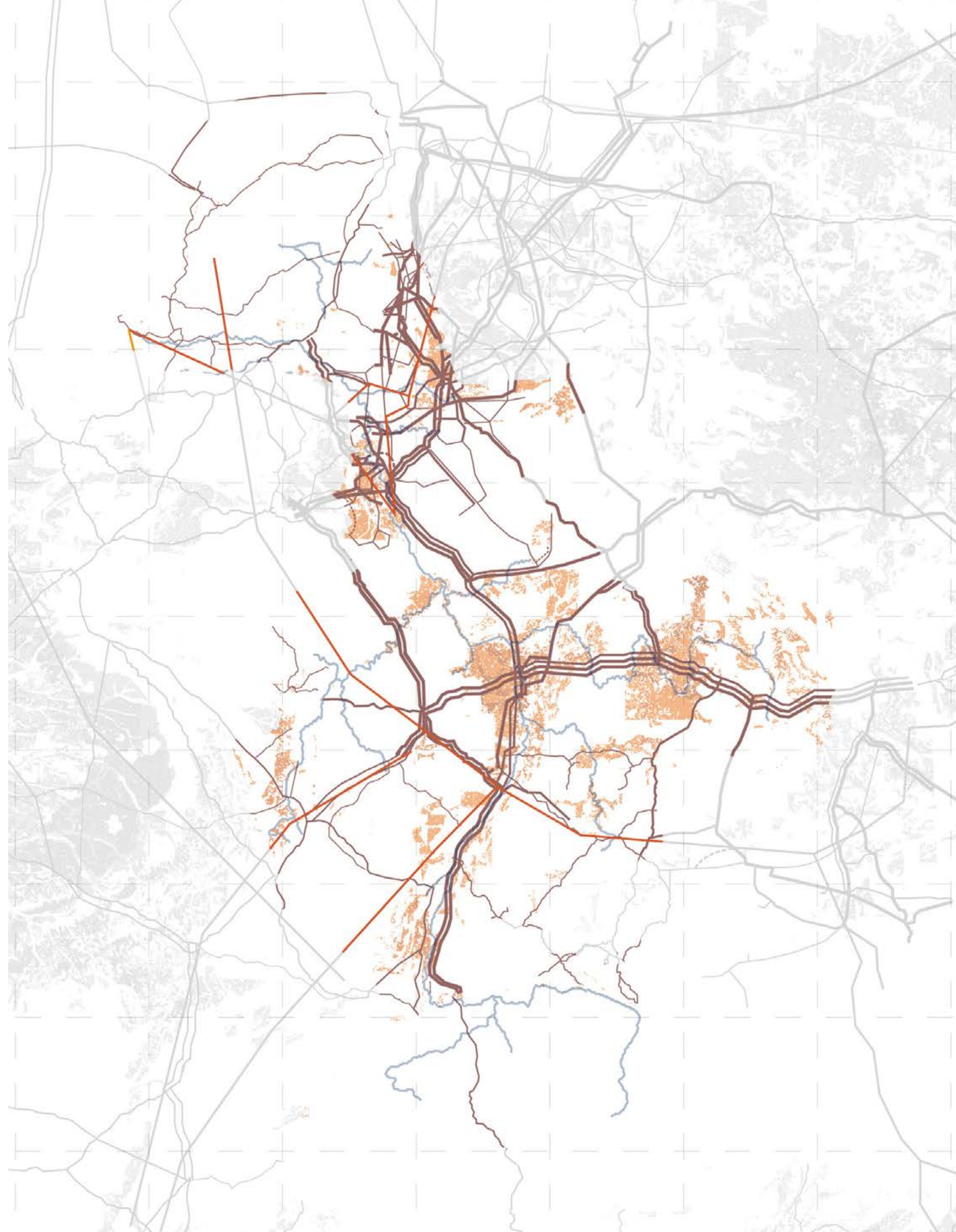
In between the lines, decarbonisation is not only about cutting down emissions. It is also pressing the urgency to address centuries of "pilotless destruction" of ecosystems, especially the atmosphere. NETs (negative emissions technologies) will need to be employed, hopefully, following up the scale-up of the conversion technologies.

NETs are generally divided in two categories: biological and industrial. Afforestation, reforestation, soil carbon sequestration, 'blue carbon' habitat restoration are some of the "planetary intelligence" (Bratton, 2021) ways to balance its levels of carbon along the biosphere. As fossil capitalism disrupted the balance of energy, to meet climate goals and avoid collapse scenarios, IPCC suggests the employment of CCS (Carbon Capture and Storage) technologies to place carbon where it came from. While these technologies are still being questioned in their efficiency and suitability, their premise is to suck carbon out of the atmosphere and place it in the geological strata and saline aquifers. In the Rhine basin, there is potential to store the historical emissions by reusing the network of the previous mode of energy to support the capture and transfer of CO_2.

"The climate system is a manifestation of the amount, distribution, and net balance of energy at Earth's surface. The total amount of energy sets the overall conditions for life. [...] Biosphere integrity is [...] defined as the totality of all ecosystems (terrestrial, freshwater, and marine) on Earth and their biota. These ecosystems and biota play a critical role in determining the state of the Earth system, regulating its material and energy flows and its responses to abrupt and gradual change." (Steffen et al. 2015)

Potential on soil to store carbon
Rhine river and main estuaries
Oil pipelines
Operating
Proposed
Projected
Gas pipelines

0 100km N



Focus: Infrastructure
Relation to energy: Potential (ton/W)
Entropy: New tensions

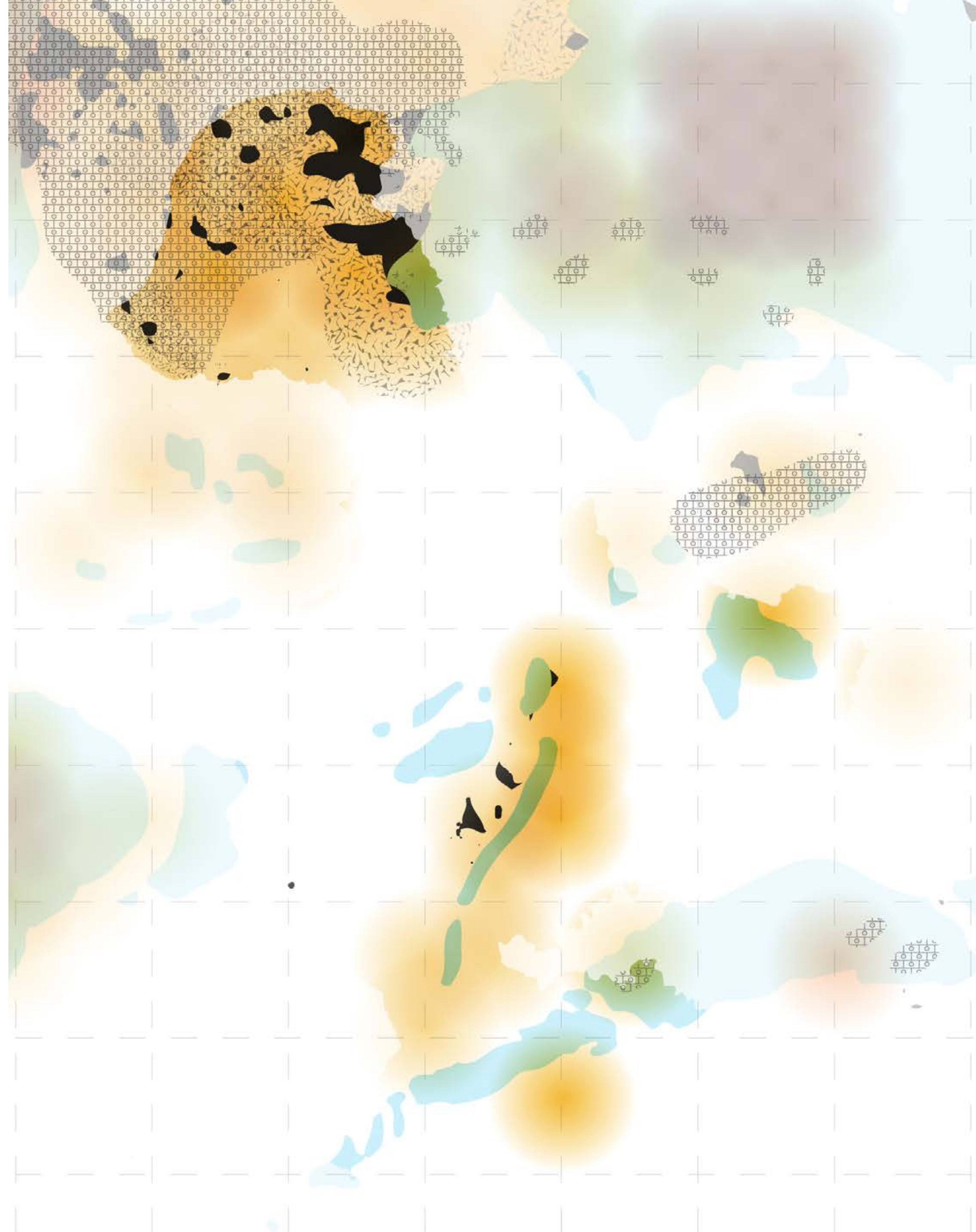
Limit

The limits of the mitigation project lie in the limits of the biological and industrial technologies for mitigation of historical GHG emissions and the avoidance of the worst scenarios of climate change. The potential lies in the areas where NETs can be implemented with a higher chance of success and maintenance, bringing along social-spatial benefits. There are studies that affirm that Europe could store centuries' worth of carbon emissions.

The map overlaps the geological limit of re-storage of captured CO_2 and the envisioned ecological corridors. The current understanding of mitigation sees value in the technological endeavour of trying to leave things "under the carpet" of Earth. Instead, a much more valuable and regenerating approach would be to emphasize the restoration of ecosystems and learn to work with the planet's natural processes of regulation.

Underground CO_2 storage
Saline aquifers
Depleted oil/gas reservers
Oil reserves
Gas reserves

0 100km N



Focus: Land-use
Relation to energy: Spatial footprint (W/m^2)
Entropy: Competition

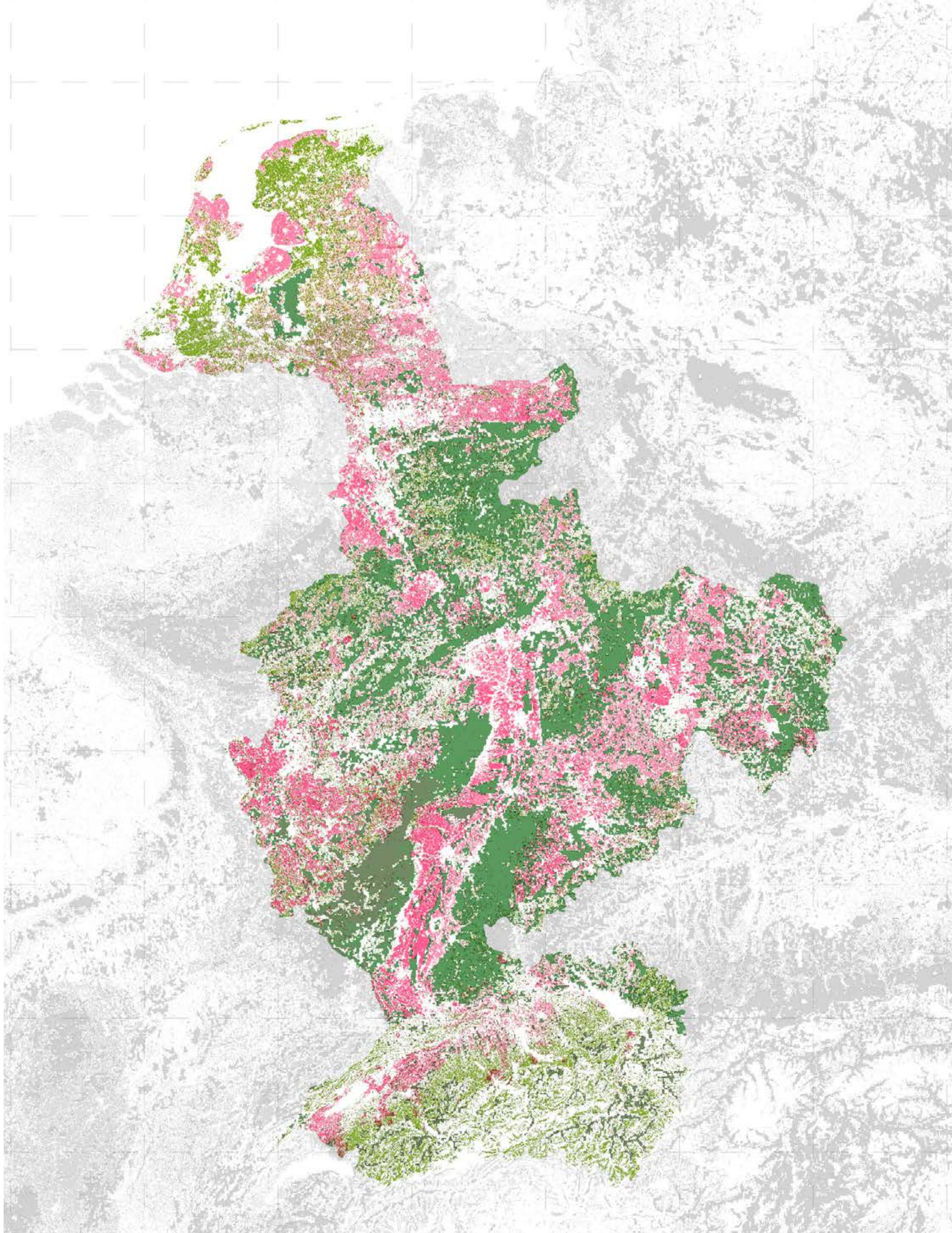
Composition

The anticipation of the deployment of the "energy transition" into the renewables is set to take over croplands, grasslands and forestry as its next operational landscapes, becoming the new hinterlands supporting agglomeration zones.

The identification of these areas and their vastness across most of the area of the basin demonstrates the potential for this project to set an alternative urbanisation pattern for the region. Eventually, it could serve as a background to ground a framework for rethinking European integration and networks beyond the typical infrastructures in Europe, becoming an alternative way of understanding territorial and regional integration.

It can fit among policies for Trans-European Networks for energy, nature and transport; however reinventing the idea of these corridors, composing habitats from its operational landscapes and forming a new backbone for European integration. For it, a new paradigm that can balance the extensive implementation of renewable energy technologies with an ecological perspective must be developed.

"In addition, in order to have a truly coherent and resilient Trans-European Nature Network, it will be important to set up ecological corridors to prevent genetic isolation, allow for species migration, and maintain and enhance healthy ecosystems. In this context, investments in green and blue infrastructure and cooperation across borders among Member States should be promoted and supported, including through the European Territorial Cooperation." (EEA, 2020)



Forestry
Croplands
Grasslands
Rhine river and main estuaries

0 100km N

Focus: Land-use
Relation to energy: Spatial footprint (W/m^2)
Entropy: Competition

Alteration

In this cartography, the conservation patches and the high fragmentation zones show the alteration needed, be it to maintain or to alter a state. Regarding land, fragmentation occurs as widely as the future operational landscapes. At this moment, a project that could address ecological concerns of connection between Natura2000 patches in its operational landscapes could have a way to influence the whole urbanisation processes in the extent of the basin.

This direction seems fitting for an ecological proposal when landscape fragmentation is one of the key drivers of biodiversity loss. In accordance with that, not only conservation patches are needed but a proposal to increase the functional connectivity between them becomes a requirement to address the need for restoration or maintenance and to build long-term thriving habitats for the biodiversity of species.

The document "Boosting ecological restoration for a wilder Europe" from the project "Rewilding Europe" is precise in its perspective of the Natura2000 patches and the problem of land fragmentation:

"Currently, many sites within the network constitute a sort of "archipelago" embedded within large areas of intensively used, fragmented and wildlife impoverished land. Because of this, the Natura 2000 network is less effective for delivering its purpose to conserve species and habitats across Europe as it compromises critical ecological processes such as the movement of species and the genetic exchange. Developing green infrastructure with the Natura 2000 network as its backbone would efficiently contribute to the goals of the Nature Directives and support global biodiversity targets. To facilitate the establishment of a trans-European network of Green Infrastructure, restoring and maintaining ecologically functional and connected landscapes is of utmost importance. For this, new tools are required to be able to support design and implementation."

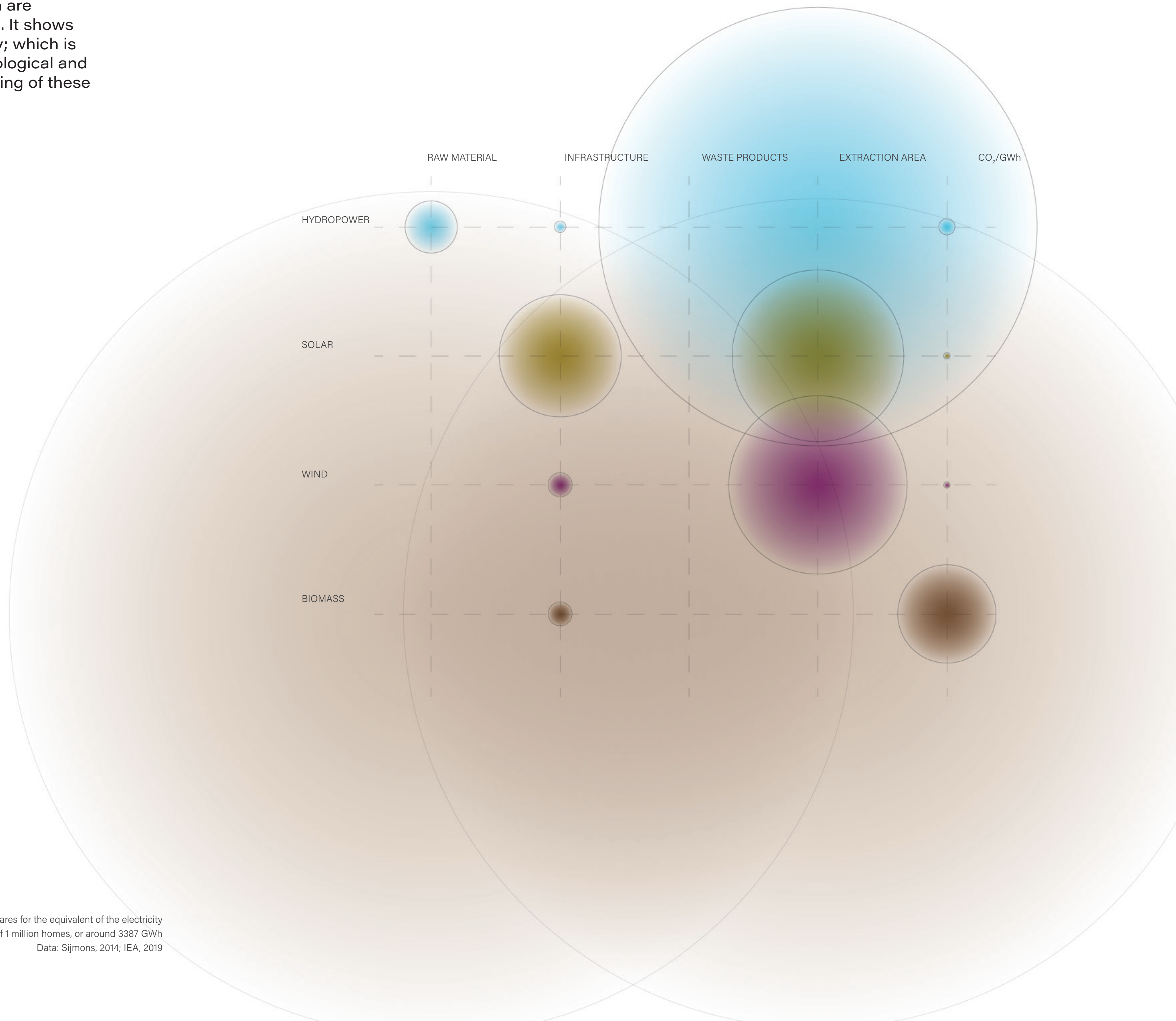
Natura2000
High fragmentation over sparsely populated areas
Rhine river and main estuaries

0 100km N

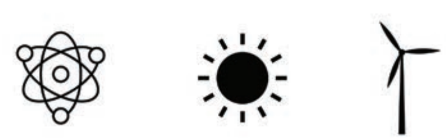
Focus: Land-use
Relation to energy: Spatial footprint (W/m^2)
Entropy: Competition

Limit

One more time, the spatial footprints of the whole chain of energy generation are organised in comparison with one another and with the total GHG emissions. It shows a larger spatial footprint in comparison to the non-renewable mode of energy; which is set to take over forests, croplands and grasslands. The vastness and the ecological and societal importance of those areas demand a reevaluation of the understanding of these landscapes being transformed into energy landscapes.



1 MW capacity being produced in 1 year ~ km²



2.6 km² | 932 km² | 195 km²

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

Composition

The map that is presented at the very beginning as "energy as a spatial project" to be extended in the renewable era becomes unpacked here in its contents. Landscapes of extraction and conversion, along with many signs of urbanisation and agricultural expansion show that the extractive model is still fully operational even in the renewables.

In addition to that, an excerpt from an interview of Bruno Oberle, the current director-general of the International Union for Conservation of Nature (IUCN) provides insight on the composition of the other geopolitics to conserving nature. Reading it in the context of this project provides interesting insight on the importance of a project to the Rhine basin.

> Q: Is it the responsibility of industrialised states to support the conservation and promotion of biodiversity in developing countries?

BO: It is not just a moral question, it is reality: developed states have a much larger footprint than others. We, per inhabitant, consume more and therefore have to contribute more to solving the problems we are causing. Secondly, our historical impact on biodiversity, as well as on climate, is much greater than that of developing countries. We are not only contributing to the loss of biodiversity today; we have also done so in the past. There is a third aspect. To protect biodiversity adequately, countries that are home to great biological wealth are asked to make more effort than others. But it is neither fair nor reasonable to ask them to finance everything simply because they have ended up with a high level of biodiversity. *We don't necessarily have to 'find money', or at least not only. We must first think about how we are using it. Every year, some $600 billion is spent worldwide on subsidies for the fossil energy industry. These subsidies could be invested in biodiversity. Subsidies to the agricultural sector also need to be reviewed. It is not a question of eliminating subsidies to agriculture, but of demanding other benefits that benefit biodiversity.*

ANTICIPATION

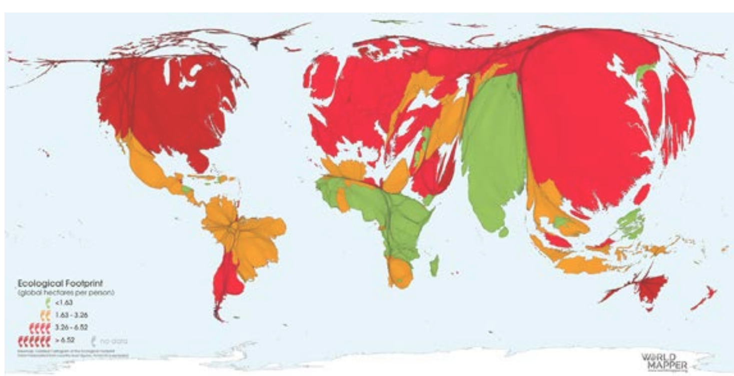
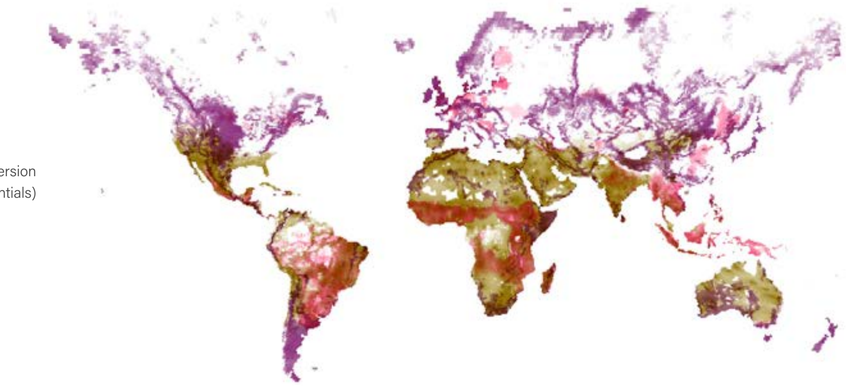


Image 28: Ecological footprint per person

Urban expansion
Agriculture expansion
Biofuels potential
Wind potential
Solar potential
Mining for renewable technologies
World river basins

Landscapes of extraction (Mining for renewables)

Landscapes of conversion (Renewable potentials)



Urbanisation expansion

Summary of the potential energy landscapes of the renewable era

Focus: Mode of energy
Relation to energy: Instability
Entropy: Productivity paradigm

Alteration

The map draws a kind of ecologically-based map. New paradigms could also lead to a new form of understanding of administrative boundaries. The current countries, where most of the policy levels find their intersection with concrete implementations, are rarely aligned with ecological limits. A proposal for the landscapes as an infrastructural productive unit where socio-ecological dynamics are interplaying could be a fitting scale and space to invest in territorial management.

The map below showing the Terrestrial Ecosystem Productivity serves as an inspiration. Times of energy transition could be used to reevaluate its own project and check if it is in a direction to aligning to the planetary's intelligence in being productive.

"Terrestrial ecosystems rely almost exclusively on the sun's energy to support the growth and metabolism of their resident organisms. Plants are quite literally biomass factories powered by sunlight, supplying organisms higher up the food chain with energy and the structural building blocks of life. Land plants, or autotrophs, are terrestrial primary producers: organisms that manufacture, through photosynthesis, new organic molecules such as carbohydrates and lipids from raw inorganic materials (CO2, water, mineral nutrients). [...] Gross primary production (GPP), shown here, is the total amount of carbon dioxide 'fixed' by land plants per unit time through the photosynthetic reduction of CO2 into organic compounds." Quoted from Gough, C.M. (2011) Terrestrial Primary Production: Fuel for Life, Nature Education Knowledge.

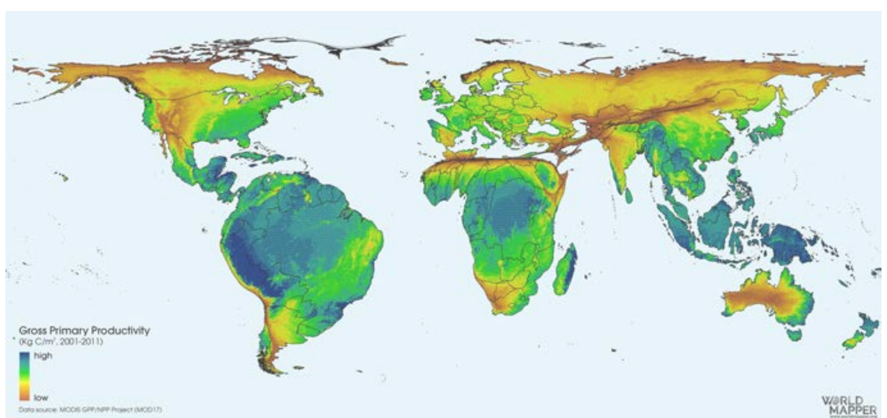
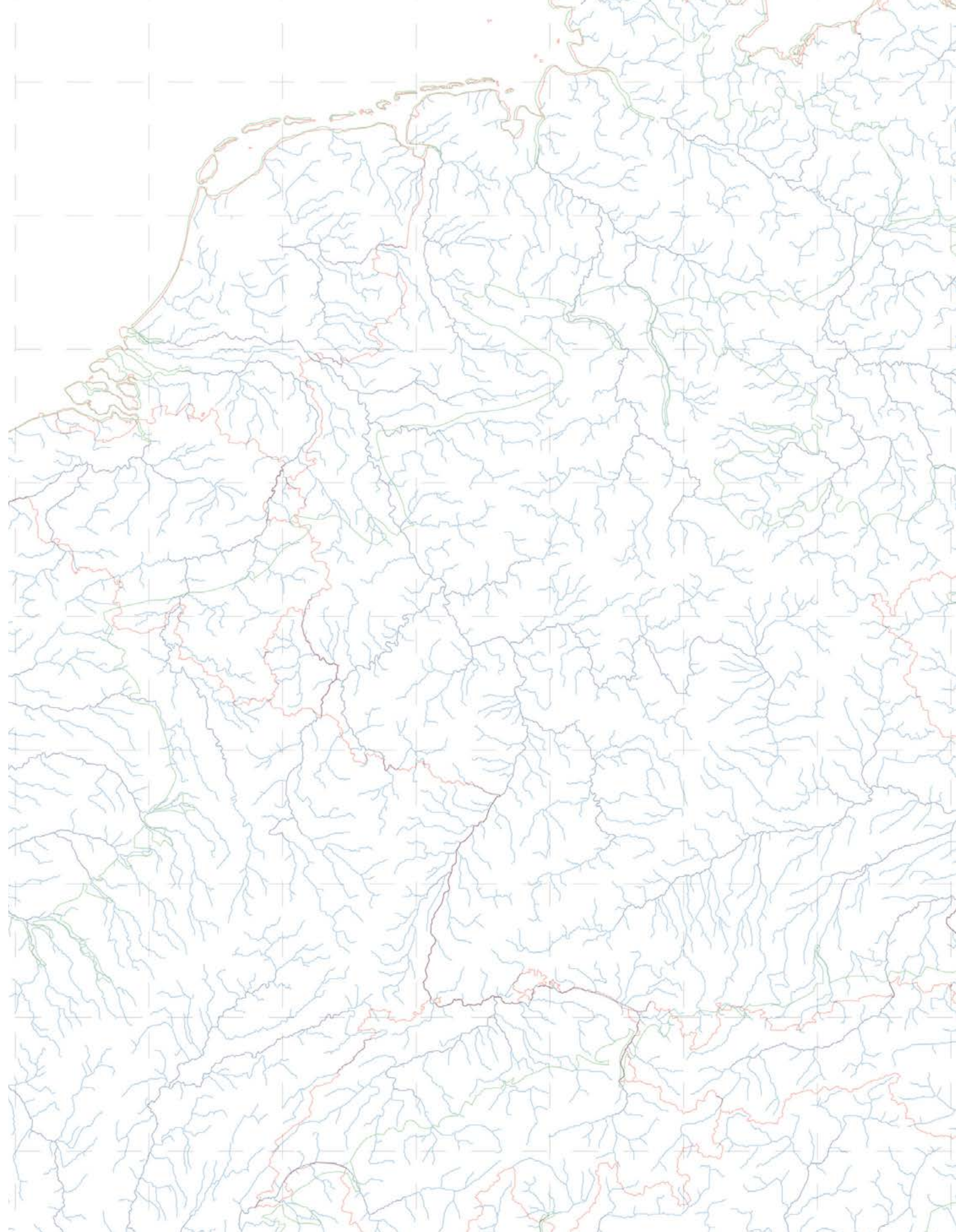


Image 27: Terrestrial Ecosystem Productivity



Administrative boundary of countries

Ecoregion

Water in the Rhine basin

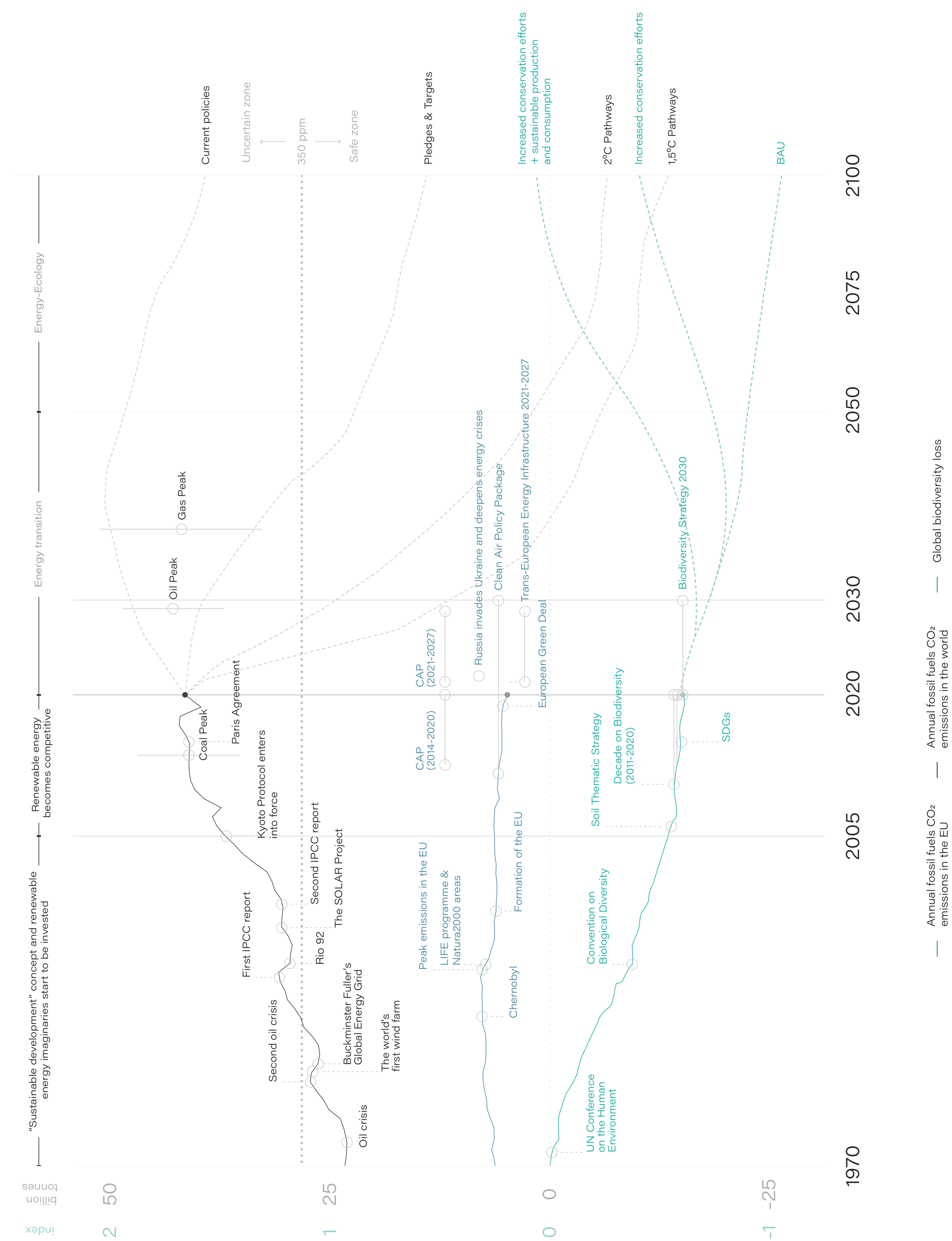
Other basins' water

0 100km N

Focus: Mode of energy
Relation to energy: Instability
Entropy: Productivity paradigm

Limit

The graphic 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.



Takeaways

The inherent issues of the new renewables temporality

What is the problem with this new scaling-up of the industrial landscape? The previous drawings were an attempt to paint a different idea about the future landscape: one that is not only sunshine and windmills but it has soil exhaustion, land fragmentation, degradation, unproductiveness, CCS plants, etc. Some shortcomings are pointed out from this exploration:

(1) Economic factor
The scaling-up will require heavy capital investment and will probably annihilate small actors. If the model of fossil-capitalism is followed, "sustainable development" will form big consortia, with substantial energy farms in the views of the Rhine. It is necessary to find instruments that support local farmers and their transition to regenerative agriculture in the productive landscapes that could combine with energy production. Some ways are already on the horizon, like the "agrivoltaics", as they are called.

(2) Sustainability as 'sustainable development'
It addresses the need for mitigation and restoration; quantifying what is needed but is unclear on qualifying the actual changes in space. It keeps the same damaging operations under a veil of sustainability. The restoration of coastal and marine habitats as well as agroecological practices in the watershed of the basin can lead to a healthier and more respectable relation to the territory and the natural processes labour.

(3) Opportunities in the productive landscape
Efficient and zero-energy operations in the agglomeration sites are essential, but most of the emissions are in a few companies' operations. As the industrial productive landscape of the fossil-fuel era with nodal mining and conversion energy landscapes phases down, the rural-urban realm is the next potential frontier to receive the renewable energy technologies in a fast and large scale-up. This competitiveness can be an opportunity for spatial sciences to explore not the exploitation of a bio-physical limit of energy conversion but the shaping of a 'living ecology' of productive spaces. How to couple food and energy crops? Afforestation and productive landscape with solar and wind energy farms? How to address landscape fragmentation within renewable energy as a new spatial project?

(4) Adding the energy layer as the experiment of new logics
Renewable energy is a new technology in a still accumulative, exploitative, over-productive logic. As a spatial project, it will explore biophysical limits, and its priority is not to deal with the inevitable consequences of historical emissions and disturbance of carbon and water cycles, leading to floods and droughts, soil degradation, unproductive or not-so productive land, dying forests, etc. Also, non-renewable technologies will still be around for a long time. The mitigation project is important, but it is also crucial that it leads to socio-ecological regenerative practices that value the work of humans and non-humans, bringing better balance to the net energy balance of Earth's life-supporting systems. The addition of the energy layer in the productive landscapes of the Rhine basin is one of the research objects in this project.

(5) The issues are not only the need to deal with the consequences of the previous era of accumulation in the subsurface, the surface and the atmosphere coupled with the depletion of many ecosystems - even far away from the location of energy production. This logic is not thoroughly dealt with yet. These are all extractive ways of energy generation. Clean energy here means dirty mining elsewhere, and effective climate action must mean decarbonisation but also justice in a planetary scale. In summary, renewable energy is, at its best form, a technology only for the current energy transition.

Image 29

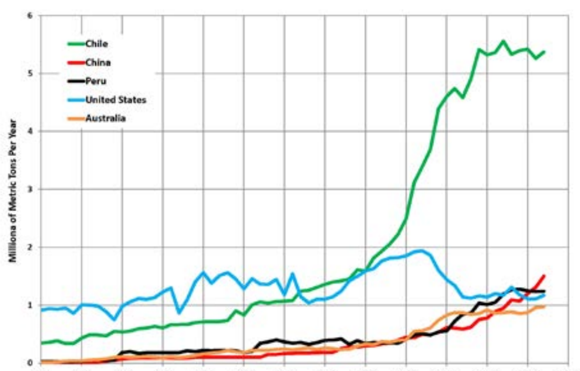


Image 30

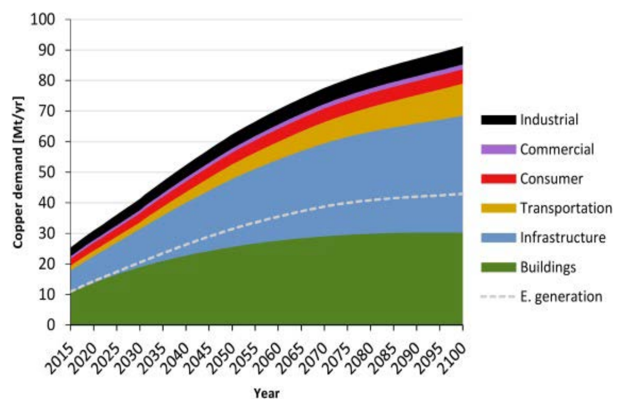


Image 31

Image 29: Many components of a solar panel include sylicon, aluminium, glass and etc.

Image 30: The rise in copper extraction with its use in renewable technologies.

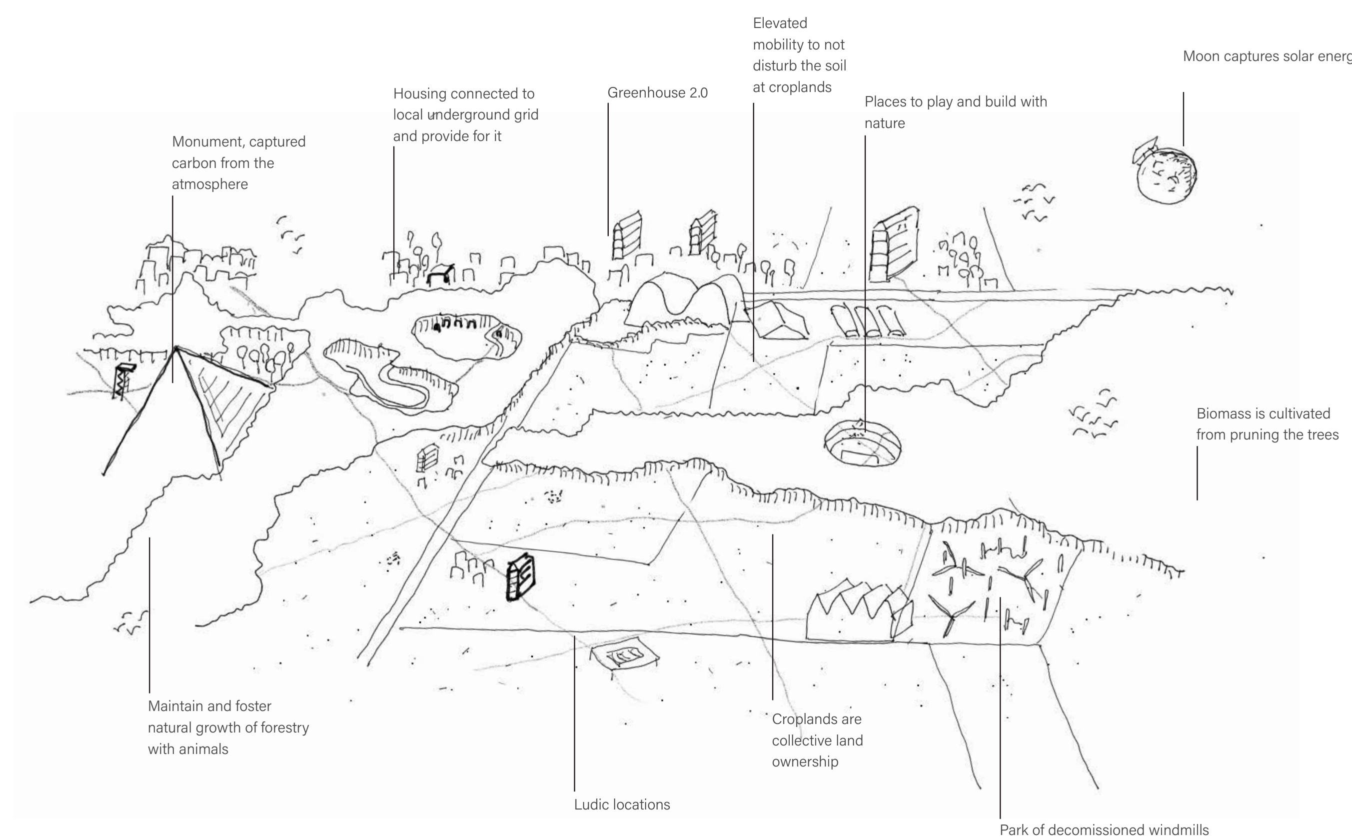
Image 31: Global copper demand by product. The dotted line for electricity generation visualizes the amount of copper demand in this subcategory of infrastructure and the growth that comes with increasing renewable energy production. Image 31: Schipper et al., 2018

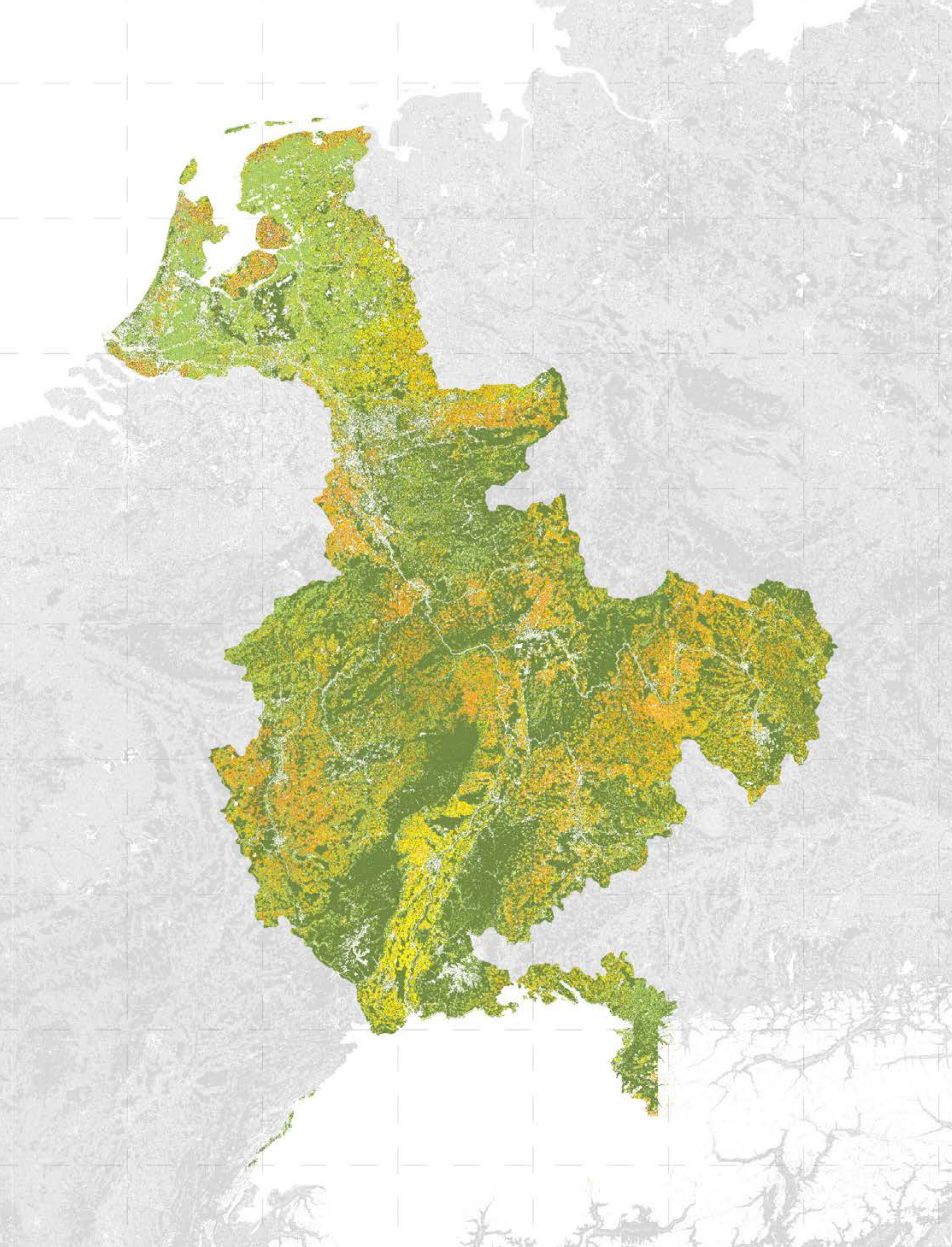
Towards a post-extractive mode of energy?

According to the dictionary, "extractive" means "tending toward or resulting in the withdrawal of natural resources by extraction with no provision for replenishment." This has been how most human activity has been dealing with the environment.

Even though the technology is not yet a reality in a scalable condition, there are hints of the use of hydrogen or deep geothermal showing the possibility of repurposing existing fossil-fuel power plants for this new technology. While it does not happen, renewables are still the best solution, coupled with a better relation to power from biomass. Its scale-up and eventual decommission should allow its operational landscapes to become ecological agents of restoration, regeneration and connection of landscapes - enhancing biodiversity and fighting climate change.

The drawing below envisions some completely different ways of living conditions.





Future operational landscapes of energy in the Rhine basin

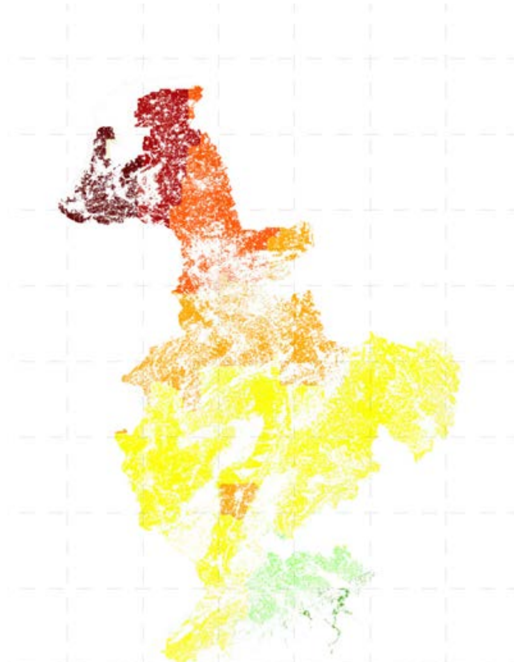
Given the inheritance and the anticipation of the energy transition; a consistent move towards renewables will see more and more land being taken for the use of energy production. The adaptation of the agglomeration zones and their built-up area is essential: PV on roofs and wind energy where possible will assist local need for energy. However, the greater network that sustains all the other activities and keep also the provision of energy for the agglomeration zones through renewable energy is still to become mature. It is expected that the "energy transition" will operate precisely this change and awake the new temporality of energy, heavily based then on renewable 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 hinterland of the Rhine basin.

The scale-up of the renewable era of energy production does not come alone. The "energy transition" will need to deal with many inherited "externalities" in the coming decades or 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 great 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. A report by the WWF attributes the decline to habitat loss, pollution, climate change, over-exploitation and the spread of invasive species and diseases. This scenario is well-known for the Rhine basin and spreads over the landscapes that the next mode of energy is set to operationalise.

A closer look at this map, highlighting some conditions for these landscapes shows a concerning set of areas that need attention.


(1)


(2)


(3)


(4)

(1) All croplands and grasslands in intensive land management.

Land-use intensity is possible to measure in the combination of the intensity of inputs. Some examples are in relation to labour, machinery and fertiliser use coupled or not by resource extraction, of forest products or livestock production. Generally, the higher intensity land use alters natural processes in such a way that it disturbs its regimes, natural regulation and vegetation succession, thus, degrading ecosystems such that they become less resilient to the risk of floods, fires and pest outbreaks.

(2) Degradation by current agricultural practices is set to decrease the soil productivity

The intensive management of the land might yield higher production, however, it comes with a limit. The next map shows an estimation of crop yields to decline in every location, in comparison to 2020's standard. Other agricultural practices are necessary.

(3) Natura2000 areas in intensive agricultural practice

There is the possibility that Natura2000 areas overlap with agricultural practices when they follow a low-intensity farming system. The categorisation known as High Nature Value (HNV) describes farming methods that are particularly valuable for wildlife and the natural environment.

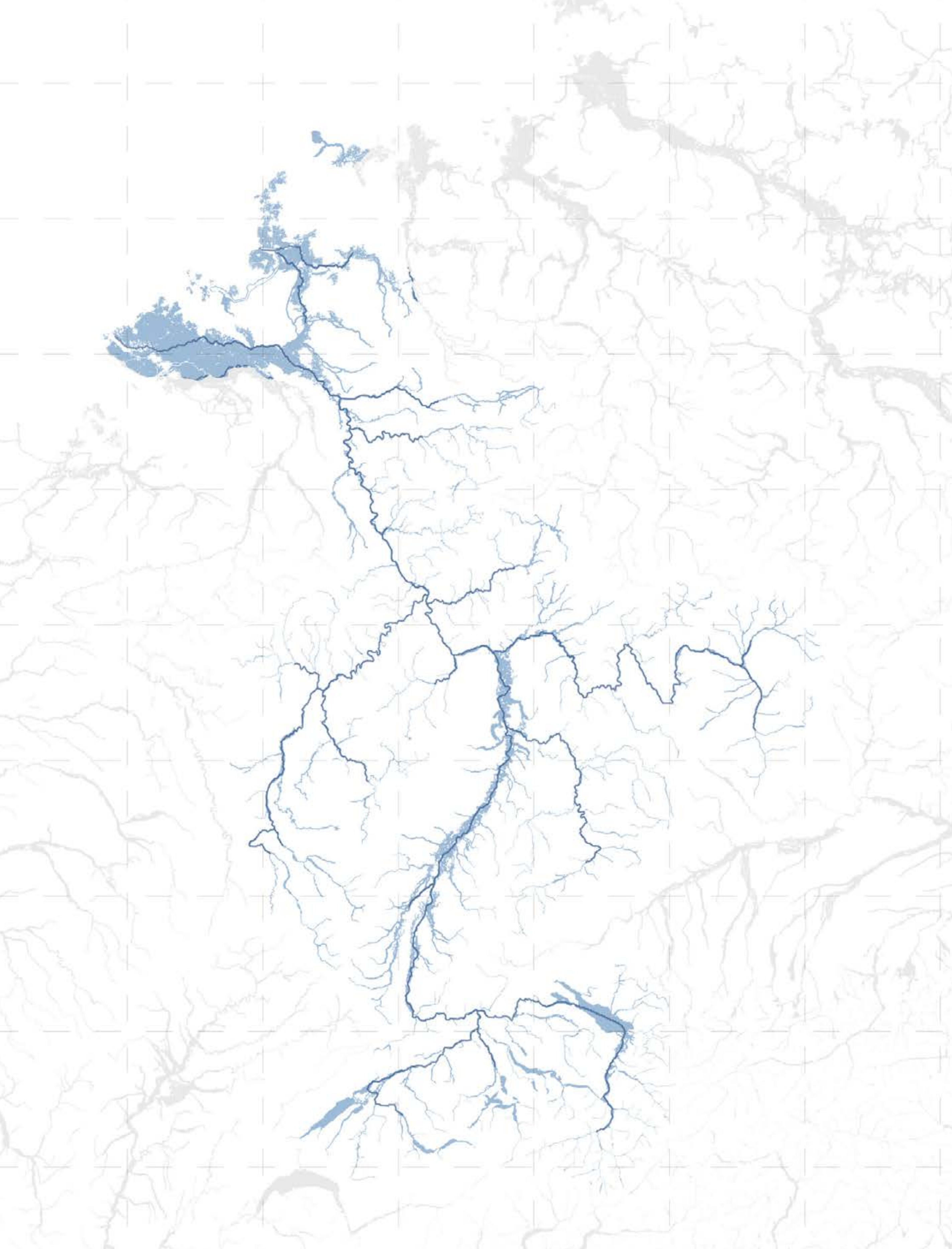
> "HNV farming relies upon the sympathetic land management practices of farmers – such as grazing with appropriate stocking rates, the traditional mowing of hay meadows, leaving fallow areas, using seaweed as fertilizer, cutting rush or undertaking habitat restoration – all vital for maintaining many of our priority habitats and ensuring the survival of our most threatened wildlife species."[12]

However, the map shows that it might not expand to influence the region where it is assigned. An area further than the plot runned under HNV must be taken into consideration and part of spatial planning so it manages a wider range of the ecosystem.

(4) Natura2000 areas in areas assigned as commercial forest

12.
High Nature Value Farming, 2013

0 100km N



Flooding prone areas

With the climate becoming more unpredictable and more extreme, water can behave in the extremes. As water levels rise, the risk of flooding looms large. At the same time, periods of drought are becoming longer and more frequent. Not only that, but the subtraction of many wetlands and the engineering and rectification of the river changed the runoff areas and the speedflow of the water.

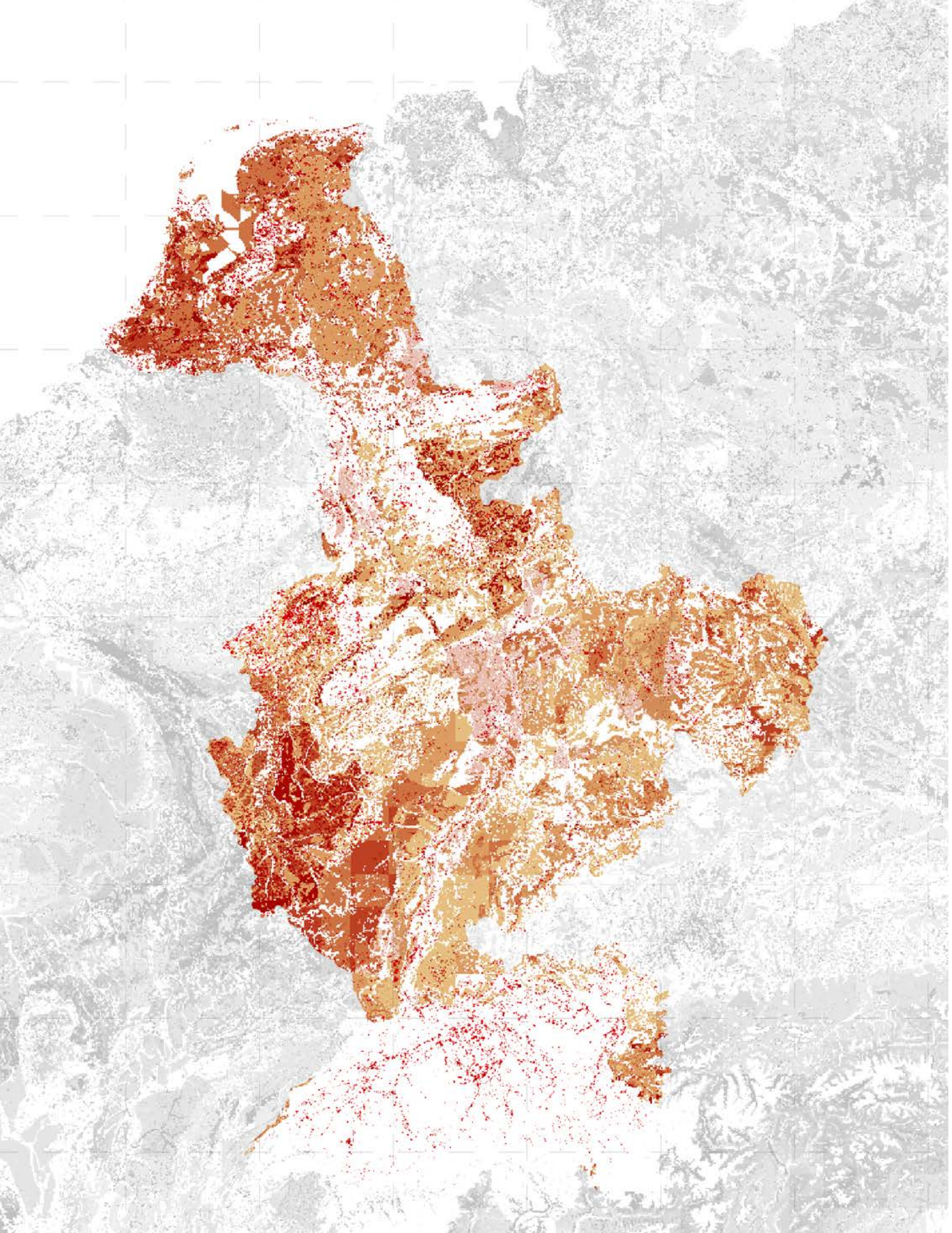
The Delta Rhine region is especially under threat, with rising sea levels and the change in water regimes coming from the river. The map shows many areas at a flood risk level by the year 2100.

Flood prone areas

Rhine river and main estuaries

0 100km N

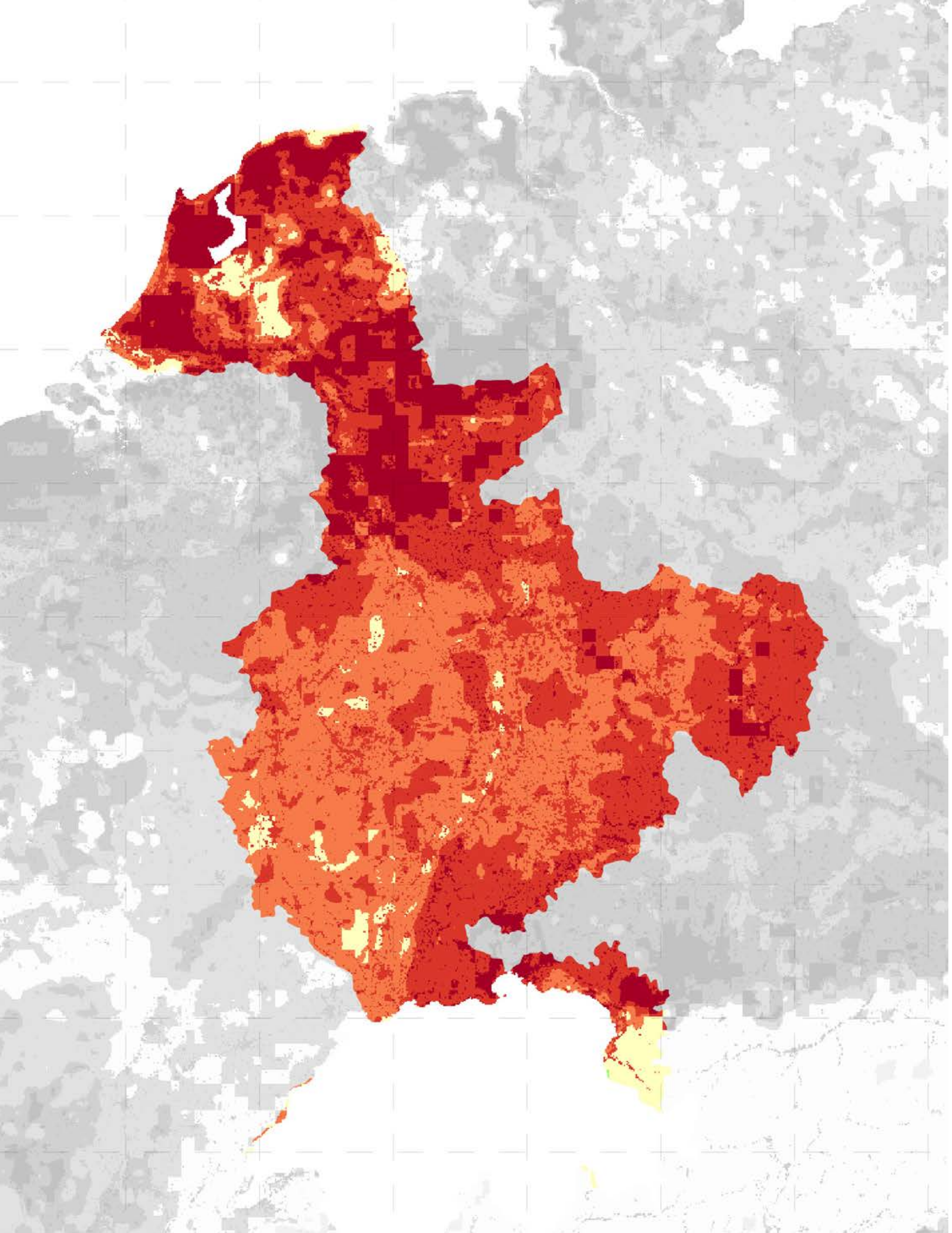
Subsurface: Soil degradation



At the very interaction between the surface and the subsurface, the consequence can be also seen in terms of soil degradation. Lack of organic content turns soil into sand and affects its health causing disturbance to crop yield, water scarcity, loss of soil biodiversity, climate change in the lack of carbon retention and other consequences. This can be measured in productivity levels that are in decline in most of the lands of the Rhine basin. Intensive practices and the use of harmful substances that prioritise crop yield to the detriment of soil health in croplands. In forestry and grasslands, deforestation and intensive grazing damage the soil.

The map brings together data from the 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. All of them from the European Soil Data Center (ESDAC).

Agriculture, deforestation, and other factors have degraded and eroded topsoil at alarming rates. There have been efforts to address these degrading conditions. One of them is the target to reach Land Degradation Neutrality (SDG Target 15.3) by 2030, which could be difficult to attain as practices to avoid, reduce, and reverse land degradation are not being implemented at sufficiently large scales (Niels Debonne et al. 2021) Globally, 52% of agricultural land is already degraded. In the Rhine basin, every agricultural land suffers some form of soil degradation.

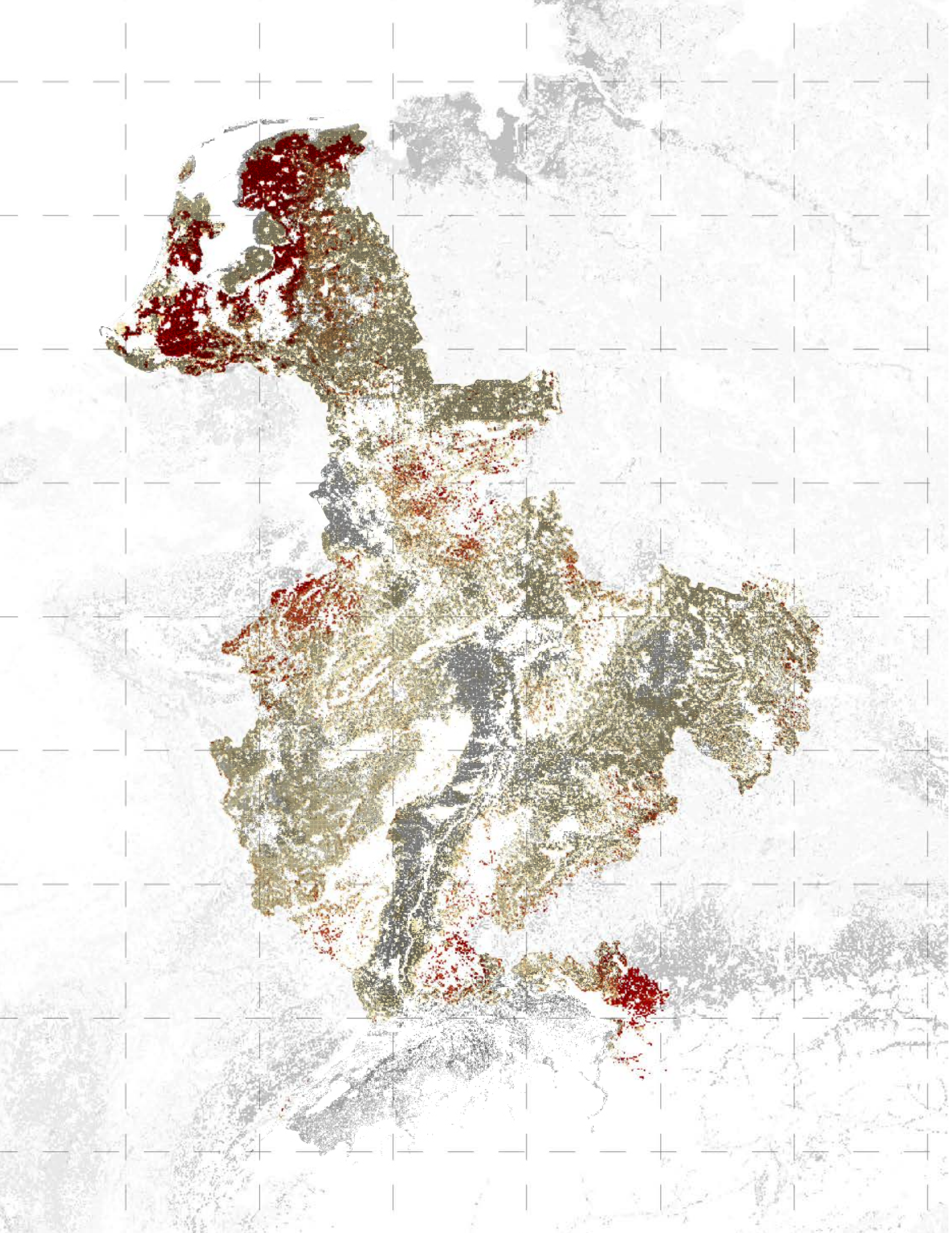


Surface: Land fragmentation

Ecological integrity is also very low in the Rhine basin. A map of 'wildness' (trophic function, connectivity, natural dynamics) which, for this project is translated as landscape fragmentation is composed of the data provided by the group of researchers under the project "Rewilding Europe".

> "The fragmentation indicator shows that the landscape connectivity is higher in Natura 2000 sites and nationally designated areas than outside protected areas (see figure), indicating that the size of the habitat patches remain larger within those sites. These results illustrate the high potential of using the Natura 2000 network as a backbone for supporting efforts to increase the ecological connectivity across European landscapes."

Further than looking at it only from the view of structures that impede the continuation of a given landscape, "the ecological integrity indicators developed in this project provide valuable information that, when combined with spatial planning methods, can be used to assess the most suitable pathways to re-connect areas of high nature value." (Fernández et al. 2020) This indicator, in addition to data on other types of soil degradation, biodiversity decline and human pressures can support more comprehensive restoration planning that will ultimately benefit from the combination of many insights that a scale perspective can make visible, ranging from local scale to European-wide. According to them, "improving wildness can result in co-benefits for enhancing biodiversity and combating climate change. For example, intensive forestry and grazing strongly impact the natural cycle of carbon; alleviating these pressures can contribute to increased carbon sequestration in natural ecosystems." Which proves to be a fitting direction for the next operational landscapes of energy.



The state of the atmosphere

"Two objectives of the Common Agricultural Policy after 2013 (CAP, 2014–2020) in the European Union are the sustainable management of natural resources and climate smart agriculture. [...] While a huge amount of information can be retrieved from LUCAS points for monitoring the environmental status of agroecosystems and assessing soil carbon sequestration, a fundamental aspect relating to climate change action is missing, namely nitrous oxide (N2O) soil emissions. This comes to add to the overall high levels of particulate matter in the atmosphere." (Lugato et al., 2020)

The atmosphere continues to be depleted not only by energetic landscapes but in many forms of industrial production.

This is not a prediction, it is an anticipation of the "externalities" that this future (although current) temporality of energy will need to deal with. However, the argument of this narrative is what will come next? How to envision a future for energy landscapes beyond the technological frames of decarbonisation and the ecological imperatives of mitigation and adaptation?

3

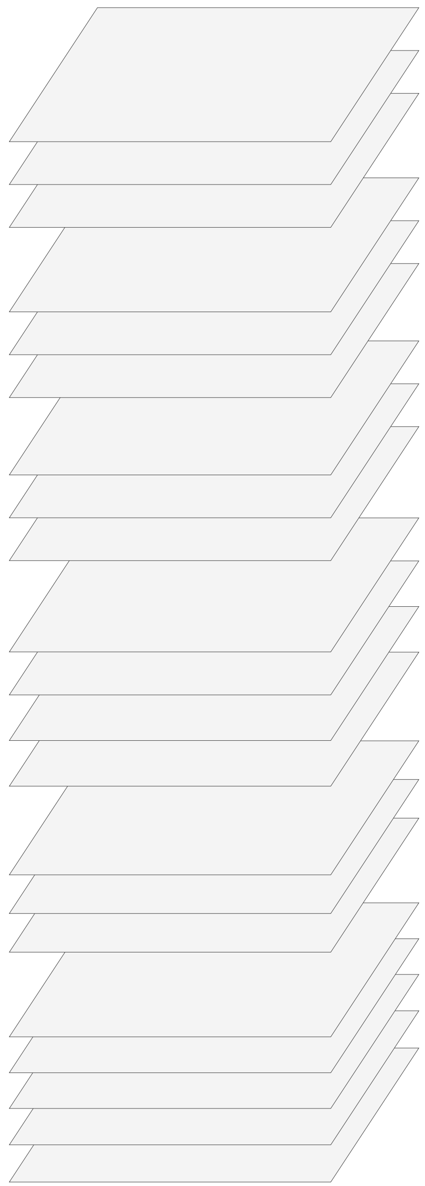
projection

Transmission line in Delft, NL
Photo by author.

Transmission line in Delft, NL
Photo by author.

Base of transmission tower in Delft, NL
Photo by author.

Cartography



Vertical approach

Energy-Ecology

"Projection" is a proposition of the "Energy-Ecology" concept in the landscapes proposed by the findings and assumptions of the "Inheritance" and "Anticipation" sections. It designs with the previous era's externalities, entropies and accumulations by using it in its favour or addressing its change.

The design workflow is done in three actions: Cartography, Deconstruction and Terraforming as means to model the elements, layers, relations and processes to be continued, interrupted or made new in the compositions and configurations of the operational landscapes of renewable energy production. First, the vertical approach of the overlay provides the infrastructural elements that compose an "Energy-Ecology Network" for the Rhine basin, part of a Trans-European Network, here called "Energy-Ecology Network". These corridors are decomposed into regions with proposed balances of industrial and biological activities. At last, "territorial typologies" speculate the terraforming of new energetic scale-up.

Energy-ecology is a constructive process to redesign the relation between energy landscapes and ecological considerations in the Rhine basin's actual landscapes, proposing new urbanisation paradigms. One of its main goals is to connect biodiversity zones by understanding the temporalities and technologies of the infrastructural spaces of energy. It is a design that builds an unbuilt space for biodiversity habitats in the ongoing transition of intertwined energy technologies and the political, economic, societal and ecological framework. The methodology that analysed the inheritance of the globalisation and anticipated the short-term effects of sustainable development can perform a grounded speculation on the long-term frameworks needed for a renewed sense of terraforming, ensuring that Earth remains capable of supporting Earth-like life. This design proposes new balances of industry and biodiversity in frameworks of coexistence that can support the regeneration of ecosystems during the upscaling of renewable energy production landscapes. At the same time, it relies on technologies and focuses on structures that have to do with reorganising an existing relational system.

"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.

"There is no way to build a world that will not be highly technological and there is no way to build a viable technological framework that is not socially sustainable." (Bratton, 2021)

Black hole image
Image 32

World as the planetary

In the same way, the other sections had their cosmology; this one can be represented by the composed image of the black hole. It is not an apocalyptical or an image to cause despair. Unlike the Blue Marble, the black hole image was not taken by a human from outer space in a position of "overview". It was composed by collecting data from many telescopes across various continents on Earth for several hours and assembled by many groups of scientists. It is a picture of Earth, looking at its surroundings. It must be understood with the same effect as the announcing of Copernicus that the Sun did not move around the Earth. This time, it is announcing a Copernican turn of a different sort, rendering humans as enablers, as mediators of a planetary intelligence.

What is its effect on urbanisation? What kind of urban is the planetary? As the project's narrative has demonstrated, the inherited infrastructures are already placed and connected - only to increase and become more efficient. This is the condition, so how might we conceive and enact a planetarity (as a way of looking to the planet) that undergirds more just future modes of energy? The direction is not a return to pre-urban paradigms but to build new ones with more industrial and biological actions to link our inhabitation modes with the planetary intelligence. To design energy is to design our organisation and possibilities, and crucially how humans treat Earth with its entities.

However, linking back to the essay from Patricia Reed mentioned in the beginning, it is still an "unconcretised existential condition" that could build pathways to inaugurate a new condition. Indeed, this does not bypass social structures because "there is no way to build a world that will not be highly technological, and there is no way to build a viable technological framework that is not socially sustainable." (Bratton, 2021) It is vital to design platforms that allow other realities, cosmologies and ways of being to coexist. For next energy modes and otherworlds; energy must be seen as an ecology, a new "Energy-Ecology".

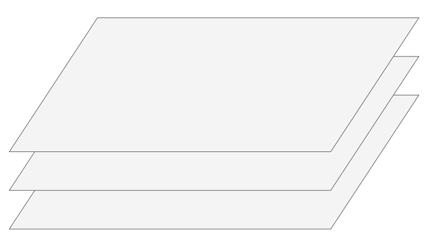
"Planetarity includes the presumption, as stated, that going forward, the distinctions between geotechnology, geopolitics, geoeconomics, and geoecology will be less clear and less distinct. The kinds of institutions and frameworks that get built will be ones that may look like a technology, they may look like politics, they may look like an economics, and they may be all of these at once in different ways." (Bratton, 2021)

Inheritance

In a summary of the investigation's first part, the map highlights some elements that must come along and contribute to the "Energy-Ecology Network".

Apart from the alarming calamity that accompanies "progress", "growth" and "globalisation"; some infrastructures can be well used in the future. One of them is the overall spread of the electricity grid. Power is usually transmitted through overhead power lines, supported by transmission towers, generating a vast network of connected lines crossing almost all the territory of the Rhine basin. Nowadays, the EU has a transmission network of 200,000 km approximately, which means around 1 million towers. (Ferrer et al. 2020) The region of these transmission lines overlaps with the future operational landscapes of energy. It highlights the potential of those areas for renewable energy technologies to link to the grid and alter the management of adjacent areas.

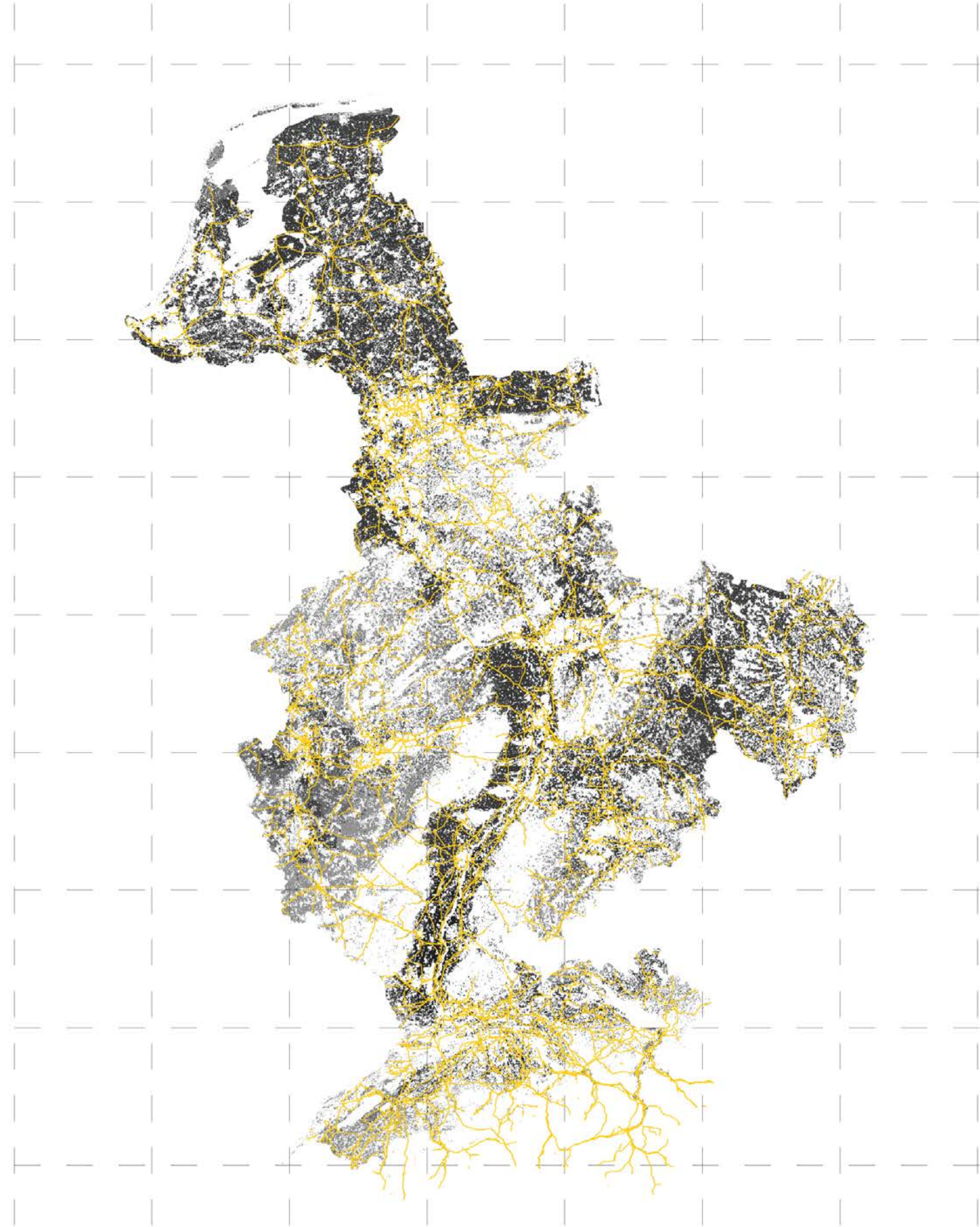
This network can be a connecting infrastructure for energy and ecological purposes. Given its presence across Europe, it could become a Trans-European Energy Network focusing on deploying renewable energy along with the Trans-European Nature Network providing green infrastructure for the Natura2000 archipelago.



Average particulate matter in the atmosphere

High voltage transmission lines

0 100km N

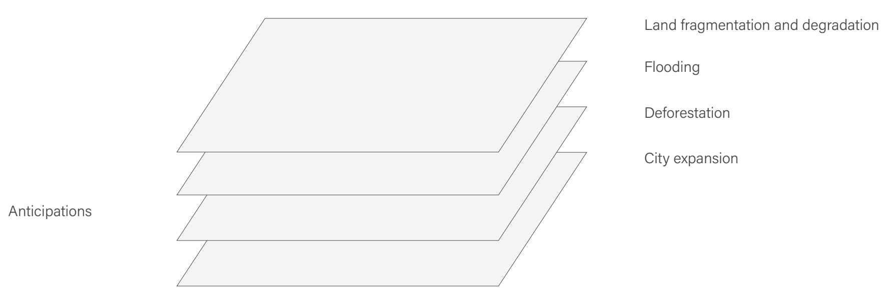


Anticipation

The summary of the second part of the investigation highlights the overall state of ecological integrity that the current "energy transition" encounters.

The current fragmentation and degradation state of natural processes points to the areas it needs attention. The influence of human activity on biodiversity and ecosystems is virtually ubiquitous in the whole extent of the basin, shaping all aspects of nature and the benefits it provides. The sustaining of a model of development that destroys rather than enhances biodiversity has significantly degraded the ecosystems that humans, fauna and flora depend upon and withdraw essential services from. "Biodiversity loss and ecosystem degradation, for example, reduces carbon sequestration and increases emissions of carbon from degraded soils accelerating climate change; reduces regulation of pests; reduces pollination and dispersal of seeds; and causes a deterioration in people's health whilst magnifying natural disasters such as fires and floods." (Fernández et al., 2020)

If the relation to energy is what carries humanity through every spatial condition, this composition raises warning flags and demands other relations to Earth's systems.



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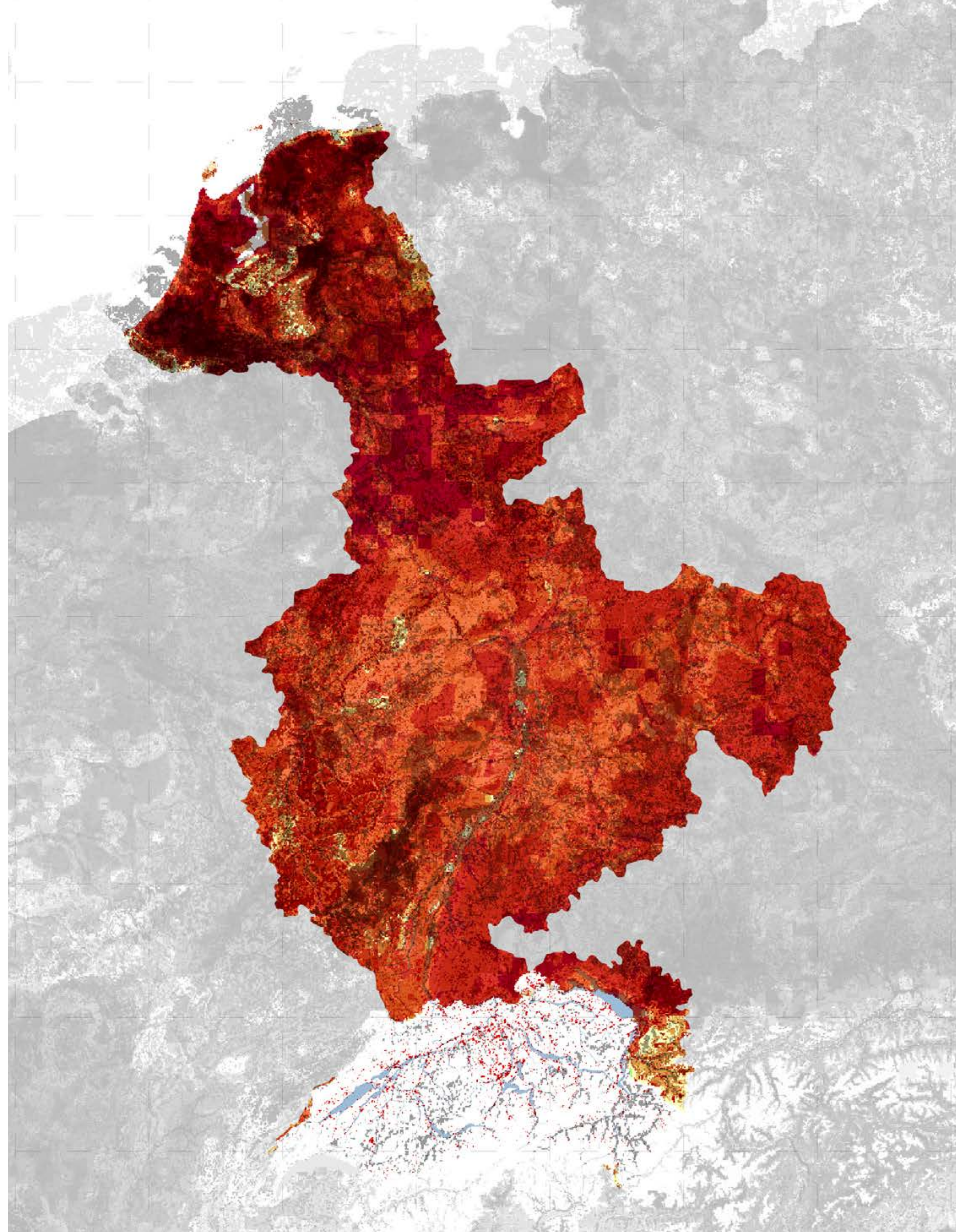
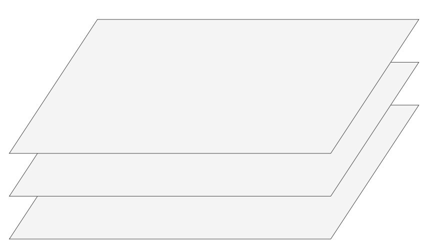


Renewable mode of energy potentials

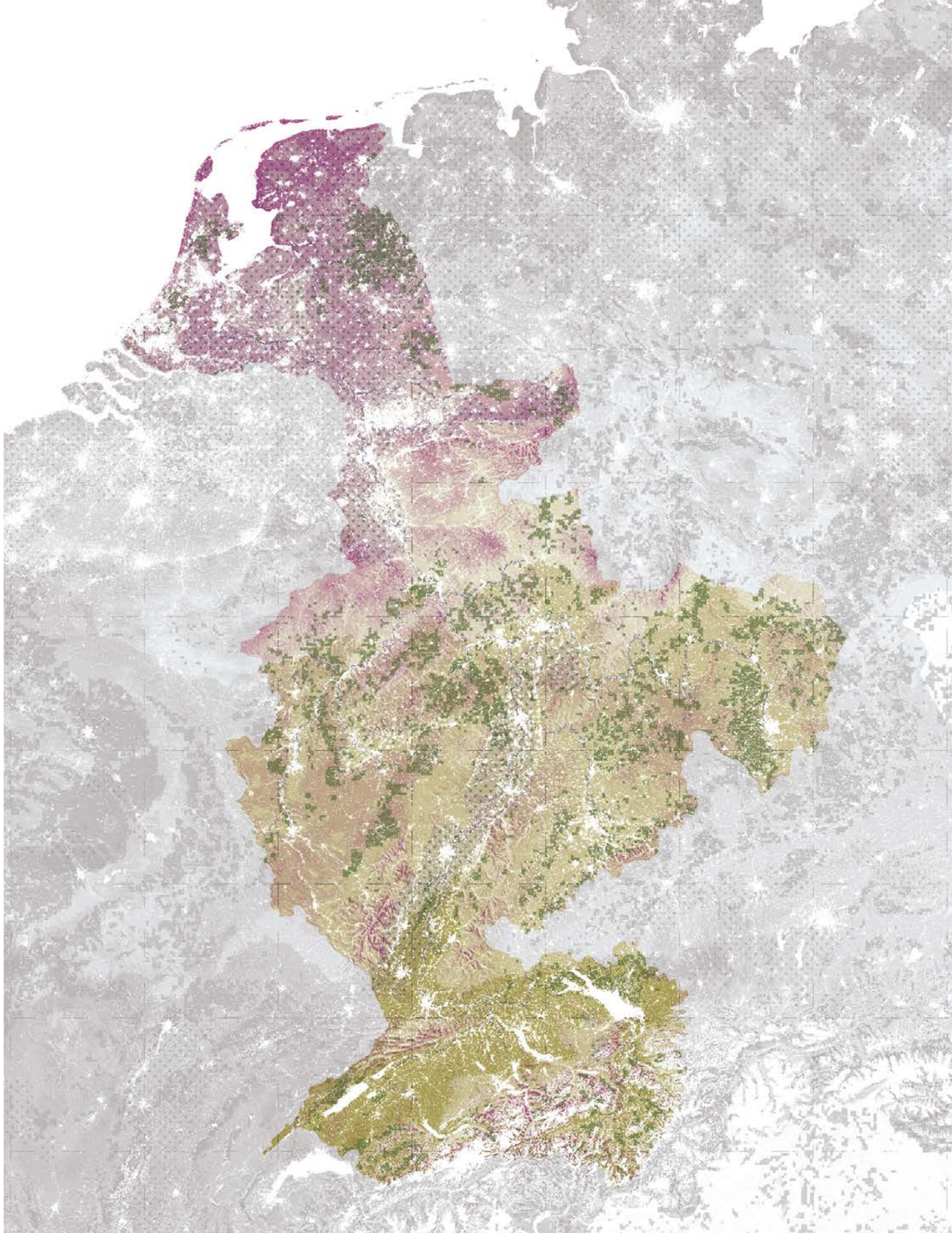
This cartography of the locations with higher potential renewable energy shows that the whole Rhine basin is full of potential for solar, wind and biomass energy. It is then a matter of how to implement structures to exploit it.

At this point, a more nuanced administration of the productivity of those regions looking not only for maximum energy output is necessary. The "Energy as coexistence" matrix, with propositions for alternative balances between industry and biodiversity, will demonstrate the need for new balances of sustainable and regenerative energetic and ecological actions in the landscape.



High geothermal suitability
Marginal land for biomass production
Wind potential (h=100m, W/m2)
Solar potential (GHI) (kWh/m2)
Rhine river and main estuaries

0 100km N

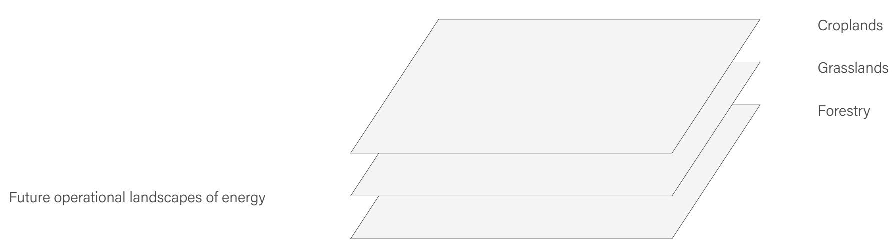


PROJECTION

Future operational landscapes of energy

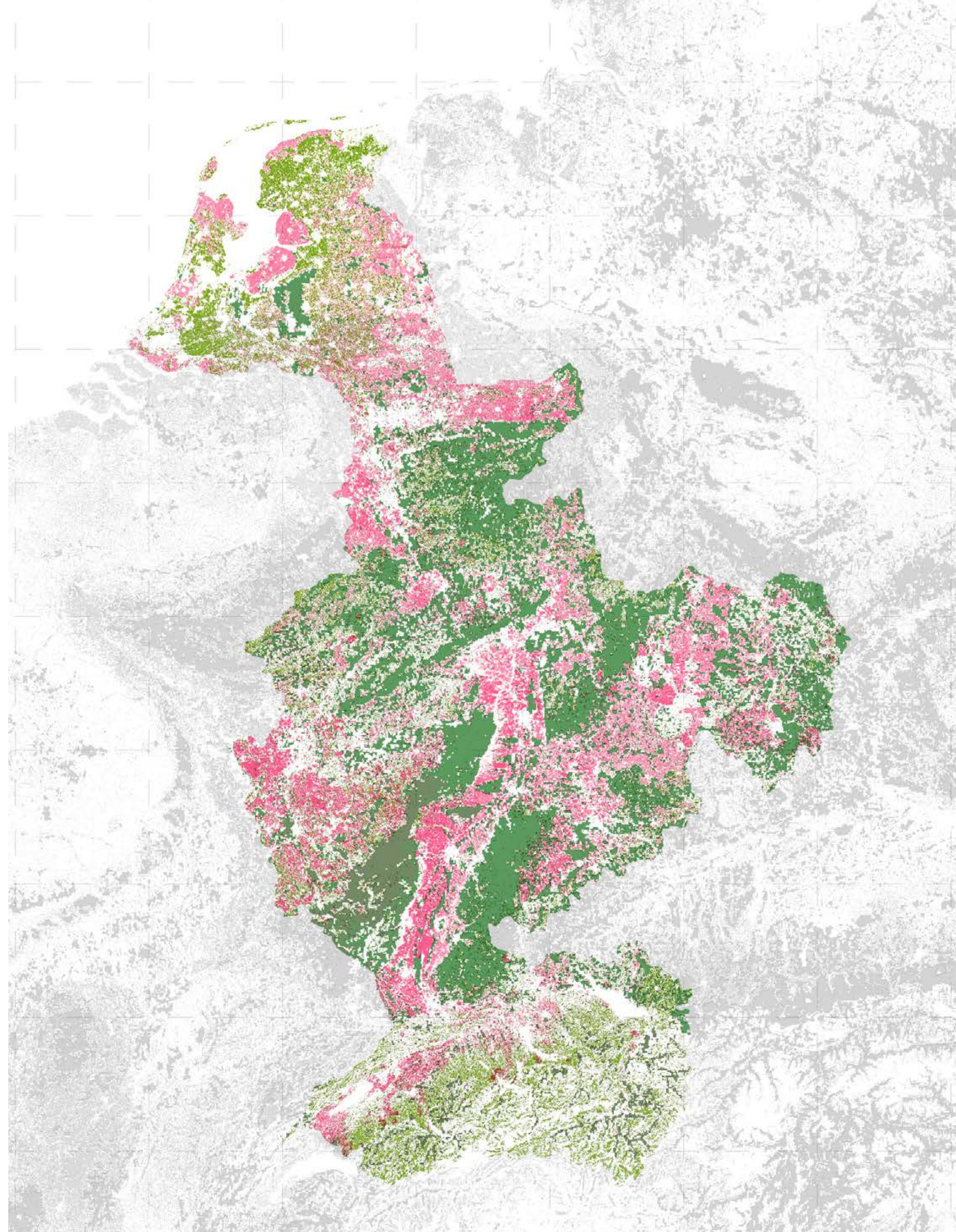
This map shows the areas that have been recognised as the main locations for this project. The addition of the previous maps shows the potential for these locations to realise energetic socio-ecological connectivity for the current and further energy transitions. Moreover, its vastness proposes another weight for urbanisation. It can be seen as a “third landscape”, where biodiversity is seen beyond conservationism and industry.

Further in the report, the proposal adds resolution to the level of the landscapes that will receive the scaling-up of mainly solar, wind and biomass production of energy. The “Energy-Ecology” in the future operational landscapes of energy act as a spatial and temporal “stepping-stone”, providing habitats for biodiversity and humans.



Forestry
Croplands
Grasslands

0 100km N

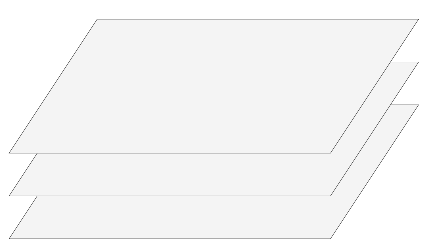


Projection

In order to fulfil the necessity to provide more basis to construct the bridge to propose inside ecological frameworks, a consultation with experts in the fields of conservation biology and ecosystem dynamics was done. The contribution of their studies is crucial as it proposes main ecological corridors that connect high ecological integrity conservation patches.

The paper 'Boosting Ecological Restoration for a Wilder Europe' identifies gaps in large-scale ecological connectivity among protected areas, including the Natura 2000 Network. In this analysis, nodes are clusters of Natura 2000 distributed in areas ≥500 km2 and with at least 10% covered by high ecological integrity, according to the previously shown "Ecological integrity" map. Following this logic, the proposed corridors pass through higher-integrity areas and conservation patches that are already being used for planning and conservation purposes at local and regional scales. However, "large-scale connectivity is insufficiently provided in planning and monitoring strategies, especially given rapid climate change." (Fernández et al., 2020) Addressing this gap, pathways were designed to maximise the inclusion of other Natura 2000 sites in the connecting corridors. The corridor configurations identified in this study help prioritise conservation and restoration policies and projects, redirecting appropriate funding for the deployment of EU-level Green Infrastructure that contributes to the goals of the Nature directives. "In addition, active restoration is also needed to enhance ecosystem functions in many other degraded ecosystems, for example, through alleviating pressures in managed forests and grasslands, restoring functional megafauna, and increasing connectivity in landscapes highly fragmented by intensive agriculture and infrastructures. In these ways, the Nature Directives' goals can be supported by expanding the areas covered by self-sustained ecosystems and by increasing the connectivity of the Natura 2000 Network through extensive degraded landscapes, where restoration action is urgently needed." (Fernández et al., 2020)

In order to support these actions, the Rhine basin is used as an example for an integrated assessment and proposal after what is inherited and what can be anticipated of depleted ecological integrity. With this contribution, the "Energy-Ecology Network" takes shape.

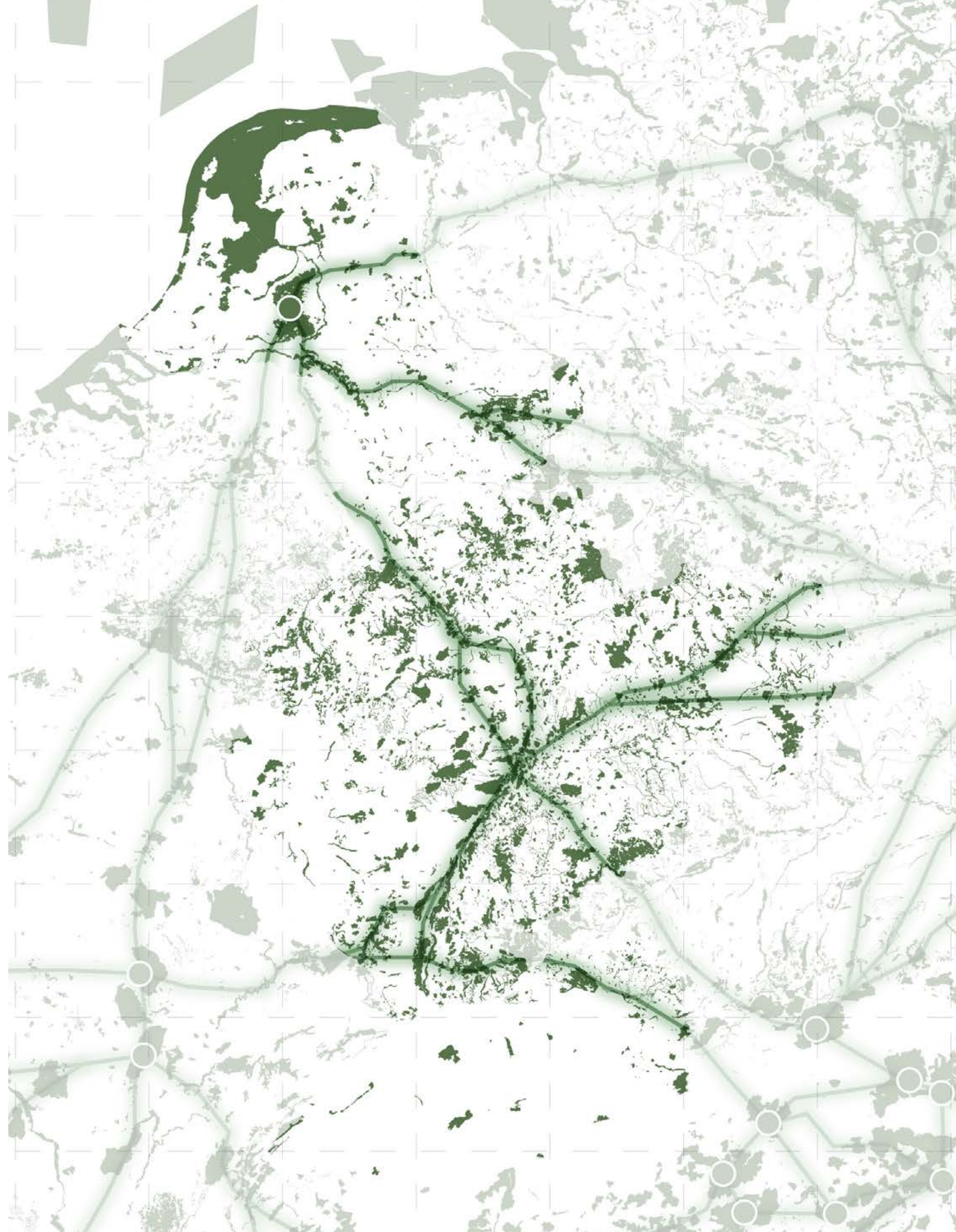


Conservation areas (Natura2000 and Emerald)

Ecological hotspot

Potential ecological corridors

0 100km N



Energy-Ecology Network

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, 2018) - and it expands as it touches or connects conservation patches not further than 5km away from each other or to keep landscape continuity.

The energetic 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 also triggers the grid's renovation towards adaptation to renewable energy technologies (its retrofitting, renovation, and actualisation). Concomitantly, 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 strengthens the overall biodiversity resilience, making the movement of species and the genetic exchange possible as it provides habitats for fauna & flora.

Several objectives are combined while deploying the 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 to design the ecotone between landscapes for energy and ecological purposes. (4) It addresses the long-term goal of restoring and conserving biodiversity in Europe, functioning as a spatio-temporal "stepping stone". Looking at the urbanisation paradigm it mediates: (1) It reuses the inherited pattern to reinvent the idea of a corridor as a platform for multiple purposes. (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, for humans and non-humans. (4) It is an expanding project. It grounds a process to deal with energy transitions, current of future ones. Altogether, it becomes an alternative urbanisation pattern for European territorial and regional integration.

In the further sections, it will add resolution to the regional and territorial scales. To demonstrate and speculate on the character of a region and its transition when approaching typical infrastructures like highways, agglomerations, and others, bringing together several actions in energy generation with ecological goals.

Main energy-ecology corridor

Secondary connecting conservatino areas

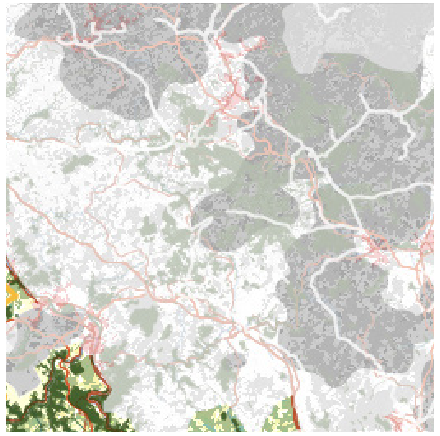
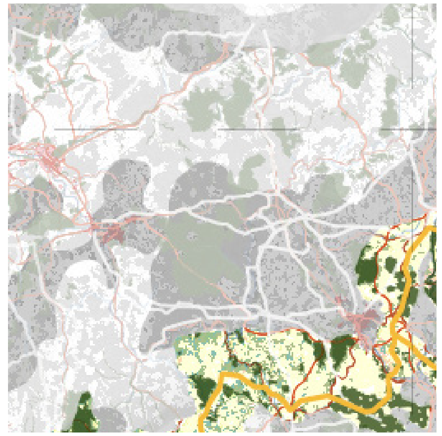
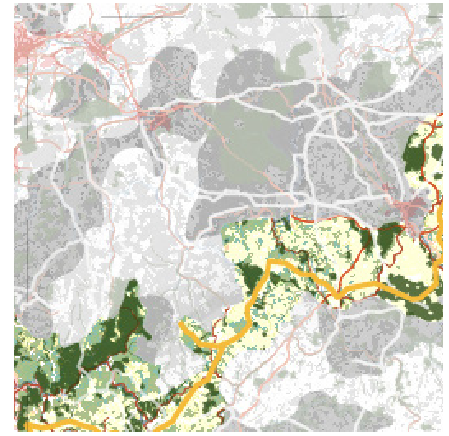
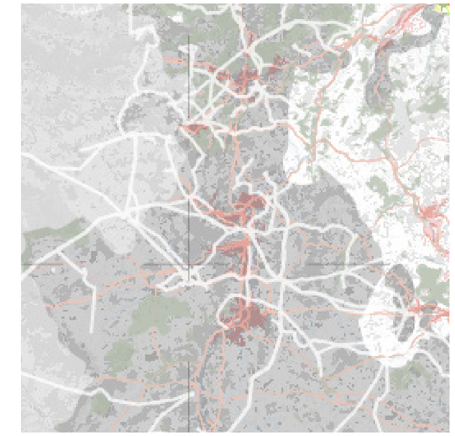
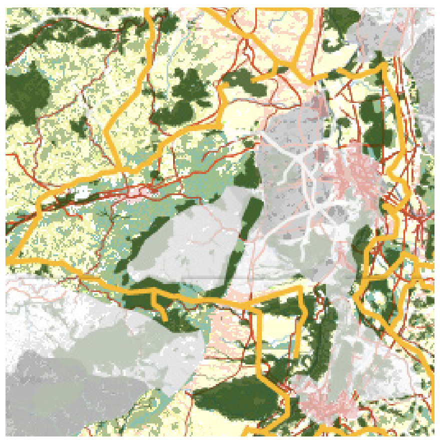
Secondary connecting degraded areas

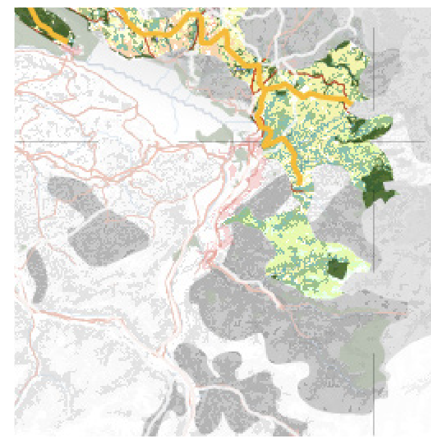
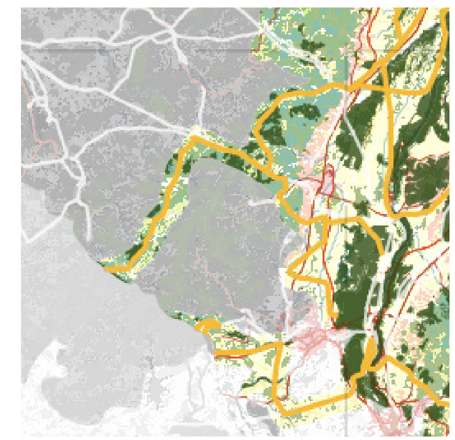
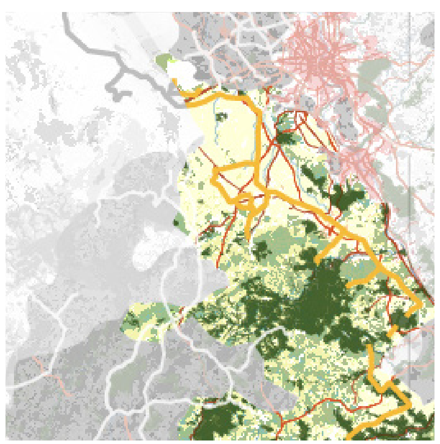
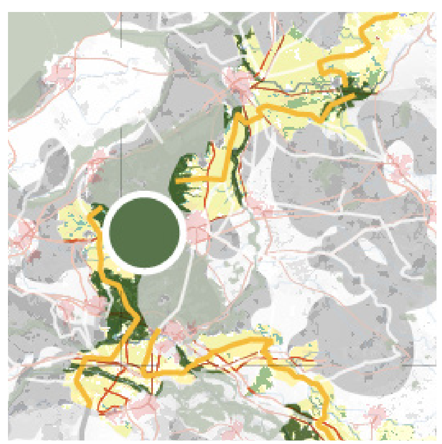
Conservation areas (Natura2000 and Emerald)

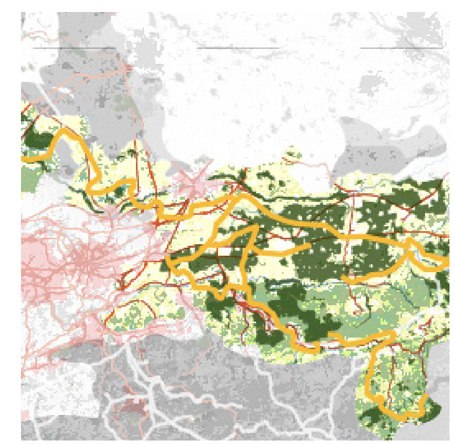
Ecological hotspot

Potential ecological corridors

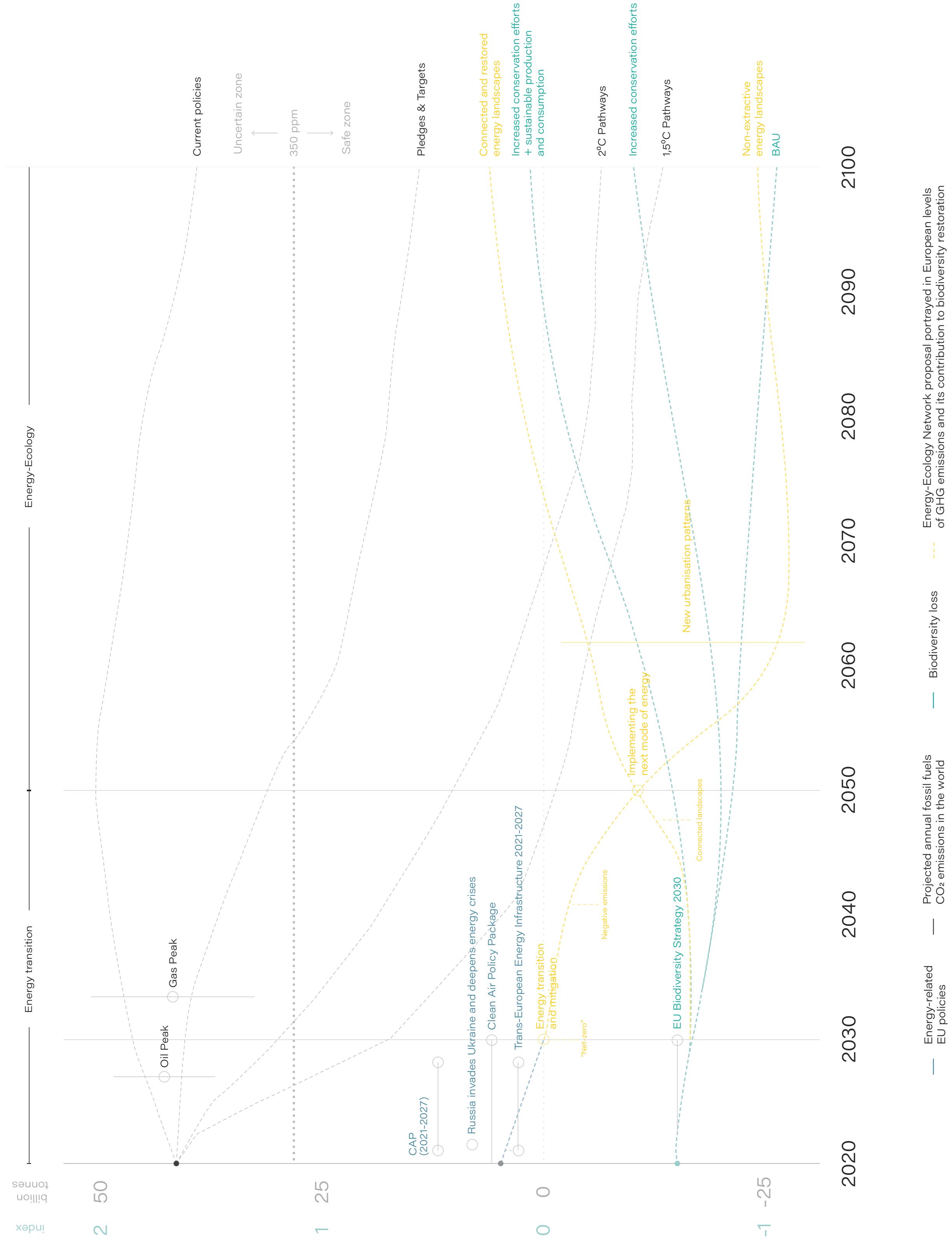
0 100km N



Deconstruction



A new temporality of energy

The graph on the left portrays only a fraction of the interweaving relationship between energy and humanity. It focuses on a new temporality inaugurated by its latest technologies and societal, political and economic changes.

As Moore and Patel (2018) highlighted before, not only a technical shift is decisive for landscape transformation. More crucial is an alternative labour-land relation, with better-regulated production balances based on alternative metrics of value. The current (and future) energy transition backgrounds the proposal of this project to compose a platform for space to accommodate more just socio-ecological alternatives. Hopefully, in this paradigm, the distinctions between technology, politics, economics, and ecology will be less clear and less distinct, being all of these at once in different ways. (Bratton, 2021)

2030, 2050, 2100

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 to mitigate the consequences of centuries of exploration of Natures. 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 CAP, and significant steps to decarbonise industries are due to that date.

2050 is 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 must prepare 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 the European urbanisation. The temporality for 2100 is precisely a project to set the scene for the next century urbanisation.

Energy as more industry and more biodiversity

The central question is that the response to anthropogenic climate change must also be anthropogenic. In other words, it must be artificial.

> "Instead of reviving ideas of 'nature', we will reclaim 'the artificial'- not as in 'fake', but rather 'designed' [...] the artificial as the trace of intention and design within patterns of emergence and vice-versa. It is a way to recognise agency by measuring the regularity of its consequential traces. [...] A resigned embrace of the artificial suggests an ontological turn of a different sort: [the recognition of] our own cognition and industry; not as immaterial, but as manifestations of a material world acting upon itself in regular intelligent patterns." (Bratton 2019)

As discussed before, energy must not be separated from its ecological context. To design energy is to design "nature". "An ecological perspective provides a very different vantage point from which energy can be seen as shared, as a characteristic of life and movement that subtends all our sociopolitical and economic systems." (Iturbe, 2021) When also adding the spatial thinking, more detailed questions on land use, regional impacts and sustainability are being gradually incorporated into energy generation perspectives. At the same time, an expanded epistemology must also develop. In order to conceive a different culture around energy, the project brings forth the concepts of industry and biodiversity. This point of departure makes it possible to say that energy must mean more industry and more biodiversity. It has always been like that. However, at this moment, this realisation can yield different outcomes.

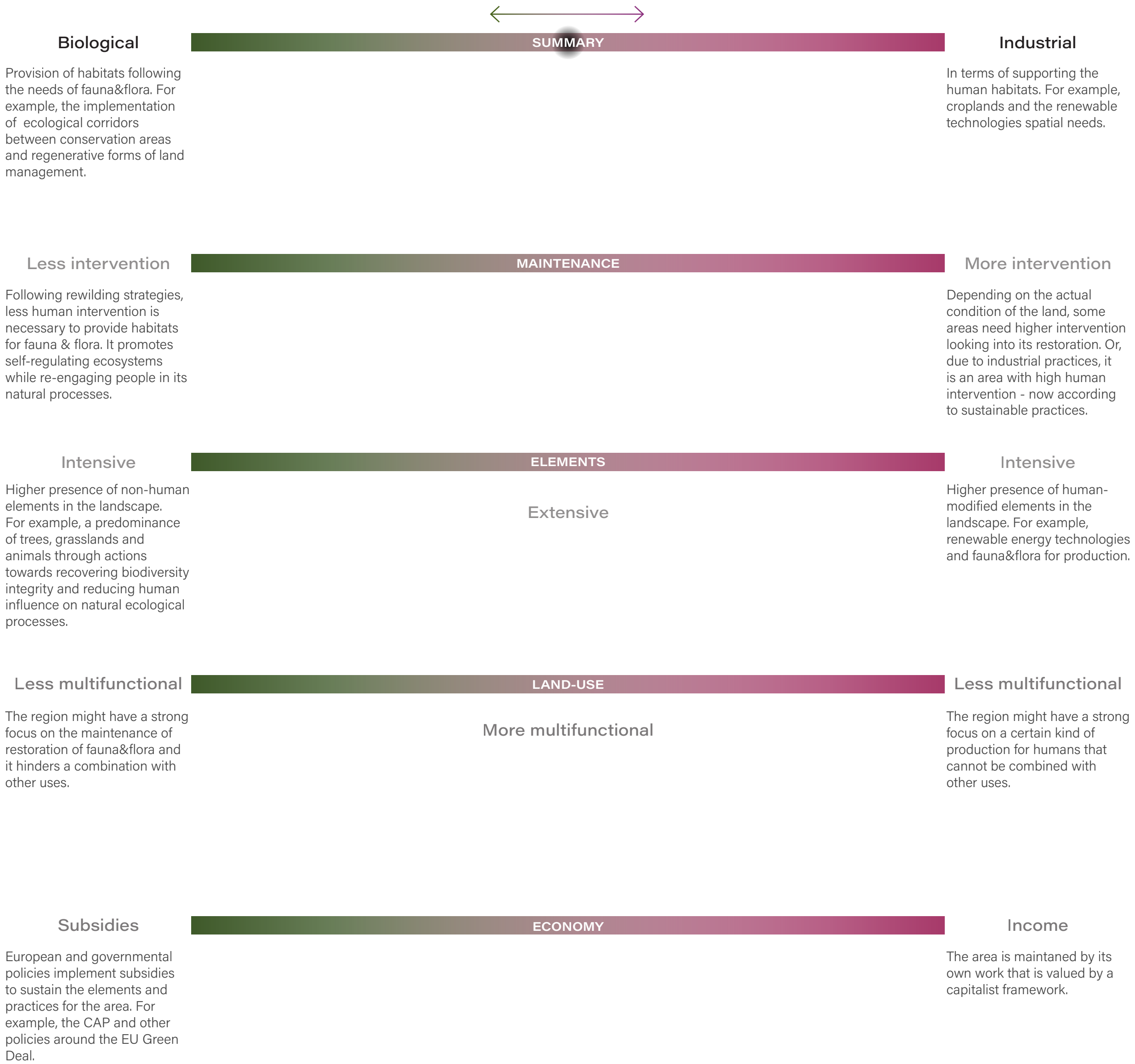
The categorisation of NETs (negative emission technologies), which are generally divided into industrial or biological - basically if they rely on human technology (as the practical application of knowledge, especially in a particular area) or not. For example, CCS (Carbon Capture and Storage) is something a tree does in its biological technological apparatus. In recent years, this has also become something that humans do industrially by building CCS plants to suck carbon back to deep geological strata. Expanding on it, "industry" refers to the overall human intelligence to intervene in planetary metabolisms (for example, energy and food) to extract, produce and distribute things that shape its inhabitation. Focusing on what "industry" means for this project, it is to pragmatically propose actions that build infrastructures that support a very different kind of productivity. One that is not necessarily human-centred and values natural processes in terms of its services. Or even centred on some humans, which works in justifying the exploitation of other human work. This industry respects the time and work value of humans and non-humans. In practice, for the energy landscapes, it means actions like regenerative agriculture, agrivoltaics, agroecology and many other measures to be added.

Biodiversity, on the other hand, refers to the overall planetary intelligence in composing habitats for its fauna and flora, including humans. It is about providing room for natural processes to display their "trace of intention and design".

> "Yet energy is not only electricity and power for machines. It is not simply the means by which the economy is built. Energy is a property of matter manifested in the ability to work, move, grow. Energy undergirds the form that individual organisms and ecological relationships take, giving everything on Earth its particular contours. Energy moves and, as it does, all life exists in a perpetual state of transformation, taking on specific form in moments and then dissolving only to define a threshold - between species, systems, or spaces." (Iturbe, 2021)

This understanding of biodiversity opens ways for complementary measures and work together with climate change mitigation and adaptation, particularly the restoration of functional and self-sustained ecosystems. The conceptual proposal of this project for coexistence is developed in the following pages.

Transmission tower in Delft, NL
Photo by author.



Balances of coexistence

Energy as coexistence

Understanding energy as coexistence is a proposal to expand on the concept of Negative Emissions Technologies (NETs), bringing together perspectives in other to provide a better understanding of the habitats it creates.

NETs are divided into two categories: biological and industrial. NETs are generally understood from a very technical point of view, relying on innovation and design from some companies to "solve" the problem of excessive levels of harmful emissions in the atmosphere. However, there are already much more efficient, reliable and safe "planetary intelligence" (Bratton, 2021) ways to balance the levels of carbon in the biosphere.

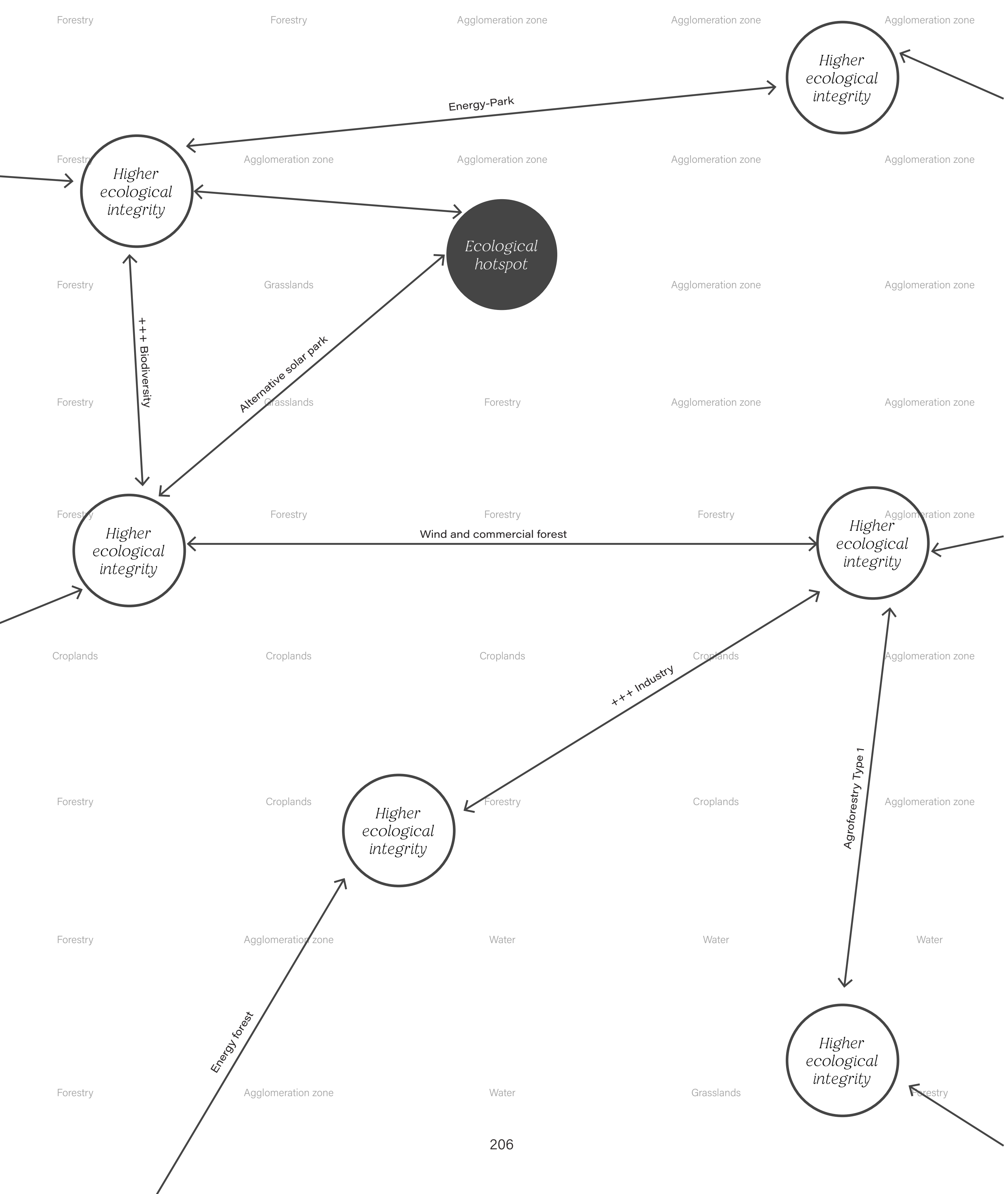
From conservation biology, "Rewilding" is a form of ecological restoration that promotes self-sustained ecosystems that require minimum human management in the long term. And as is well known, the repair and maintenance of biologically diverse and functional ecosystems are of the utmost importance to achieve the objectives of the European Birds and Habitats Directives and a new EU Green Deal. Rewilding pursues effective large-scale restoration of self-sustained and functional ecosystems through the recovery of natural ecological processes and the functions and services of wildlife. Some of its main components fall under the umbrella of biological NETs, as the restoration of ecological functions for wild species and their interactions enhance their connectivity within and among habitats and promotes self-regulating ecosystem dynamics and vegetation succession. When the synergies among these three components are improved, ecological functionality is reached, with higher ecosystem resilience and biodiversity value. "Thus, ecological restoration in line with rewilding principles can enhance, across many ecosystems, the provision of a wide range of services to people, such as carbon sequestration by naturally functioning vegetation, reduction of fire risk through the browsing and grazing activity of large herbivores and free movement across connected habitats of pollinator species and seed dispersers, among other benefits." "Biodiversity and climate policies should acknowledge that reducing human control on ecosystems is often a cost-effective approach to address restoration targets."

All in all, biological NETs are a proposal for less human intervention, which is not the case for industrial NETs.

Afforestation, reforestation, soil carbon sequestration, and 'blue carbon' habitat restoration are some active restoration practices to counter the depletion of ecosystems. But it should also include many other agriculture and forestry management practices in this classification.

Industrial CCS must be employed to capture the emissions in the atmosphere. At the production edge, renewable energy technologies like solar, wind and biomass are essential to decrease the carbon footprint of energy conversion. The energy production that maintains habitats is not only based on electricity and heat but also on a much broader ecosystem. As Iturbe mentioned, "Energy is a property of matter manifested in the ability to work, move, grow. Energy undergirds the form that individual organisms and ecological relationships take, giving everything on Earth its particular contours." To understand that is to realise that all forms of regenerative and sustainable agriculture, forestry and grassland management are part of an industrial NET. Its gains involve lower emissions and active human intervention to produce (or to "generate energy") in a respectable and just relation between human work and the natural processes work. Elements of sustainable agriculture can include permaculture, mixed farming, multiple cropping and crop rotation. Agroforestry and agroecology is already a form of coexistence with forestry management. Regarding the latter, logging activities can take many forms of limited and selective harvesting, which could even improve the health of an ecosystem in deforested or degraded land - the case of many areas in the Rhine basin.

To sum up, primarily, these two perspectives could be combined for a long-term "energy transition" not only into new technologies but into a socio-ecological understanding of energy as part of society and creating other forms of inhabiting the Earth. Building on this view, the matrix on the left provides some tools for assessing the coexistence balances of energy production with an ecological backbone according to its maintenance practices, the elements and actions, the envisioned priority of land uses and overall economic support.



Corridor Typologies

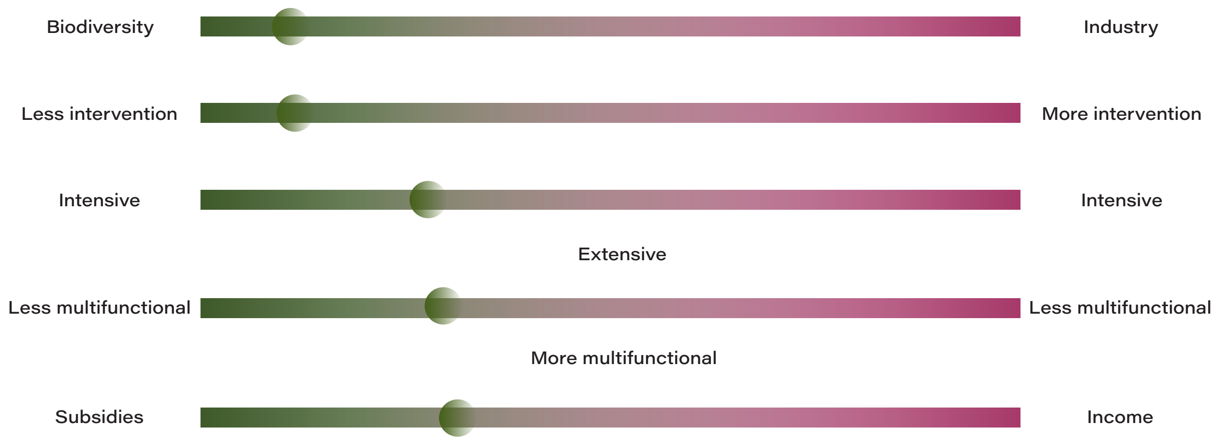
The next set of parameters and visuals aim to look at the regional level in order to demonstrate the interregional conditions that the Energy-Ecology Network will propose upon its implementation.

The Energy-Ecology Network is not a one-size-fits-all project. At the scale presented in the following pages, it is possible to demonstrate the nuances of the many parameters affecting the landscape over time, across its atmosphere-surface-subsurface continuum.

The scale of a "corridor typology" demonstrates a higher resolution to the gradients inside and outside the network, with a set of actions that provide more just balances depending on the region's needs. For example, a densely populated area surrounding the future operational landscapes of energy might focus on recreational and cultural purposes so that the region might prioritise the development into an Energy-Park. The following pages demonstrate the transformation of an area like the Vosges, with many Natura2000 areas and mainly forestry land cover. The other example is for the north of the Netherlands, a region heavily industrialised by agriculture that suffers from high soil degradation and fragmented landscapes that hurt ecological integrity so that it could benefit from better industry-biodiversity management.

The following energy resolution as a spatio-temporal project speculates on the possibility of the Energy-Ecology Network installing a character for a specific part of the corridor.

+++ Biodiversity

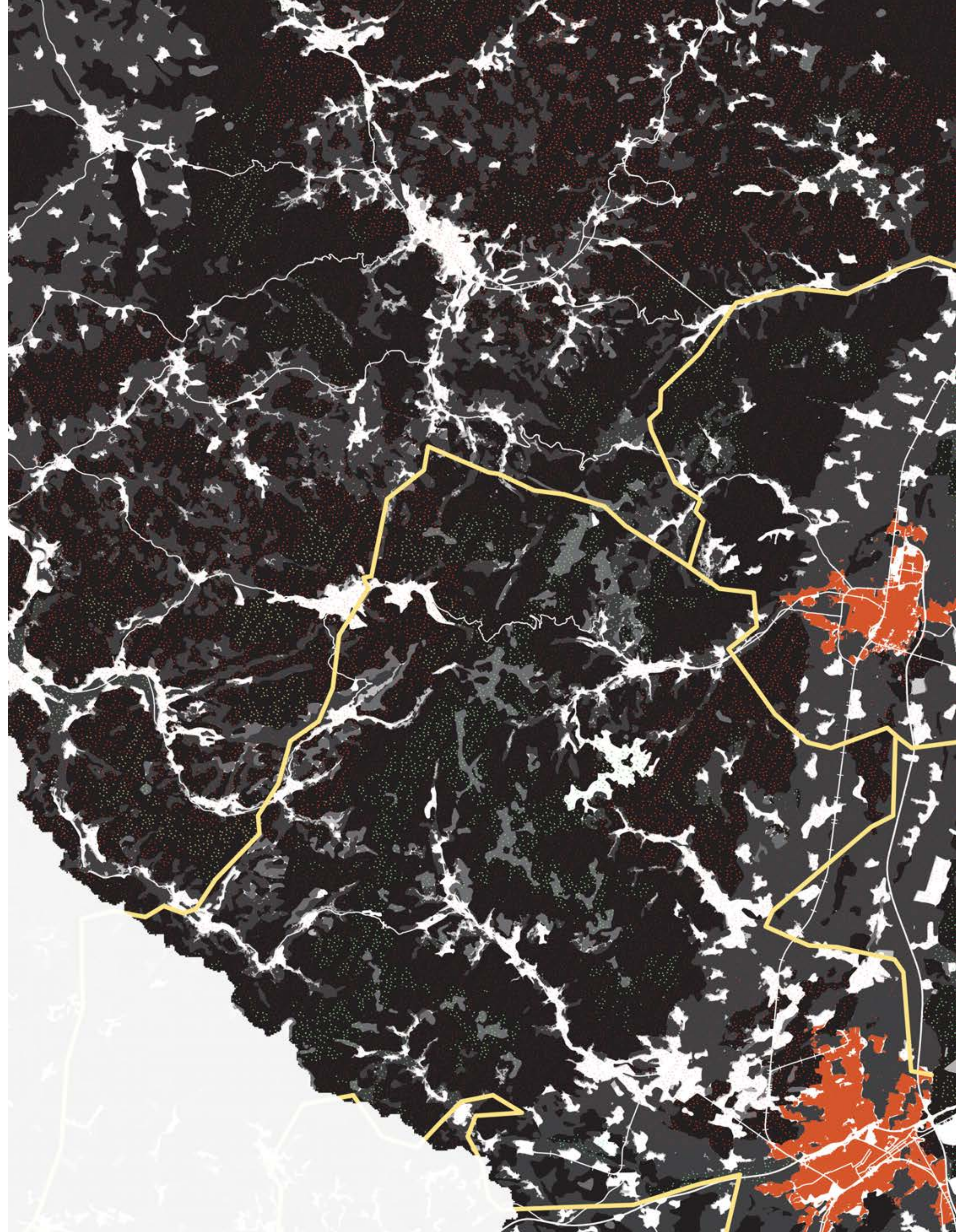


Balances of coexistence

The corridor typology "+++ Biodiversity" is one of many proposals that must be moulded when encountering local contestations. In this case, the high priority to assemble an ecological corridor for biodiversity by connecting the Natura2000 patches seems the most fitting for a region predominantly characterised by forestry landscapes - which could be better managed and connected.

The map on the right is an abstraction of the Vosges region. It has high levels of soil degradation and land fragmentation, with the presence of highways and sometimes railways cutting habitats. It has large extents of forestry being used for wood production. The assigned corridor typology is, since the first steps, directed for less intervention and providing more habitats for fauna & flora.

The table above proposes a set of overall goals with the gradients transition represented on the plan. The configurations and parameters of these interventions are deconstructed in the following pages.



2030

Landscape (Land cover)	*Elements (Land-use)*	*Energy-Ecology intervention*	*Category*	*Intensity*	*Action*
Built-up	Inhabitation				
	Power plant		Production of electricity	+	From forestry residues
	Highway				
	Railway				
Forestry	Woodland	Renewable energy	Primary forestry residues Secondary forestry residues	++ ++	Available residues only from residue extraction but no stomp removal allowed
		Habitat for humans	Recreation	+	Allow for sustainable use of the areas
		Habitats for biodiversity	Effective ecological corridor	+++	Assign areas for low intervention and begin implementation
		CCS	Biological	+	Practises of restoration of soil health Low intervention of the forest
		Soil and nutrient protection	Restoration	+	Practises of restoration of soil health
		Foster local community	Eco-tourism	+	Assign areas
	Natura 2000	Renewable energy	Primary forestry residues	+	Available residues only from residue extraction but no stomp removal allowed
		Habitat for biodiversity	Conservation	++	Rewilding practices
	For production	Foster local community	Roundwood production	+	Reduce competing demand for non-energy purposes
		Renewable energy	Roundwood production	+	Increased woodland productivity by fertilization harvest mechanisation efficiency and increased mobilisation of wood from smallholders Biomass from stews
Ecotone	Meadows or forestry	Habitat for humans	Recreational park	+	
		Renewable energy	Primary residues Secondary residues Solar park	++ + +	Available residues only from residue extraction but no stomp removal allowed Accessible PV structure
		CCS	CCS plant	+	
	Croplands	Food production	Agrivoltaics or other combinations	+	Food and other biomass production

Parameters

- High-voltage transmission lines
- Energy-ecology corridor (5km buffer zone)
- Conservation areas (Natura2000)
- Commercial forest
- Agglomeration zones > 1M inhabitants
- Agglomeration zones < 1M inhabitants
- Highway and railway
- Soil degradation and high GHG emissions
- Forestry and woodlands
- Grasslands, heathlands and shrublands
- Croplands

From the present moment until 2030, the EU and most policies are organised around implementing the European Green Deal. The rapid scale-up of provision of electricity by renewable energy sources, following the necessity but also economic opportunities and policy directives, will see Energy-Ecology corridors being most efficiently assigned between the closest Natura2000 patches. Overall, the goal is to build the area of the Energy-Ecology Network and begin the first practices that will guarantee the livelihood of fauna & flora concomitantly with assigning better management of residues for energy production.

0 5 km N

2050

Landscape (Land cover)	*Elements (Land-use)*	*Energy-ecology intervention*	*Category*	*Intensity*	*Action*
Built-up	Inhabitation				
	Power plant		Production of electricity	++	From forestry residues
	Highway				Minimun 2km wide brige for fauna&flora habitats
	Railway				
Forestry	Woodland	Renewable energy	Primary forestry residues Secondary forestry residues	++ ++	Available residues only from residue extraction, stomp removal allowed
		Habitat for humans	Recreation	+	Allow for sustainable use of the areas
		CCS	Biological	+++	Practises of restoration of soil health Low intervention of the forest
		Soil and nutrient protection	Restoration	++	Practises of restoration of soil health
		Foster local community	Eco-tourism	+	Assign areas
		Food production	Agroforestry	+	Food and other biomass production
	Natura 2000	Renewable energy	Primary forestry residues	+	Available residues only from residue extraction but no stomp removal allowed
		Habitat for biodiversity	Conservation	+++	Rewilding practises
	For production	Renewable energy	Primary forestry residues Secondary forestry residues	+++ +++	Increase in contribution from small holders Reduce competing demand for non-energy purposes
		Foster local community	Roundwood production	+	Important areas become conserved and subsidies to holders for maintenance following rewilding principles Biomass from stews
		Food production	Agroforestry	+	Food and other biomass production
	Ecological corridor	Habitats for biodiversity	Rewilding	+++	Expansion and establishment of conservation corridors between fragmented patches
Ecotone	Meadows or forestry	Habitat for humans	Recreational park	+	
		Renewable energy	Primary residues Secondary residues	++ ++	Available residues only from residue extraction but no stomp removal allowed
			Solar park	+++	Accessible PV structure
		CCS	CCS plant	++	
		Food production	Agroforestry	+	Food and other biomass production
		Habitats for biodiversity	Rewilding	+	Conservation patches to connect areas

Parameters

- High-voltage transmission lines
- Energy-ecology corridor (5km buffer zone)
- Conservation areas (Natura2000)
- Commercial forest
- Agglomeration zones > 1M inhabitants
- Agglomeration zones < 1M inhabitants
- Highway and railway
- Soil degradation and high GHG emissions
- Forestry and woodlands
- Grasslands, heathlands and shrublands
- Croplands

After a revision of the goals for the energy transition and the realisation of harsher effects of climate change and biosphere degradation kicking in, the EU and most policies are organised around implementing a revised version of the European Green Deal. It will provide a race toward fully implementing a renewable energy grid. This phase aims to establish the Energy-Ecology corridor and organise its expansions and habitats. Renewable energy is produced like never before, but at the same time, an ecological corridor appears following the transmission lines and providing habitats for fauna & flora.

0 5 km N

2100

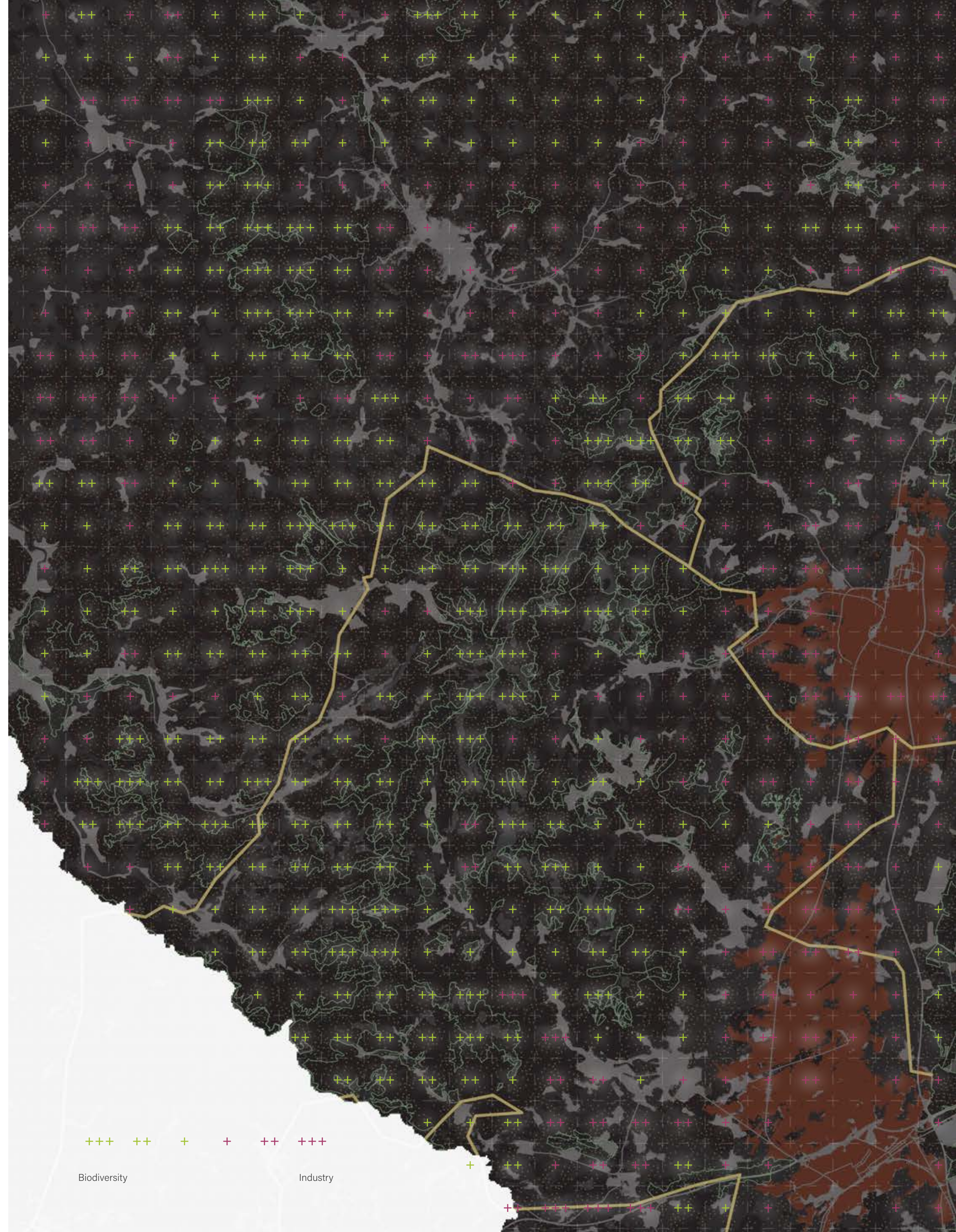
Landscape (Land cover)	*Elements (Land-use)*	*Energy-ecology intervention*	*Category*	*Intensity*	*Action*
Built-up	Inhabitation				
	Power plant		Production of electricity	++	From forestry residues
	Highway				Minimum 2km wide brige for fauna&flora habitats
	Railway				
Forestry	Woodland	Energy production	Primary forestry residues Secondary forestry residues Non-extractive	++ ++ ++	Available residues only from residue extraction, stomp removal not allowed Scaling-up, assign areas
		Habitat for humans	Recreation	+	Allow for sustainable use of the areas
		CCS	Biological	++	Practices of restoration of soil health Low intervention of the forest
		Soil and nutrient protection	Restoration	++	Practices of restoration of soil health
		Foster local community	Eco-tourism	++	Assign areas
	Natura 2000	Habitat for biodiversity	Conservation	+++	Rewilding practices
	For production	Energy production	Primary forestry residues Secondary forestry residues	++	Increase in contribution from small holders Reduce competing demand for non-energy purposes
		Foster local community	Roundwood production	++	Important areas become conserved and subsidies to holders for maintenance following rewilding principles Biomass from stews
		Food production	Agroforestry	++	Food and other biomass production
	Ecological corridor	Habitats for biodiversity	Rewilding	+++	Expansion and establishment of effective conservation corridors between fragmented patches
Ecotone	Meadows or forestry	Habitat for humans	Recreational park	++	
		Renewable energy	Primary residues Secondary residues	+ +	Available residues only from residue extraction but no stomp removal allowed
		CCS	CCS plant	+	
		Food production	Agroforestry	+	Food and other biomass production

Parameters

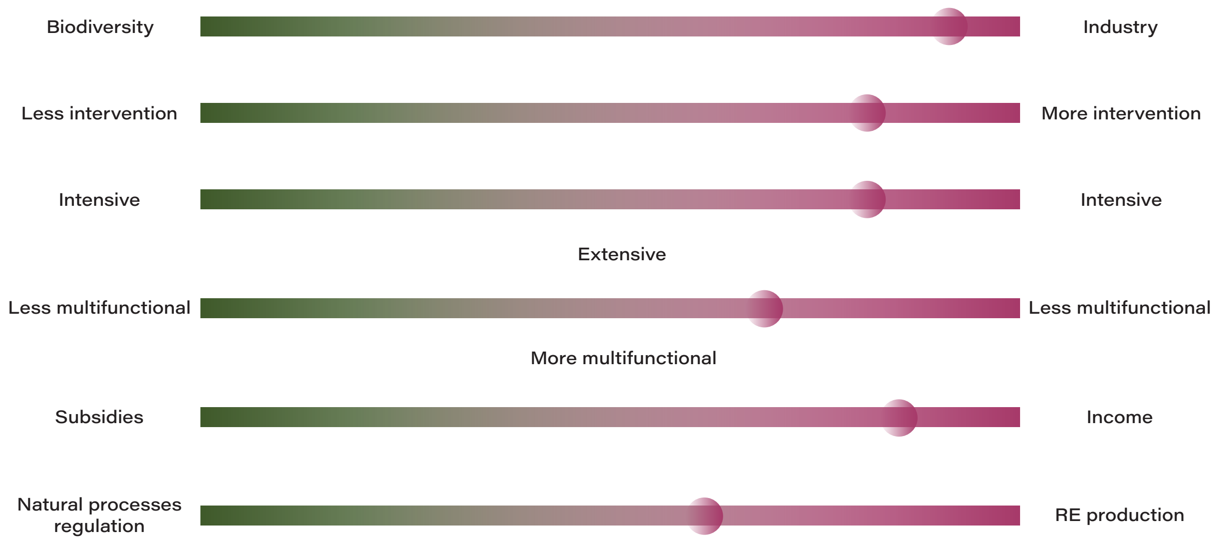
- High-voltage transmission lines
- Energy-ecology corridor (5km buffer zone)
- Conservation areas (Natura2000)
- Commercial forest
- Agglomeration zones > 1M inhabitants
- Agglomeration zones < 1M inhabitants
- Highway and railway
- Soil degradation and high GHG emissions
- Forestry and woodlands
- Grasslands, heathlands and shrublands
- Croplands

The inauguration of another century inherits now the consequences and restorations of the century of overall systems degradation and restoration. In a hopeful future, the next temporality of energy landscapes will be non-extractive, and this time-frame envisions its scaling-up. This phase imagines a post-extractive energy temporality in which its previous productive landscapes can be given to ecological purposes. The Energy-Ecology corridor becomes a haven of flourishing species. Land can rest, and ecotones are parks of biomass production, educational, aesthetic, and cultural heritage values, as well as recreation and tourism respectably taking form attentive to the ecological purposes of the area.
As areas are being restored and connected, the EEN can expand to transform in other directions of the transmission lines.

0 5 km N



+++ Industry



Balances of coexistence

- High-voltage transmission lines
- Energy-ecology corridor (5km buffer zone)
- Conservation areas (Natura2000)
- Commercial forest
- Agglomeration zones > 1M inhabitants
- Agglomeration zones < 1M inhabitants
- Highway and railway
- Soil degradation and high GHG emissions
- Forestry and woodlands
- Grasslands, heathlands and shrublands
- Croplands

The corridor typology "+++ Industry" is one of many proposals for corridors that must be moulded when encountering local contestations. In this case, the highest priority lies in assembling spatially the renewed concept of "Industry" proposed in the Energy-Ecology temporality.

The map on the right is an abstraction of the northern region of the Netherlands that encounters with Germany. It has high levels of soil exhaustion and land fragmentation, with the presence of highways and sometimes railways cutting habitats. It also has one of the highest GHG emissions levels for croplands in the Rhine basin.

The assigned corridor typology is, since the first steps, directed for a new paradigm of human intervention. It balances the production and introduces connections and habitats for diverse fauna & flora.

The table above proposes a set of overall goals with the gradients transition represented on the plan. The configurations and parameters of these interventions are deconstructed in the following pages.

0 5 km N

2030

Landscape (Land cover)	*Elements (Land-use)*	*Energy-Ecology intervention*	*Category*	*RE and intensity*	*Action*
Built-up	Inhabitation				
	Power plant		Production of electricity	++	From croplands residues
	Highway				
	Railway				
Croplands	Arable land Intensive or Greenhouses	Renewable energy	Solar energy	++	Agrivoltaics
			Biomass	++	Biofuel crops grow in competition with feed crops Collection rate of residues from pruning and grasses
		Food production	Regenerative practices	++	Avoid emissions and lower nitrogen level on soil
		CCS	Industrial	+	Assign areas
		Soil and nutrient protection	Restoration	+	Practises of restoration of soil health
		Water regulation	Flood protection w/ wetlands	+	Assign areas
	Arable land Extensive or livestock	Habitats for biodiversity	Rewilding	+	Low intervention patches as "stepping-stones"
		Renewable energy	Solar energy	++	Agrivoltaics
			Biomass	++	Biofuel crops grow in competition with feed crops Collection rate of residues from pruning and grasses
			Wind energy	++	
		Food production	Regenerative practices	++	Avoid emissions and lower nitrogen level on soil
		CCS	Industrial	+	Assign areas
		Soil and nutrient protection	Restoration	+	Practises of restoration of soil health
		Water regulation	Flood protection w/ wetlands	+	Assign areas
	HNV or Natura 2000	Renewable energy	Biomass	+	Collection rate of residues from pruning and grasses
		Habitat for biodiversity	Conservation	++	Lower intervention
Ecotone	Meadows or forestry	Habitat for humans	Recreational park	+	Accessible PV structure
		Renewable energy	Primary residues Secondary residues	+ +	Available residues only from residue extraction but no stomp removal allowed
			Solar park	+	Accessible PV structure
		CCS	CCS plant	+	Assign areas
	Near cities	Foster local community	Educational	+	Visitations on Energy-Parks
		Habitat for humans	Energy-Industry-Park	+	Recreation and tourism

- High-voltage transmission lines
- Energy-ecology corridor (5km buffer zone)
- Conservation areas (Natura2000)
- Commercial forest
- Agglomeration zones > 1M inhabitants
- Agglomeration zones < 1M inhabitants
- Highway and railway
- Soil degradation and high GHG emissions
- Forestry and woodlands
- Grasslands, heathlands and shrublands
- Croplands

Parameters

From the present moment until 2030, the assigning of the Energy-Ecology Network will take advantage of the subsidies from the CAP to implement the changes needed on croplands. Agrivoltaics are especially implemented in vineyards and berries. Biomass pruning transforms areas that need land rest. The understanding of agricultural practices as biological NET transforms the priorities of the area.

0 5 km N

2050

Landscape (Land cover)	*Elements (Land-use)*	*Energy-ecology intervention*	*Category*	*RE and intensity*	*Action*
Built-up	Inhabitation				
	Power plant		Production of electricity	++	From croplands residues
	Highway				Minimun 2km wide bridge for fauna&flora habitats
	Railway				
Croplands	Arable land Intensive or Greenhouses	Renewable energy	Solar energy	+++	Agrivoltaics
			Biomass	+++	Biofuel crops grow in competition with feed crops Collection rate of residues from pruning and grasses
		Food production	Regenerative practices	++	Avoid emissions and lower nitrogen level on soil
		CCS	Industrial	++	Assign areas
		Soil and nutrient protection	Restoration	+	Practises of restoration of soil health
		Water regulation	Flood protection w/ wetlands	+	Assign areas
	Arable land Extensive or livestock	Habitats for biodiversity	Rewilding	++	Low intervention patches as "stepping-stones"
		Renewable energy	Solar energy	+++	Agrivoltaics
			Biomass	+	Biofuel crops grow in competition with feed crops Collection rate of residues from pruning and grasses
			Wind energy	+++	Begins decomission
		Food production	Regenerative practices	+++	Avoid emissions and use livestock as maintenance
		CCS	Industrial	+	Assign areas
		Soil and nutrient protection	Restoration	+	Practises of restoration of soil health
		Water regulation	Flood protection w/ wetlands	+	Natural water regulation
	HNV or Natura 2000	Renewable energy	Biomass	+	Collection rate of residues from pruning and grasses
		Habitat for biodiversity	Conservation	++	Lower intervention
Ecotone	Meadows or forestry	Habitat for humans	Recreational park	++	Accessible PV structure
		Renewable energy	Primary residues Secondary residues	+++ +++	Available residues only from residue extraction but no stomp removal allowed
			Solar park	+++	Accessible PV structure
		CCS	CCS plant	++	Assign areas
		Habitat for biodiversity	Effective ecological corridor	++	Assign areas
	Near cities	Foster local community	Educational	++	Visitations on Energy-Parks
		Habitat for humans	Energy-Industry-Park	++	Recreation and tourism

Parameters

- High-voltage transmission lines
- Energy-ecology corridor (5km buffer zone)
- Conservation areas (Natura2000)
- Commercial forest
- Agglomeration zones > 1M inhabitants
- Agglomeration zones < 1M inhabitants
- Highway and railway
- Soil degradation and high GHG emissions
- Forestry and woodlands
- Grasslands, heathlands and shrublands
- Croplands

After a revision of the goals for the energy transition and the realisation of harsher effects of climate change and biosphere degradation kicking in, the EU and most policies are organised around implementing a revised version of the European Green Deal. It will provide a race toward fully implementing a renewable energy grid. This phase aims to establish the Energy-Ecology corridor and organise its expansions and habitats. Renewable energy is produced like never before, but at the same time, an ecological corridor appears following the transmission lines and providing habitats for fauna & flora.

0 5 km N

2100

Landscape (Land cover)	*Elements (Land-use)*	*Energy-ecology intervention*	*Category*	*RE and intensity*	*Action*
Built-up	Inhabitation				
	Power plant		Production of electricity	++	From croplands residues
	Highway				Minimum 2km wide bridge for fauna&flora habitats
	Railway				Underground
Croplands	Arable land Intensive or Greenhouses	Energy production	Solar energy	+	Agrivoltaics
			Biomass	++	Biofuel crops grow in competition with feed crops Collection rate of residues from pruning and grasses
			Non-extractive energy	++	Assign areas
		Food production	Regenerative practices	++	Sustainable agriculture
		CCS	Industrial	+	Assign areas
		Soil and nutrient protection	Restoration	+	Practises of restoration of soil health
		Water regulation	Flood protection w/ wetlands	+	Assign areas
	Arable land Extensive or livestock	Habitats for biodiversity	Rewilding	+++	Low intervention patches as "stepping-stones"
		Energy production	Solar energy	+	Agrivoltaics
			Biomass	++	Biofuel crops grow in competition with feed crops Collection rate of residues from pruning and grasses
			Non-extractive energy	+	Assign areas
		Food production	Regenerative practices	+++	Avoid emissions and use livestock as maintenance
		CCS	Industrial	+	Begins decomission
		Soil and nutrient protection	Restoration	+	Practises of restoration of soil health
		Water regulation	Flood protection w/ wetlands	+	Natural water regulation
	HNV or Natura 2000	Renewable energy	Biomass	+	Collection rate of residues from pruning and grasses
		Habitat for biodiversity	Conservation	+++	Lower intervention
Ecotone	Meadows or forestry	Habitat for humans	Recreational park	+	Accessible PV structure
		Energy production	Primary residues Secondary residues	++ ++	Available residues only from residue extraction but no stomp removal allowed
			Solar park	++	Accessible PV structure
			Non-extractive energy	++	Assign areas
		CCS	CCS plant	+	Begins decomission
		Habitat for biodiversity	Effective ecological corridor	+++	Assign areas
	Near cities	Foster local community	Educational	++	Visitations on Energy-Parks
		Habitat for humans	Energy-Industry-Park	++	Recreation and tourism

Parameters

- High-voltage transmission lines
- Energy-ecology corridor (5km buffer zone)
- Conservation areas (Natura2000)
- Commercial forest
- Agglomeration zones > 1M inhabitants
- Agglomeration zones < 1M inhabitants
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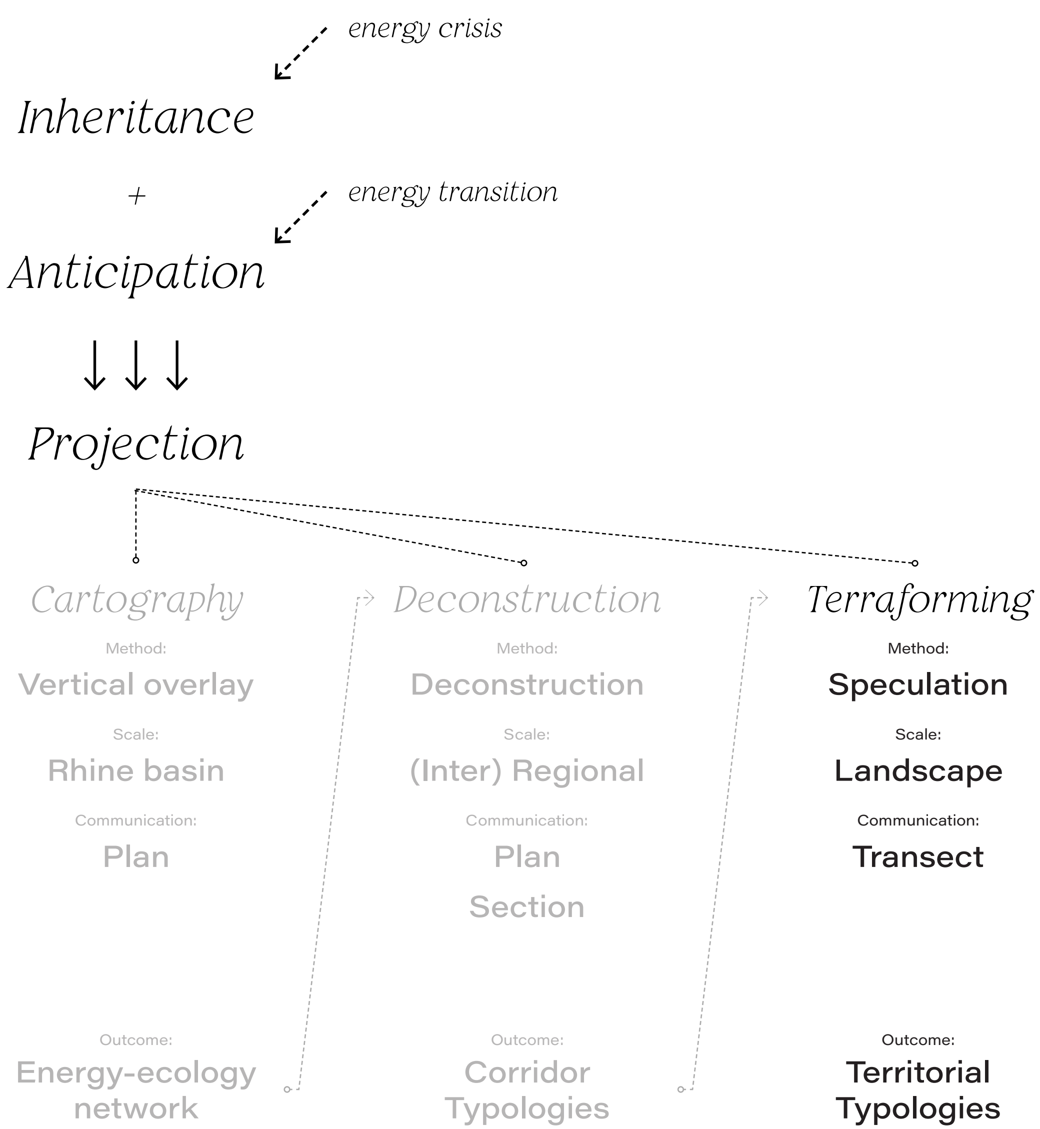
- Forestry and woodlands
- Grasslands, heathlands and shrublands
- Croplands

The inauguration of another century inherits now the consequences and restorations of the century of overall systems degradation and restoration. In a hopeful future, the next temporality of energy landscapes will be non-extractive, and this time-frame envisions its scaling-up. This phase imagines a post-extractive energy temporality in which its previous productive landscapes can be given to ecological purposes. The Energy-Ecology corridor becomes a haven of flourishing species. Land can rest, and ecotones are parks of biomass production, educational, aesthetic, and cultural heritage values, as well as recreation and tourism respectably taking form attentive to the ecological purposes of the area.

0 5 km N

Terraforming

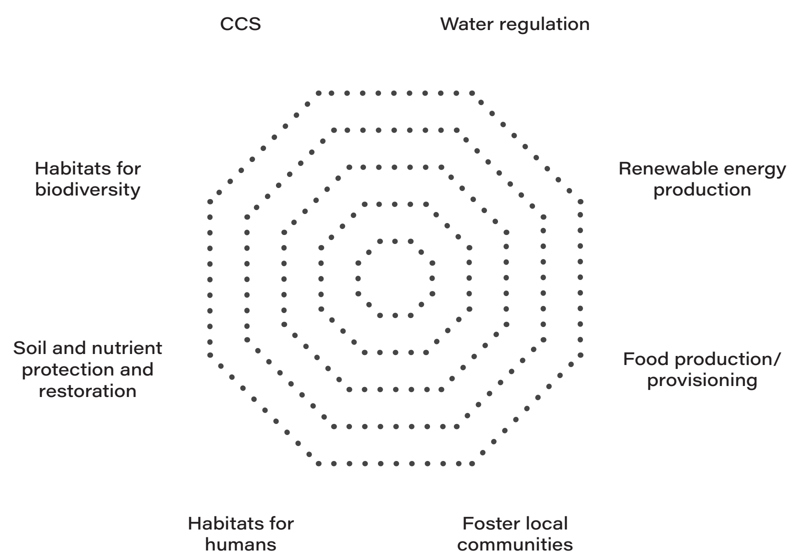


The terraforming of future operational landscapes of energy

Terraforming is something that humanity does as it inhabits the Earth. It adapts and is adapted to its conditions. Moreover, if the relation to energy carries humanity through every new spatial possibility, in that case, another significant terraforming is set to happen in some decades, triggered by the energy transition from non-renewable to renewable energy conversion technologies yielding different spatial outcomes. However, this will not be the last one. The understanding of a continuous transitional process is what asks for the nuance to not design a solution but to speculate on intentioned terraforming, with a design that mediates other ways of seeing the world. As said before, the terraforming is assembling an alternative brief that sets other futures today. It must reflect a position of care towards the habitats for the entities of Earth in the inevitable state of climate instability.

For that reason, the last part of the "projection" adds more resolution on the territorial scale showing the transitions for the future operational landscapes of energy. It focuses on the configurations and elements of how each typology of energy landscape can behave in 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. Not only that, but also proposes new forms of coexistence on the ground, between elements, according to distances, through space and time.

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.



CCS (Carbon capture and storage)
It means NETs that are biological or industrial. Afforestation, reforestation, soil carbon sequestration, 'blue carbon' habitat restoration are some of the "planetary intelligence" to balance the levels of carbon along the biosphere. Industrial CCS technologies can also contribute to lower emissions already on the atmosphere.

Water regulation
Restoring the soil's quality and health leads to water regulation in the site and the region. (e.g. hazard regulation such as flood protection, water purification and filtration)

Renewable energy production
In the forms of wind, solar and biomass technologies and respecting the ecological limits to its operation, each form of energy production must be used in the most efficient way possible. When non-extractive or other more respectable ways of dealing with the natural processes for energy generation become available, they will substitute this category.

Food production/provisioning
Through regenerative agriculture, agroforestry, agroecology and many other methods that are more just towards the natural processes temporality and yield; the methods of food provisioning must be in line with ecological limits (for example, crop pollination is a consequence of providing habitats for biodiversity) and the objectives of the region.

Foster local community
Implementing this Energy-Ecology must be beneficial for the overall livelihood of the region's inhabitants and find a balance between short and long-term benefits.

Habitats for humans
Forms of human involvement such as educational, aesthetic, and cultural heritage values as well as recreation and tourism take form in a respectable manner to the energy and ecological purposes of the area.

Soil and nutrient protection and restoration
Any form of production must respect the soil limitations and work within ecological limits. Also, practices of restoration are incentivised in more degraded zones - also to restore its stability.

Habitats for biodiversity
Ensure the continuation and thriving of fauna and flora species and their ecological needs through restoration and increased lower intervention in each kind of land-use. Which for humans may also benefit as "disease/pest control."

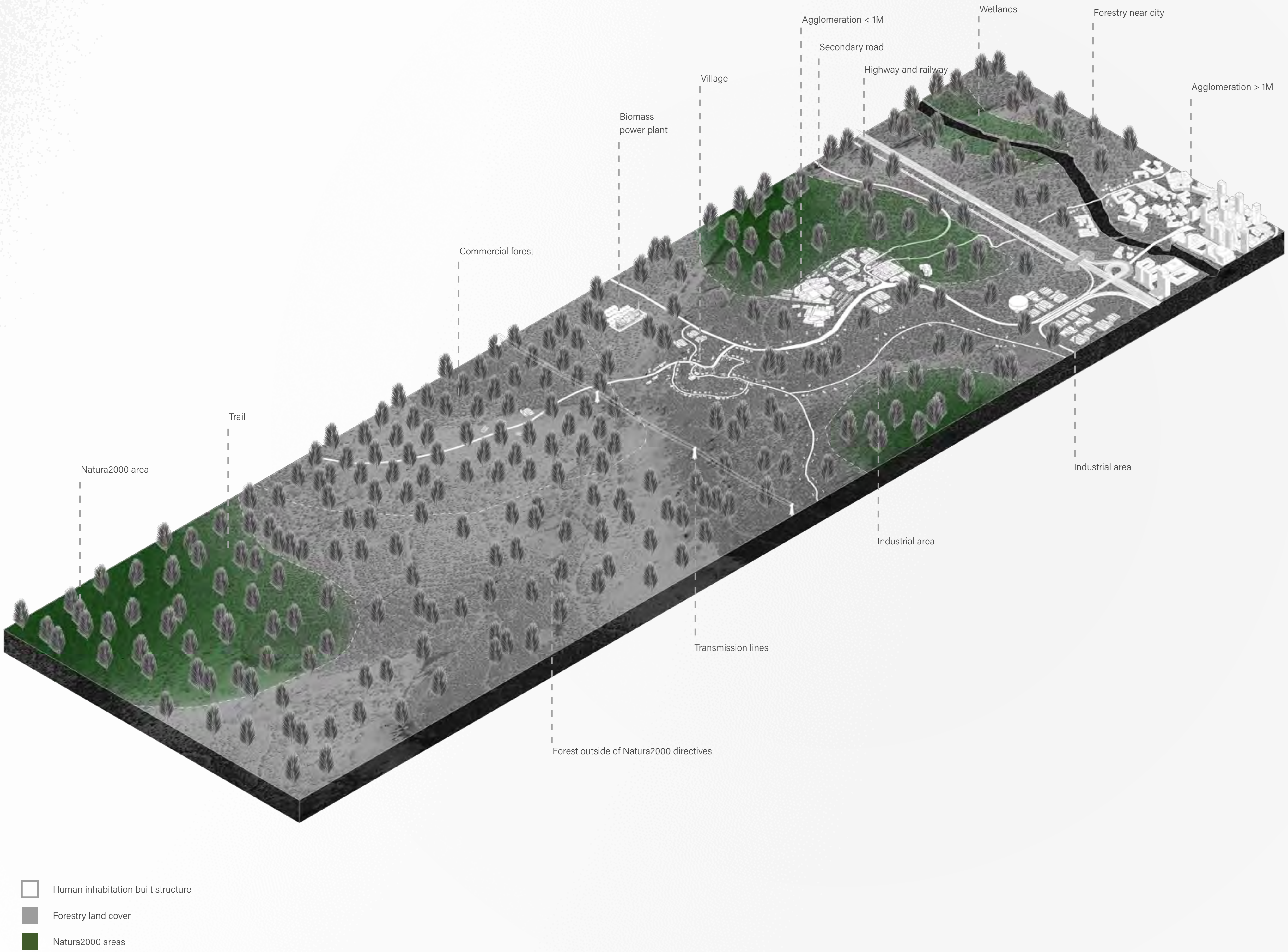
Energy-ecology goals/
interventions

Energy as regeneration of ecosystems

Adding to the previous framework, regeneration is a quality given to the energy infrastructure and its landscapes. Under the Energy-Ecology concept, this qualitative assessment is based on the frameworks of Rewilding perspectives (Navarro and Pereira, 2012) on landscape, tweaked to include the provision of energy.

For energy production to operate as an instrument for ecological restoration, the renewable landscapes of energy production should be about combining all of these qualities to some degree, depending on the potential, use and implementation zone in the overall "Energy-Ecology Network". Although many of them can be regarded as "ecosystem services", which have a very human-centred relationship to natural processes, the framework does not exclude the presence and needs of humanity; it aims to bring forward the focus to concomitantly regenerate ecosystems for a socio-ecologically just balance.

Woodland and forestry

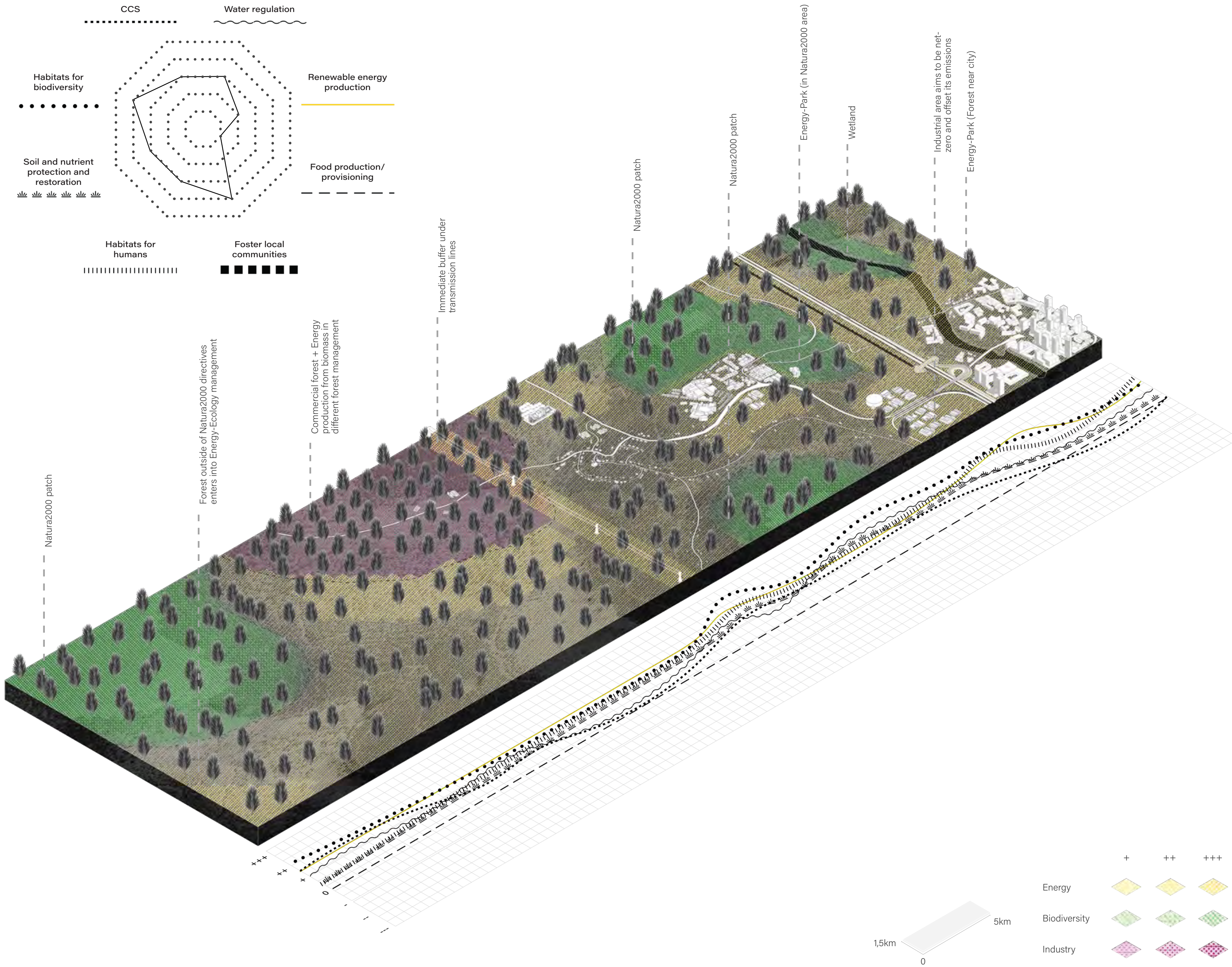


The forest land-use is one that is still to be fully explored again. Its main element is one of the most efficiently of natural ecosystems: trees.

Inside the Rhine basin landscape, they are mostly found in two categories: coniferous and broadleaf trees. One stays green during every season as the other works with a different strategy, losing its leaves during winter only to grow back again in warmer seasons.

To address both climate change and biosphere degradation, they are an important ally. Forest restoration could sequester up to two-thirds of accumulated emissions of CO_2 in the atmosphere, contributing decisively to limiting global warming to below 1.5°C, but these efforts will only be effective if directed towards restoring natural, biologically complex and self-sustaining forests. However, not all proposed approaches to ecosystem restoration are equally suitable to contribute effectively to these goals. For example, active afforestation through plantation forestry of just one or a few rapid-growing species often exacerbates rather than properly addresses environmental problems, and may result in impoverished biodiversity, and does not guarantee self-sustained and resilient ecosystem functions in time. The "Energy-Ecology" concept can provide a way to implement efficient ways to deal with forests welcoming practices for lower intervention or with a new industrial of approaching them.

The typological transect of a forestry landscape on the left portrays the current condition, with the elements that are most found in the territory of the Rhine basin. The next pages will show the speculation until a new temporality of energy landscapes.



2030

Natura2000 patches
The "free-standing" patches will receive lower intervention and become designated to rewilding.

Forest outside of Natura2000 directives
A different regime for biomass extraction is fully realised. Forestry harvest patterns are according to strict sustainability criteria and available residues only from residue extraction, but no stomp removal allowed.

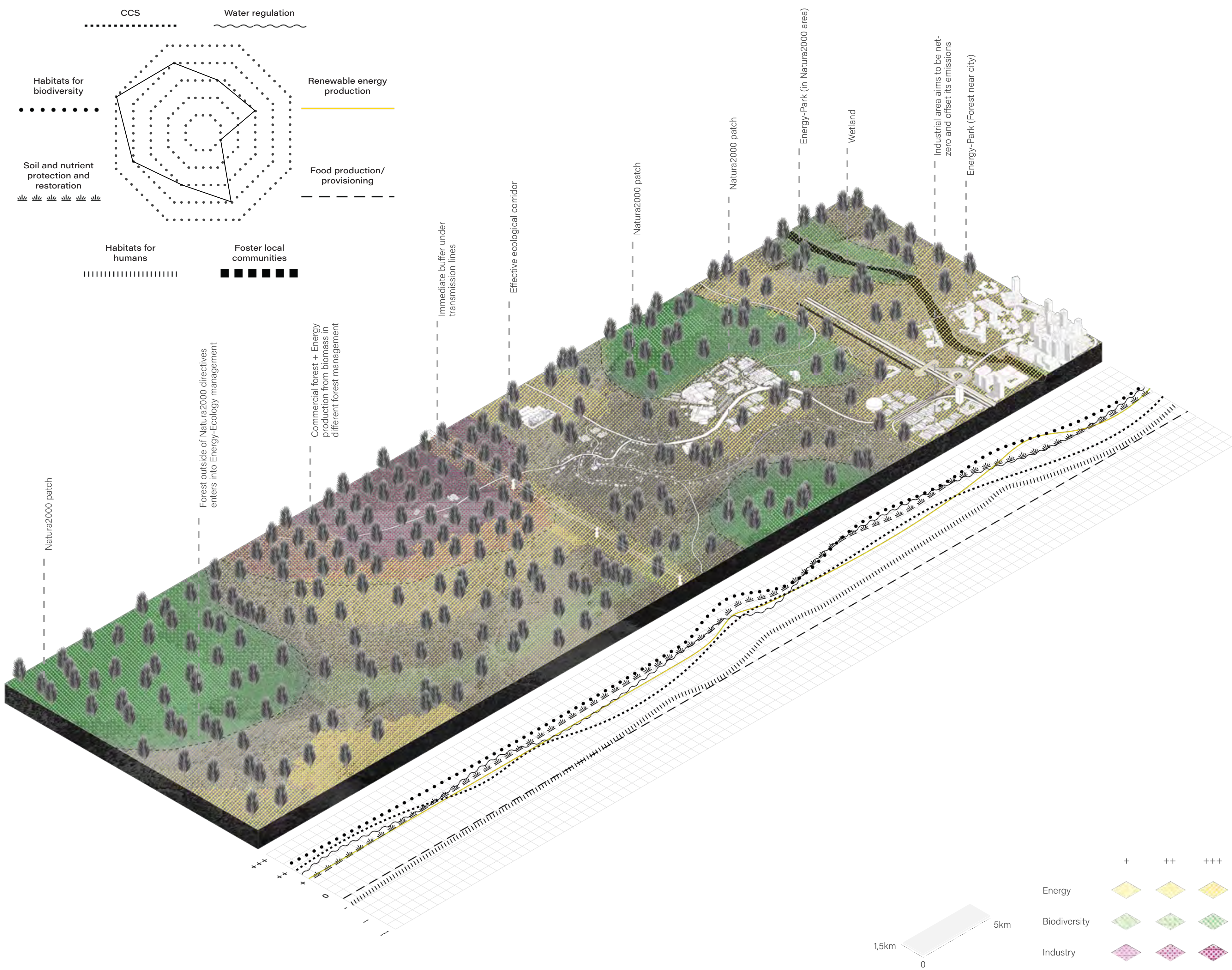
Commercial forest
Different forest management to improve the health of the overall ecosystem in already deforested or degraded land. Stem wood and forestry residues available for energy production. Wind energy is introduced, however, following the local needs.

Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass where available residues come only from residue extraction, with no stomp removal allowed.

Energy-Park (in Natura2000 area)
Introduces energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. As it lies on a protected area, patches of no intervention are strategically positioned to be further connected when the need for energy production is lower.

Wetland
Aims at moderate energy production, leaving space for restoration of its soil and ecological functions. Using solar panels, wind turbines and biomass production to redesign the area.

Energy-Park (Forest near city)
Focus on intensive energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. In the ecotone closer to the city, industrial CCS technologies are also installed.



2050

Natura2000 patches
The "free-standing" patches are havens for fauna & flora and become better connected through the EEN management and especially through the assigning of an ecological corridor.

Forest outside of Natura2000 directives
A different regime for biomass extraction is fully realised. Forestry harvest patterns are according to strict sustainability criteria and available residues only from residue extraction, but no stomp removal allowed.

Commercial forest
Different forest management to improve the health of the overall ecosystem in already deforested or degraded land. Stem wood and forestry residues available for energy production increase. Wind energy begins to be decomissioned.

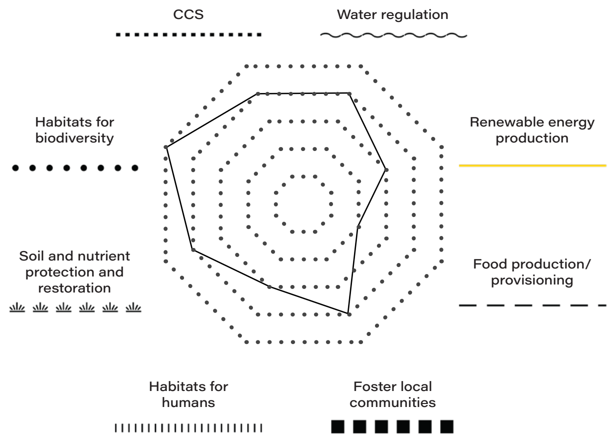
Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass where available residues come only from residue extraction, with no stomp removal allowed.

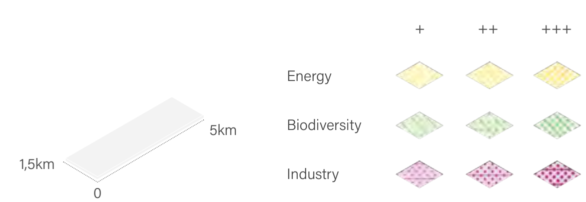
Effective ecological corridor
At this stage, the corridor takes shape and connects the Natura2000 patches in a type of forestry management that focus on low intervention.

Energy-Park (in Natura2000 area)
Focus on moderate energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. As it lies on a protected area, patches of no intervention are strategically positioned to be further connected when the need for energy production is lower.

Wetland
Aims at moderate energy production, leaving space for restoration of its soil and ecological functions. Using solar panels, wind turbines and biomass production to redesign the area.

Energy-Park (Forest near city)
Focus on intensive energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. In the ecotone closer to the city, industrial CCS technologies converts the captured carbon for other uses, creating monuments and investing in a circular economy.





2100

<u>Natura2000 patches</u>
The "free-standing" patches are havens for fauna & flora and become better connected through the EEN management and especially through the assigning of an ecological corridor.

<u>Forest outside of Natura2000 directives</u>
A different regime for biomass extraction is fully realised. Forestry harvest patterns are according to strict sustainability criteria and available residues only from residue extraction, but no stomp removal allowed.

<u>Commercial forest</u>
Different forest management to improve the health of the overall ecosystem in already deforested or degraded land. Stem wood and forestry residues available for energy production increase. Wind energy begins to be decomissioned.

<u>Immediate buffer under transmission lines</u>
Focus on intensive (as maximum inside a sustainable management) energy production from biomass where available residues come only from residue extraction, with no stomp removal allowed.

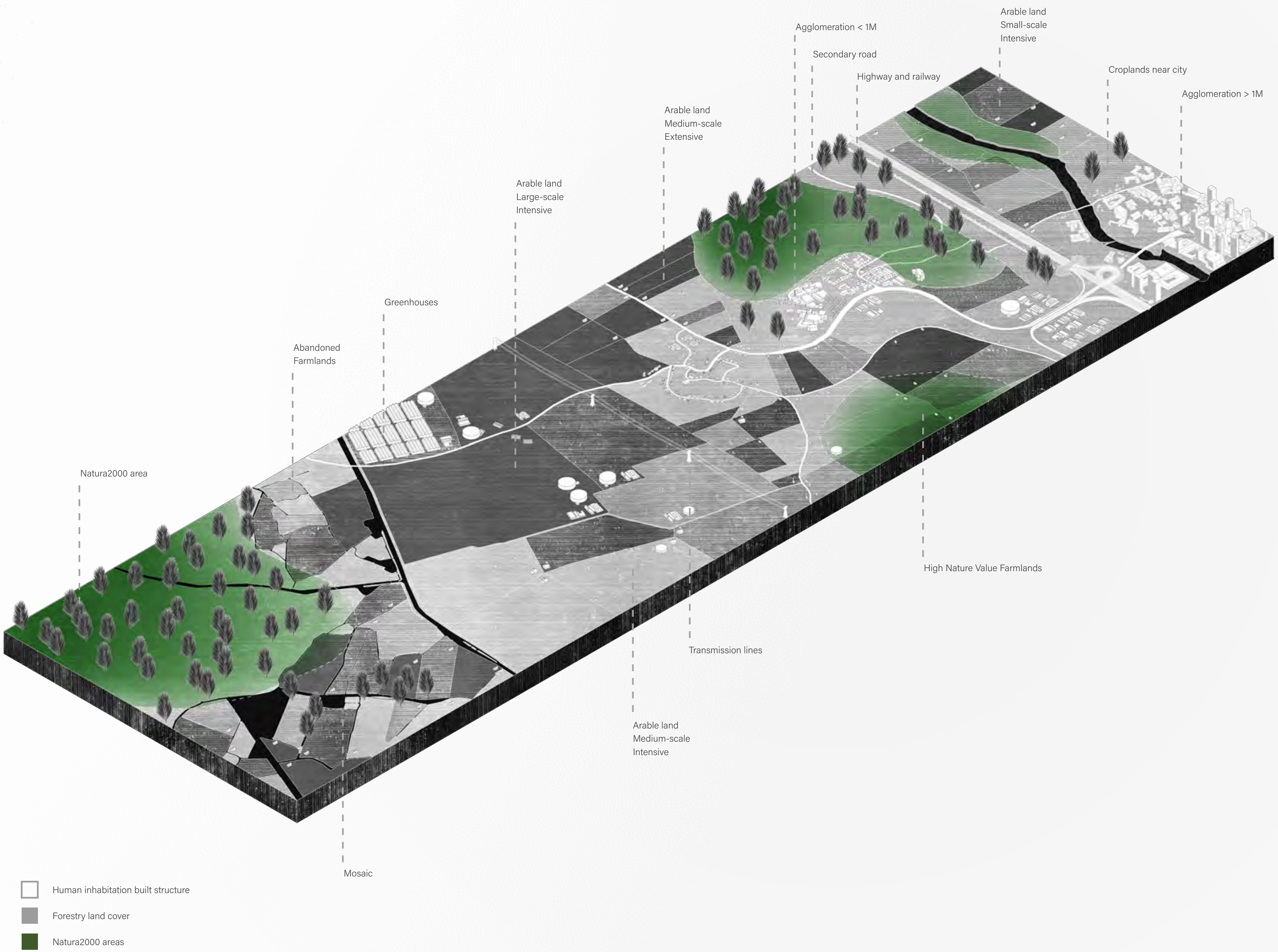
<u>Effective ecological corridor</u>
At this stage, the corridor takes shape and connects the Natura2000 patches in a type of forestry management that focus on low intervention.

<u>Energy-Park (in Natura2000 area)</u>
Focus on moderate energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. As it lies on a protected area, patches of no intervention are strategically positioned to be further connected when the need for energy production is lower.

<u>Wetland</u>
Aims at moderate energy production, leaving space for restoration of its soil and ecological functions. Using solar panels, wind turbines and biomass production to redesign the area.

<u>Energy-Park (Forest near city)</u>
Experiment on a mix of conservation practices with new energy production technologies for educational purposes. It is a learning space for the near-city to learn about new productive landscapes spatialities. In the ecotone closer to the city, industrial CCS technologies converts the captured carbon for other uses, creating monuments and investing in a circular economy.

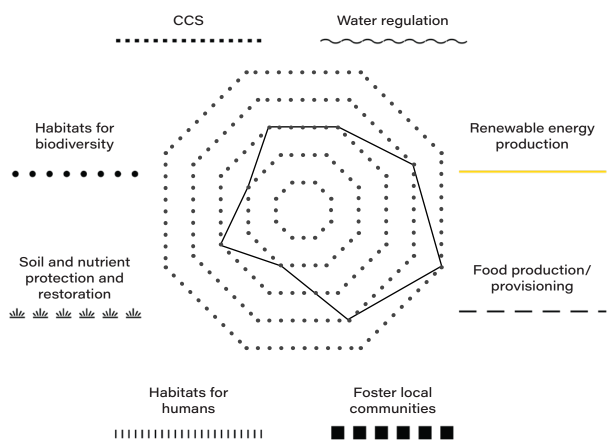
Croplands

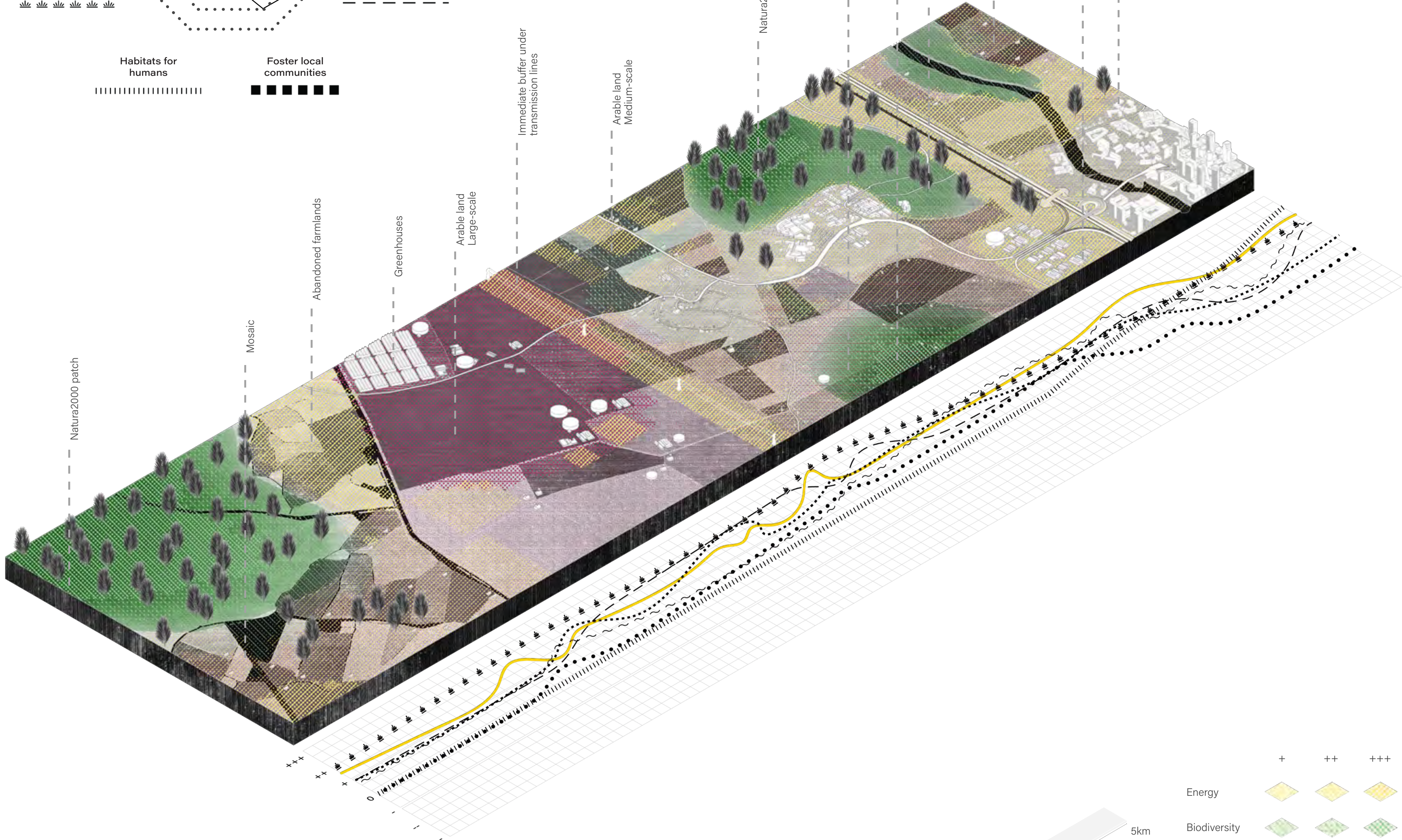


The proposal inside temporalities aims to not only design the probable and the possible, but also to expand and demonstrate land management aspects inside the translation of the Energy-Ecology Network in agricultural landscapes. The urban design of this typology envisions new paradigms in response to energetic demand, climatic response and definition of ecological areas for expansion.

According to Peter Verburg (Verburg et al., 2013), three important dimensions of present-day agricultural landscapes are land cover, land management and landscape structure. The Energy-Ecology Network is a novel landscape structure for those lands, balancing new values of energy and ecological provisioning. Its land cover is varied, and not taken into consideration in the resolution of the study, being relevant when encountering local situations. The land management aspect is, however, highly important. The ways in which the vegetation, soil, and water are treated in agricultural practices yield highly different spatial outcomes, with higher productivity and/or degradation.

To better understand the large 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 EEN is being implemented. Instead of addressing a location, this method reduces the variety in 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 for each purpose - industry or biodiversity. This form of representation aims to serve as an assessment to assist and visualise landscapes' influence on environmental change.





2030

Natura2000 patches
The "free-standing" patches will receive lower intervention and become designated to rewilding.

Mosaic
Regenerative agriculture is new norm to restore degrade soil and foster the recovery and resilience of natural processes.

Abandoned farmlands
A different regime for biomass extraction is fully realised, according to strict sustainability criteria and available residues only from residue extraction, but no stomp removal allowed.

Greenhouses
Its expansion is only allowed if associated with PV panels and introduces industrial CCS technologies.

Arable land | Large scale
Regenerative agriculture is new norm to restore degrade soil and foster the recovery and resilience of natural processes to revert the common association of intensive large-scale arable land with intensive feed crops that degrade the soil with high amounts of nitrogen input and GHG emissions.

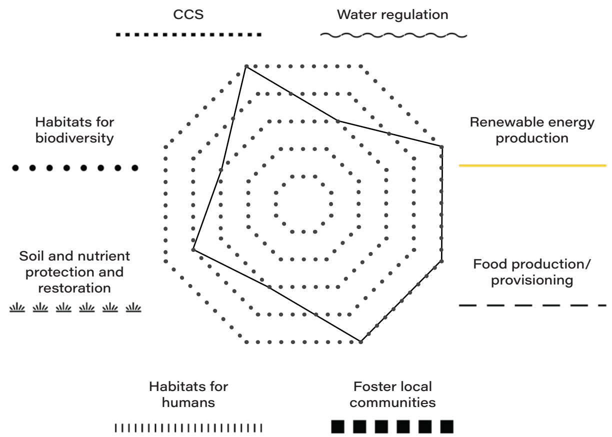
Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass where available residues come only from residue extraction, with no stomp removal allowed.

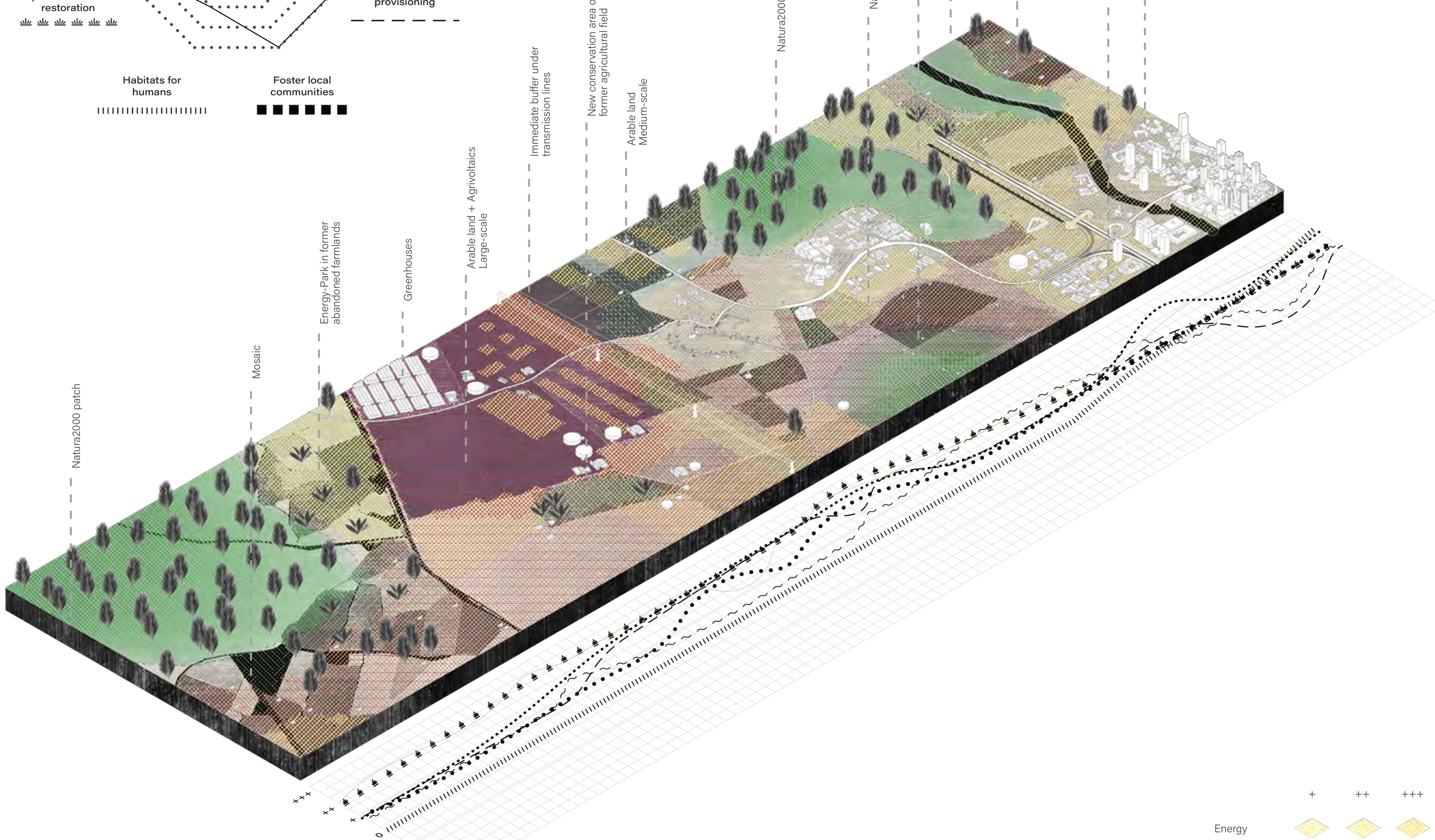
Arable land | Medium scale
Regenerative agriculture is new norm to restore degrade soil and foster the recovery and resilience of natural processes. Medium-scale arable lands also benefit from the CAP and energy policies to prioritise renewable energy production, like the agrivoltaics system or agroecology/agroforestry that includes a sustainable biomass extraction regime.

High-Nature-Value Farmlands
Low-intensity farming for the continuing long-term existence of structural diversity and the habitats for flora & fauna.

Arable land | Small scale
Regenerative agriculture is new norm to restore degrade soil and foster the recovery and resilience of natural processes. To foster its implementation, it benefits from the CAP and energy financing systems to introduce renewable energy production, like the agrivoltaics system.

Energy-Industry-Park (Croplands near city)
Focus on intensive energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. In the ecotone closer to the city, industrial CCS technologies are also installed.





2050

Natura2000 patches
The "free-standing" patches are havens for fauna & flora and become better connected through the EEN management and especially through the assigning of an ecological corridor.

Mosaic
Regenerative agriculture practices are intensified. It also introduces energy production from solar, wind and biomass.

Abandoned farmlands
Intensive energy production from wind energy with the regime for biomass extraction in strict sustainability criteria and available residues only from residue extraction, but no stomp removal allowed. Envisioning to be part of the effective ecological corridor in the future.

Greenhouses 2.0
Its expansion is only allowed if associated with PV panels, high sustainable practices and industrial CCS technologies.

Arable land | Large scale
Regenerative agriculture practices are sustained along with patches assigned to intensive energy production.

Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass, agrivoltaics, wind energy and new technologies.

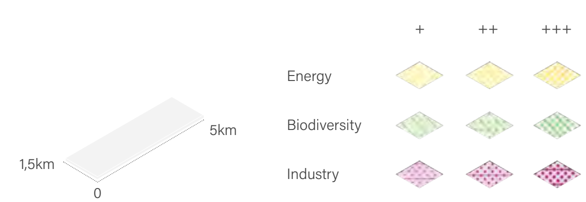
New conservation area on former agricultural field
In order to build an ecological corridor, certain fields focus intensively on practices of rewilding.

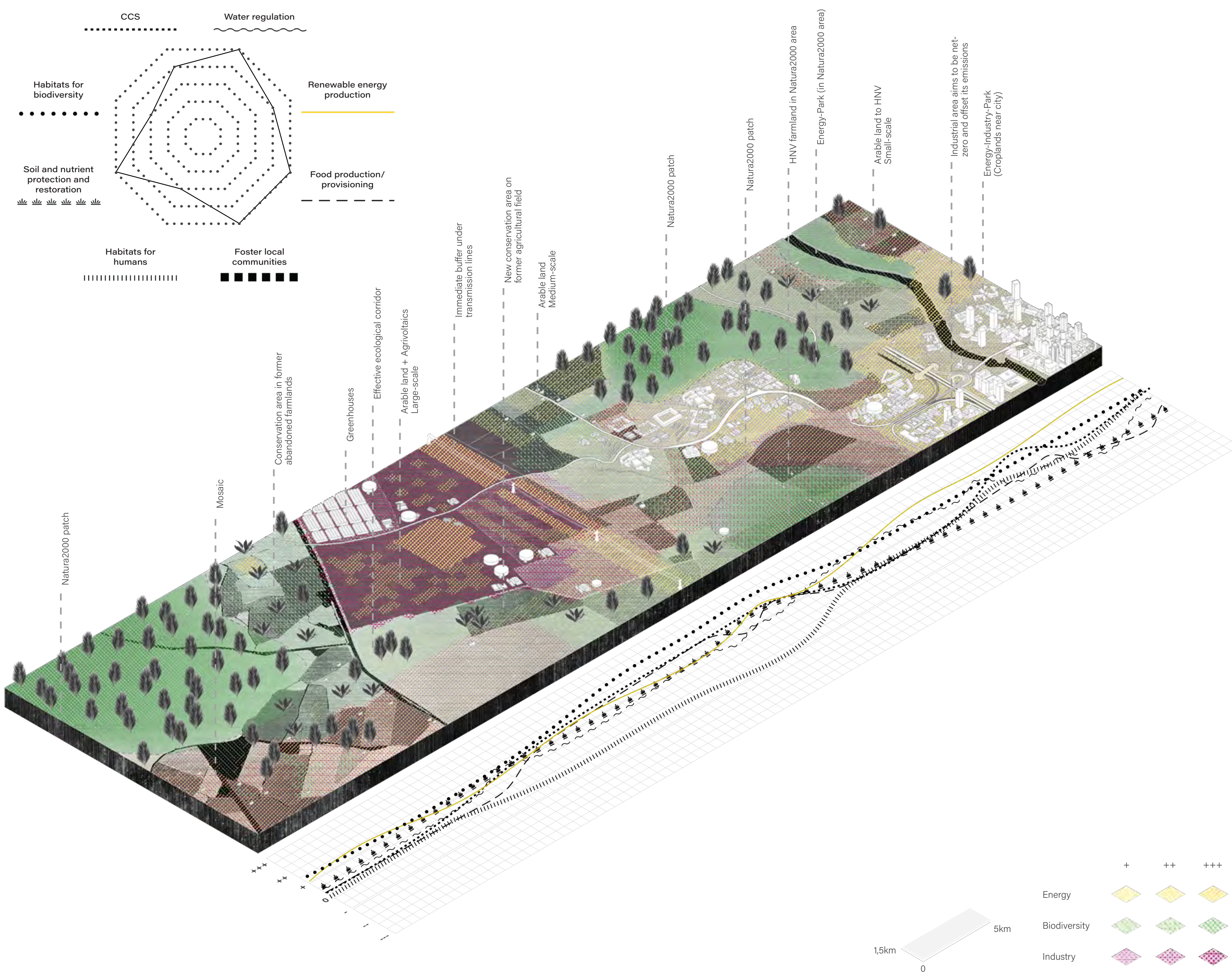
Arable land | Medium scale
Regenerative agriculture practices are intensified, especially in the patches assigned to low and moderate energy production. Also certain fields begin to focus intensively on practices of rewilding.

High-Nature-Value Farmlands
Low-intensity farming for the continuing long-term existence of structural diversity and the habitats for flora & fauna.

Arable land | Small scale
Regenerative agriculture practices are intensified, especially in the patches assigned to low and moderate energy production. Also certain fields begin to focus intensively on practices of rewilding.

Energy-Industry-Park (Croplands near city)
Focus on intensive energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about productive landscapes with energy production. In the ecotone closer to the city, industrial CCS technologies converts the captured carbon for other uses, creating monuments and investing in a circular economy.





2100

Natura2000 patches
The patches are havens for fauna & flora and become better connected through the EEN management and especially through the assigning of an ecological corridor.

Mosaic
Regenerative agriculture practices are intensified. Energy production from solar, wind and biomass is maintained but newer technologies for energy production is introduced along with conservation areas.

Abandoned farmlands
These areas transition from an energy production to a conservation area with some areas for non-extractive energy production.

Greenhouses 2.0
Its expansion is only allowed if associated with PV panels and high sustainable practices. Industrial CCS begins to be decomissioned.

Arable land | Large scale
Regenerative agriculture practices are sustained. Patches for energy production begins to receive new technologies.

Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass, agrivoltaics and wind energy.

Effective ecological corridor
The corridor connects the Natura2000 patches in a management that focus on low intervention.

New conservation area on former agricultural field
In order to build an ecological corridor, certain fields begin to focus intensively on practices of rewilding.

Arable land | Medium scale
Regenerative agriculture practices are sustained. Patches for energy production begins to receive new technologies. Certain fields become conservations areas or HNV.

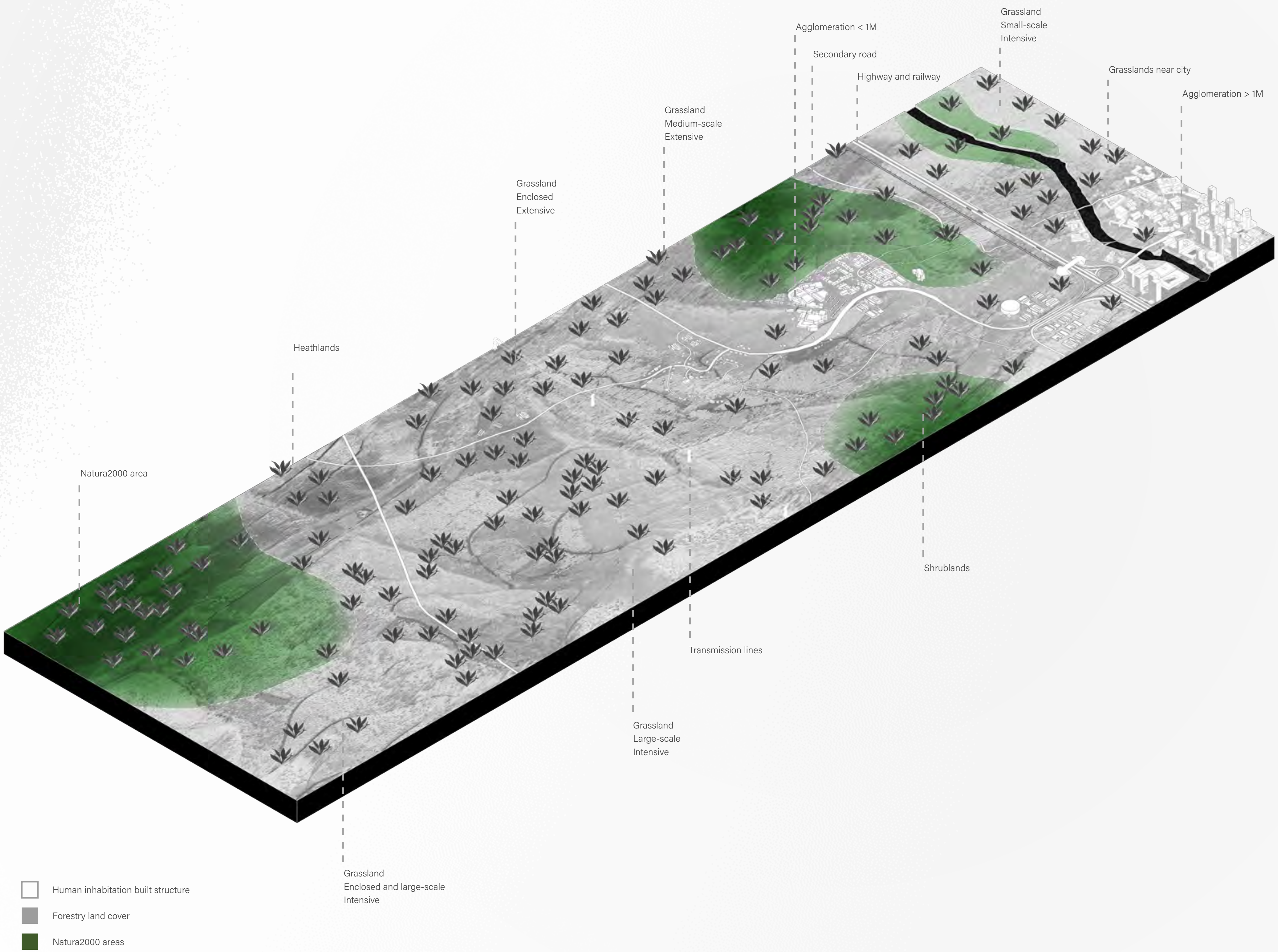
High-Nature-Value Farmlands
Low-intensity farming for the continuing long-term existence of structural diversity and the habitats for flora & fauna.

Energy-Park (in Natura2000 area)
Focus on moderate energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. Patches of no intervention are connected to each other and to the ecological corridor.

Arable land | Small scale
Regenerative agriculture practices are sustained. Patches for energy production begins to receive new technologies. Certain fields become conservations areas or HNV.

Energy-Industry-Park (Croplands near city)
Experiment on a mix of conservation practices with new energy production technologies for educational purposes. It is a learning space for the near-city to learn about new productive landscapes spatialities. In the ecotone closer to the city, industrial CCS technologies converts the captured carbon for other uses, creating monuments and investing in a circular economy.

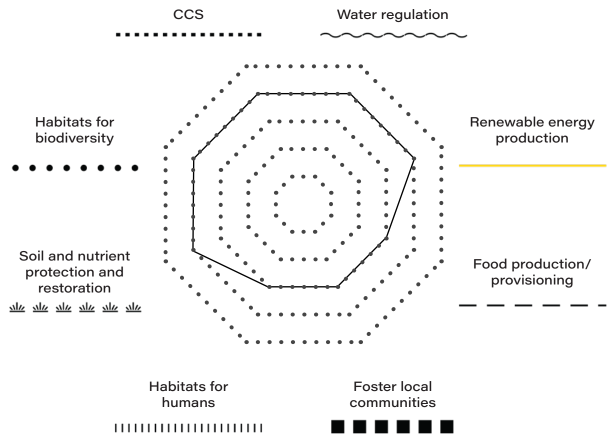
Grasslands, heathland and shrublands

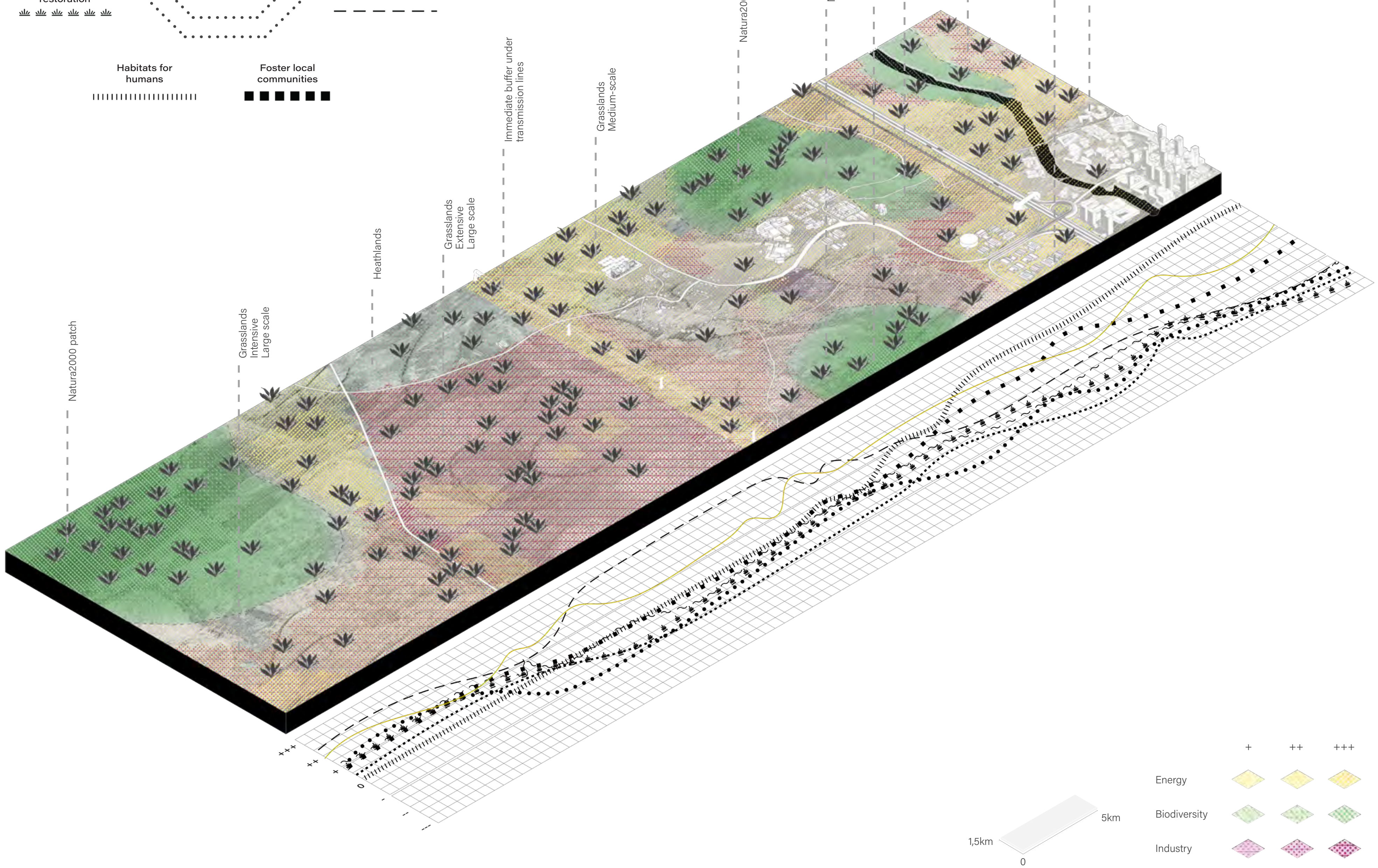


The temperate grassland biome is made up of large open areas of grasses and shrubs, where trees can be present, but they are infrequent. UNESCO defines grassland as "land covered with herbaceous plants with less than 10% tree and shrub cover." There are many types of grasslands in the Rhine Basin boundaries. Here they are gathered as an ecosystem. Its further particularities are to be designed in other resolution when encountering local contestations.

The ecosystem recognised as grasslands 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 therefore 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 important to mention the links between the agricultural and grassland habitats. It is hard to find, in the Rhine basin, a grassland ecosystem that has not been modified and, to a significant extent, been created and maintained by agricultural activities. These grasslands are maintained through farmers' grazing and/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 provides an opportunity for the transition of these areas under the Energy-Ecology frameworks, with alternative management policies aimed at providing energy as it recovers landscapes with higher-value nature. The rewilding in these areas can also provide new services to society, such as carbon sequestration, recreation and regulation of natural disturbances. (Fernández et al., 2020) As the balance tilts towards increased biodiversity, many benefits are also enjoyed by the humans; for example, the reduction of fire risk through the browsing and grazing activity of large herbivores.





2030

Natura2000 patches
The "free-standing" patches will receive lower intervention and become designated to rewilding.

Grasslands | Intensive
Energy production is introduced as alternative to intensive livestock or other productive practices, making it possible for the soil to rest and recover. Introduction of industrial CCS technologies.

Heathlands
Low intervention practices aim at maintaining or restoring these ecosystems.

Grasslands | Extensive
Energy production is introduced in combination with other productive practices.

Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass where available residues come only from residue extraction, with no stomp removal allowed.

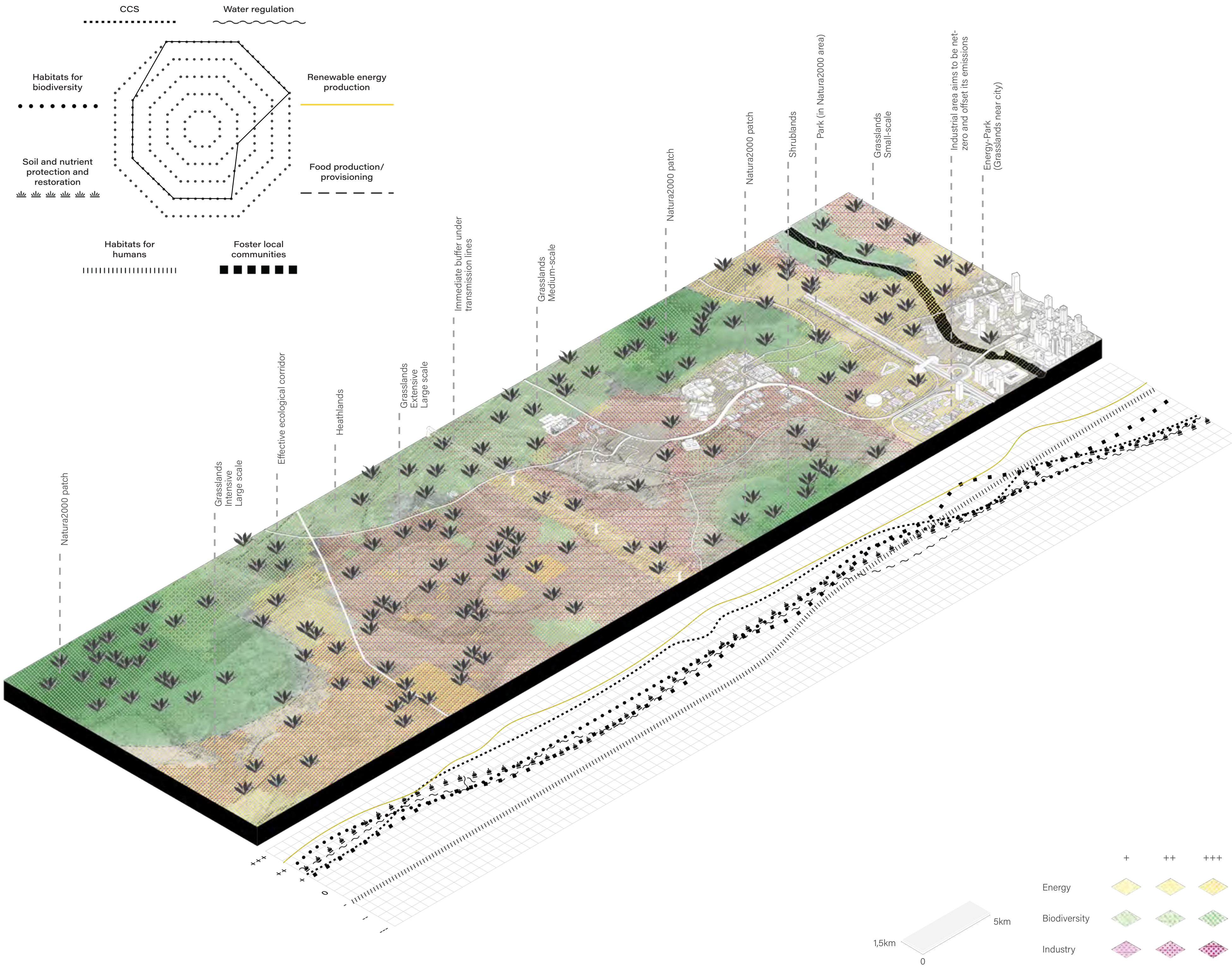
Grasslands | Medium scale
Energy production is rapidly introduced in combination with other productive practices. Some patches are reserved for conservation in order to later join in an ecological corridor. Introduction of industrial CCS technologies.

Shrublands
Low intervention practices aim at maintaining or restoring these ecosystems.

Park (in Natura 2000 area)
Low intervention practices find a balance with current productive practices in order to further preserve the area.

Grasslands | Small scale
Energy production is introduced in combination with other productive practices. Some patches are reserved for conservation in order to later join in an ecological corridor. Introduction of industrial CCS technologies.

Energy-Industry-Park (Grasslands near city)
Focus on intensive energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about energy. In the ecotone closer to the city, industrial CCS technologies are also installed.



2050

Natura2000 patches
The "free-standing" patches are havens for fauna & flora and become better connected through the EEN management and especially through the assigning of an ecological corridor.

Grasslands | Intensive
Energy production is prioritised as alternative to intensive livestock or other productive practices, with high implementation of solar, wind and biomass regimes in an ecological design. Industrial CCS technologies scale-up.

Effective ecological corridor
The corridor connects the Natura2000 patches in a management that focus on low intervention even though it still has some biomass extraction.

Heathlands
Low intervention practices aim at maintaining or restoring these ecosystems.

Grasslands | Extensive
Energy production is intensified and combined with other productive practices, with high implementation of solar, wind and biomass regimes in an ecological design. Industrial CCS technologies scale-up.

Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass where available residues come only from residue extraction, with no stomp removal allowed.

Grasslands | Medium scale
Energy production is combined with patches that are part of an ecological corridor. Industrial CCS technologies scale-up.

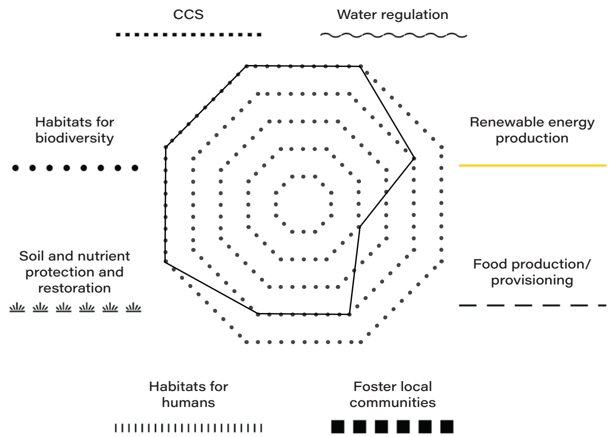
Shrublands
Low intervention practices aim at maintaining or restoring these ecosystems.

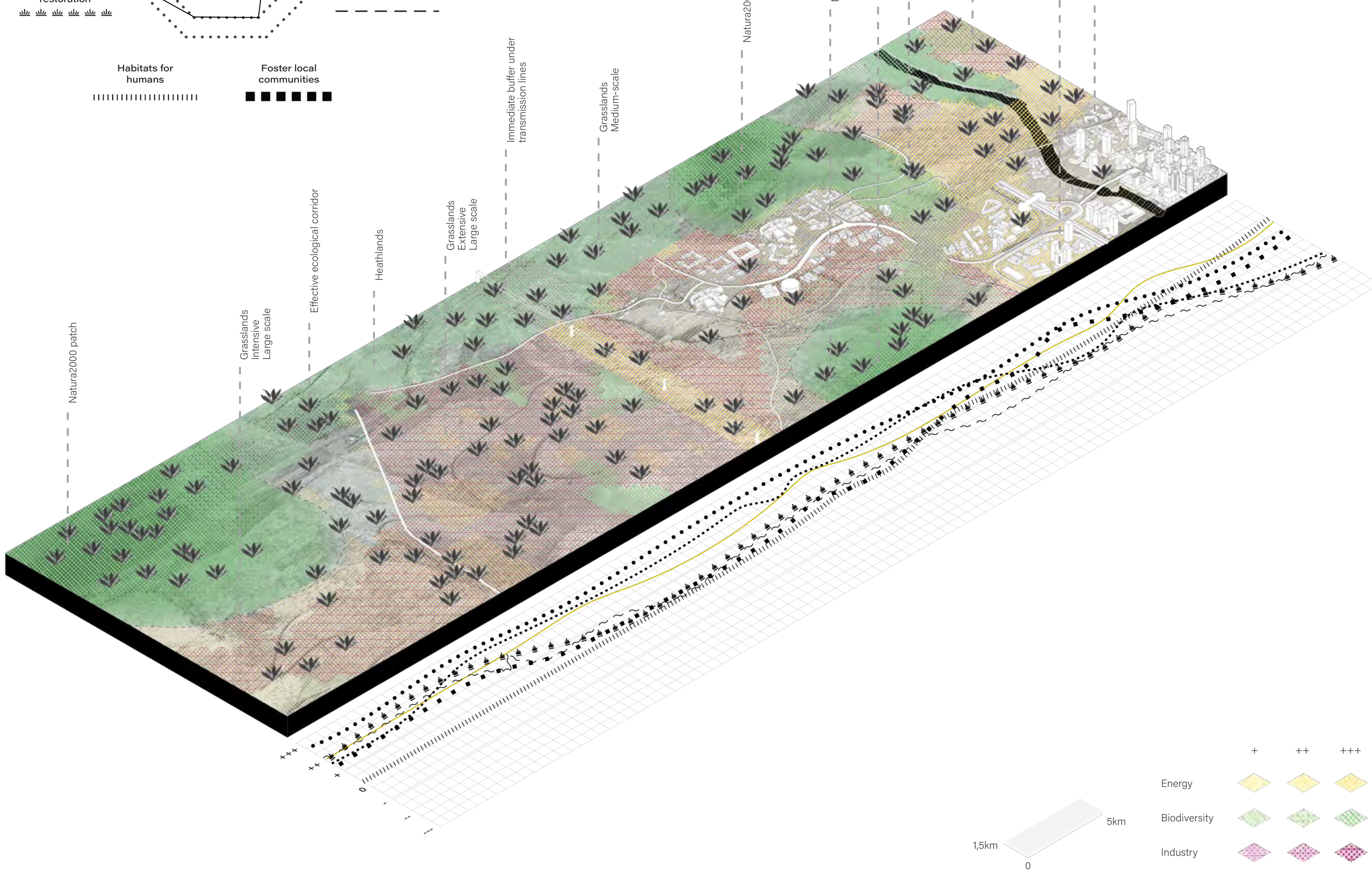
Park (in Natura 2000 area)
Low intervention practices find a balance with current productive practices in order to further preserve the area.

Grasslands | Small scale
Energy production is combined with patches that are part of an ecological corridor. Industrial CCS technologies scale-up.

Energy-Industry-Park (Grasslands near city)
Focus on intensive energy production and high levels of educational, cultural and recreational use among renewable energy technologies. It is a learning space for the near-city to learn about productive landscapes with energy production. In the ecotone closer to the city, industrial CCS technologies converts the captured carbon for other uses, creating monuments and investing in a circular economy.

2100





Natura2000 patches
The patches are havens for fauna & flora and become better connected through the EEN management and especially through the assigning of an ecological corridor.

Grasslands | Intensive
Energy production and other productive practices introduces non-extractive and new energy production technologies.

Effective ecological corridor
The corridor connects the Natura2000 patches in a management that focus on low intervention.

Heathlands
Low intervention practices aim at maintaining or restoring these ecosystems.

Grasslands | Extensive
Energy production is intensified and combined with other productive practices, with high implementation of solar, wind and biomass regimes in an ecological design. Industrial CCS technologies scale-up.

Immediate buffer under transmission lines
Focus on intensive (as maximum inside a sustainable management) energy production from biomass where available residues come only from residue extraction, with no stomp removal allowed.

Grasslands | Medium scale
Energy production is combined with patches that are part of an ecological corridor. Industrial CCS technologies are decomissioned.

Shrublands
Low intervention practices aim at maintaining or restoring these ecosystems.

Park (in Natura 2000 area)
The area is preserved but also allowed visitation, turning into a preserved park.

Grasslands | Small scale
Energy production is combined with patches that are part of an ecological corridor. Industrial CCS technologies are decomissioned.

Energy-Industry-Park (Grasslands near city)
Experiment on a mix of conservation practices with new energy production technologies for educational purposes. It is a learning space for the near-city to learn about new productive landscapes spatialities. In the ecotone closer to the city, industrial CCS technologies converts the captured carbon for other uses, creating monuments and investing in a circular economy.

Resonances

Reflection

The choice of my method

The project follows a methodology identifying the evidence of energy landscapes to inform the next steps. Energy landscapes follow a temporality strongly linked with technologies and their translation to spatial possibilities. The interdisciplinary search on literature review and research of various data sets informed the fundamental understanding of energy as a spatio-temporal project. By looking into the previous energy modes, their operationalisation and consequences, it provided the support to work with the chosen perspectives, time-frames and territorial typologies to make visible a more ecological possibility for implementing energy technologies in the scale of the Rhine basin.

The methods followed, with their vertical and horizontal, trans-scalar and temporal approaches, aim to make sense of the complexity of the territory. Some more specific aspects provide an elaboration on the process; reflecting on the methods, findings and proposals of the thesis:

(1) Relation between research and design (planning, processes and products)

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, evidence pointed to the current state of "energy transition" as one incapable of addressing the looming planetary issues of climate change and biosphere degradation, showing that perhaps the next mode of energy could address it adequately. This is laid out in a series of cartographies on the Rhine basin anticipating the renewable forms of energy landscapes summarised in the "Anticipation" section.

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 be the transitional territory for a new coexistence and balance between the provision of energy and ecological systems. Fulfilling the necessity to provide more basis to construct the bridge to propose inside ecological frameworks, a consultation with experts in the fields of biodiversity conservation and ecosystem dynamics was done. The contribution of their studies and sets of maps were crucial for the "Projection" section of this thesis. The first part of this section, "Cartography", overlays different kinds of infrastructures from the "Inheritance" and "Anticipation" reflections and takeaways and, adding the ecological perspective, builds a Rhine scale Energy-Ecology Network that implements the renewable mode of energy understanding its transitional essence and building connections between fragmented conservation areas as its alternative balance of energy production provides restoration of ecosystems and habitats for humans and biodiversity.

Different from scientific modelling, this is a type of projective future that belongs to the design field. It follows a method developed by Ian McHarg called the "suitability index". This cartographic method provides systems of infrastructural sites along the whole watershed that highlight the energetic conditions to interrupt, continue, or be proposed anew. Already heading towards a proposal, the cartographic overlay provides the infrastructural elements to be brought to the "Projection" and compose the Energy-Ecology Network. The Energy-Ecology Network is then demonstrated by designing ways to translate it to regional corridors and to typologies found in the landscapes of the scale-up of the renewable mode of energy. This is to provide frameworks that address the climate and biodiversity crises with restoration projects in many implementation scales. The elements and landscapes that form this network are refined in the following chapters of "Deconstruction" and "Terraforming". The former provides many corridor typologies for an inter-regional perspective on the "archipelago" of conservation. This is done through plans and sections for each relevant time frame with new balances influenced by an alternative understanding of Energy with Ecology. The latter shows the transition of the future operational

landscapes of energy production that form the network and uses typological transects to unpack the gradients, configurations and relations in these crucial landscapes.

Argumentation

All in all, it understands that transition is always happening and proposes to make the most of each period and energetic conditions for a terraforming that supports Earth-like life. It is worth mentioning that this method could be repeated for future energy modes, according to the need of designated areas for the human or the fauna and flora types of habitats and uses.

This highlights that not only the back and forth between the planetary, European, Rhine basin, regional and even local scales are invested with the proposals, but also time-scales are identified. They are 2030, 2050 and 2100. Apart from their specificities and scientific, ecological, societal and economic predictions that converge in them, they form a set of short, medium and long-term speculative framing needed for this terraforming.

'Energy as a spatio-temporal project: temporalities of energy landscapes in the Rhine basin" is a project for transitioning infrastructure, a kind of infrastructural landscape design. This method and proposal suggest that this understanding can "unlock" more socio-ecological structures, in this case, demonstrated through/for energy landscapes.

(2) The relation to the graduation studio methodological line of inquiry, reflecting upon the scientific relevance of the work

The research and design methods described above follow the line of inquiry and its bibliography, investing it with the perspective of energy landscapes, which takes its contours.

The interpretation of MATTER, TOPOS, HABITAT and GEOPOLITICS in energy landscapes is further explained in the section "Analytical framework", which also applies to the "Main adaptive cycles" as used in the first investigations in the studio activities.
The "Projection", which features the design interventions, follows the lines of Cartography, Deconstruction and Terraforming as means to model the elements, layers, relations and processes to be continued, interrupted or made new in the compositions and configurations of operational landscapes of renewable energy production.

What is the relation between the graduation (project) topic, the studio topic, your master's track (Urbanism), and your master's programme (MSc AUBS)?

The relation between this graduation project and the Transitional Territories studio is the same interest in dealing with the changing nature of the territorial project. The project is set within the Rhine basin and the conditions its watershed makes possible, from the Alps to the Delta region. Then, the instrument of Urban Design and Spatial Planning is used in a strategic approach to investigate, explore and propose, from the state of energy crises and transitions, in the ever-changing interrelations between natural processes, societal practices, and (geo)political frameworks that are influenced and influence landscapes of energy. Regarding the master track of urbanism, which is used to focus on the issues of the urban built space, the project looks at the other side of this process, the landscapes of "extended urbanisation" and its "operational landscapes". (Katsikis, 2020) This is also part of urbanisation, so it should be an object of research of the urbanism studies. Concerning the overall MSc AUBS program provided by the Faculty of Architecture and the Built Environment, this master thesis is a kind of "architecture of the territory" (Topalovic, 2016) that is a fitting engagement of the urban design at territorial scales, broadening the understanding of territory from the purely technical or administrative domain and also seeing it as design.

The learning experience

Personally, the process of elaboration of this thesis has developed my analytic, critical, conceptual and communication approach to understanding space not only as a planner or designer but as a thinker. I credit it to my mentors' constant insight and the chosen topic of discussion - energy landscapes.

The methods and pedagogy of the "Transitional Territories" studio have assisted me in deepening and outwork theoretical questions on the ambition of Spatial Planning and Urban Design towards a programmatic realignment to take more to the heart concerns of what is known about the biosphere humans inhabit and propose, in research and design a necessary repositioning. To "accomplish" - or just to build in this direction - this thesis let me construct interdisciplinary knowledge to try to operate in the complexity of present conditions regarding energy systems and planetary-scale degradation as a spatial endeavour. The other task was repositioning the design task itself for the current condition to "design with the externalities", as Rania Ghosn puts it.

Current limitations and next challenges

In these conditions of possibility, the aim of this project is not to pretend to be holistic. The topic of energy is chosen because it acts as a hinge, articulating other projects inside climate agreements, economic opportunities and the scaling-up of technologies. The current limitations of this project are:

(1) Location. It is composed of the data and information available for the European context, in a Northern West Europe that does not suffer from energy scarcity and has high economic potential. The methodology of this project could be invested in other regions of the planet and take different contours.

(2) Focused on the conversion landscapes of energy. As explained in the first pages of this document, energy creates different kinds of landscapes. However, those are the ones with higher potential for tensions in the Rhine basin territory.

(3) Energy is raw potential that can take the form of usable electricity, heat and raw fuels to power various aspects of life. This project limits its focus to electricity and its sources.

(4) As elaborated throughout the thesis, the "energy transition" is understood in the national policies and continental European Green Deal as having multidimensional impacts. Here, the project limits its focus to studying the territorial conditions of energy transition in areas of tension between the operational landscapes, transitioning modes of energy and its socio-ecological implications.

(5) The current productivity and growth-based world-ecology will not be dismantled by any project alone. However, this project aims to build on the basis of a broad counter-hegemony for socio-ecologically just futures. (Srnicek & Williams, 2016)

(6) The project can be positioned along with other spatial concepts like "Horizontal metropolis". However, it provides another understanding of urbanisation or of an urban network. The next challenge is to be more precise about the composition of this "third landscape" that builds a platform for many spatial concepts and other more engineering or conservation perspectives on the territory.

The project's focus was to primarily assemble a Rhine basin "Energy-Ecology Network" that could provide a basis for the next steps ahead in terms of looking at the territory further than administrative boundaries and imagining its interregional integration for a more socio-ecologically just urbanisation and urban networks. In order to advance the study, it is possible to anticipate some of the next challenges:

(1) More precise design of ecotones:
Even though the "Deconstruction" and "Terraforming" parts of the report demonstrate the overall composition and configurations that will be taking place in the identified typologies of the scale-up of the renewable era, the further design of the ecotones, the gradients and transitions in the landscapes can be the object of local and regional landscape design and planning.

(2) Input from more empirical research
As the science of movement ecology grows and its contributions become clearer (Fraser et al. 2018), we anticipate that corridor design prescriptions will better reflect connectivity from the animal's perspective. (Ford et al. 2020) The areas of designated and effective ecological corridors are locally dependent. However, these studies are not a concretised subject. (Beier & Gregory 2012) suggests a rule of thumb of 2 km, whether other sources suggest up to 6km wide designated corridor to that a minimum of 4,5 km effective corridor for biodiversity can be realised. As this science progresses, it will inform more precise balances in translating the "Energy-Ecology Network" into specific situations and considering the biodiversity's ways of being.

(3) Discussion with stakeholders:
The further design challenges will need to meet the contestations of farmers and villages along with conservation and energy demands. This political dimension tests the effectiveness of the "energy-ecology" corridor and its landscapes to articulate different cosmologies and situations as it keeps its envisioning scaling-up and systemic change.

(4) Supra-regional administrative structures:
The work demonstrates the potential for a Rhine basin scale translation of its ecological and energetic potential into its landscapes. However, this might demand other structures and institutions to implement, regulate and assess the proposal.

Societal relevance

In the structure, a word repeats, which is world. This word repeats because this work builds in a broader perspective of work as the force of building and maintaining particular dynamics, or in this project's vocabulary: worlds. Nowadays, it is, arguably, only possible to think of society in terms of growth and development. Even inside "energy transition", "sustainable development" backs up many unfitting interventions if seen from the perspective of socio-ecological local contestations.

Post-growth imaginaries are being drawn in philosophy, economy and sociological studies; this project aims to take it to the spatial project of energy. Whether we run up against biophysical and societal limits or successfully transform management patterns in such a way that they are more just and in pathways to abandon the chasing of output growth. However, what would it look like in space? The contribution to constructing visualisations for worldviews woven in a transdisciplinary way is also relevant. In that sense, story-telling is essential and the structure follows a speculative narrative approach to render worlds simultaneously "comprehensible and fantastic", as Design Earth poses in their book Geostories. This is crucial to move away from the visual rhetoric of crisis and build a visual vocabulary of "radical hope", as Faranak Miraftab puts it so that it is possible to envision futures worth living.

Energy as a spatio-temporal project, in this century, could begin to compose alternative "already not yet" contingencies when encountering tensions in the territory. How should we act today to reach the desired futures? Proposing more platforms for these discussions than answers to these questions is crucial for decision-making today, yet evaluating the effect of interventions is very challenging. The method, frameworks and concepts put forward in the project can be used elsewhere; becoming elements needed to compose the radically different counter-hegemonies in the scaling-up of the deployment of renewable era of energy.

This work also grounds European integration with infrastructures that differ from those proposed in the Trans-European Networks of Nature, Energy and Transport. Working with what is inherited and proposing other managements, it builds another backbone for the urbanisation of Europe through the Energy-Ecology Network and its territorial typologies. This is relevant in proposing qualitative assessment and balances, which, when discussed according to local contestations, will highlight the value given to many living conditions and the quality and quantity of habitats humans share with other sentient beings.

"In contrast to a master plan, the proposed territorial strategies are flexible, and able to respond to various and unpredictable scenarios of growth and shrinkage." (Topalovic, 2016)

Scientific relevance

The project hopes to add to the already growing body of knowledge regarding energy and its spatial configurations, spatial planning and urban design, which has been the focus of many theses, dissertations and applied research, inside and outside the academia.

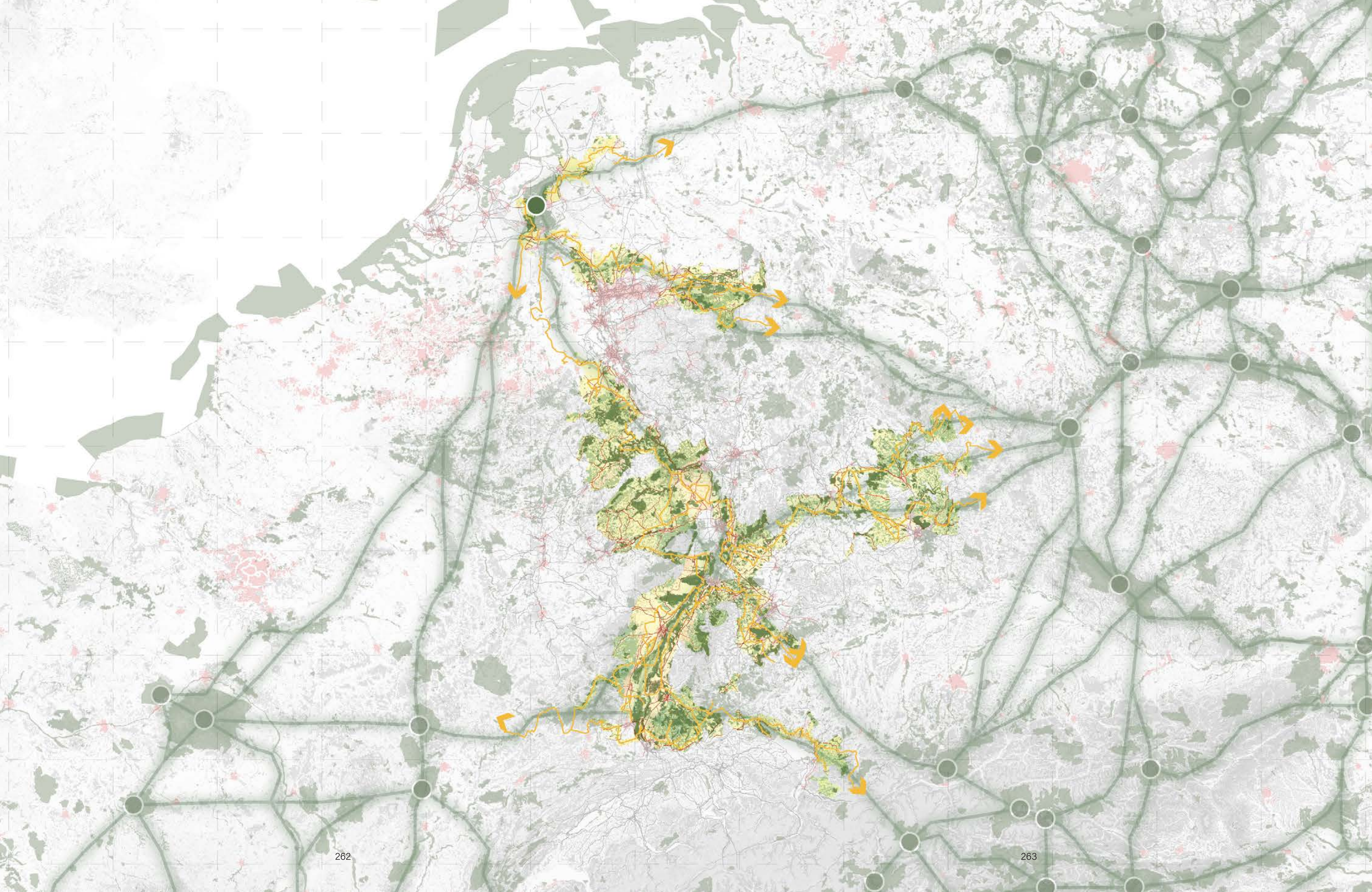
The effort of this project is peculiar in the aim to, through spatial thinking, propose incremental coexistence typologies for the scaling-up of renewable technologies in specific landscapes and, crucially, for future energy modes. The proposition of a network that achieves ecological aims through the deployment of energy technologies in space and along its temporalities is worth further research, application and deconstructions.

Consequently, it bridges a gap between technical energy studies, policy documents and climate reports with spatial design. Technological advancements in the field of renewable energy, the European Green Deal or the Paris Agreement and climate reports, for example, the ones by IPCC, focus on technologies, countries and its administrative boundaries or the whole globe. These perspectives need further operationalisation happening on a regional scale and related to the functioning of whole ecosystems, socio-economical settings and their range of influence, like the Rhine basin watershed and the possible conditions. This is related to providing a qualitative and contextual approach to the energy crisis and its transition as a spatio-temporal project, bringing social, political and ecological fields together in space and inside a territorial condition. In that sense, an "architecture of the territory" proves to be a fitting engagement of the urban design at territorial scales, broadening the understanding of territory from the purely technical or administrative domain. (Topalovic, 2016) In parallel, there is an effort to build upon the concept of planetary urbanisation theorised by Neil Brenner and Christian Schmid, which helps reframe the urban problematic of the last decades, a very elusive and unstable category. This is not a coincidence; social and climatic conditions only promise to become more unstable due to climatic instabilities. In this sense, the frameworks could help build new urbanisation patterns that support the needs of humanity and living beings as it restores, connects and regenerates landscapes and habitats. Moreover, the project can be positioned along with other spatial concepts like the "Horizontal Metropolis", proposed by Paola Vigano. However, it provides another understanding of urbanisation or of an urban network, particularly behaving like a "third landscape" that builds a platform for many spatial concepts and other more engineering or conservation perspectives on the territory.

It problematises the future role of the architect as a figure that not only can design forms and buildings but much more crucially design systems of thinking at a planetary scale. The future of architecture concerning fragile planetary systems means more than singular structural objects and urban networks but the building of infrastructures that can support a very different kind of society. "The old idea of infrastructures as 'grey buildings behind a chain-link fence' gives way to a different social and political imaginary for how planetary metabolisms of energy, food, information, and so on are produced, refined and distributed." (Bratton, 2021)

Lastly, another contribution is its methodology and the placing of values with landscape design. It is speculative but understanding the technical capacities of architecture, urbanism and engineering so that they can realise their contemporary potential - not only in the "now", but in every "now" that is to come. It imagines a framework to be implemented at contemporary conditions, which could be called something along the lines of "infrastructural landscape design."

"When we talk about the future of architecture in relation to fragile planetary systems, that means building infrastructures that can support a very different kind of society." (Bratton, 2021)



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My heart is with everyone in the Transitional Territories studio and hope to see you around!

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Meu coração está com todos no estúdio Transitional Territories, espero vê-los por aí!

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Images

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Image 2: [Energy landscape of extraction.] (n.d.). [Photograph]. https://i.pinimg.com/originals/b5/af/7c/b5af7c5a803c637498e054c5ddb2a210.jpg

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Image 9: Global Landscape Connectivity. (n.d.). [Map]. http://atlas-for-the-end-of-the-world.com/world-maps/world-maps-global-landscape-connectivity.html

Image 10: EEA. (2022). Coverage of protected areas in the EU-27 land area in 2010–2021 [Graph]. https://www.eea.europa.eu/data-and-maps/daviz/coverage-of-terrestrial-protected-areas#tab-chart-1

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Image 23: WorldMapper.org. (n.d.). Carbon Dioxide Emissions Decline 1990–2015 [Illustration]. WorldMapper. https://worldmapper.org/maps/co2decline-1990to2015/

Image 24: Smith, M. (n.d.). [Sheep among solar panels]. https://www.verisk.com/contentassets/371e7f12751942fa8be7bef5f3246515/sheep-in-the-grass.png

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Image 30: Production trends in the top five copper-producing nations. (2013). [Graph]. https://upload.wikimedia.org/wikipedia/commons/9/9a/Top-5-Copper-Producers.png

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Glossary

ACCUMULATION

1. "The current epoch is one of accumulation: not only of capital (primitive or otherwise) but also of raw, often unruly material; from plastic in the ocean and carbon in the atmosphere to people, buildings and cities. Of anxiety, and of a recognition of the difficulty of finding effective means for intervening in the behaviors and practices that engender these patterns." (Nick Axel et al, 2019)

AGROBIODIVERSITY
1: Includes wild plants closely related to crops (crop wild relatives), cultivated plants (landraces) and livestock varieties. Agrobiodiversity can be an objective of protected areas for crop wild relatives, traditional and threatened landraces, particularly those reliant on traditional cultural practices; and/or traditional and threatened livestock races, especially if they are reliant on traditional cultural management systems that are compatible with "wild biodiversity".

BUFFER ZONE
1: Areas between core protected areas and the surrounding landscape or seascape which protect the network from potentially damaging external influences and which are essentially transitional areas.

CARE
1: Care acknowledges vulnerability, interconnectedness, dependency, embodiment.
2: Care is a selective mode of attention: it circumscribes and cherishes some things, lives, or phenomena as its objects.
3: You care when you have already chosen an object to care about.
4: You care when you feel worried, attentiveness, and thoughtfulness.
5: To care is affirming otherness,
6: 'Care includes everything that we do to maintain, continue and repair our world so that we can live in it as well as possible. That world includes our bodies, ourselves and our environment, all of which we seek to interweave in a complex, life-sustaining web.'
7: "To care is to be truly present, accepting the mistakes made so far, still maintaining a proactive thrust. We become-with each other -in unexpected collaborations and combination- or not at all. Becoming-with other humans, but more importantly with non-human others."
8; 'Insisting on practice brings us back to the hands-on side of care in the purpose of thinking with others. That is, looking at care as a practical everyday commitment, as something we do that affects the meaning of thinking-for.' (in 'Nothing comes without its world' by María Bellacasa)

(the notion of):
1: The notion of care can be applied in many circumstances as long as it creates a possibility of relation and interdependence which positions itself in a space in-between. The relation does not mean any conflict or dissension, but precisely in this difference that we build our interdependence and a singular caring attitude.
2: The notion of care should be seen "as a practical everyday commitment, as something we do that affects the meaning of thinking-for", or, affects why and how we do something for the other.
3: Care encompasses every single dimension of our lives: it interprets the information we receive with our senses and it designs paths in our consciousness towards a mindset for actions based in our interconnected common reality and state. Terms like "entanglement", "relationality", "sociality" are frequent and point to our interdependence not as a "social contract" but as a condition. The notion of care is an alternative frame of reference to our living on many scales.

DISPERSAL
1: (ecology) Dispersal is an ecological process that involves the movement of an individual or multiple individuals away from the population in which they were born to another location, or population, where they will settle and reproduce. The two most common forms of dispersal are: natal or dispersal. (Nature magazine)

ECOLOGICAL CORRIDOR
1: Way to maintain vital ecological or environmental connectivity by maintaining physical linkages between core areas.

ECOLOGY
1: the totality or pattern of relations between organisms and their environment.

ECOSYSTEM
1: A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

EXTRACTIVE:
1: tending toward or resulting in withdrawal of natural resources by extraction with no provision for replenishment.

FORAGING
1: (Ecology) Foraging is the act of gathering wild food for free. Although it's gained far greater popularity in recent years, for our distant ancestors foraging would simply have been a way of life – a necessity in fact. (Wikipedia, 2022)

INDUSTRY
1d: systematic labor especially for some useful purpose or the creation of something of value
2: diligence in an employment or pursuit. Especially: steady or habitual effort.
MFWYTBI: work done by humans by altering or manufacturing technologies and changing matter to support their different forms of inhabitation.

MIXED CROPPING
1: "To employ diversity in order to achieve resilient, agroecological European plant-based production systems. Mixed crops from "plant teams" can contribute to soil fertility, productivity of the "main" crop and suppression of weeds, diseases, and infestations. Mixed crops also offer opportunities for increasing biodiversity both above and below ground by providing food and hiding areas through more diverse and increased amounts of biomass above and below ground."

'MODES OF BEING'
1: The sum of thoughts that form a base for actions and relations.
2: "The dualism of mind-body, self-nature, human-animal, normalcy-exception, risk-safety is a universalist dogma that emerged out of a specific time and place (namely the Western Enlightenment). This dogma is so entrenched that to engage in 'alternative' theorizing, which reflects on how we co-produce knowledge in relation to a multiplicity of beings, is labeled as naïve, superstitious, or worse—'pre-modern' magic (Bennett 2010)." (Bellacasa, 2012)
3: "Wynter's discussion indicates how we might find ways to do the planetary otherwise. If the subject or human were here to become planetary, following Spivak read along with Wynter, the universal designations of human and planet would be re-made and re-imagined. If Wynter proposes being human as praxis as a way to rework the possibilities for opening the category of the human, being planetary as praxis is a way to engage with the planetary-human joins that might also be re-imagined." in 'Becoming Planetary' by Jennifer Gabrys

PIXEL CROPPING
1: "Pixel cropping is a cropping system design and management method that mobilizes high-resolution diversity in arable fields. It is grounded in the hypothesis that high-resolution spatial, temporal, and genetic diversity will enhance ecological processes that support crop production and agro-ecosystem service delivery. In pixel plots we grow multiple food and service crops in complex arrangements in which individual communities of plants are allocated to small 'pixels.' Ideally, pixel plots should be designed so that the right plant community is allocated to the right location, at the right time, and at the right resolution. Determining what is right for each plant community should be based on the intrinsic behavior and needs of each crop and the (dis)services it provides to its neighbors. Pixel size and shape should be determined by the optimal ecological niche of each crop and the context in which it is grown, and matching crop communities to the right place in the field should be determined based on soil characteristics and othervenvironmental factors."
Publications: Automating Agroecology : How to Design a Farming Robot Without a Monocultural Mindset?
Conclusion:

PLANETARY (SEE ALSO 'MODES OF BEING')
1: It is a structural condition, not a theme or discourse. Is it just a description or could it become a new frame of reference for us to start thinking about? To orientate our ideas and activities and look for social transformation. (Patricia Reed)
2: "The planetary is an ongoing process of creating, articulating, and transforming human subjects and collective inhabitations." (Jennifer Gabrys)
3: Being human and becoming collective.
4: "The question of the planetary cannot be addressed without also reworking divisions of the human and the injustices that result from these limited modes of being." (Jennifer Gabrys)
5; "The Planetary stands for an Earth taken as an impersonal (geochemical, geological and geophysical) process, not as an object, not as a scale, but as a dynamic reality of folding and unfolding complex adaptive systems at various levels (hydrological cycle of the planet, metabolisms of carbon or nitrogen, ecosystem food chains, etc.). This imagination of

the planet appears right before our eyes as a complicated, precarious, and striated terrain. It does not allow for a smooth appropriation of vernacular cosmologies into one grand narrative of Western globalisation, itself only a provincial perspective. Instead, we need a framework of situatedness that puts every site on Earth on an equal footing: working towards cosmological multiplicity under a common frame of reference."
Source

PRECARITY
1: Dependent on chance circumstances, unknown conditions, or uncertain developments. Also characterised by a lack of security or stability that threatens with danger.

PRODUCTION
1: The creation of utility. The total output of a commodity or an industry.

PRODUCTIVE
1: Having the quality or power or producing especially in abundance.
2: Effective in bringing about.

STRIP CROPPING
1: "This long-term system experiment is examining the effects of three dimensions of crop diversification (time, space and genes) on the provision of agro-ecosystem services. We're also investigating the interactions between those three dimensions of crop diversity. The experimental design is informed by agronomic norms of the past, viable options for innovation within current cropping systems and future agronomic frontiers."

TECHNOLOGY
1a: the practical application of knowledge especially in a particular area : ENGINEERING sense
b: a capability given by the practical application of knowledge. Eg.: a car's fuel-saving technology
2: a manner of accomplishing a task especially using technical processes, methods, or knowledge. Eg.: new technologies for information storage
3: the specialized aspects of a particular field of endeavor. Eg.: educational technology
4: there are industrial and biological technologies. For example, CCS (Carbon Capture and Storage) is something that a tree does, in its biological technological apparatus. In recent years, this has also become something that humans do industrially, by building CCS plants to suck carbon back to deep geological strata.

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TRANSITIONAL TERRITORIES
2021/2022