Mosaic Energyscapes

Research report

Marcello Corradi - 4937422

TU Delft Faculty of Architecture
Department of Urbanism - Chair of Landscape Architecture

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Author: Marcello Corradi

First Mentor: Ir. Frits D. van Loon

Second Mentor: Ir. Annebregje Snijders

Delegate board of examiners: Dr. Ir. Franklin D. van der Hoeven

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Thank you.

To my aunt Rosy, I would not be where i got without you.

To conclude, also to myself. Thank you for being determined and stubborn, you gave me a very hard time in some occasions, but we proved we could get through. Don't ever forget it.

TU Delft

LANDSCAPE ARCHITECTURE

Abstract

Every time that a natural force, either animal, atmospheric or geological, leaves a trace on Earth, its landscape evolves. The ever recombining result of interactions between these systems defines the kind and amount of natural resources available, triggering new reactions and needs in the species that inhabit our planet. Extracting and transforming resources to create a safe environment where to settle is a dynamic that most species adopt. Humans are the clearest, most urgent example of this. The impact of our kind's creations on existing ecosystems and atmospheric phenomena is becoming increasingly worrying and it is at the foundation of Landscape design's practice to understand, catalyse and try to guide the spatial and ecological impact of productive systems.

Energy has always been the key resource on which our society thrives, both in its direct use and in its storage and transportation. Considering humans as part of nature, the prior goal of this research is to review and propose sustainable assets for the landscapes created and targeted for harvesting, synthesising and storing energy. Currently such man-made environments are mostly alienated from everyday life and aggregated into large-scale areas.

Energy transition is not only a climate-related issue, it also configures as a societal necessity. Electricity and heat are invisible forces both as phenomena and processes, power plants have the reputation of extremely technical and often unsafe places and the awareness about their impact on an environment is marginal and rarely comes from direct experience.

While us all depend on energy, its sources and infrastructures are generally kept as minimal as possible in our lives. (Sijmons, 2014)

This thesis tackles the described issues through the design of the energy transition of Parkstad Limburg, located in the south of the Netherlands. The region has been the main energy production area of the country during the previous energy period, characterised by coal mining, but with the transition to natural gas extraction it lost its role and has been facing a constant shrinkage, thus a drop in social economy, identity, employment rates and wealth.

The objectives and topics treated in this research explore how can different methods and clustering of energy and fuel production be designed as synergies between industrial, urban and ecological environments and how these can involve and welcome actors of different species, with different goals and needs. Such spatial solutions are obtained through studying and balancing how can sustainability, inclusiveness, and ecological and leisure value be prioritised over mere income, maintaining at the same time a positive rate of profitability.

The vault stone of this research by design of power parks for Parkstad is the strategic positioning and the definition of an effective landscape structure, composed both by Carbon Recycling fuel plants and a mosaic of energy artifacts. The theorised system is based in fact on reintroducing CO_2 in the energy production flow rather than completely replacing the current one.

The final goal of this research is in fact to design a landscape of energy artifacts that are deeply rooted in the local landscape typologies, both protecting their ecosystems and initiating a synergy between Parkstad's green infrastructure and transportation infrastructure as intended in TUDelft flowscapes position.



Fuel storage and wind turbines near Schiphol airport.

SOURCE: Photograph taken by author

Personal position

World view

Starting from J. Keulartz's and M. Drenthen's concepts of emergent Nature and Nature as culture, as described in their book "New visions of Nature", I adress Nature as an emerging, holistic system that contains, defines and is defined by everything that can be perceived by who inhabits it, wether human or not. In this sense, all the different species that belong to it transform it according to their needs. This dynamic makes the very concept of nature evolve through time, in relation to the goals and perception abilities of each specie. In my opinion, a Landscape architect shall find design solutions to provide all the inhabitants of an environment with places for their self-realisation, while protecting or improving the existing ecosystem and cultural identity of the territory where the design is placed.

Ambition

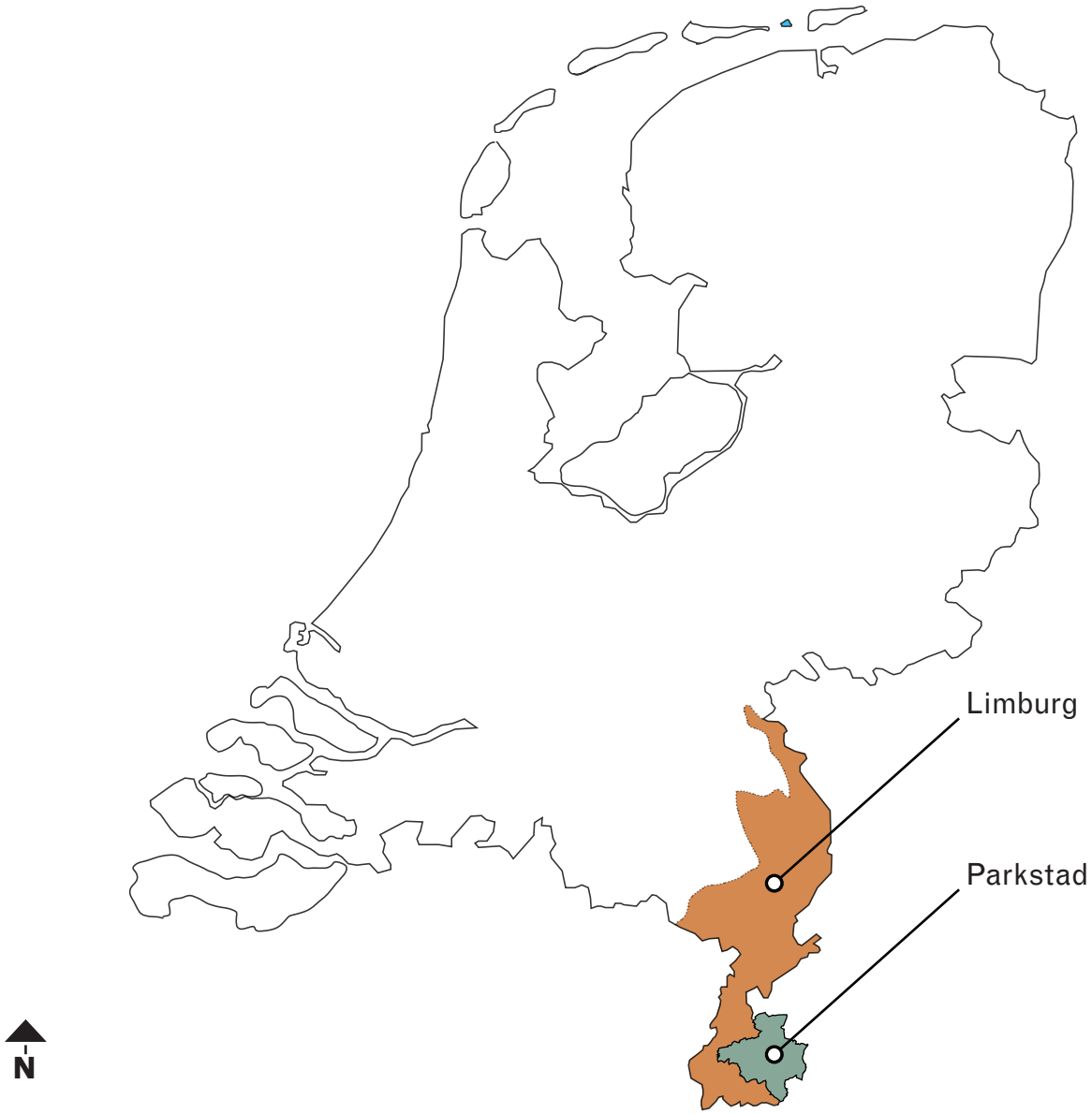
Since I moved to Rotterdam in 2017 and started studying Landscape architecture in TUDelft in 2018, I have found a deeper connection with the practice of designing. What I aim for is to leave a trace on this planet, experience how it feels to walk through something that originated in my head and find a way to make such place open to host other creative acts of other creative beings. To do so, I aim to improve my skills on how to work with processes that unfold through time and that provide a continuity between scales, from the region to the artifact. I think that the Netherlands at the moment is the country where I can acheive this due to the flexibility and amount of experimental projects that can be found here.

Fascination

I have always been fascinated by the creative research and by industrial realities. The need for either comfort or expression that drives the first, combined with the set of skills, resources, tools available, and societal needs that defines the latter is here read as what characterises living societies structure and identity: from the scale of the specie, through cultures and territorial groups, to that of the individual. The research I present here explores how can the energy industry evolve into an element that counters the current Climate Crisis rather than feeding it and how by doing so it can become local, landscape-related and nature inclusive. I believe that energy production landscapes deserve to be both included and inclusive within the urban ecosystem.



Researched territory



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1.

Introduction

Parkstad Limburg, before coal

Parkstad Limburg, in the southernmost province of the Netherlands, is characterised by a landscape of plateaus, carved on their ridges by brooks that descend towards river valleys. It is mainly composed by a loamy soil which deposited during the last ice age and represents a very good ground for cultivation. The region has in fact been chosen as a place where to settle since prehistoric times: the first evidence of human settlements dates around 250.000 years ago. The specific geomorphology of the area, which belongs to the Roerdaslenk, and its strategic positioning in the Europen territory, are what defined the use and kind of settlements that interested it throughout history.

Romans urbanised it first and founded Coriovallum (Heerlen) at the heart of the valley surrounded by plateaus and in the crossing point between Via Trevorium and Via Belgica, connecting namely the South-East to the North-West and the West to the East of the empire. They also started building villas on the plateaus, all facing the lower city. During roman times and after their retreat, the area slowly merged Germanic and Frankish populations, where the second ones had a greater influence. It is notable that Charlemagne had his palace built in Aachen, (Aquae Granni) during the late VIII century.

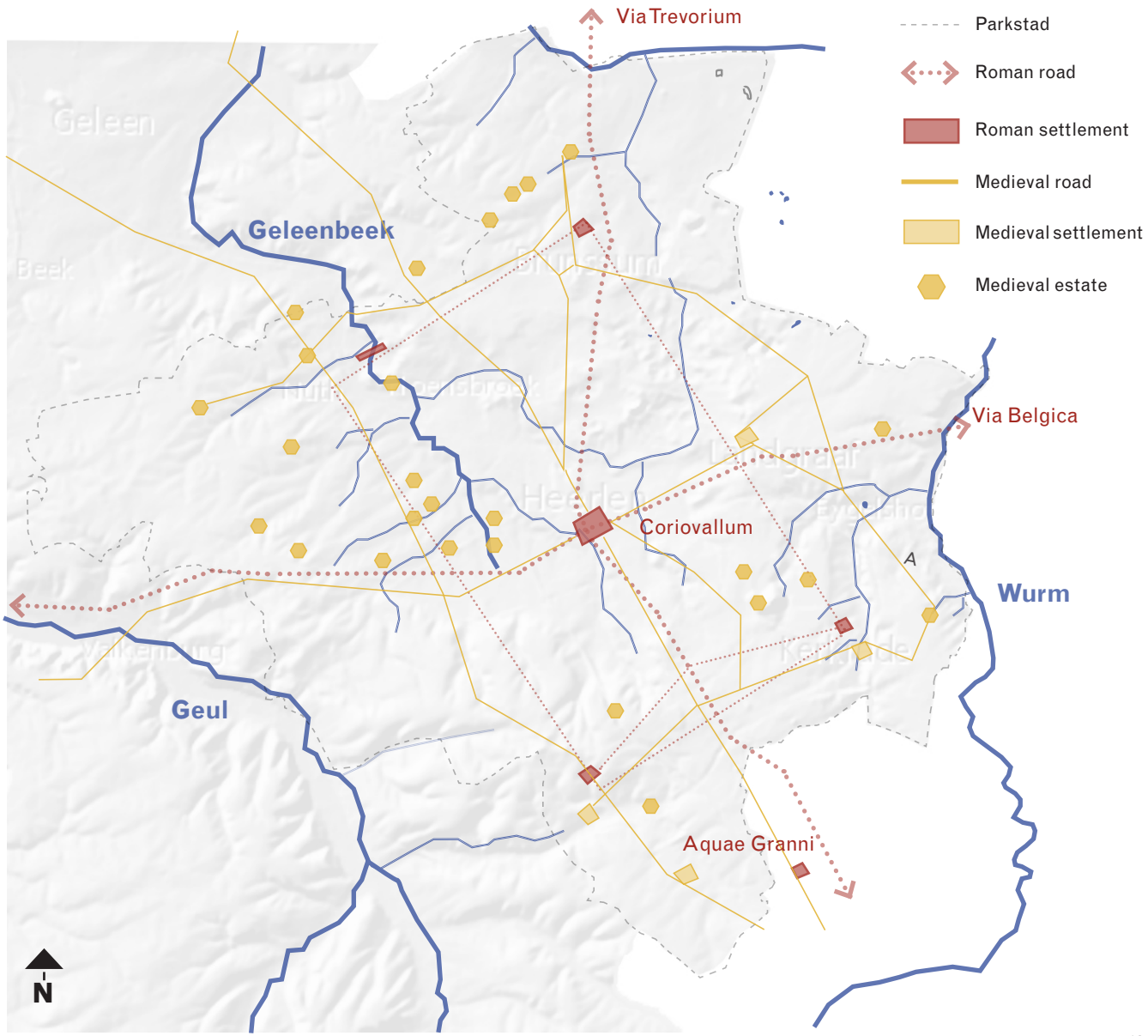
After the emperor's death in 814 AC, the Normans raided the area and the villas and farms built by the Romans and developed by the Franks met their demise. It was however during the IX century that Normans turned to Christianity and during the following centuries noblemen started gaining more and more influence in the governance of the region. Trade and industry started booming within the cities that grew in the valleys and lower plateaus. The products and resources traded there came from the agricultural lands and the estate landscape.

These worked in fact both as the main productive areas of the region, and as display of prestige and power for the nobles, especially given their position on the higher plateaus and overlooking the settlements. This lack of centralised power and its spatial impact continued until Charles V became both emperor of the Holy Roman Empire and King of Spain.

Once his son succeded to him, Spain started gaining ever more influence on the Empire and this, also triggered by Martin Luther's protestant Reformation, led to the Eighty-years war of independence of the Dutch united provinces (1568AC-1648AC). A religious schism divided the northern provinces of the Netherlands, which became protestant, from the Limburg region, which remained loyal to Spain, thus catholic. Limburg eventually united with the other provinces under King William I in the XIXcentury, however in the span of 30 years some southern provinces left to become the kingdom of Belgium, dividing Limburg in two.

Productionwise, the area has mainly been dedicated to agricultural uses and to the extraction of limestone, which deposited into the soil during the Mesozoic Era and is dug up by the brooks that carve the plateaus in their way towards the river valleys. This material is still largely found in most of the estates' castles and farmhouses that spread throughout the region.

The road and infrastructural system of the area increased through time, but it developed along and around the lines firstly set by the romans. Echoes of these periods are still visible in the non-urban portions of the landscape, especially due to the important role that the agricultural land maintained and due to the increasing touristic sector, which mainly focuses on these characteristics.



Sources: diagram made by author, information taken from Limburgemigrant.nl, Google maps and Wikipedia


Remains of the roman baths - Heerlen

SOURCE: Corvinus.nl


Impression of Coriovallum by Mikko Kriek

SOURCE: Corvinus.nl

Sint Pancratiuskerk - Heerlen



SOURCE: Photograph taken by author

Kasteel Rivieren - Voerendaal



SOURCE: Google maps | Erik van den Ham

Parkstad Limburg, during coal

Parkstad Limburg had its wealthiest moment during the first half of the twentieth century: since it lays over the coal deposit that runs across Europe and through Germany and Belgium, the state bought most of the strategic lots in between the several municipalities composing the area and opened up minining sites. Along with these, private mines started appearing in the immediate following years.

The intensive mining and the consequent wealth triggered urbanisation and drastically changed the landscape of the region, creating a sharp division between the agricultural fields and the cluster of urban municipalities. Next to the mining authority, the religious cast of a region that remained highly catholic was the dominating power of this territory. This dual influence highly defined both the social assets and rate of births of Parkstad, whose population rose faster and higher than ever before.

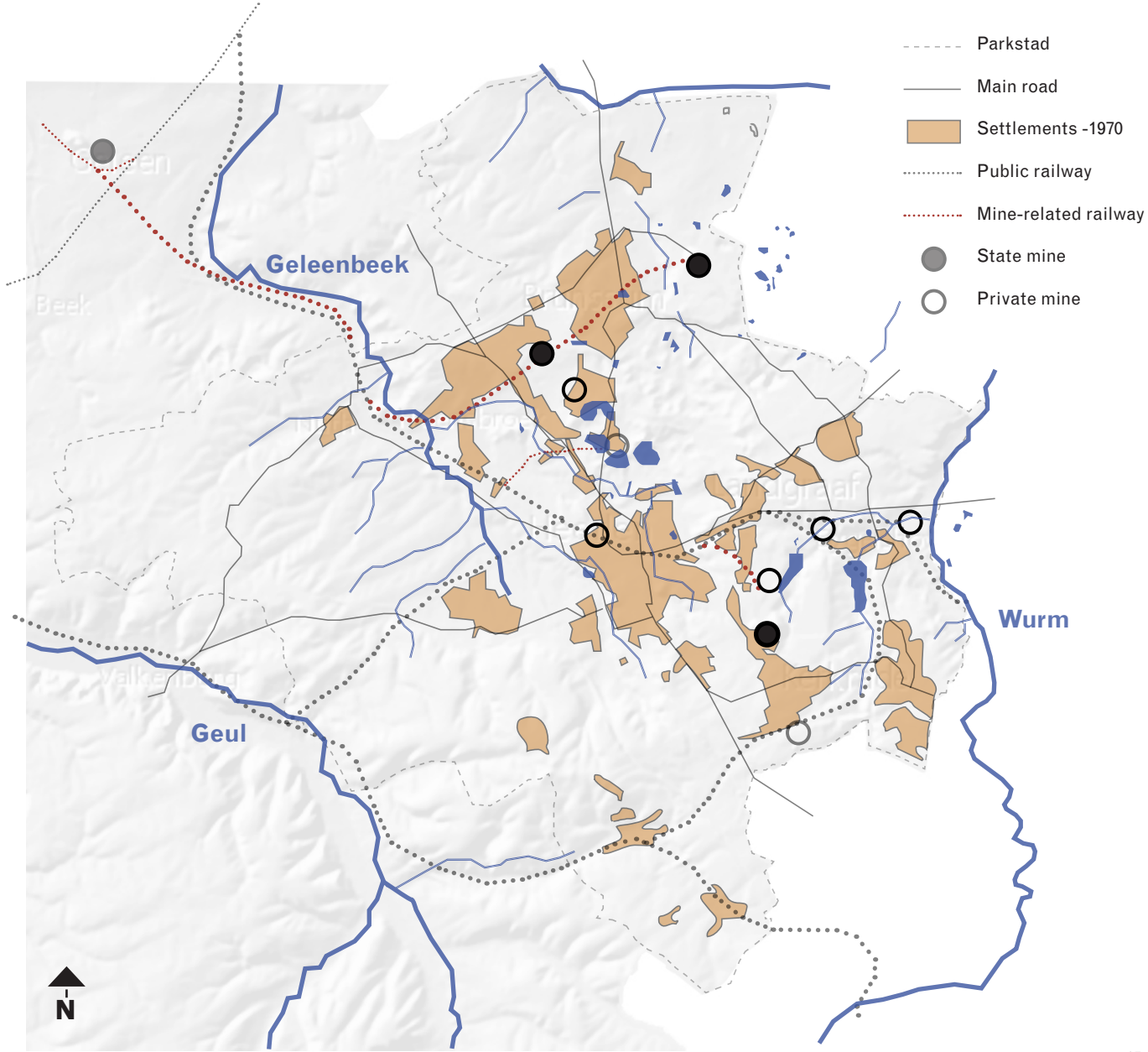
High-end housing started appearing around the mines, since the engineers that moved in needed a place to stay in their immediate vicinity, and slag heaps grew taller and taller, in contrast with the native "skyline" of the plateaus. Mining also drastically affected the water system of the region, which saw a constellation of water basins appearing around the coal extraction sites. The railway system, both for traffic of resources and workers, also developed, making the division between urban municipalities and agricultural ones even stronger.

Differently from the other areas of Limburg, Parkstad presents a more polycentric pattern of urbanity and infrastructures, precisely due to the fact that it grew in between several existing municipalities and around a scattered cluster of mining areas.



Oranje Nassau I mine shaft - Heerlen

SOURCE: Wikimedia



Sources: diagram made by author, information taken from Limburgemigrant.nl, Topotijdreis.nl and Wikipedia


Bus station - Heerlen
B
SOURCE: Photograph taken by author


Domaniale mijn - Kerkrade
SOURCE: Wikipedia


Silver sand pit - Brunssum
SOURCE: Photograph taken by author


Whilelminaberg - Landgraaf
SOURCE: Wikipedia

Parkstad Limburg, after coal

After the shutting down of the state mines in the late 1960s, the region of Parkstad Limburg entered an extremely negative phase, characterised by a massive loss of employment, thus wealth and social economy. A few decades of drug abuse and loss of faith characterised the general approach of the population, and the ongoing process of shrinkage started.

To recover from this, the number of municipalities has been decreased first to nine and then to eight, four urban and four agricultural, and a unique organ has been created to guide the region towards a better condition. This organ is Parkstad Limburg. A both physical and conceptual transition has also been implemented to shift from "Black", the coal city, to "Green", the park city.

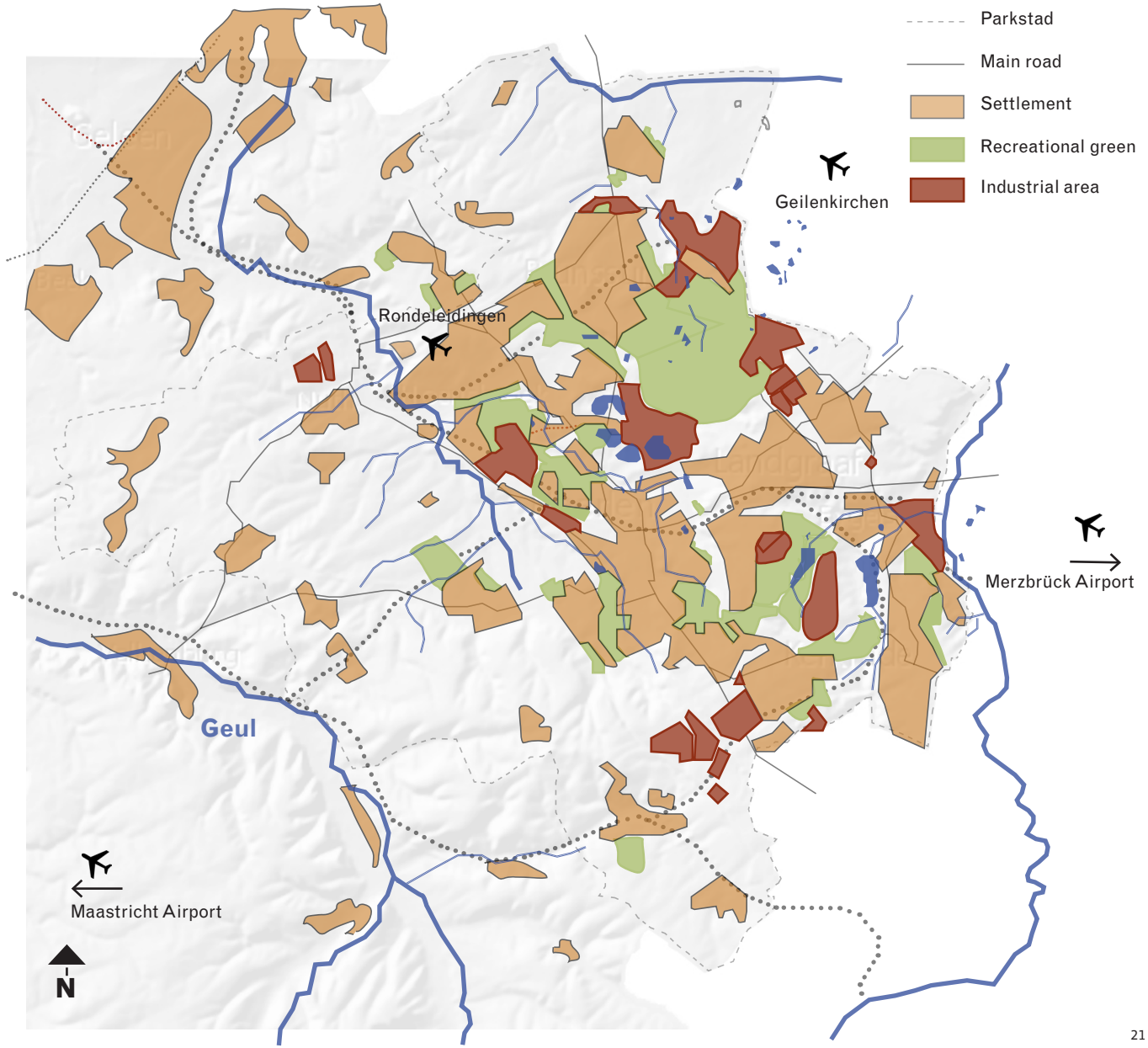
Parkstad is now the urban region of the Netherlands with the highest percentage of green areas, anyhow their quality is often neglected. One of the main strategies adopted to tackle the loss in social economy and shrinkage of the region is a strengthening of the transportation infrastructure, both in terms of energy production and in terms of flows of employment. Parkstad is in fact in the near vicinity of four airports, and has a direct access both to Germany and Belgium, where higher numbers of employment opportunities are found. Accessibility to education is also highly present, due to its proximity to both Aachen and Maastricht.

However, the shrinkage is ognoing also due to the tendency of directly moving to the areas where there is employment rather than commuting. To tackle this, the strategy Parkstad is adopting now is to evolve into a urban laboratory for sustainable energy production, hoping to cut the cost of energy consumption to attract people back.

Energy neutral housing - Parkstad



SOURCE: Palet 3.0



Sources: diagram made by author, information taken from Euroscopemag.eu, Topotijdreis.nl and Wikipedia


Mijnwater heating station - Heerlen
SOURCE: Volantis



SOURCE: Palet 3.0

Energy neutral housing - Parkstad



SOURCE: Palet 3.0

Zuid Limburg & Parkstad - Flows

It is interesting to notice how the areas where the shrinkage happens in highest percentages are those closer to the border with Germany, where large amounts of employment are found.

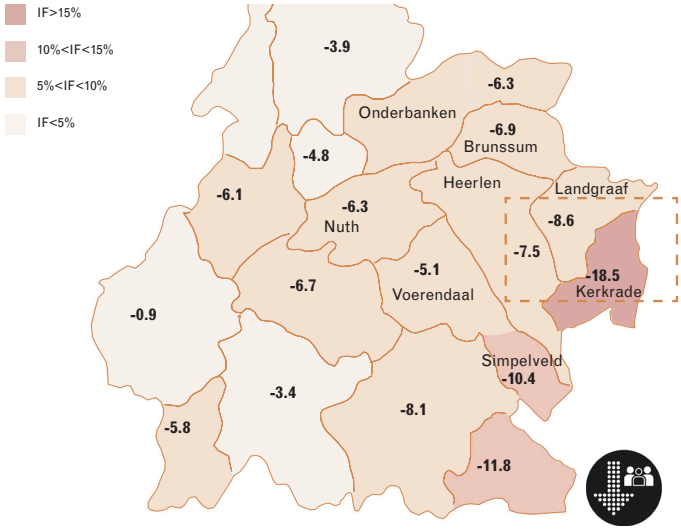
Another interesting pattern overlapping with the rates of inhabitant fluctuation is the one that shows those urban municipalities where most mining sites used to be in function. There, in particular in Heerlen and Kerkrade, are still found most of the industrial sites and both the energy consumption and the carbon dioxide emissions reach the highest levels registered within Parkstad.

It seems that even though these cities provide most of the leisure activities of the area, a solid infrastructural connection with the neighboring nations, industries and a direct access to the national park in Brunssum, the shrinking happens faster than in most of Zuid Limburg.

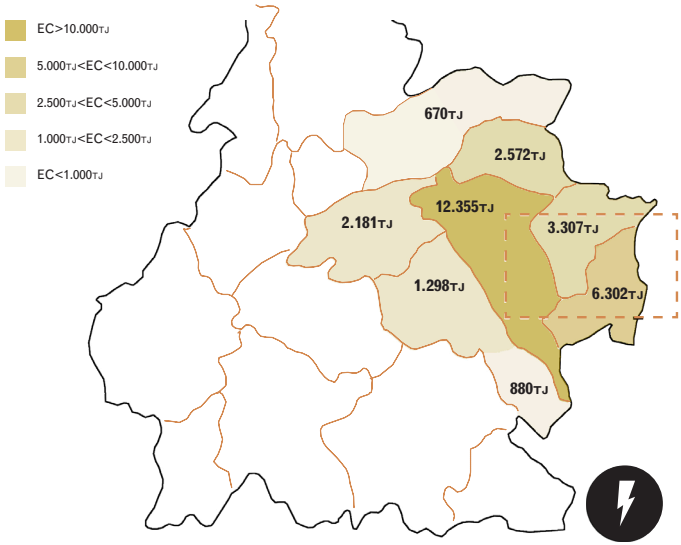
The agricultural lands, which experienced a less drastic turn of event and shift in their productive role with the closing of the mines, lose inhabitants at a slightly slower rate. The difference found between the urban and the agricultural municipalities can also be observed in the Natura 2000 plan, which protects mainly the strips of forestry on the ridges of the agricultural plateaus to then jump directly to the large national park in Brunssum, the Brunssummersheide.

Ironically, in this plan, the urban green of Parkstad, literally translated into "park city", seems to be mostly left out.

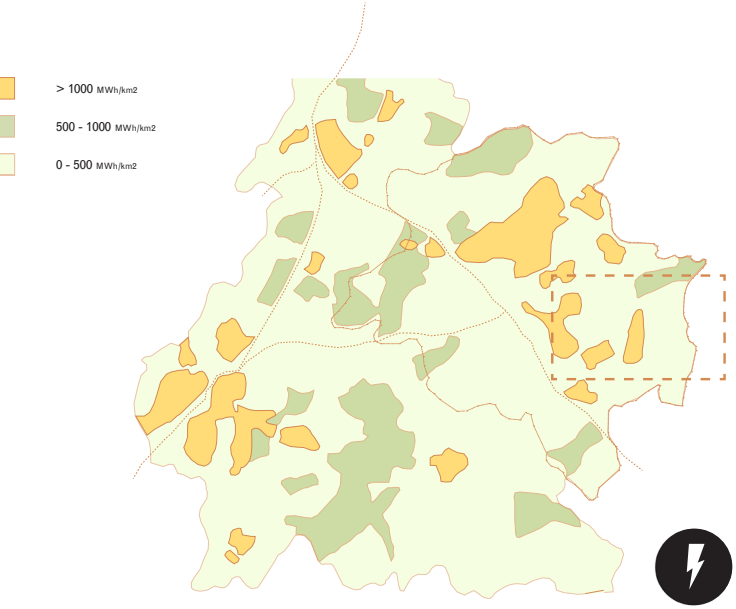
Diagrams made by author, data obtained from cited sources.



Inhabitan fluctuation: Source: Central bureau voor statistik

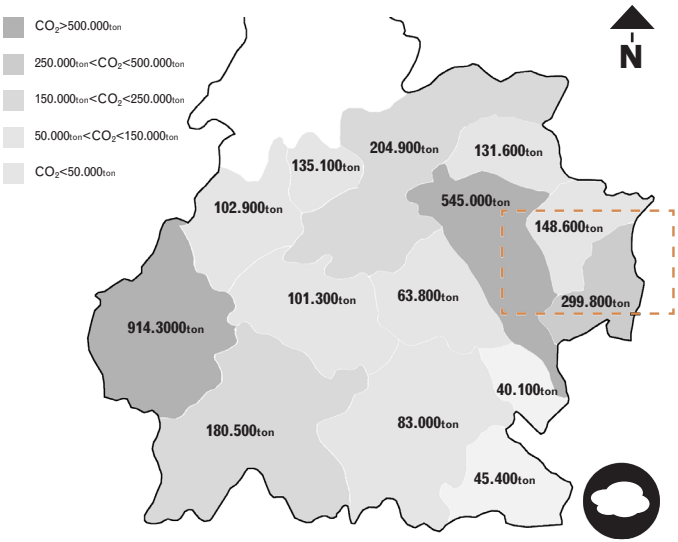


Energy consumption/Gemeente: Source: PALET 3.0



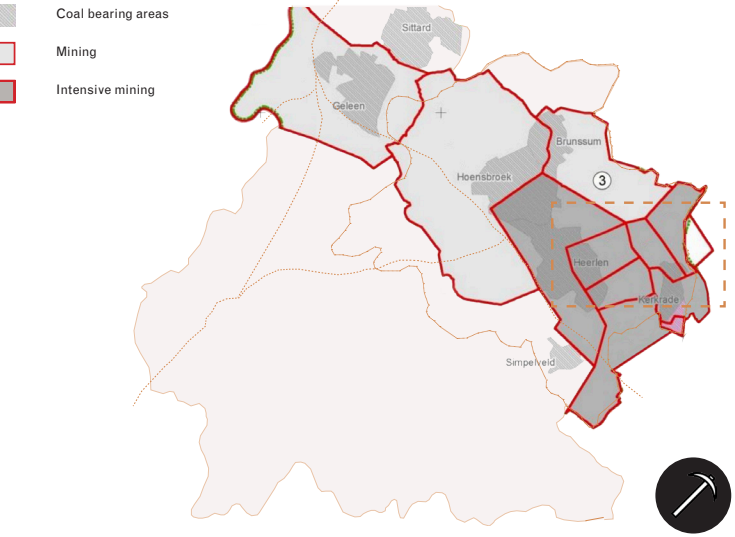
Energy consumption/Area:

Source: Central bureau voor statistik



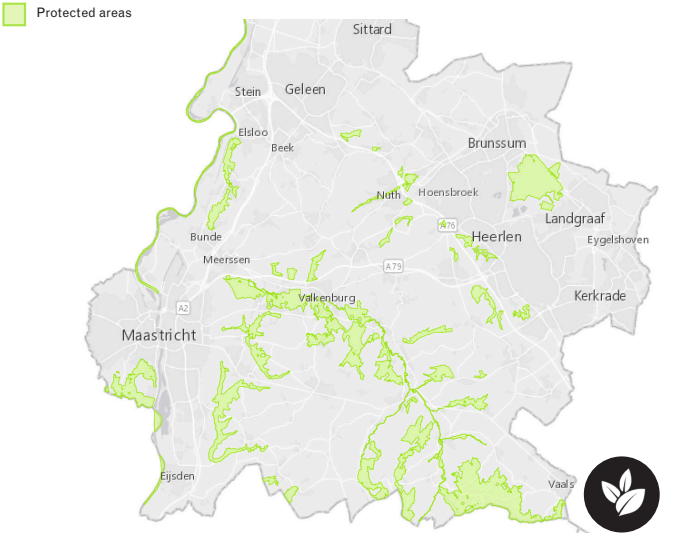
CO_2 Emissions:

Source: Klimaatmonitor databank



Coal bearing and mining areas:

Source: Project group GS-ZL



Natura 2000:

Source: Natura 2000

Parkstad goals, not an isolated case


SOURCE: Shutterstock.com

Parkstad Limburg has energy neutrality as one of its goals both for ecological and social reasons, however it is not unrelated to the national energy situation: the whole Netherlands, in respect with the Paris agreement, aims now at becoming energy neutral. After being sewed by Urgenda along with nearly 900 co-claimants, which accused it of emitting unsustainable amounts of CO_2, the Dutch Government started seriously tackling the energy transition issue and both funds and policies are being tailored for several of its regions.

Goals:

2020	2040	2050
- 20%emissions + 20% renewable sources	- 40%emissions + 32% renewable sources	Energy neutral

Dutch energy condition



SOURCE: Redactie/anp

According to Rijkswaterstaat and the Centraal Bureau voor de statistiek, in 2017 136.992.600 tonnes of CO_2 have been emitted into the atmosphere in the Netherlands, relating to a energy consumption of 3157 PJ, having as main energy carriers natural gas (>41%), petroleum (~39%) and coal (~12), slightly more than 8 percent comes from renewable sources, nuclear energy and waste.The natural gas extraction in Groningen is though causing small yet dangerous earthquakes and is intended to be completely halted by 2030.

Sources: RWS, CBS, Reuters

"Currently, Dutch natural gas is the primary source of energy for heating homes, buildings, greenhouses and tap water. The use of this gas will need to be drastically reduced in order to make our energy supply more sustainable, in the first place by focussing on energy conservation."

Ministry of Economic Affairs of the Netherlands - Energy report, 2016

"The Netherlands lags many other EU countries in terms of renewable energy but is catching up. [...] Renewable energy comes mainly from biofuels, waste, and wind. Solar, hydro, and nuclear energy play a minor role."

U.S.A Department of Commerce - Netherlands energy, 2017

"CO_2 emissions in the Netherlands should be reduced by half by 2030 and by 95% by 2050. The Dutch government has decided this following the Paris Climate Agreement."

TNO Innovation for life - CO_2 reductie in Nederland, 2017

Dutch energy transitions

Transitioning from one dominant system of energy harvesting to a new one leaves behind traces both in the built environment, namely the power plants and the infrastructure used for energy distribution, and in the natural environment, which is the source from which energy is extracted. It is peculiar how often these two sides of the same coin undergo different evolution and rearrangement. While the edifices are usually either upgraded to serve the new energy system or are turned into cultural hubs due to their level of equipment, the landscapes gain an iconic value, attracting curiosity and greatly influencing the cultural aspect of a whole territory, rather than that of a city or a neighborhood.

Such dynamic can be easily observed in the Netherlands. Most of its landscapes bear a great man-driven influence, making it one of the most unique, yet debatable ones in Europe. To better formulate and research how can the ongoing energy transition be implemented, the first step moved here is to look back at the previous energy periods, the transitions from one another, the traces they left and the atmospheric impact they caused.

With the diagramatic analysis here shown, it is highlighted how the inheritance of the gas energy period is an invisible one. While the peat extraction literally influenced the shape of the country and the coal mining created new urbanities, railroads, water bodies and morphologies that are now cultural, ecologic and leisure nodes in Zuid Limburg, the traces of the gas energy period are to be found in a capillar infrastructural system that reaches into every house, industry and human activity. Such network should not become obsolete, and it is at the foundation of this research by design to develop an adaptive system that can include it.

CO_2





Peat energy period

Coal

Transition





energy period



Gas energy period

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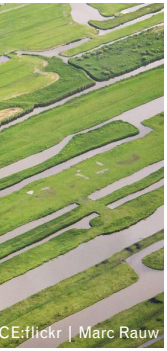
Clean energy period

Transition

Transition





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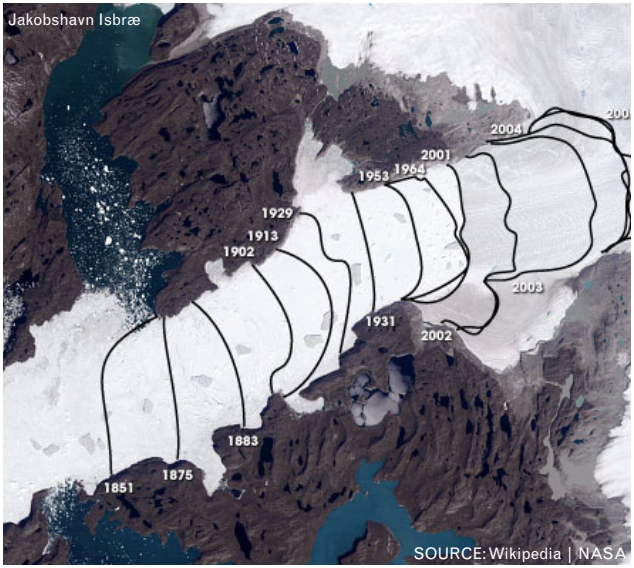
Energy transition as a necessity



In the mediatic and cultural turmoil of today, climate change is the hottest topic. While it is true that the Earth is subject to cycles of heat change, it is also undeniable that the situation is shifting at a worrying rate, making it impossible for most species to adapt in time.

Sea-level rise, draughts, and more violent storms are only few of the threats that need to be faced. Fossil-based energy production and the consequent vertiginous amount of CO_2 emissions has been proven to be one of the main causes of this, but the fact that fossil reserves are not endless entails also future geopolitical, social and economic issues. (Sijmons, 2014)

Energy transition as a spatial concept



As argued by Dirk Sijmons and H+N+S Landscape Architects, the impact and form of energy harvesting in a region closely relates to its morphology, resources availability, society values and atmospheric conditions.

For this reason, it is important to reconnect both the aesthetics and technical assets of sustainable energy-producing objects to the specific site where they are placed, trying to create local energy ecosystems.

As mentioned before, the main goal of this research by design is to study and propose "power parks" for Parkstad, using these spaces as tools to improve the region's biodiversity and leisure opportunities. These should also provide the inhabitants with areas to become more aware about energy production.

‘‘ Energy and space change each other, and they change together over the course of history. It is not far-fetched to divide human history into periods based on the dominant form of energy, and each energy period also has its own characteristic spatial manifestations.’’

‘‘With the energy transition in mind, we can look at the same space with new eyes, and discover something there that had not been seen before: different spatial qualities, different forms of using space and a different perception of space.’’

‘‘At international climate conferences, solemn agreements are made again and again to do everything possible to limit this increase to 2°C. That will only happen if every coal plant is closed (or if the plants are all equipped with CO_2 storage).’’

Dirk Sijmons - Landscape and energy, 2014

Problem statement

Parkstad Limburg is experiencing a constant shrinkage, which started in the late 60s with the shutting off of the coal mining industry: their main source of wealth, employment and driving force in shaping the landscape during modern times.

To tackle this problem, the cooperating set of municipalities that compose Parkstad tried and still works towards a both physical and conceptual rebranding of the region. This is implemented by promoting a transition from Black to Green, namely from coal mining to park city. What this transformation is currently lacking is though that the role of preexisting productive and energy landscapes has been so far replaced rather than led to a more sustainable and contemporary evolution.

The resulting main problem that the region has to face is the loss in social economy: the decrease of inhabitants is proportional with the amount of employment opportunities, average age, education possibilities and business development.

Economically speaking, the region is striving to adopt cooperational solutions in production and especially to become energy neutral. This would in fact drastically cut the yearly costs of energy consumption, estimated now to be around 500 millions of euros, and allow to reinvest the saved money in development and employment solutions.

Parkstad is mainly focusing on energy neutral housing and on municipality-based solutions, yet the costs of this transition are extremely high and do not involve, create nor protect the landscape of the area, which is currently sharply divided between agricultural areas and urban ones. This division both disconnects the heritage of the region from its modern life and does not provide a set of ecological stepping stones for the species inhabiting the area.

These issues are here tackled as parts of a single problem that interests Parkstad landscape's system as a whole. In this way, it needs to be revealed and enhanced.

Research questions

Research question:

How can sustainable energy production landscapes be integrated with the natural and urban environment of Parkstad to generate employment and enhance leisure and biodiversity?

Sub questions:

- What are the best solutions to tackle the issue of CO_2 emission?

- What are the societal, technical and shaping roles of these places in relation to the growth of cities and contemporary needs of communities?

- Do these aspects that involve proximity, security, health, employment and flows of materials define the boundary, extension and location of these areas or is the idea of energy production landscapes and power plants more dependent on a past conception, rooted into different needs, flows and community assets?

2.

Frameworks

Theoretical Background

-“Uncovering” Industrial symbiosis.
[M. R. Chertow, 2007]



-Landscape and Energy, designing transition.
[D. Sijmons, J. Hugtenburg, A. van Hoorn, nai010 pulishers, 2014]



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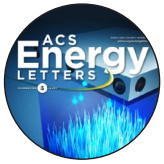
[M. van Stiphout, 2019]



-Scales of governance and environmental justice for adaptation and mitigation of climate change.
[W. N. Adger, 2001]



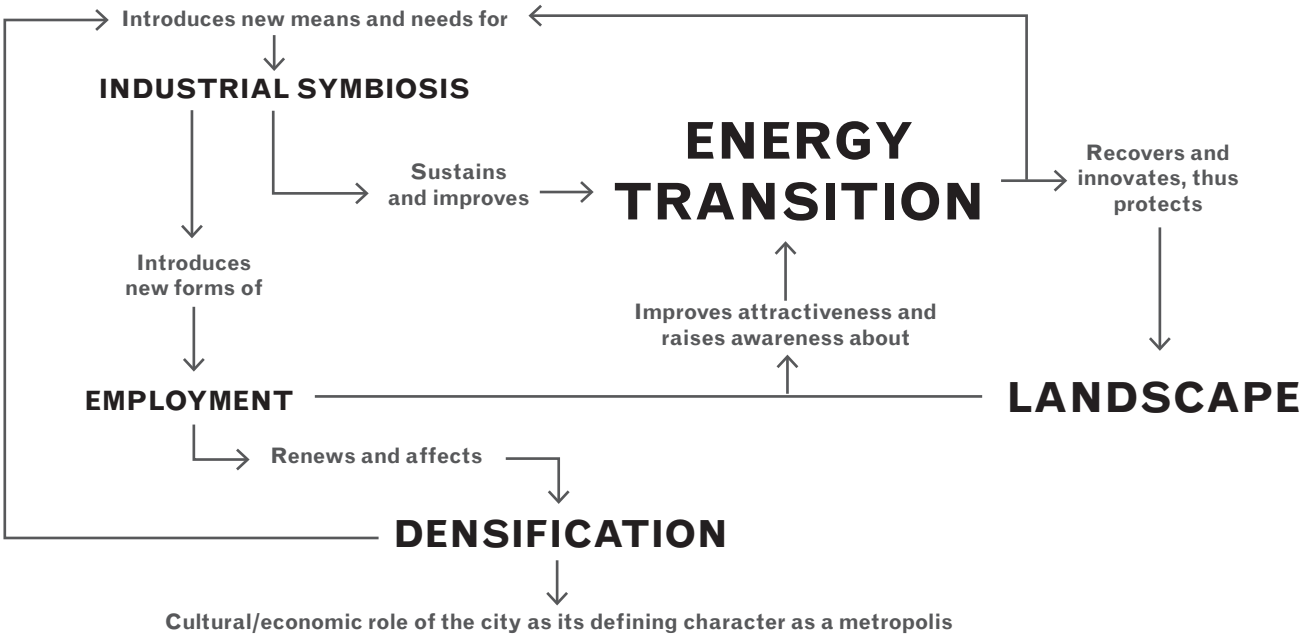
-CO2 Electroreduction from carbonate electrolyte.
[ACS Energy Lett. 2019, 4, 1427−1431]



-The metropolis in retrospect, from the trading metropolis to the global metropolis.
[L. Bourdeau - Lepage, J. Huriot, 2005]



Theoretical Framework



With the goal of improving Parkstad's attractiveness both on a social and ecological level, energy transition configures here both as a tool and as a goal. Its effects and relation with the natural, cultural and urban landscape of the area are thus firstly investigated to develop solutions that can directly link energy artifacts to landscape typologies in such a way that can welcome and attract the inhabitants of the area without being disruptive for the species found there.

This dynamic is set to protect said landscape by tranforming them into energy-producing ones and the tool to achieve this is that of industrial symbiosis: a diversified system of activities and artifacts that share and re-integrate their by-products into a larger, circular flow.

The envisioned nature-inclusive powerpark would work in accordance with the region's goal of becoming energy neutral in order to counteract its shrinkage, attract highly specialised workers and provide at the same time non-specialised employment opportunities.

The symbiosis between the maintenance of a natural environment, the production of clean fuel and energy, the construction and maintenance of the energy artifacts and the distribution of said green energy will in fact provide a wide range of job opportunities. In this way, Parkstad shall counter its shrinkage and turn into an open-air laboratory for clean energy production, bringing it closer to the role of a metropolis on an international level.

Methods used

-Desk analysis
This method inquires both projects that have been proposed within Parkstad and that deal more generally speaking with energy transition and integration of industrial landscapes with urban and natural realities, parallely to analysing several existing powerplants. The aim is to achieve a deeper understanding and more professional insight over the issue.

-Spatial footprint graphs and comparisons.
Taking Dirk Sijmons' "Landscape and Energy" as main reference, these tools are intended to provide a technical comparison of required areas, thus scales of intervention in relation to the desired amount of energy that needs to be produced in each municipality. Through the technique comparison in scale, these technical elaborations can provide a territorial insight over the landscapes that either can contain or are created by the systematic repetition of buildings that convert natural sources into energy and fuel. This method has mainly been implemented in the analysis of energy artifacts.

-Pattern study.
Since energy objects and spaces are based on specific natural sources and usually create industrial landscapes by means of repetition, the analysis and definition of both their aesthetic and functional patterns are of prior importance. This method has been used as the main one during the analysis phase both for the artifacts and the landscape system.

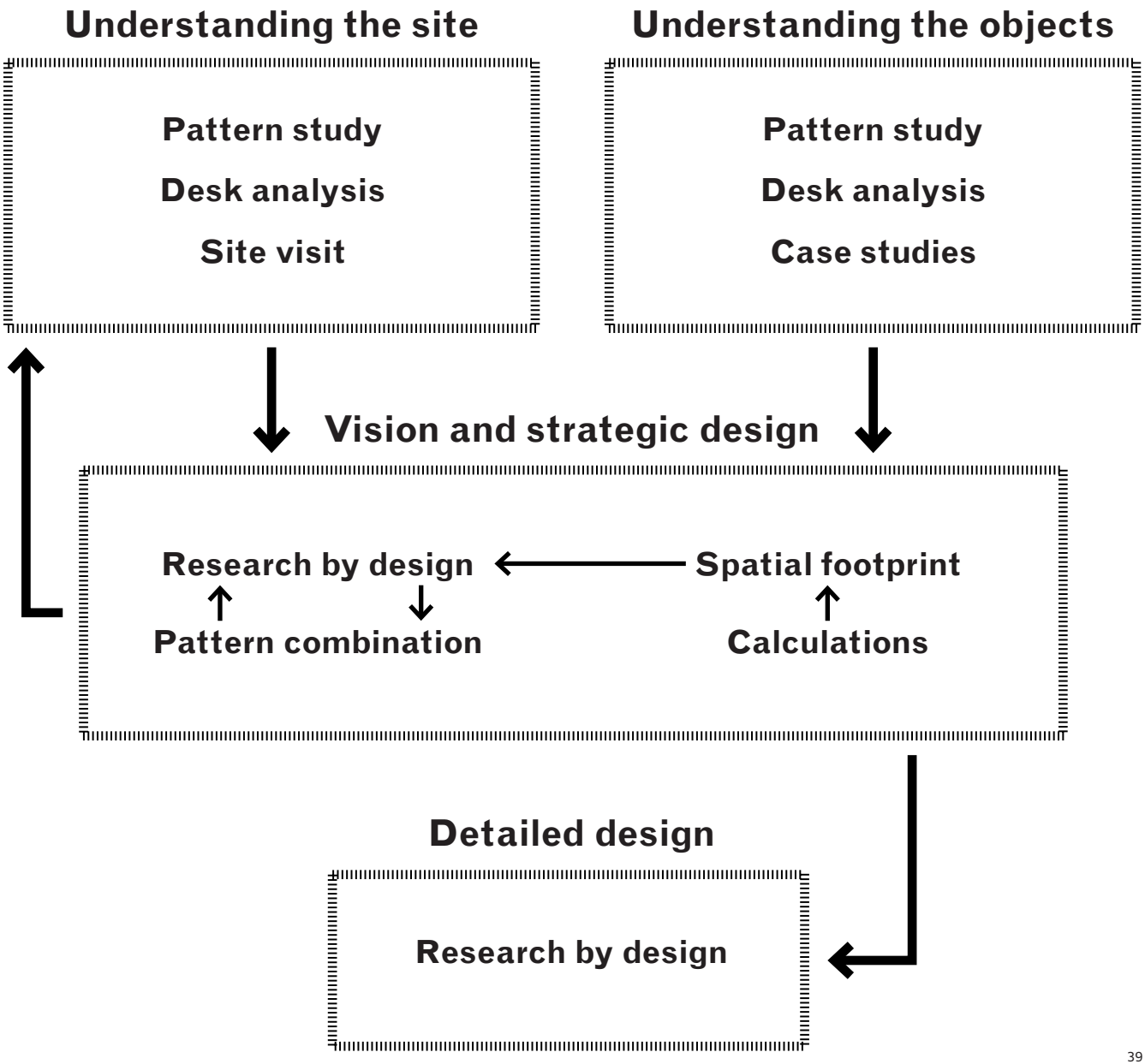
-Research by design.
Mainly focusing on spatial and cultural requirements, outcomes and impacts of energy artifacts over a landscape, this inquiry aims to translate the researched pattern into a system of artifacts that cooperate with each other. In order to define which synergies, arrangements and varieties of objects will be related to specific landscape typologies, the main tool used is research by design. The continuous inquiry and rearrangement of the design itself is in fact what guarantees the best result that the author can obtain in the span of time dedicated to the project.

-Case studies.
This method inquires both projects that have been proposed within Parkstad and that deal more generally speaking with energy transition and integration of industrial landscapes with urban and natural realities, parallely to analysing several existing powerplants. The aim is to achieve a deeper understanding and more professional insight over the issue.

-Site visit.

-Calculations.
After the general elements and units are defined, the amount of objects needed is calculated in relation to the regional needs and datas.

Methodological framework



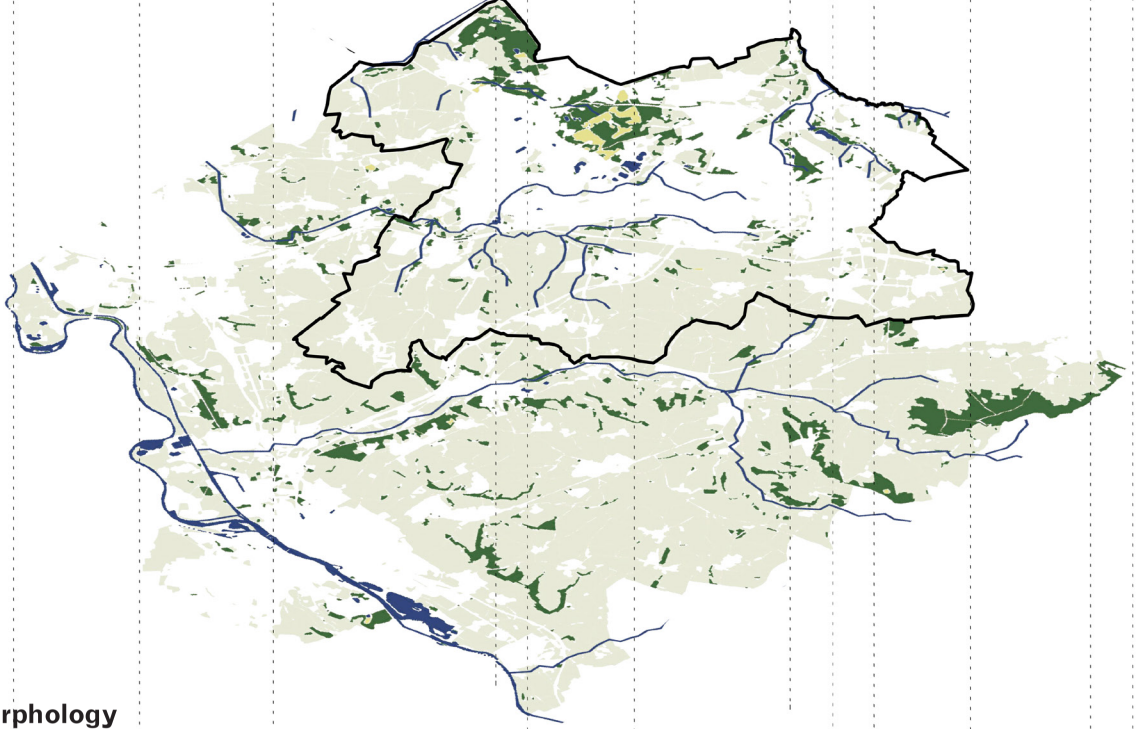
3.

Landscape analysis

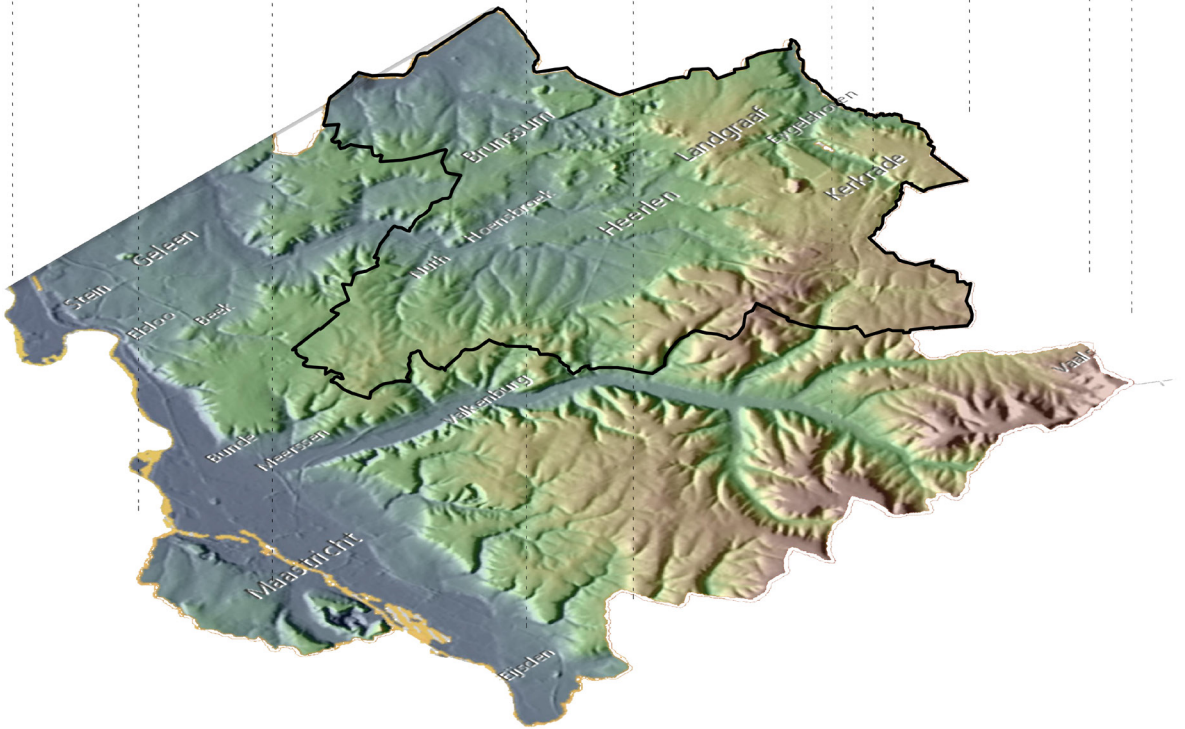
3.1

Landscape system

Zuid Limburg - Layer analysis



Morphology


Brunssum
Landgraaf
Kerkrade
Heerlen
Voerendaal
Simpelveld
Vaals
Gulpen
Wittem
Eijsden

Leisure and Urbanity

The range of activities to be found in parkstad is diversified, yet contained. Within the urban fabric, mainly on top of the plateaus, are found museums, a science park and sporting venues. These mostly relate either to the structures or traces on the land left by the coal mining period.

All around Whilelminaberg, the most evident trace of the mining period next to the constellation of basins, are found most of the leisure activities of the urban municipalities. Its morphology, in sharp contrast with the softer profile of the plateaus of the region, is given by the accumulation of discard materials from the mining of wells deep within the soil. This slag heap, as these elements are called, is now an icon of the region and some of the activities that revolve around it became iconic as well. The clearest example is Pinkpop, the oldest ongoing festival in the Netherlands, which celebrated its 50th anniversary in 2019. The area for the festival itself lays falt at the feet of the slag heaps, but interests also most of the open fields of the lower plateaus around it for camping. Moving up the slag heap are found Snowworld, an indoor artificial ski track, and the "Langste trap", or longest stairway, which is an extremely succesful sporting element for the locals.
At Whilhelminaberg's peak is found a panoramic platform that allows to see both Germany and Belgium. Nature related leisure facilities such as Mondo Verde, a showcase of many gardens typologies found around the world, and the Gaia Zoo are also found in its immediate vicinity.

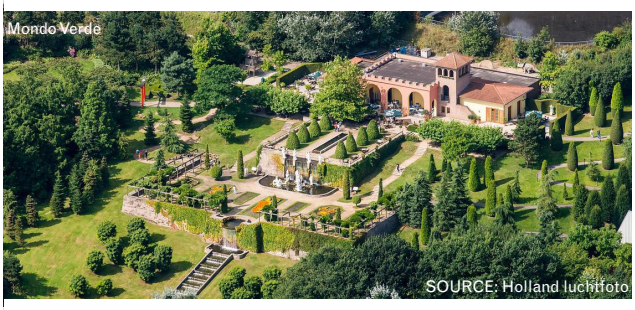
The other main kind of tourism of the area is due to the pictoresque rural landscape, laying on the flatter and descending plateaus and along the wider portions of the brook valleys. Here former farms, estates and castles that are either preserved or turned into restaurants and attractions can be visited.


Pinkpop, 50th edition

SOURCE: Pinkpop.nl


Snow World, interior

SOURCE: Adrem autoverhuur Limburg

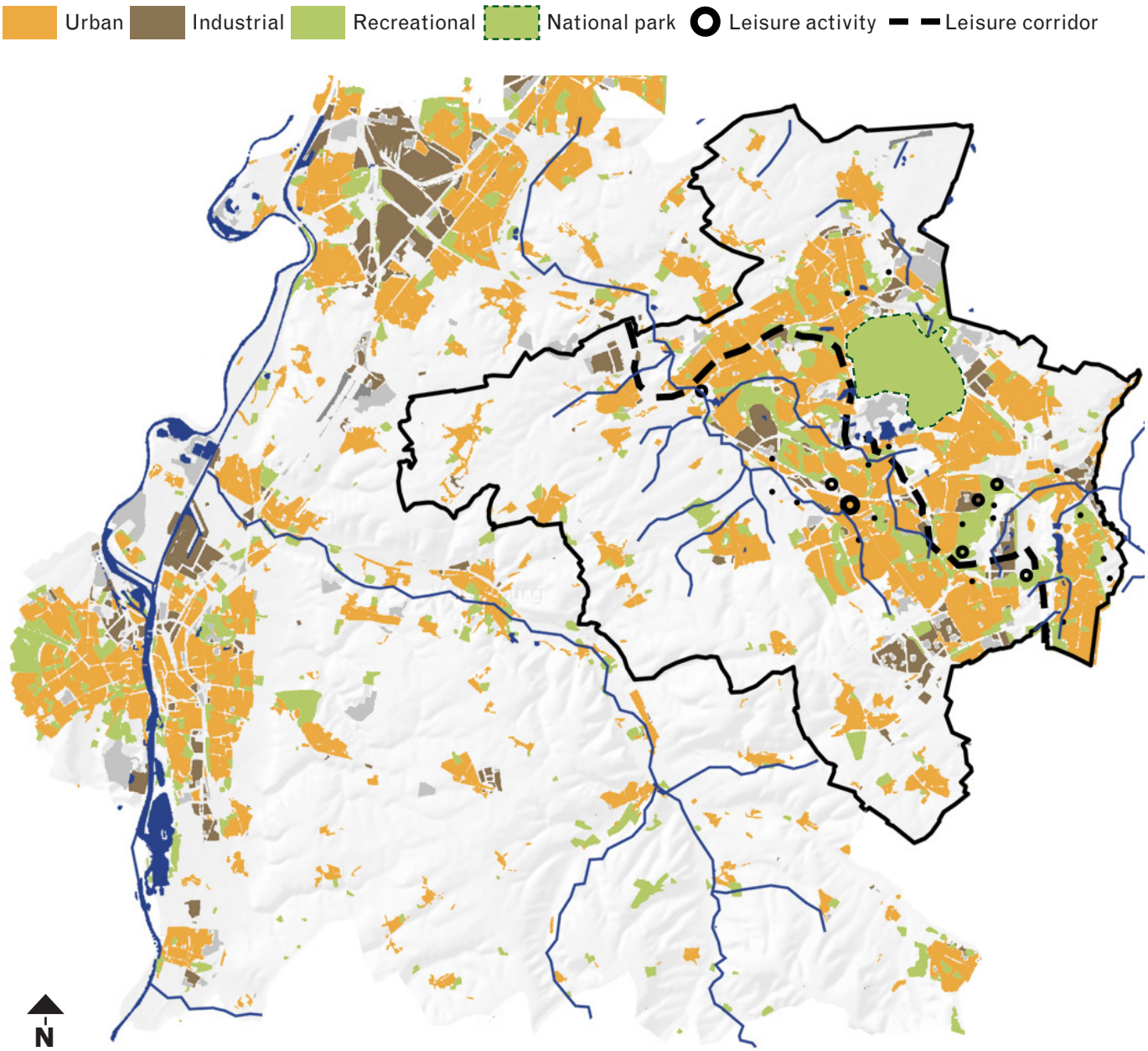

Mondo Verde

SOURCE: Holland luchtfoto



Zuid limburg wine tourism

SOURCE: vakantiehuis.nl


Urban
Industrial
Recreational
National park
Leisure activity
Leisure corridor
N

Transportation infrastructure

As introduced before, Parkstad presents a complex transportation infrastructure, which has been greatly influenced by its historical development, mainly in relation to production. It is interesting to notice that this pattern is not found in other urban areas in Zuid Limburg, particularly due to the different roles these cities had during the coal energy period.

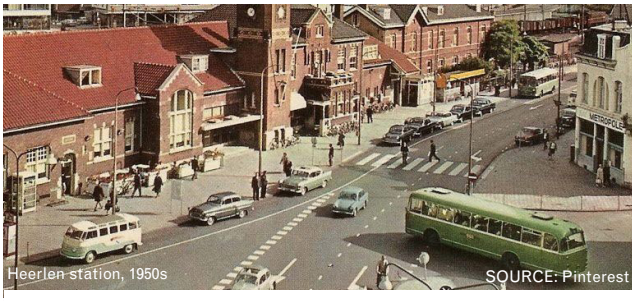
Polycentric (A)
Parkstad's traffic system develops mainly along and intersecting the two roman roads going from SoutEast to NortWest and from West to East.
The infrastructure appears here to not circle around one main centre, rather to run across the region in a widespread way. This aspect is due to the growth of the multiple municipalities bbetween and around the mines during the coal energy period.

Historic (B)
Maastricht's road system configures as a more traditional one, where there is one main regional axis cutting through a denser, net of streets. These circle around the historical centre of the city and across the Meuse.

Industry based (C)
The infrastructure of the small municipalities of Geleen, Elslo, Stein and Beek mainly develops within and around the common industrial area found at their centre.

On the right, a comparison between the evolution and refurbishment of the central stations of Heerlen and Maastricht. These images are included in this analysis as an example of different architectonical approaches to the element of transportation between Parkstad, polycentric and aiming at a more hi-tech image, and Maastricht, which remained more traditional, also due to a growth in wealth and educational facilities during the last seventy years.


Heerlen station, present day
SOURCE: Aerophotostock.com

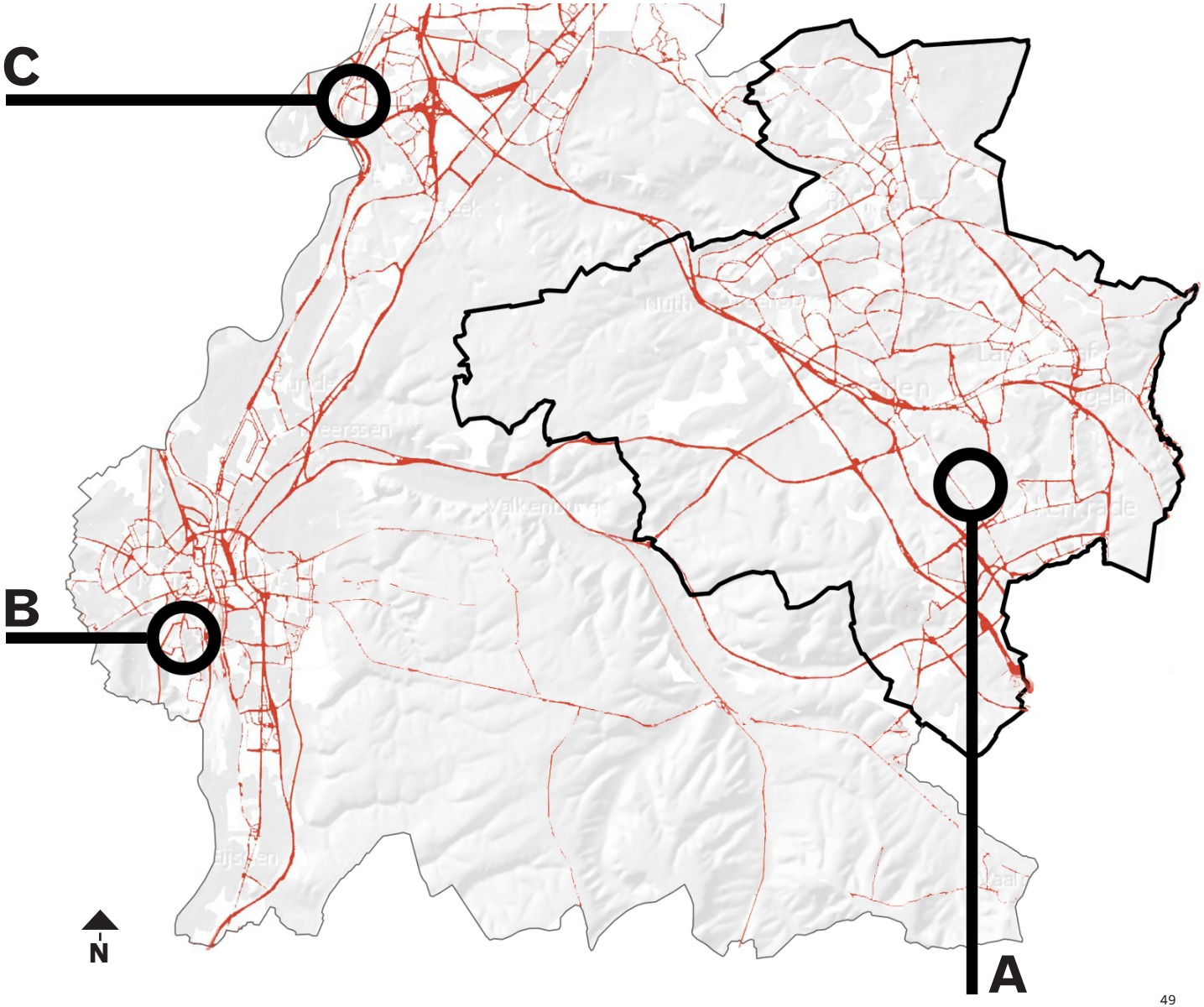

Heerlen station, 1950s
SOURCE: Pinterest

Maastricht station, present day


SOURCE: Sygic travel

Maastricht station, 1930s


SOURCE: Google Maps | Filip Visser


C
B
A
N

Morphology - Soil, Origin

Zuid Limubrg is mainly composed of low plateaus of loamy, very fertile soil that are eroded on their ridges by small streams of water.

These plateaus are the result both of eolian sedimentation during the last ice age and of the tectonic movements of the African and Scandinavian plates.

The first one pushes from South to North against the central European plates, creating thus a subduction that contributes to the formation of mountains such as the Alpes along with other hilly morphologies. The second one moves steadily upwards due to the liquefaction of ice, this pulls along the plates to which Parkstad belongs, flattening the hills into gradually lower, descending plateaus .

These landscapes lay on top of several substrata, mainly characterised by coal beds, chalk, sandstone and limestone.

These elements are found both in the architecture and history of the region, since the very fertile soil is perfect for agriculture, the limestone is largely used in vernaculare constructions and the coal beds defined a whole enrgy period and growth of the region.

PALEOZOIC

CARBONIFEROUS

Rocks from the Carboniferous period, mostly repeating sequences of **limestone, sandstone, shale and coal beds**, outcrop in the southeastern province of Limburg. Younger sediments (Permian in age) are not exposed at surface.

From 359 to 299 Million years ago

ERA

PERIOD

EPOCH

Sources: diagram made by author, data obtained from Wikipedia

MESOZOIC → CENOZOIC

TRIASSIC

Within the Triassic rocks, two major groups of sediments are recognised: the Lower Germanic Trias Group, a mainly clastic succession, and the Upper Germanic Trias Group, comprising an alternation of **clastics, carbonates and evaporites.**

From 252 to 201 Million years ago

JURASSIC

The Posidonia Shale formation develops comprising **finely laminated layers of oil shales** formed of **fine-grained sediments** intercalated with **bituminous limestones**.

From 201 to 145 Million years ago

CRETACEOUS

Covered by a warm, shallow (inland) sea in which **thick successions of chalk** were deposited, the Schoonebeek **oil-bearing sandstones** form the source rock for the east Netherlands oil.

From 145 to 66 Million years ago

OLIGOCENE

Earth's **crust falling by about 2km**. Decrease recorded by the accumulation of sediments.

From 34 to 23 Million years ago

MIOCENE

Sludge filled in bby the sea, **flooding from north of the Netherlands and Belgium**.

From 23 to 5 Million years ago

PLIOCENE

Less active streams, marine sands (the Oosterhout formation) deposited once again, plus sand and gravel from the Rhine.

From 5 to 2.6 Million years ago

PLEISTOCENE

Present-day Netherlands start forming by sediments and as the result of glacio-fluvial, eolian and marine sedimentation. Eolian dunes, a horseshoe shaped moraine and the rivers influence are still visible all over the country..

From 2.6 Million years ago to 11.700 years ago

Morphology - Soil, characteristics

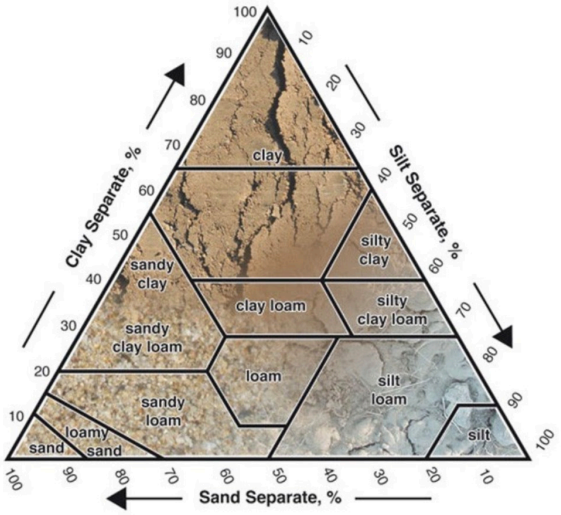
Loamy soils generally contain more nutrients, moisture, and humus than sandy soils, have better drainage and infiltration of water and air than silt and clay-rich soils, and are easier to till than clay soils.

The soil's texture, and its ability to retain nutrients and water are crucial. Loam soil is suitable for growing most plant varieties.

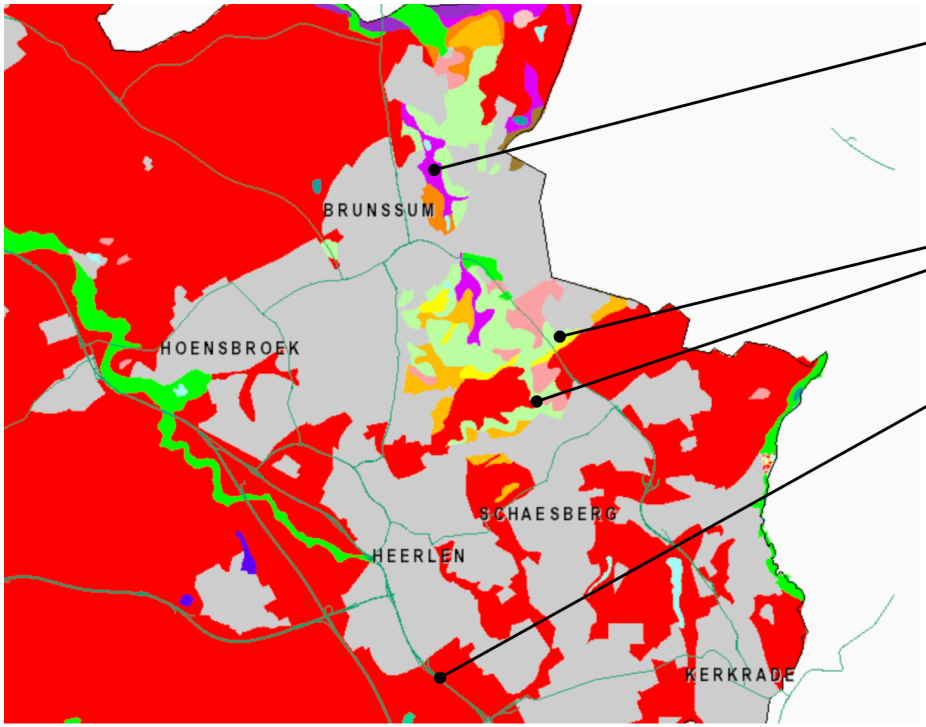
Loess, also known in daily terms as Limburg clay, is an aeolian deposit of silt. In terms of composition, loess mainly contains siliciclastics (quartz and other silicates), but it can also contain a small fraction of clay minerals . Sometimes that fraction has grown since the moment of sedimentation due to chemical weathering. The loess in north-western Europe dates from the Saalien and the last part of the Weichsel glacial.

The Weichsel caused the drying of the North Sea. The sediment on the seabed became the source of the loess deposits. The light material was supplied by the wind and has deposited in a wide zone from Belgian and Dutch Limburg through Germany to deep in Poland , Romania and Austria.

Loess bottoms are very suitable for agriculture. The first agriculture in the Netherlands took place on the loess in South Limburg. The farmers came from Central Europe , which has similar soils. Bare loess bottoms are highly sensitive to erosion. Limes from the parent material loess partly dissolve in rain and then settle lower in the profile. The loess particles are thus bonded together in the vertical direction. As a result, the valleys and hollow roads formed in loess can often have steep walls.



Source: Wikipedia



- Ground surface on deep peat
- Ground surface on peat on sand
- Clay deck on peat
- Clay deck on peat on sand
- Sand deck on peat on sand
- Peat on immature clay
- Mineral poor sand in drifting dunes and beaches
- Mineral poor sand
- Weak, loamy fine sand
- Weak, loamy fine sand on coarse sand
- Strong, loamy fine sand on loam
- Fine sand
- Strong, loamy fine sand
- Course sand
- Sandy clay with homogeneous profile
- Light clay with homogeneous profile
- Clay with heavy mid-layer of subsoil
- Clay on peat
- Clay on fine sand
- Clay on course sand
- Loam
- Water
- Buildings





Sources: pdok.nl; Wikipedia



Water system

Differently from most of the Netherlands, the water system of Zuid Limburg does not require continuous drainage and artificial movement of water.

Parkstad is in particular enclosed by three rivers, the Geul, the Geleenbeek and the Wurm, and cut through by a forth one, the Geleenbeek. These rivers are alimented by the several brooks that cut through the ridges of the plateaus of the area. Their streams flow in turn into the major river systems of the Meuse, springin from France, and the Roer, originating in Switzerland. They both flow from South to North and end their journey in the North Sea, having Zeeland and Zuid-Holland as their delta regions.

The active erosion of the ridges caused by the brooks is one of the driving forces of Zuid Limburg landscape due to the several amount of different biotopes they generate and the minerals and stones the either reveal or carry downstream.

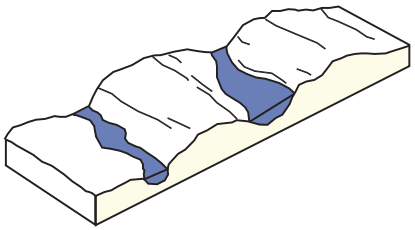
It is interesting to notice how several artificial basins are found throughout the region, mainly in the lower, more flat plateaus and in the valleys of the major rivers. These still water element are opposed to the more continuous flows of the rivers, especially to the movement of the water within the brooks, and find their origin in agricultural and industrial purposes.

Most of these basins, especially in Parkstad, were in fact built next to the mining sites in aid of the coal extraction. Nowadays, these elements configure important ecological and leisure areas as they attract several species, most of all reptiles, and contribute to the iconic image of estates.

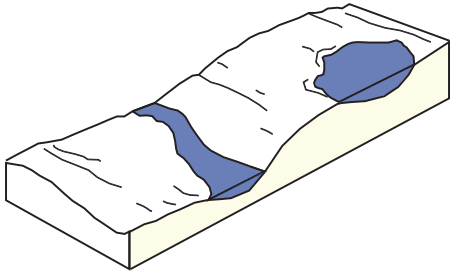
RIVER

BROOK

CANAL



Section AA



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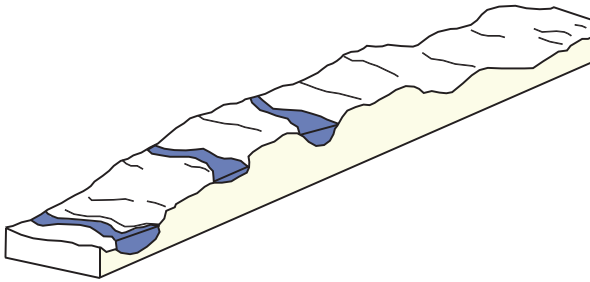
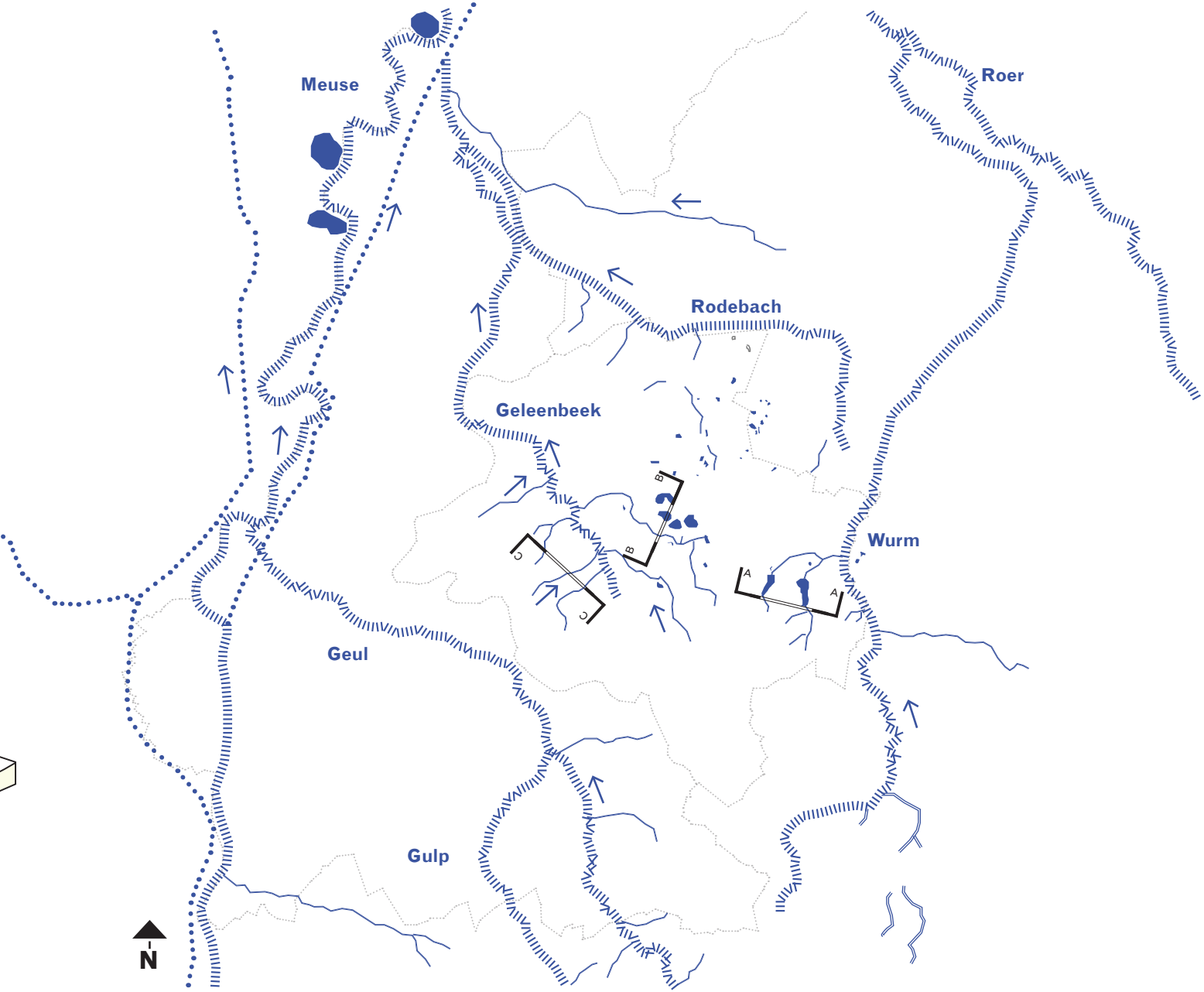


Section CC

Source: diagrams made by author


Meuse
Roer
Rodebach
Geleenbeek
Wurm
Geul
Gulp
A
A
B
B
C
C
N

Green infrastructure

Parkstad is, in percentage, the greenest urban region in the Netherlands, yet it lacks some fundamental qualities for its natural and agricultural system. Most of the region is occupied by agricultural fields, mainly found on top of the lower, South-western plateaus and on the ones in between the Geleenbeek and the Geul.

These landscapes are home to many species and are one of the main touristic attractions of the region, yet they create a widespread barrier for the species found in the forested parts of the region.

Relatively isolated patches of forestry are in fact found all around Zuid Limburg, mainly on the ridges of the plateaus. These linear clusters outline the division and gradient from plateau to valley and are mostly characterised by temperate deciduous forests and by slopes too step for crops or industrial activities to be placed there.

Two national parks, the Brunssumersheide and the Vijlenerbos also belongs to the region, but lack any kind of ecological corridor for non flying species to move from one another.

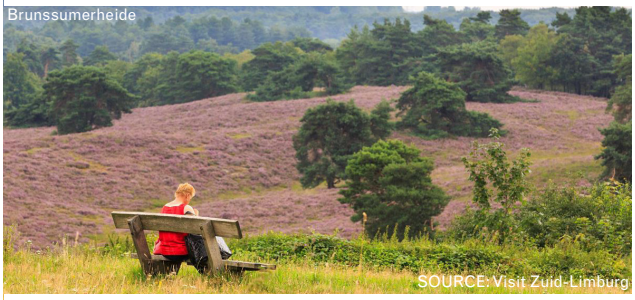
The outcome of such a dispersed and relegated cluster of biotopes is a wide variety of species. However, the most vulnerable, such as small rodents and reptiles, have in this way small chances of survival if their isolated ecological patch is targeted for another use. Most of them are safeguarded by the Natura 2000 program, yet there is space for improvement.


Koumenberg

SOURCE: Google maps | Harry Raaijmakers


Cranenweyer

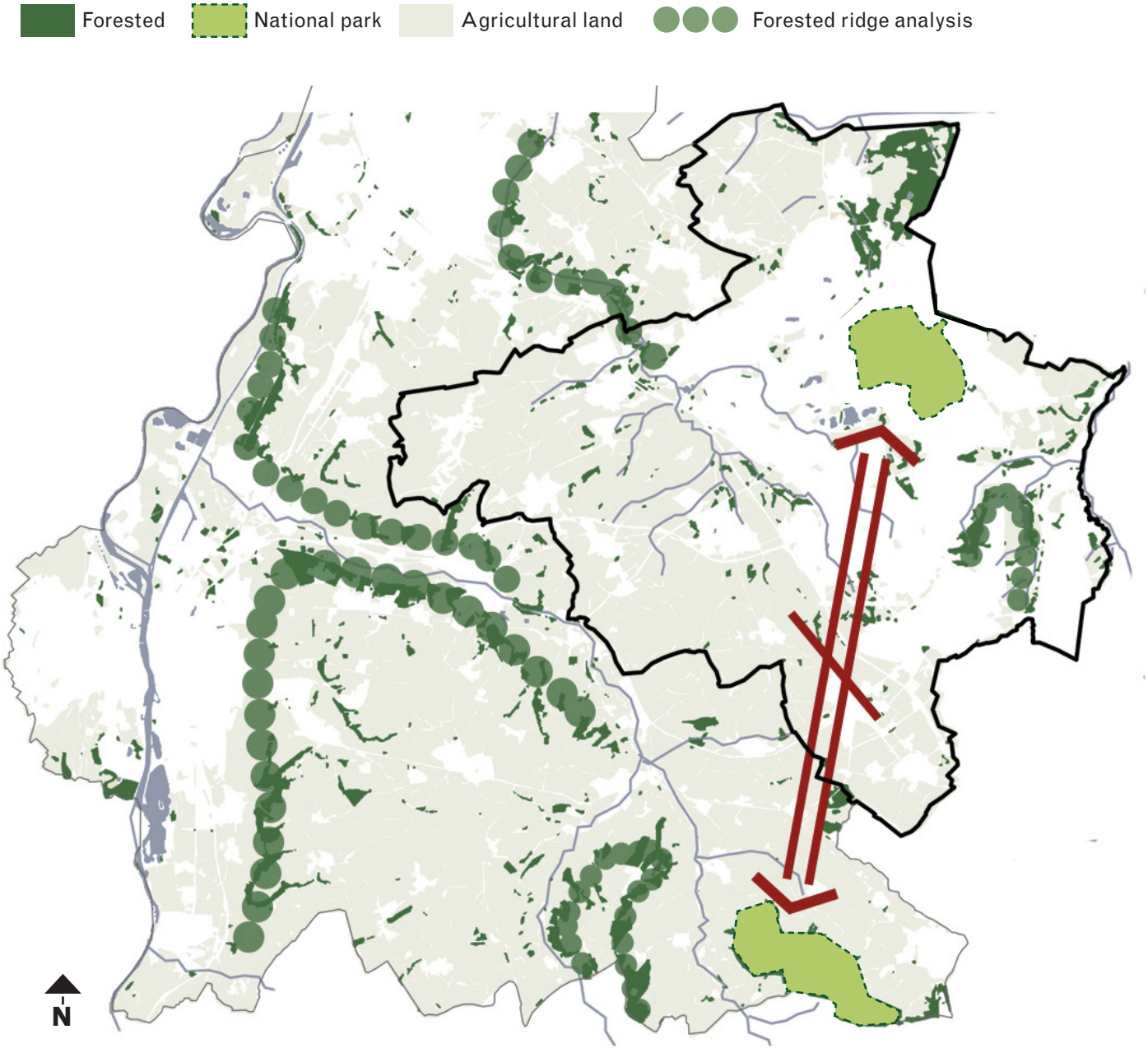
SOURCE: Google maps | John


Brunssumerheide

SOURCE: Visit Zuid-Limburg


Vijlenerbos

SOURCE: Google Maps | Filip Visser



Source: diagram made by author, data obtained from pdok.nl

3.2

Landscape typologies

Plateaus

Parkstad's plateaus belong to the landscape system of the Rhine-Meuse Euregion, and descend from the steeper, higher ones found in the South-Eastern border with Germany towards the lower, softer ones both on the West, flanking the Mesue valley, and on the North, where Brunssumersheide national park is found. Parkstad's urban areas are along the Geleenbeek, mainly on its northern side, and on the lower, wider and more flat plateaus around it. It can be observed that, within Parkstad, this typology is the preferred one for urban areas.

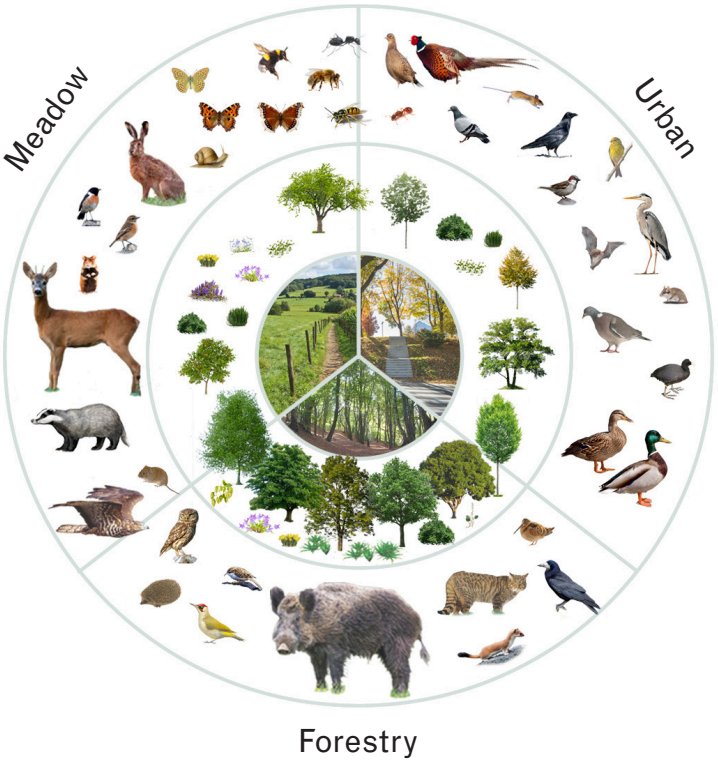
The higher plateaus south of the Geleenbeek are used for agriculture and present several estates with castles and farms at either the threshold between the plateau itself and its ridge, or where a brook cuts through them.This disposition is due both to the overlook the estate gains over the lower valley and city and to the accessibility to both flowing water, which used to power the mills, and wide agricultural fields. The energy objects typically observed on these plateaus are windmills, which are however very few in number.

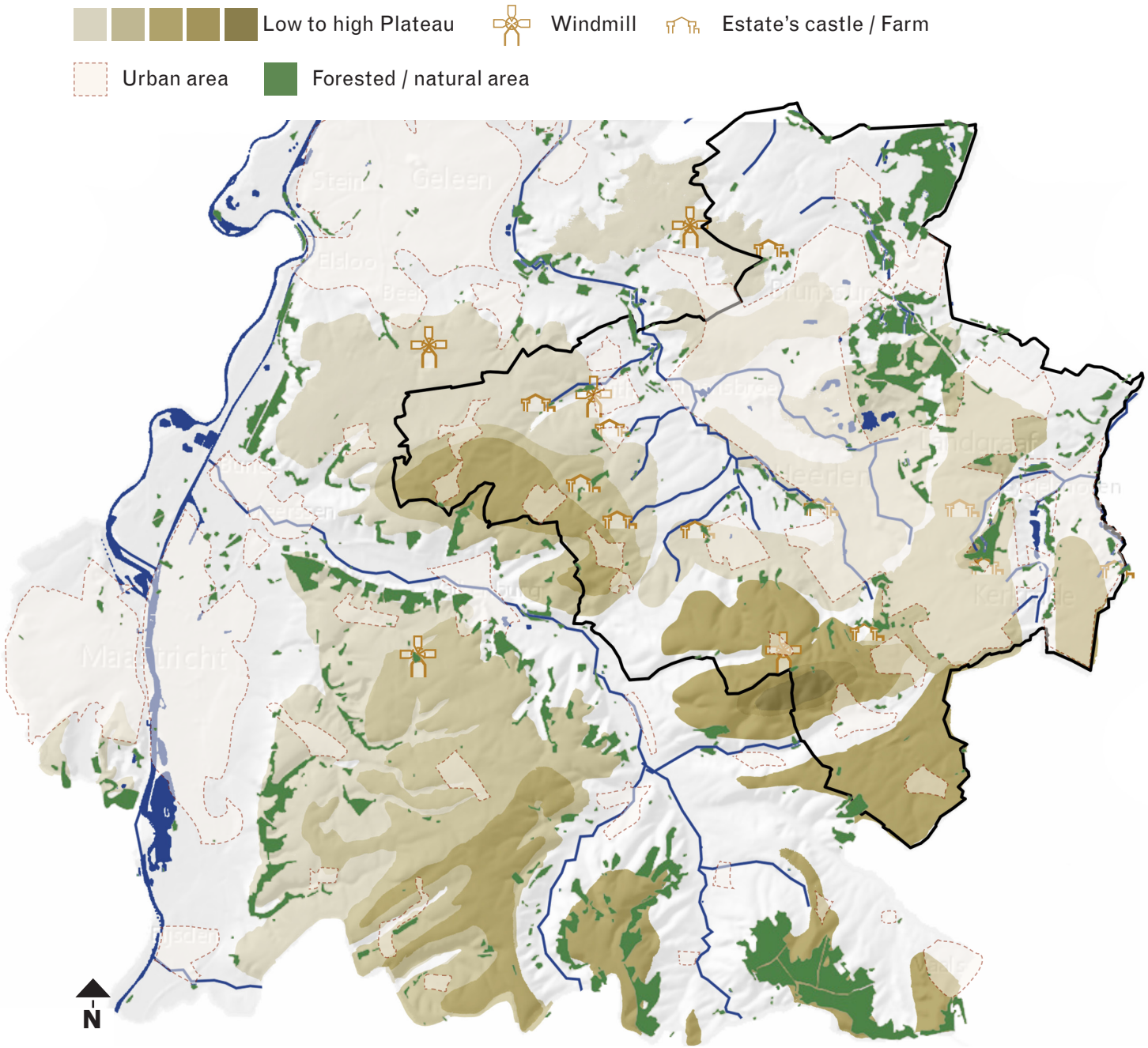
The variety of both flora and fauna is rich, and animals that are usually difficult or even impossible to find in the rest of the country are found. Game can be spotted in the deciduous forests, and many birds of prey fly from the forests over the meadows to feed. In the agricultural fields live a wide range of insects and butterflies and in the most ecologically healthy areas wild hamsters and hedehogs can be found. One of the most iconic elements of the region are the fruit orchards, usually grown on plateaus.

The urban nature is rich, especially in terms of birds and small rodents. Farm animals and pets haven't been included in this analysis, however it is important to state the remarkable amount of horses bred in the area.

For the complete list of species, see Appendix [1]







Source: diagrams made by author, land use data obtained from pdok.nl

Ridges

Ridges have very discontinuous perimeters and greatly show the influence of the brooks flow over the landscape. The water carves in fact through them, creating narrow, descending corridoors.

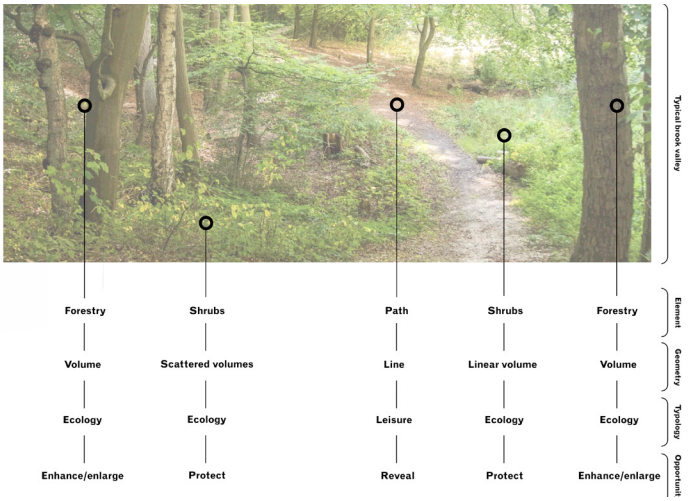
Mainly kept as ecological elements, they barely present any built facility or human activity, also due to their steeper sections.

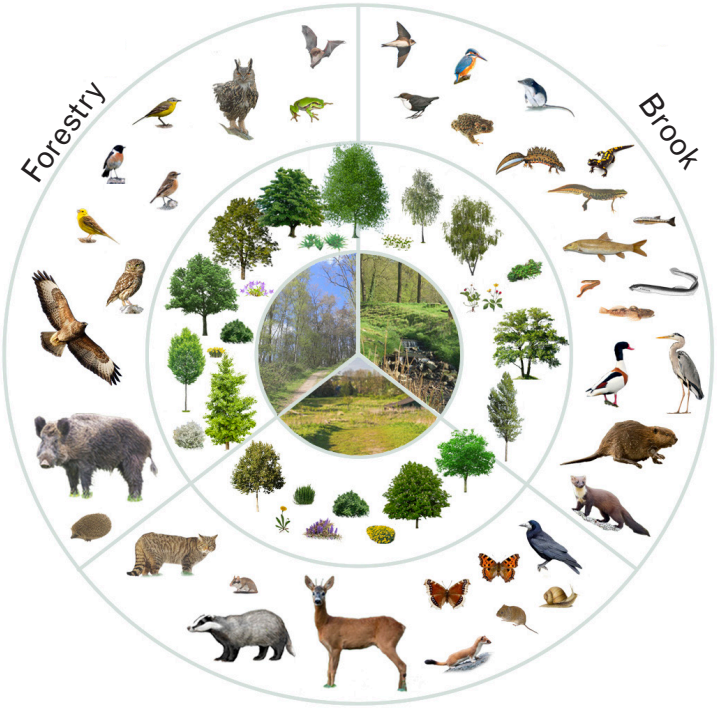
Neither estates nor energy artifacts are found here, with the only exception of the few built onto the softer ridges, where occasionaly are also observed basins and water depuration facilities. These elements are the real theaters of the ecologic diversity of the region.

It is here in fact that most of the water-related wildlife is found. Many reptiles, such as newts and tree frogs, thrive in the close proximity of the brooks, where also bats and fishing birds dwell. Beavers and other small rodents can also be found close to the water.

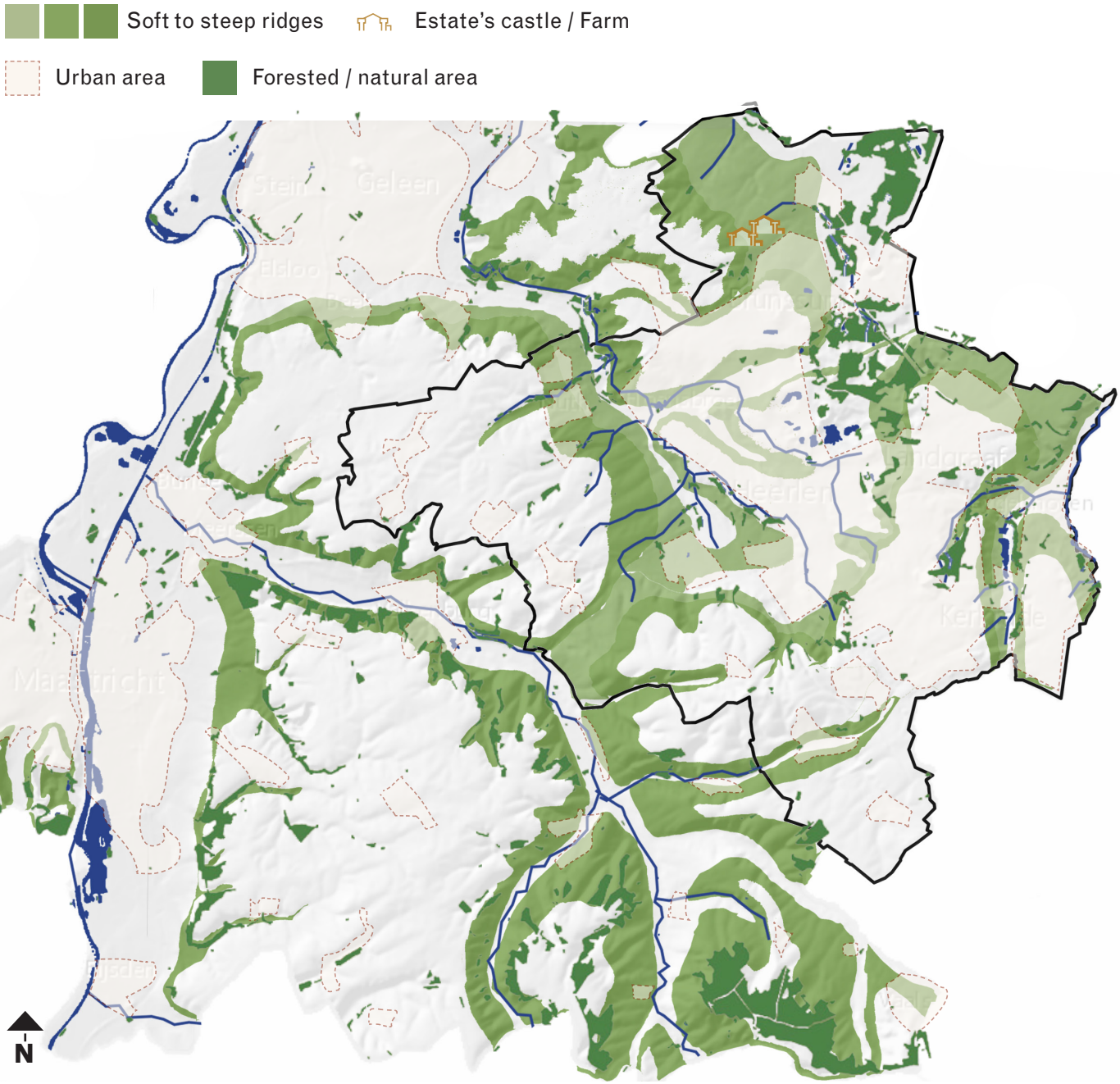
The fauna observed in the forested ridges is very similar with the one found on the flatter areas of the region, however more reserved animals are easier to spot here. Among the several species of trees found in the area, adlers, ashes, beeches, birches, hornbeams, oaks, and lindens are the most diffused.

Grasslands are less present within this landscape element.





For the complete list of species, see Appendix [1]



Source: diagrams made by author, land use data obtained from pdok.nl

Valleys

Valleys present a high number of estates, but mainly on the points where the brooks flow into the rivers. Here are in fact often found watermills, very much present in the region.

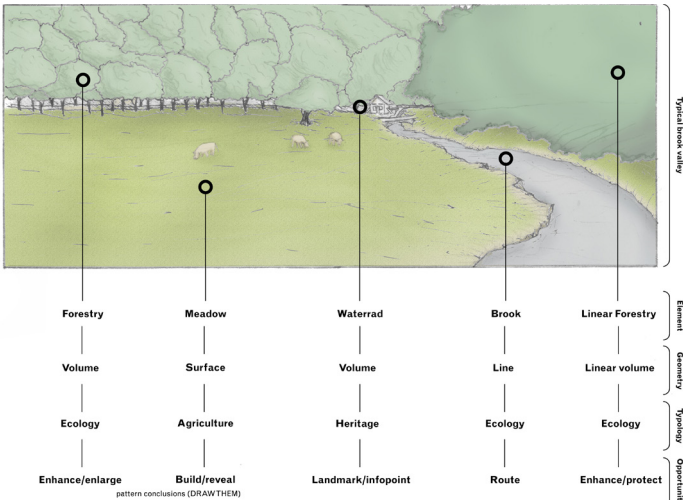
It is also interesting to notice how the estates still present are in the portions of the land where there used to be farms before the massive urbanisation triggered by the coal mining period reshaped all the land found in between the mining sites and the cities of the valley and lower plateaus.

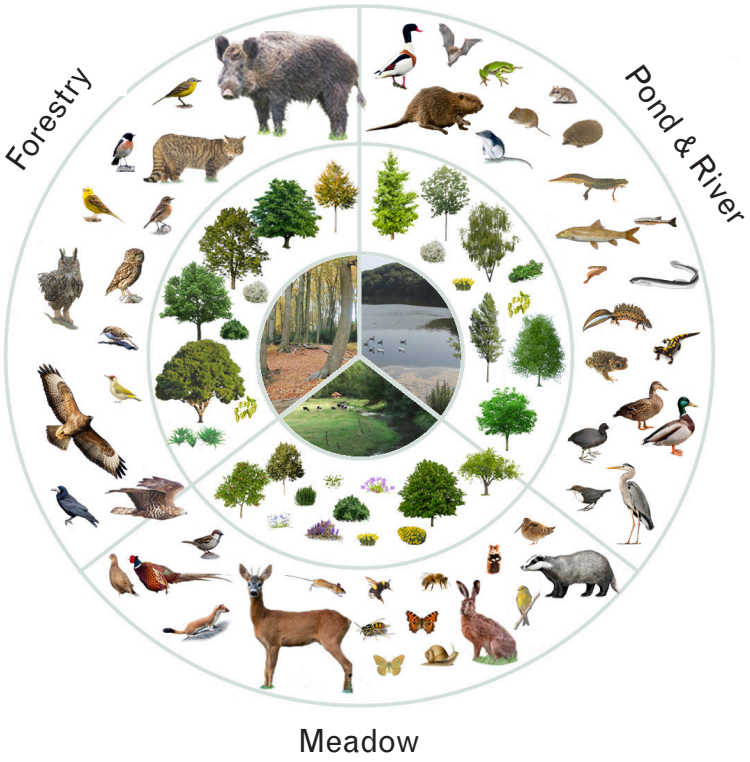
Most of these places are now turistic and have a small portion of forestry or a water basin next to them, but have been engulfed by the city.

Due to the great amount of both natural and artificial basins along the water streams, most of the animals that inhabit this region can be observed here. These ponds, even if most of them has an industrial origin, represent important ecological stepping stones in the region, in particular for the many, small reptiles, fishing birds and bats.

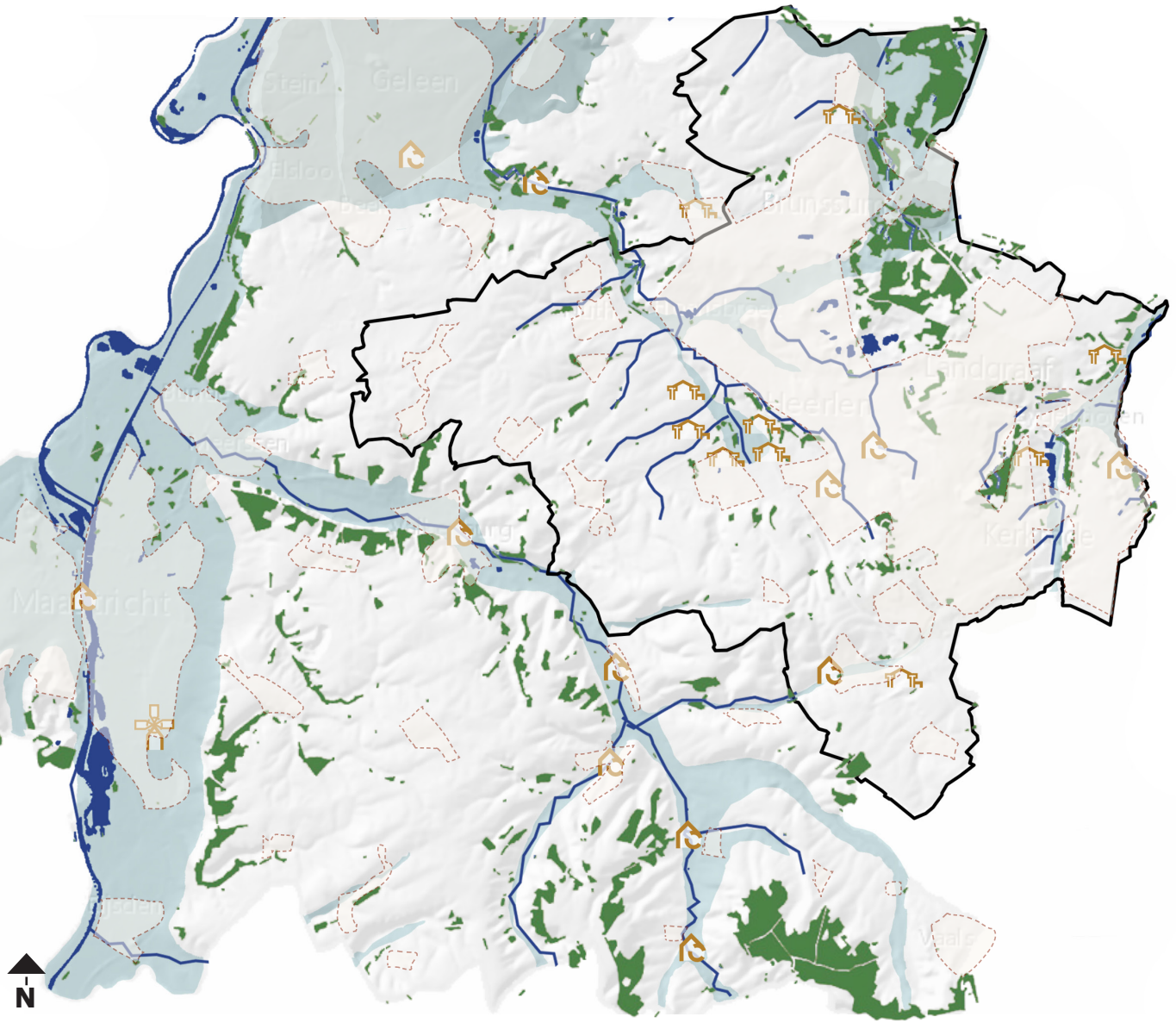
Species that prefer colder and more humid environments, along with a great variety of water plants, are easily observed here, due to the lower position in the morphology, the shade provided by the forested areas and the presence of water.

Several estates can also be found along the streams, which configure a good source of water for the farm animals. It is interesting to notice the difference between the banks on the side of the farms, more eroded and soft due to the big animals approaching the water, and the ones on forested sides, whith harder edges and a wider biodiversity.





For the complete list of species, see Appendix [1]



Source: diagrams made by author, land use data obtained from pdok.nl

4

Energy artifacts analysis

Energy artifacts - Considerations

One of the main issues of energy systems today, is the amount of energy that gets lost or dissipated both in its production and transportation. (Sijmons, 2014)

In order to design a nature inclusive power plant, the first step moved into this research targeted a wide variety of sustainable energy objects, both with the intention of learning the different options on the market and of understanding the spatial implications of each of the analysed artifacts.

The presented energy systems have been selected due to their low, or negative CO_2 emissions and their being based on sustainable energy sources. Secondly, these artifacts need to have a clear, identifiable shape due to their educational role within powerparks. For these reasons, the list here presented is limited to those energy objects I have been able to find and study that satisfy these conditions.

In order to compare the energy artifacts with each other, a grading has been defined. The criteria here included focus mainly at the impact of the power park both over the ecological and social context.

Spatial footprint, in order to be able to translate and quantify energy needs and dynamics into spatial ones.

Efficiency, in order to have a unit to compare the production of the artifacts that harvest energy from the same source. If combined with the spatial footprint and the atmospheric data [Appendix 2], this allows also to compare energy objects that use different sources with each other.

Lifespan and recyclability adress the temporal impact these artifacts have on the production system, how often and how much needs to be built, and on the ecological system, how often and how much waste needs to be collected and dealt with.

Labor intensity, based on the factors of modularity, level of automatisation assembly and possibility to build the artifact in Parkstad. These factors, selected by the author, are chosen to get an indicative insight on how much employment and work the construction of a power park can provide Parkstad with. In order to define how local an artifact can be, a research of which factories and production companies can be found within parkstad has been done. [Appendix 3]

While the first four factors are physically quantifiable and present a clear preference related to production and natural impacts, the fifth one partly deals with employment and commerce, having thus a morelocal connotation and a direct impact on Parkstad's social capital .

For these reasons, artifacts that have a contained spatial footprint, high efficiency, a long lifespan, high rates of recyclability and modularity, local production and require both machine and hand assembly will be preferred.

The data presented in the following catalog is based on several articles sourced underneath the conclusions. [Appendix 4]

Grading criteria

Spatial footprint - Hectars needed for 1 million households



Efficiency - Capacity factor = Maximum theoretical output



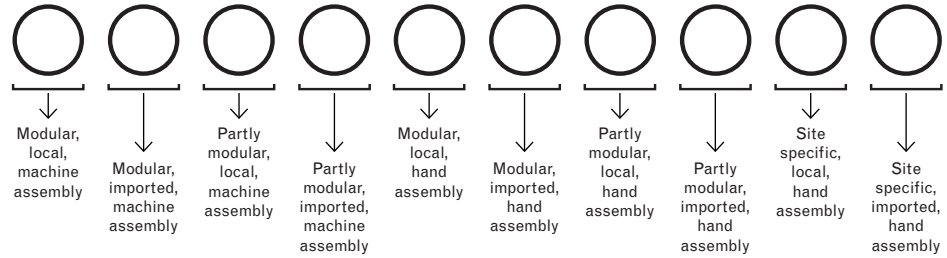
Lifespan



Recyclability



Labor intensity



Sustainable gas production - CO_2 Recycling

TECHNICALITIES

- Yearly recycled CO_2: 6000 ton
- Yearly biomethanol produced: 5000 ton
- Area required : ~ 7.000 m^2
- Investment : ~ 8 million
- Input : Water, 5MW low voltage D.C., CO_2
- Output : O_2, Biomethanol or methane
- Need for fuel/gas storage
- Need for carbon capture elements
- Sabatier reaction:

ISSUES & OPPORTUNITIES

- Technical inaccessible areas
- Iconic image of storage and converters
- Buildings complex and possible division
- Tower as design element
- Dangerous for migrating birds
- Possibility to further



SOURCE: LinkedIN | Carbon Recycling International


SOURCE: Carbon Recycling International

Spatial footprint



Efficiency



Lifespan (Anodes and cathodes)



Recyclability

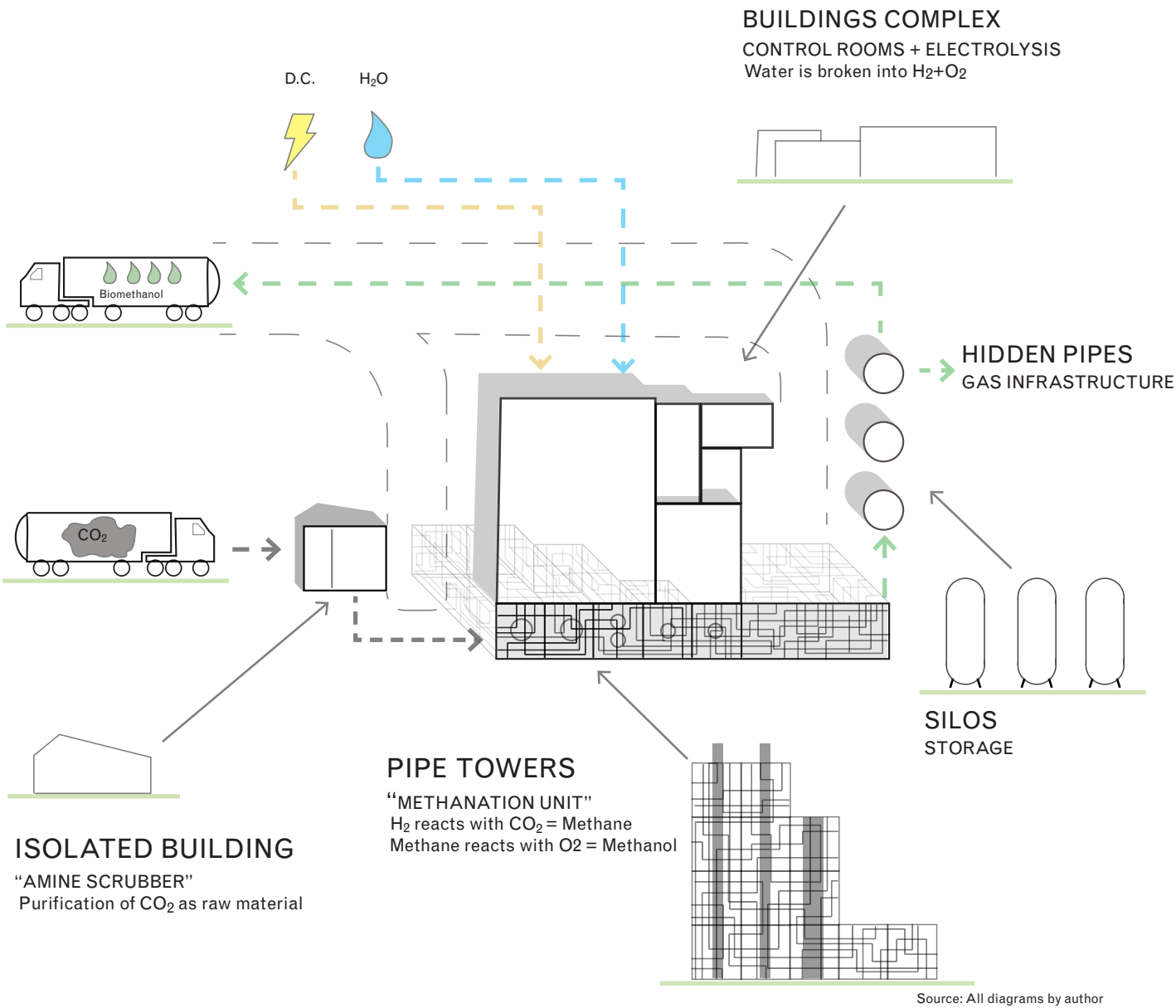


Labor intensity



Sources:
[1] Energy storage and the Tesla battery, Levien van Zon, (jun 3, 2015), published onto "The substance of sustainability".
[2] Carbon recycling international, https://www.carbonrecycling.is/
[3] Wikipedia, https://en.wikipedia.org/wiki/Sabatier_reaction

Flow diagram & Pattern analysis



Source: All diagrams by author

Sustainable energy production - Wind turbines

TECHNICALITIES

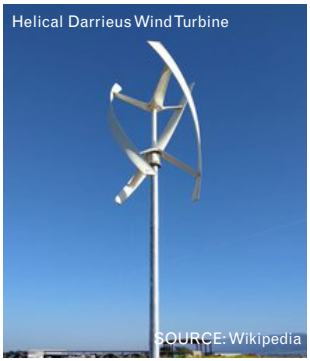
Horizontal axis:
- Blade length: 20 to 80 meters
- Altitude: 70 to 160 meters
- Noise: 5-60 dB

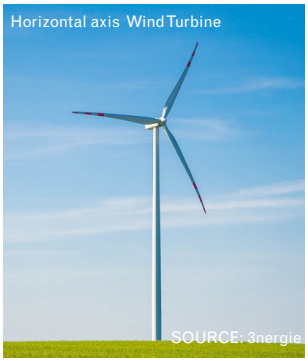
Vertical axis:
- Darrieus
- Giromill
- Savonius (works with slow winds

For h=1 m and r=0.5 m, wind v=10 m/s the maximum power would be of 180 W
- Noise: 0-10 dB

ISSUES & OPPORTUNITIES

- Wind intermittency
- Relatively short lifespan
- Need for a low ground surface roughness
- Tower as design element
- Dangerous for migrating birds
- Enormous scale









Spatial footprint



Efficiency



Lifespan



Recyclability

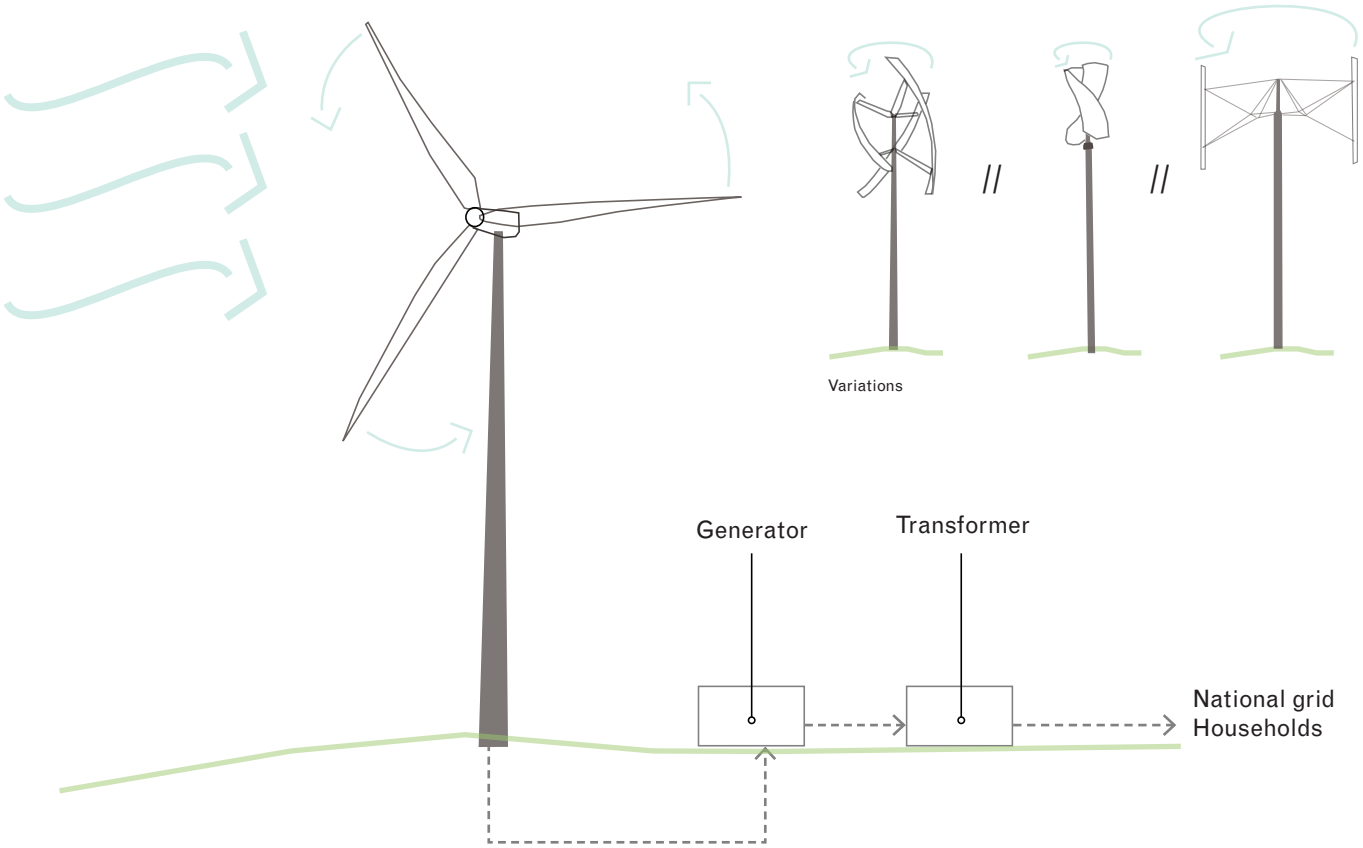


Labor intensity



Sources:
[1]https://greenliving.lovetoknow.com/Efficiency_of_Wind_Energy
[2]https://www.npr.org/2019/09/10/759376113/unfurling-the-waste-problem-caused-by-wind-energy?t=1587541312689
[3]https://www.ewea.org/wind-energy-basics/faq/
[4]Landscape and Energy, Designing Transition; Dirk Sijmons, Jasper Hugtenburg, Fred Feddes, Anton van Hoorn; Published by NAI010 Publishers, Rotterdam, 2014

Flow diagram & Pattern analysis



Pattern analysis of Gull Lake power facility

Source: All diagrams by author

Sustainable energy production - Kite generators

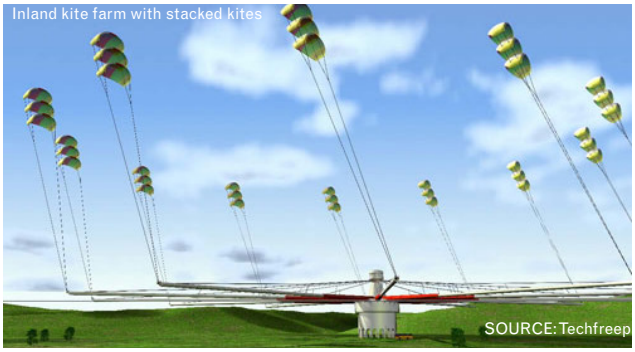
TECHNICALITIES

- Altitude range: 70 - 450m
- Nominal power: 100 kW
- Peak power: 180 kW
- Yearly power output: 450 MWh/y
- Generation phase producing energy
- Retraction phase consuming energy

ISSUES AND OPPORTUNITIES

- Different combinations of kites
- Dynamic element
- Fabric easy to color
- Rope might be dangerous for birds
- Generation phase producing energy
- Retraction phase consuming energy
- Small scale and almost absent noise
- Possibility to have fixed or moving ground station





Spatial footprint



Efficiency



Lifespan



Recyclability

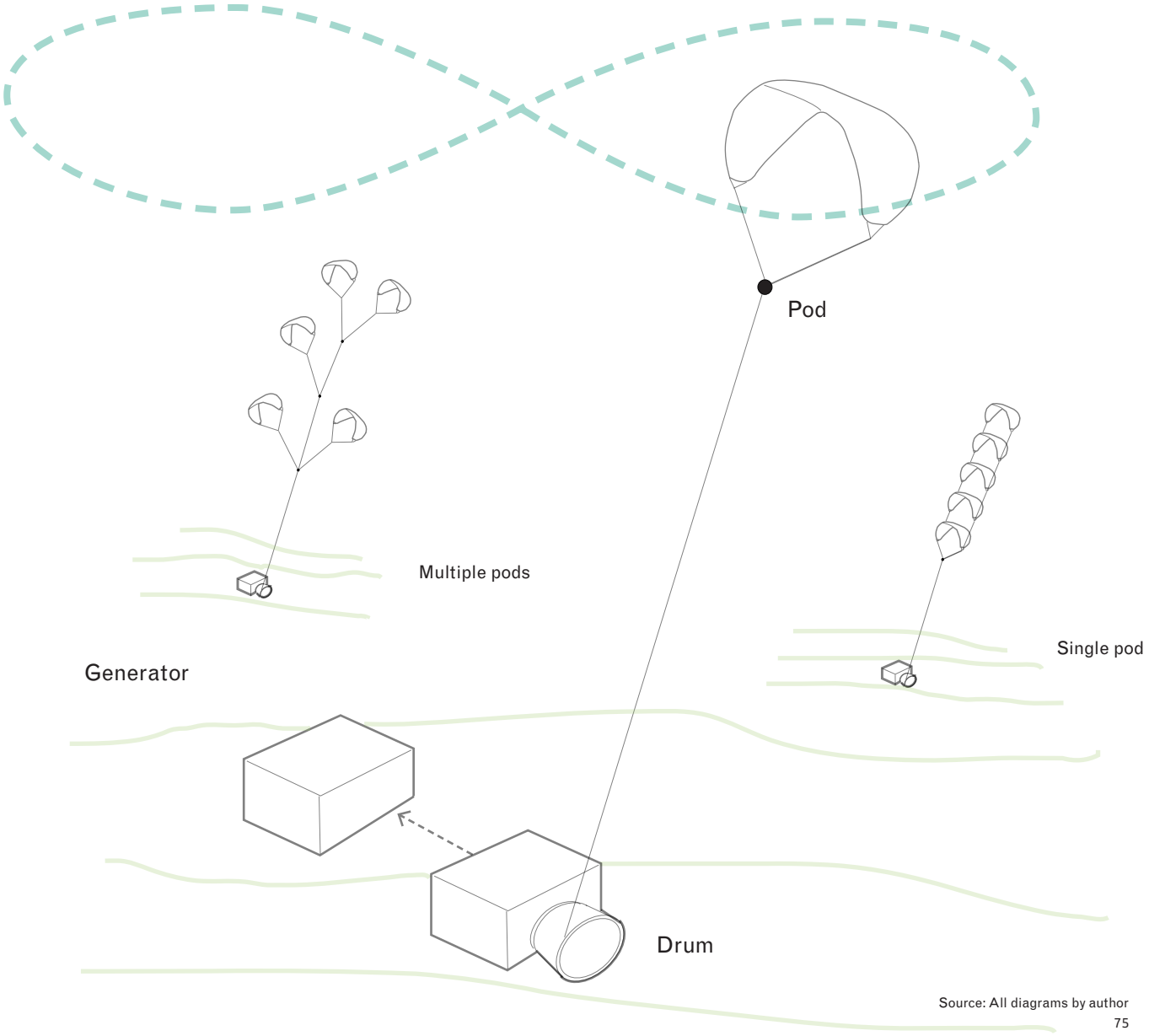


Labor intensity



Sources:
[1]Airborne Wind Energy Systems: A review of the technologies; Antonello Cherubini, Andrea Papini, Rocco Vertechy, Marco Fontana; published in Renewable and Sustainable Energy Reviews, Volume 51, November 2015, Pages 1461-1476
[2]https://kitepower.nl/tech/

Flow diagram & Pattern analysis



Source: All diagrams by author

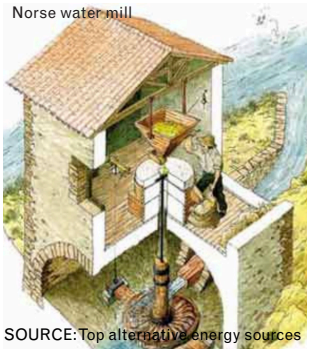
Sustainable energy production - Hydroelectric

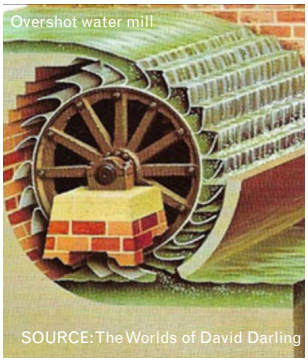
TECHNICALITIES

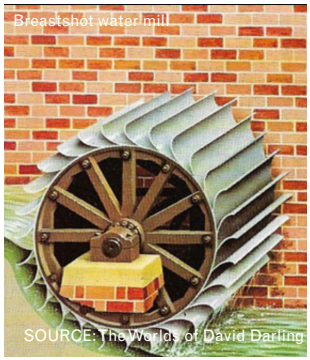
- “Vertical axis”, horizontal, usually underwater
 [Low efficiency]
- “Stream”, vertical, built above a water stream
 [50-60% efficiency]
- “Undershot”, vertical, hit by water at 1/4 height
 [50-60% efficiency]
- “Breastshot”, vertical, hit by water above 1/4 height
 [50-60% efficiency]
- “Overshot”, vertical, hit by water from above
 [80-90% efficiency]

ISSUES AND OPPORTUNITIES

- Iconic link with area
- Multiscalar
- Low impact on native species
- Possibility to build with wood or aluminum
- Visible icon of flowing water even from far
- Need for artificial canals









Spatial footprint



Efficiency



Lifespan



Recyclability

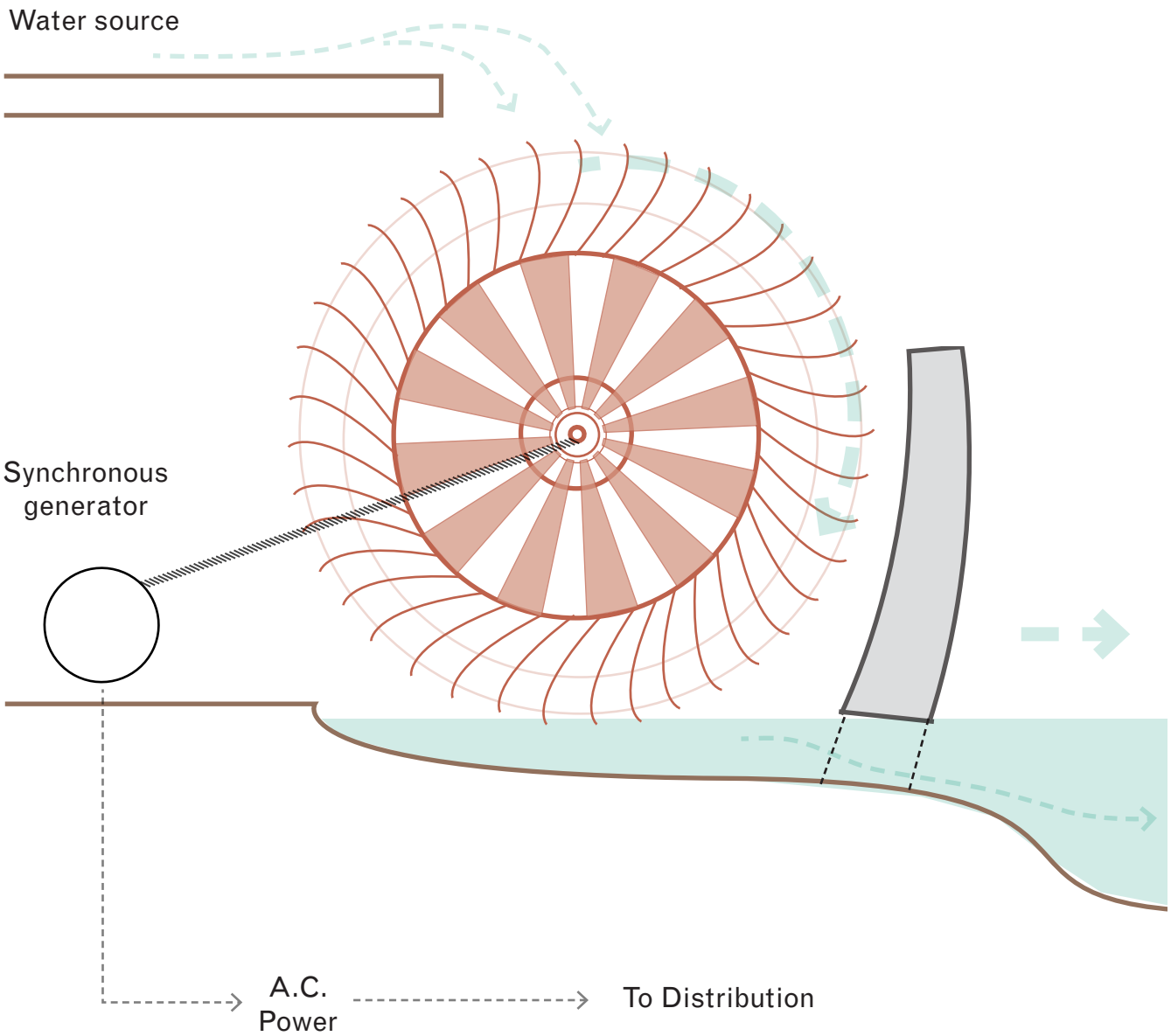


Labor intensity



Sources:
[1] Small-scale hydropower in the Netherlands: Problems and strategies of system builders; Tanja N.Manders, Johanna I.Höffken, Erik B.A.van der Vleuten; published in Renewable and Sustainable Energy Reviews, Volume 59, June 2016, Pages 1493-1503
[2] Converting a Watermill into a Hydroelectric Plant; Daniel Lehmann; published in Renewable Energy World, March 2012, Issue 2 and Volume 20.

Flow diagram & Pattern analysis



Source: All diagrams by author

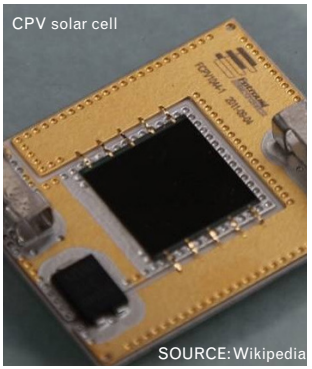
Sustainable energy production - Solar panels

TECHNICALITIES

- Specialised construction
- Need for cabling
- Direct exposition to sunlight
- High construction cost

ISSUES AND OPPORTUNITIES

- Flexible disposition
- Core geometry: Surface
- Reflectivity / Heat irradiation
- Already inserted and normalised in housing
- Multiscalar
- Thin film solar cells usable over curved surfaces









Spatial footprint

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Efficiency

●●○○○○○○○○

Lifespan €

●●○○○○○○○○

Recyclability

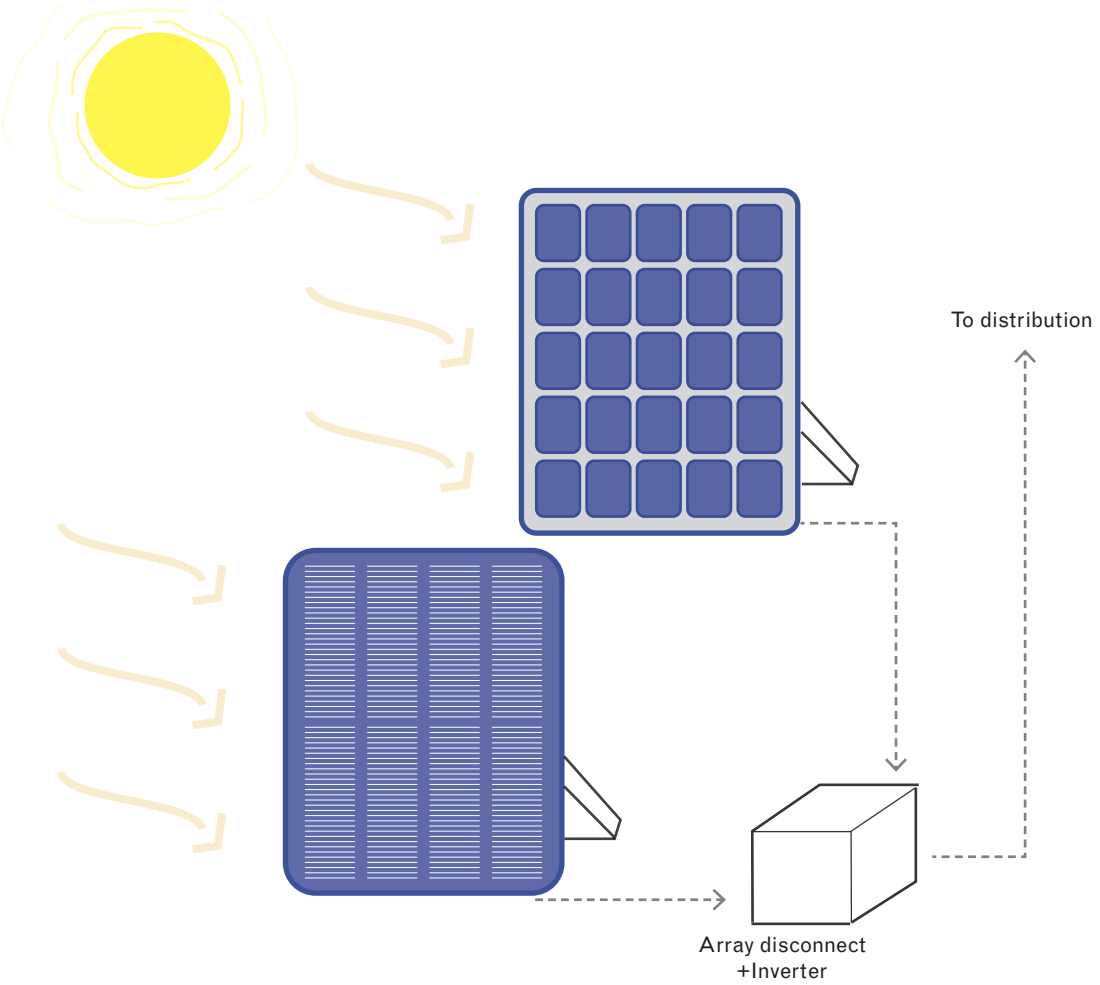
●●●●●●●●●○

Labor intensity

●○○○○○○○○○

Sources:
[1] Wikipedia, https://en.wikipedia.org/wiki/Thin-film_solar_cell ;
[2] "Photovoltaics Report". Fraunhofer ISE. July 28, 2014. Archived from the original (PDF) on August 31, 2014. Retrieved August 31, 2014.
[3] "The Real Lifespan of Solar Panels". EnergyInformative. May 7, 2014.
[4] The Opportunities of Solar Panel Recycling, What Happens to PV Panels When Their Life Cycle Ends, Attila Tamas Vekony, 10 March 2020, Greenmatch
https://www.greenmatch.co.uk/blog/2017/10/the-opportunities-of-solar-panel-recycling

Flow diagram & Pattern analysis



Source: All diagrams by author

Sustainable heat production - Geothermal

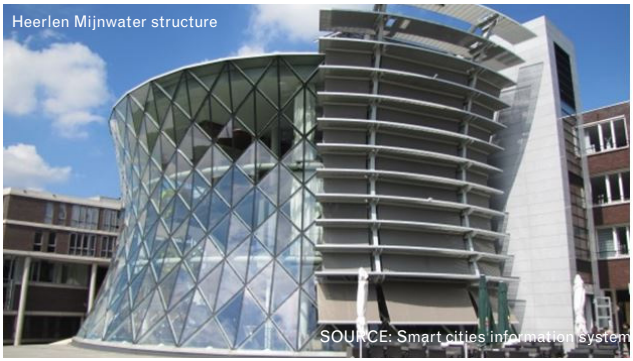
TECHNICALITIES

- Specialised construction
- Monitoring of mine water
- Need for pumps
- Connection with residential heat infrastructure

DESIGN ISSUES & OPPORTUNITIES

- Not directly visible
- Lack of iconic mine sites still unused
- Already implemented
- Focus on the building rather than the object





Spatial footprint - kwh/m²

●●●●●●●●●●

Lifespan

●●●●●●●●●●

Recyclability

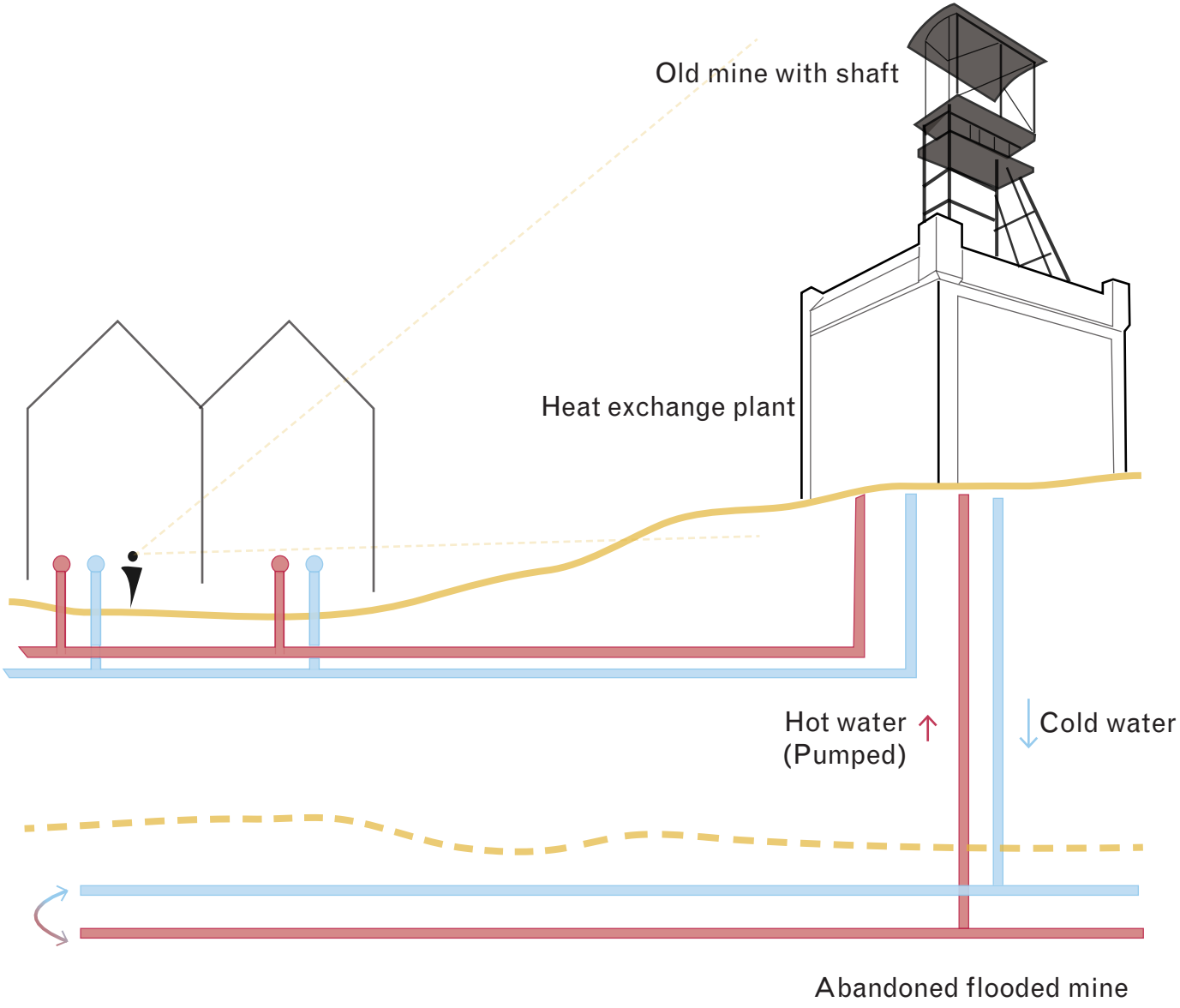
●○○○○○○○○○

Labor intensity

●○○○○○○○○○

Sources:
[1] Minewater 2.0 project in Heerlen the Netherlands: transformation of a geothermal mine water pilot project into a full scale hybrid sustainable energy infrastructure for heating and cooling; René Verhoeven, Eric Willems, Virginie Harcouët-Menou, Eva De Boever, Louis Hiddes, Peter Op 't Veld, Elianne Demollin; https://www.researchgate.net/publication/260043754_Minewater_20_Project_in_Heerlen_the_Netherlands_Transformation_of_a_Geothermal_Mine_Water_Pilot_Project_into_a_Full_Scale_Hybrid_Sustainable_Energy_Infrastructure_for_Heating_and_Cooling

Flow diagram & Pattern analysis



Source: All diagrams by author

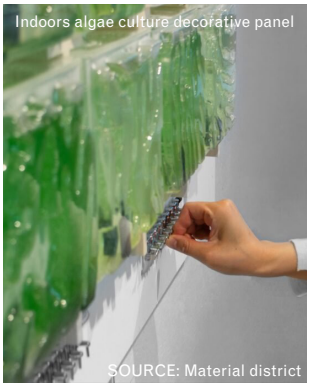
Sustainable heat production - Algae farming

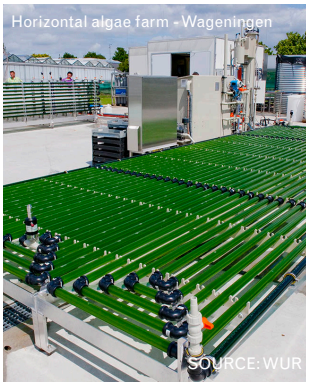
TECHNICALITIES

- Need for incinerators
- Need for storage and collectors
- Input : Water, Sunlight, Soil
- Output : O_2 , CO_2, Energy, Ashes

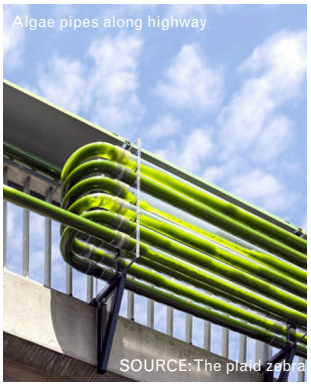
DESIGN ISSUES & OPPORTUNITIES

- Designing with plants
- Extreme design flexibility
- Multiscalar
- Wide range of species
- Un-specialised job opportunities
- Natural CO_2 capture
- Re-use and purification of wastewater
- Food source
- High cost if used for fuel production
- Usable for medic purposes
- Easy to place along highways


Indoors algae culture decorative panel
SOURCE: Material district


Horizontal algae farm - Wageningen
SOURCE: WUR


Pools algae farm
SOURCE: Aquaculturealliance.org


Algae pipes along highway
SOURCE: The plaid zebra

Spatial footprint

●●●●●●●●●● X3

Lifespan €

●●●●●●●●●●

Recyclability

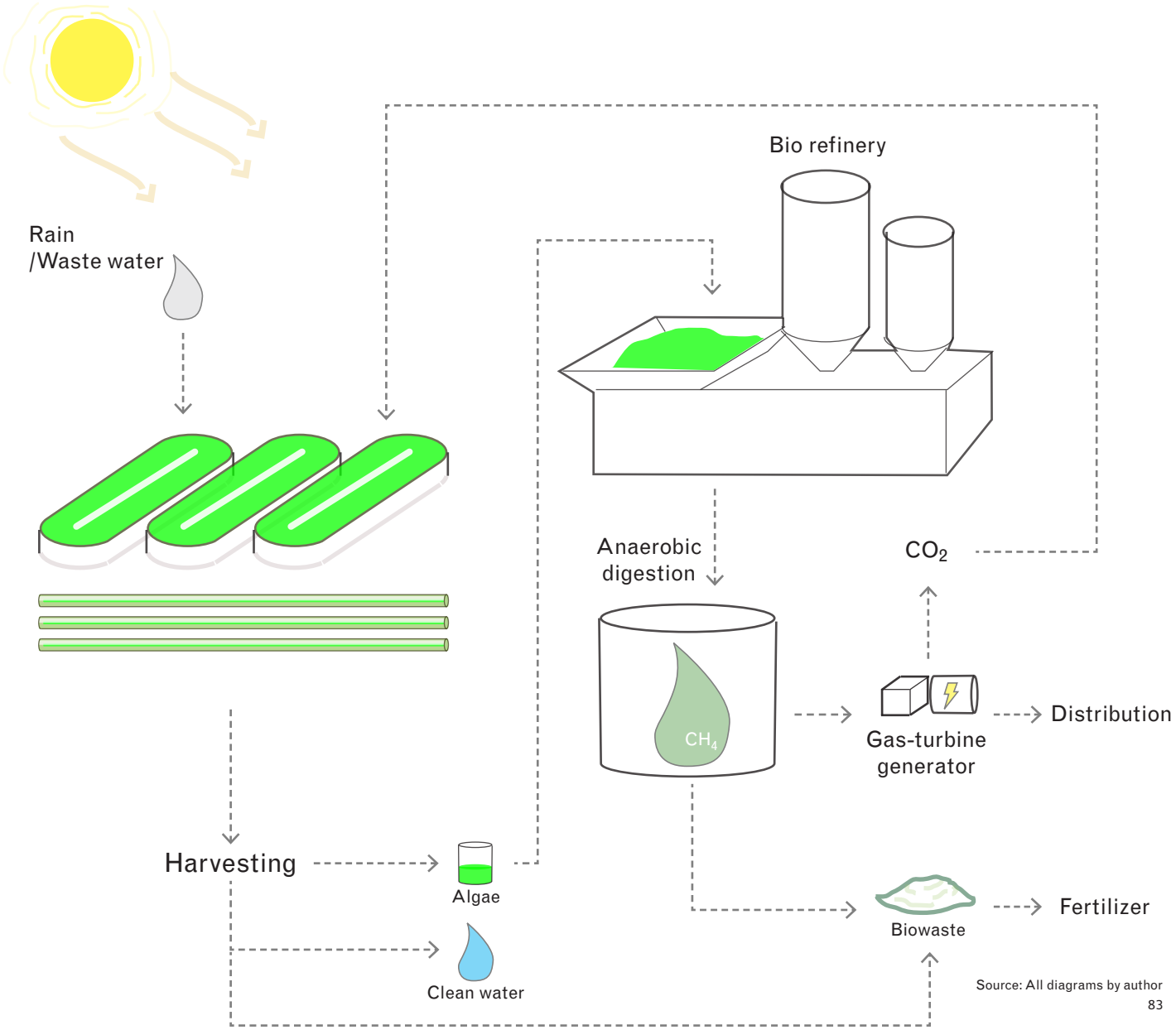
●●●●●●●●●●

Labor intensity

●○○○○○○○○○

Sources:
[1]Biomass-Based Products and Chemicals; David C. Dayton, Ofei D. Mante, published in Analytical Methods for Biomass Characterization and Conversion, 2020
[2] Wikipedia, https://en.wikipedia.org/wiki/Algae_fuel
[3] Omega-3 fatty acids for nutrition and medicine: considering microalgae oil as a vegetarian source of EPA and DHA.; Scott D Doughman, Srirama Krupanidhi, Carani B. Sanjeevi; Published in Current diabetes reviews 2007

Flow diagram & Pattern analysis



Source: All diagrams by author

Energy artifacts - Dimension for a 5MW capacity

400m
300m
200m
100m
0m

Shown below the George Olah Plant next to Blue Lagoon, Iceland, opened in 2013.

The measures are in order: Height, lenght, width:

Buildings complex:
~ (7.5x25x40)m

Amine scrubber:
~ (5x10x7.5)m

Methanation unit
~ (20x30x5)m

Electricity needed:
5MW

Sources:Measured on Google Earth



Shown below one of the 11 wind turbines at Gull Lake power facility, Canada, realised between 2002 and 2003.

Capacity of each turbine:
0.66MW

Total capacity:
11MW

Minimum distance between turbines:
300m

Height:
50m

Rotor diameter:
96m

Tower diameter:
~4m

Sources: Saskpower, Google Earth



X5

Shown below half NIST's Gaithersburg solar farm, Maryland, opened in 2019.

Capacity:
5MW

Dimensions:
340x175m

Sources:Solar power world, Google Earth



X2

Shown below N-ERGIE Biomasse Gmbh power plant in Nürnberg, Germany, realised in 2012.

Capacity:
6MW

Dimensions:

Area:
~37.000 m^2

Sources: Saskpower, Google Earth



+



Shown below KiteGen's experimental kite generator with a nominal capacity of 3MW, Asti, Italy, realised between 2010 and 2012. The dome-shaped generator is placed on top of a hill, in a forest.

Capacity:
3MW

Dimensions (Generator):

Diameter:
~12m

Kite's wingspan:
~ 10m

Sources: KiteGen.it, Google Earth



X2

Shown below, as a diagram in scale, nine helical savonius wind turbines. The data has been taken from AMGPowerSolution, manufacturers of several house-scaled energy objects.

Capacity:
3MW

Dimensions:

Rotor diameter:
0.52m

Blades height:
1.62m

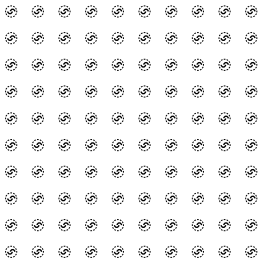
Mount height:
7-12m

Started wind speed:
1.3m/s

Rated wind speed:
11m/s

Rated power 2000W

Sources: AMGPowersolutions.com, Google Earth



X25

Among the sustainable energy artifacts analysed, the ones that produce energy or fuels, wihch in turn can be burnt to generate energy, are here taken into account. To better understand the spatial impact and characteristics of these elements, a set of recently realised power plants have been selected and compared in scale. Considering that the energy industry and its elements are in constant development, the date of construction of these plants is used to obtain an analysis as close to the state of the art as possible in the moment of this research.

As stated before, the powerpark this research by design aims for is meant to tackle the CO_2 emissions emergency by reintroducing it as a source in our energy system. In parallel to this, it also aims at drawing people closer to energy production itself by integrating it with of leisure and ecological spaces. Bearing this in mind, the facilities collected here all have a capicity equal or slightly greater than 5MW, which is the energy consumption of the pilot George Olah plant in Iceland, used here as a reference and model unit.

The energy consumption of Kerkrade in 2016 was 6.302 TJ, equal to 1.750.555 MWh, and its recorded carbon dioxide emissions 299.800ton (Palet 3.0). One George Olah Plant can absorb 6.000ton of CO2 and produce 5000L of methanol per year (carbon recycling international), and methanol's energy density is 15.9 MJ/L (Wikipedia).

The number of Carbon recycling plants needed to fully absorb Kerkrade emissions is 50, while the number needed to meet its energy demand is an enormous 79.270. For this reason, the variety of energy artifacts will play a major role in energising the region, knowing that the carbon recycling plants would not suffice alone.

Energy artifacts - Conclusions & Patterns

A selection has been made among the several artifacts analysed, according both to their grading and to their design flexibility. Namely, the artifacts that will be used are:

- **Carbon recycling plants**, as the key element in the clean gas production and air purification.

- **Savonius wind turbines**, due to their ability to move and generate low amount of energy during slow winds.

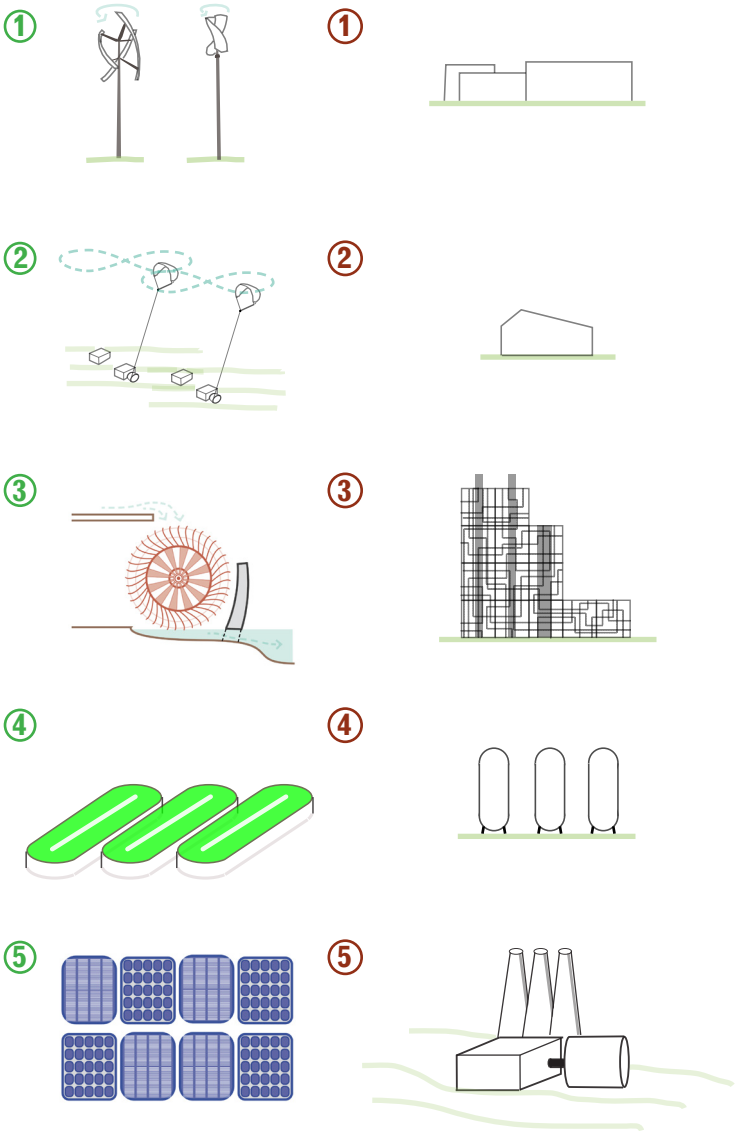
- **Kite generators**, due to their low impact, good efficiency and compactness.

- **Overshot watermills**, due to their strong link with the iconic landscape.

- **Algae pools**, due to their simple geometry and need for similar support as the carbon plant.

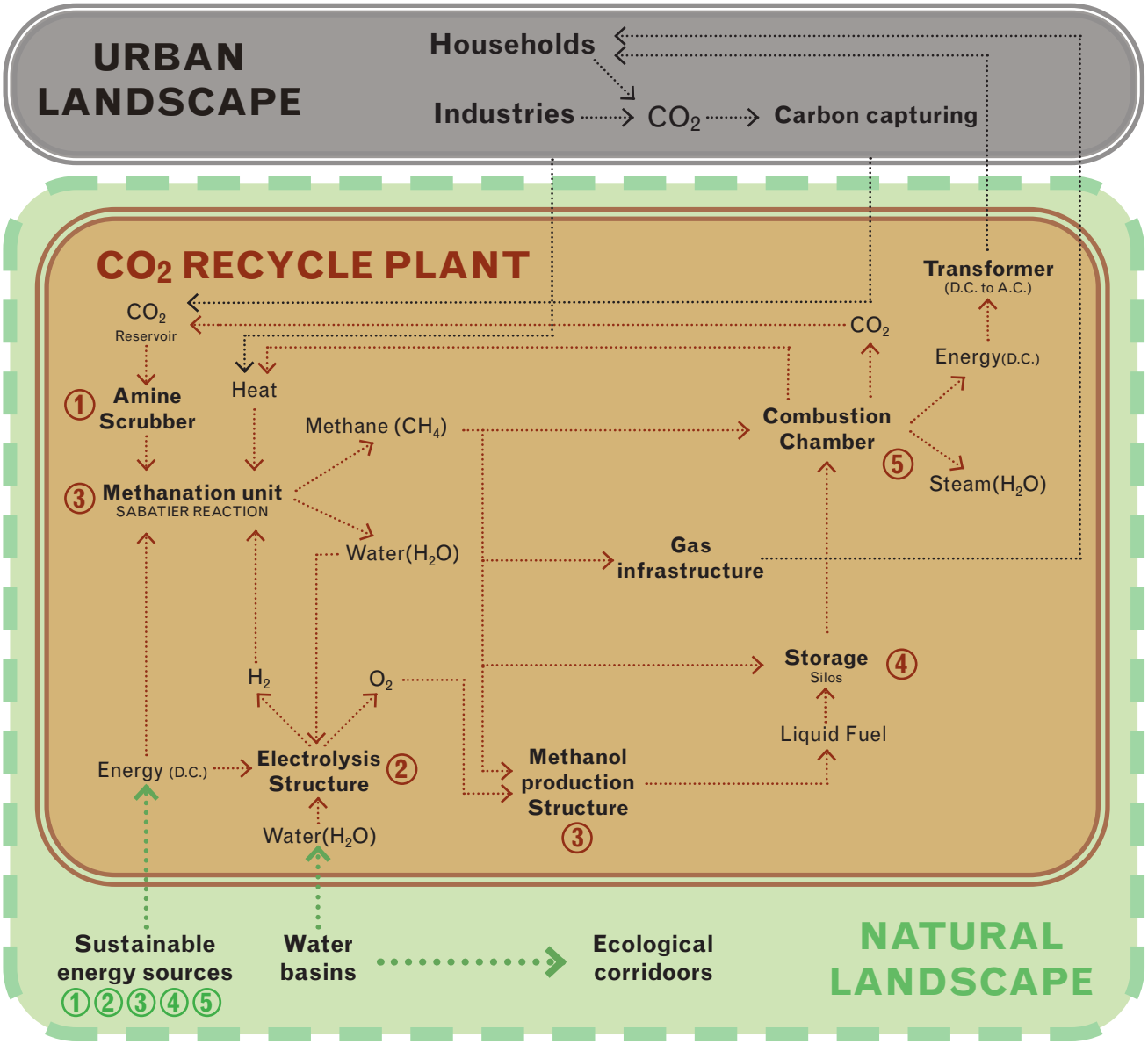
- **Thin film solar panels**, due to their extreme design adaptability as surfaces and high rate of recyclabilty.

Generally speaking, small scale artifacts have been preferred to large elements. This decision is due to the intention of creating a diverse and various power park, capable to harvest the right amount of energy needed to provide the local carbon recycling plant and dwellings. Working as a central element in the neighborhood and as a link between industry and ecology, these energy landscapes are meant in turn to meet the locals energy needs, while increasing the quality and amount of natural areas within the city and improve its air quality. Mine heating has been excluded for the reasons that it already configures an on-going process of sustainable heat production, it can not be planned in ecological areas and is not directly visible to the visitors. This research does not propose an alternative to it, rather a system that can work in parallel.



Source: All diagrams by author

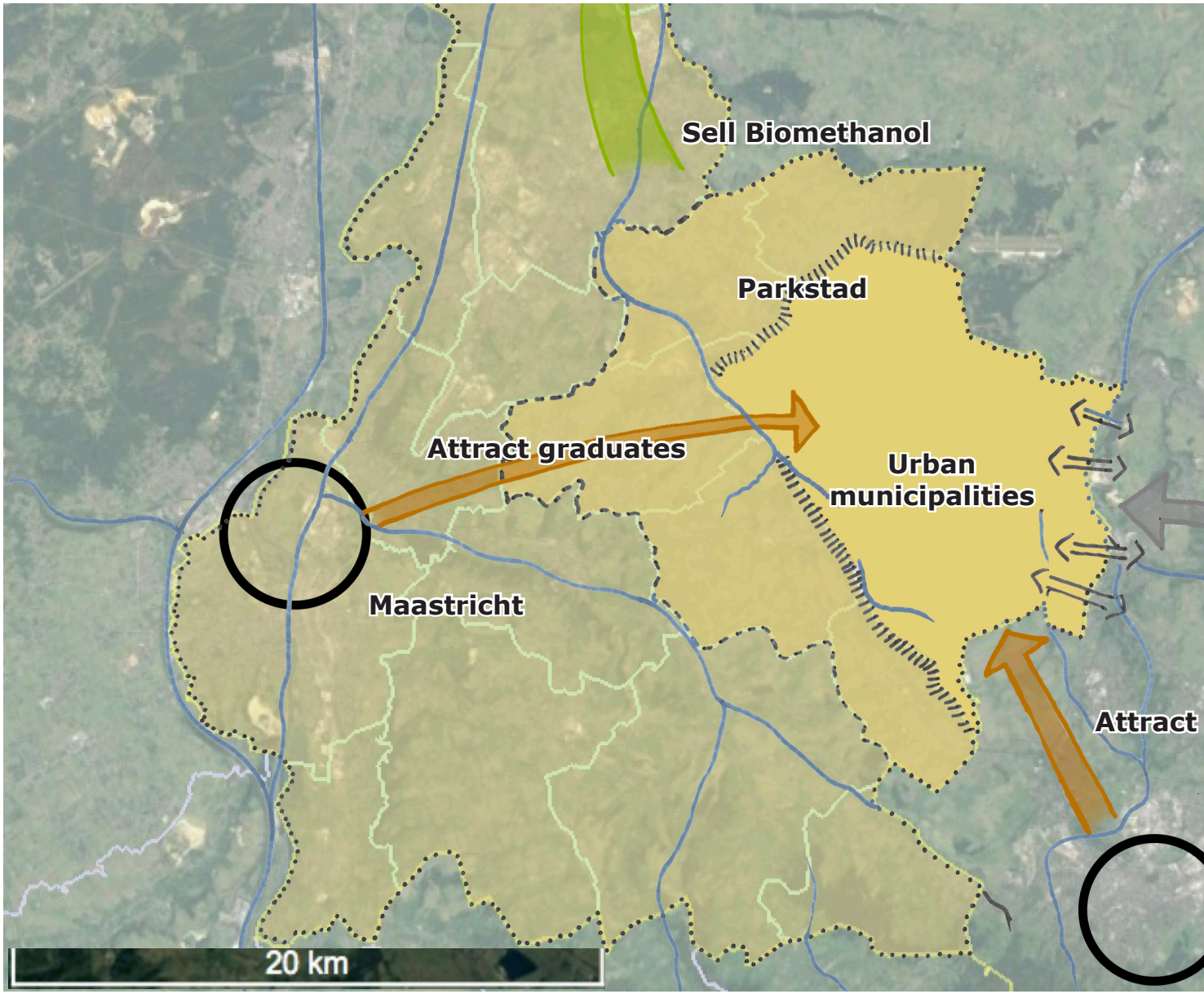
Mosaic energyscape - Conceptual ensemble



5.

Vision

International vision





SOURCE: Underlaying map obtained from Google Earth, diagram by author

As mentioned before, the goal this research by design has fixed on the international scale, Zuid Limburg within the Rhine-Meuse Euregion, is to create employment and attract both labor workers and specialised professionals, countering the shrinkage that affects the region.

The main strategy adopted is to turn Parkstad into energy neutral, cutting thus the costs of life, by means of a mosaic of power parks. These will also increase the amount of employment opportunities in different fields: engineers, labor workers, farmers and nature lovers will all be needed to work side by side for the maintenance and construction of the energy artifacts and the ecological parts of the carbon recycling system.

Also, the goal in a larger time perspective is to transform Parkstad into an open air laboratory for green gas and energy production, and the abundance of empty apartments and lots provides large amounts of space for creatives and graduates.

Due to the close vicinity to two large university cities, namely Aachen in Germany and Maastricht in Limburg, and to one of the main Coal plants of Germany, the implementation of a CO_2 recycling powerplant that produces fuel can, once tested on the local scale, open the region to new markets, considering in particular that Groningen gas plants are planned to be shut down in the near future.

Regional vision

In order to provide a series of ecological stepping stones for the species that inhabit the region, the landscape typology of the ridges is mainly targeted.

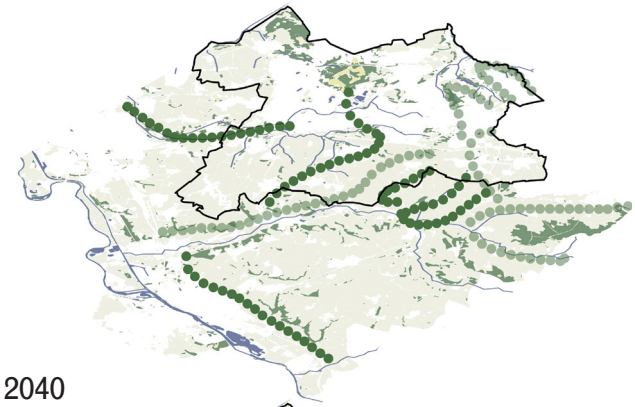
These slender elements, result of the water carving the plateaus in its journey towards the rivers, have a widespread outreach within the region. In addition to this, the accessibility to water is a constant that provides habitats to the more vulnerable species, such as the reptiles found in the area.

In such a way, a set of narrow, elongated corridoors would cover the entire region, without occupying large amounts of space and restoring an already existing natural system rather than imposing a new one. It is also important to take into account that the plateaus' ridges already host lesser activities related to urban life or agricultural purposes than the tops and the valleys. Due to this reason, the costs and impacts of acquiring the land and demolishing structures where needed would be lower.

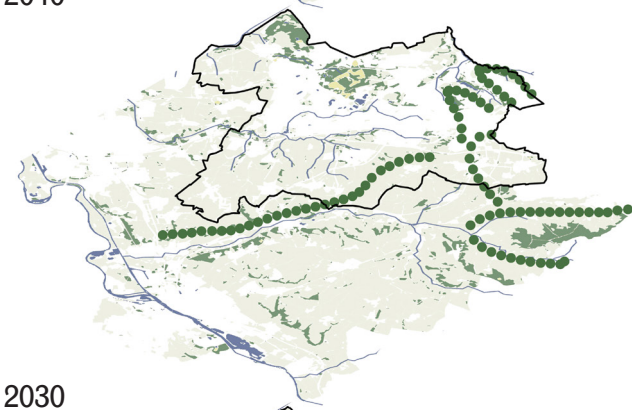
The conceptual power park landscape structure developes starting from this, where the ridges of the plateaus function as their spine. It is in fact perpendicularly and along these lines that the presented sections are organised within the landscape.

The high rate of accessibility to water, ecology and generally to several portions of the region is also an important factor for a transition to a local-based energy system.

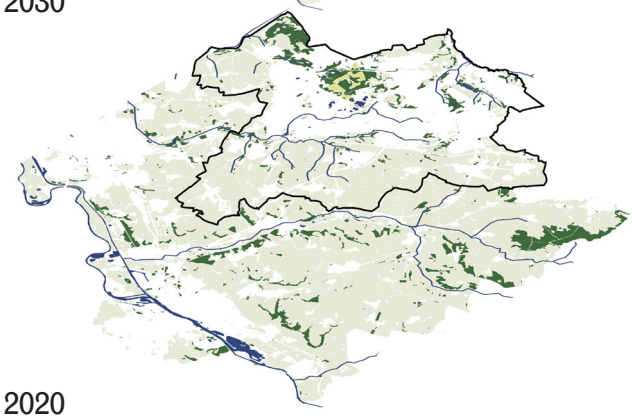
The power parks designed along the ridges would also introduce, underline or strengthen leisure corridoors along the streaming waterbodies, represented with the orange dashed line in the map.



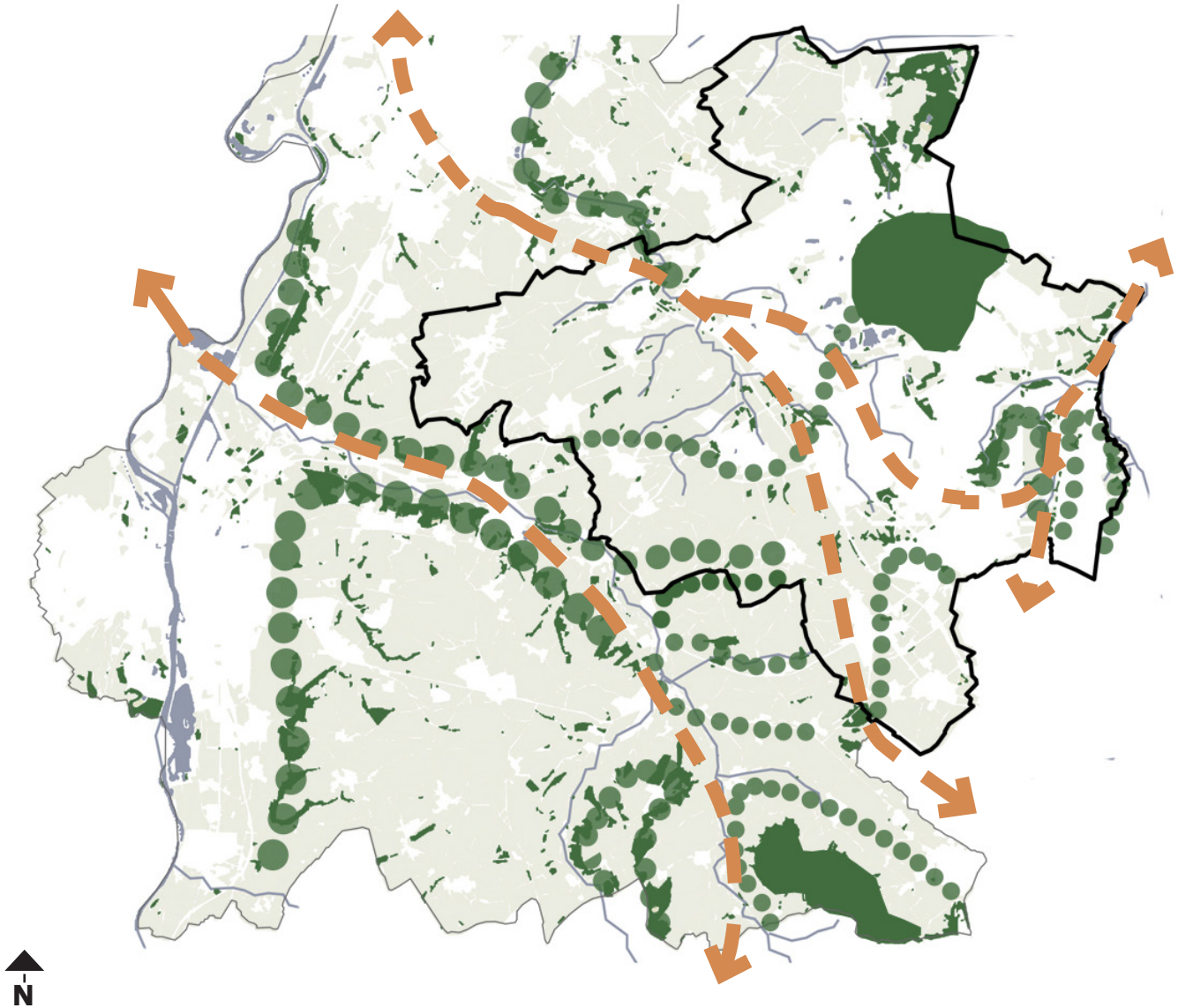
2040



2030



2020



Source: diagram made by author, data obtained from pdok.nl

Metropolitan condition

As introduced before, the four urban municipalities of Parkstad present a rich yet dispersed and discontinuous system of ecologically valuable zones.

These merge with rescreational activities in most of the areas where coal mining left its trace, such as the Whilelminaberg area and, with a completely different kind of nature, the Brunssummerheide.

There is a clear correlation between the water system, which in many of its stretches is underground and not feasible, and the forested parts found along the ridges. This is also evident in the water basins, now serving mainly ecological purposes, left behind by the mining activity.

These landscape elements have been in fact formed by the action of the water, eroding the plateaus, and still present in some, isolated cases the typical traits of Zuid Limburg native landscape even in the urban fabric.

In conclusion, the results obtained through the analysis can also be observed on this scale: the leisure and green systems are deeply rooted in the water system.

Furthermore, these are discontinuous on two levels: the metropolitan one, in which different islands of activities are interrupted by residential and industrial areas, and the regional one, where the urban green is strongly divided by the rural one due to the highway system and the wide agricultural land.





Metropolitan vision - 2050

The proposed green and blue structure for 2050 aims mainly at solving two problems.

In the first place, there is the goal to create a power park, with high accessibility both from within the city and on a regional level, which could produce enough energy to serve the local community while absorbing CO2 from the atmosphere.

Secondly, this powerpark should play a positive influence on the life conditions of the inhabitants of the area, both human and not. In this sense, it should improve the recreational value of the area where it will be built and at the same time improve the chances of mobility of more vulnerable species, improving the biodiversity of the area.

To achieve this dual agenda, a linear structure has been preferred.

This choice will in fact allow to create a system of interconnected ecological corridors, while ensuring a local reach throughout the metropolis. In this way, all the inhabitants of Parkstad's metropolis will be able to explore and enjoy power production landscapes, while their air will get cleaner and their bills will get lower





Site selection - Kerkrade and Landgraaf

By breaking down the concept of a sustainable and urban-integrated system of energy production into its possible uses, locations and implication, I realised that all the scenarios developed up until this point are based on the concept of accessibility.

In particular, water and infrastructures are the two necessary conditions for development. Considering also that one of the main goals on the regional level is to trigger flow of resources, people and energy, the range of sites to be selected for the design becomes narrower.

The conditions said site needs to satisfy are:

- Proximity to water

- Proximity to the border

- Abundance of scattered neglected lots

- Direct connection with residential areas

- Access to leisure

- Access to infrastructures

- Relation with industries

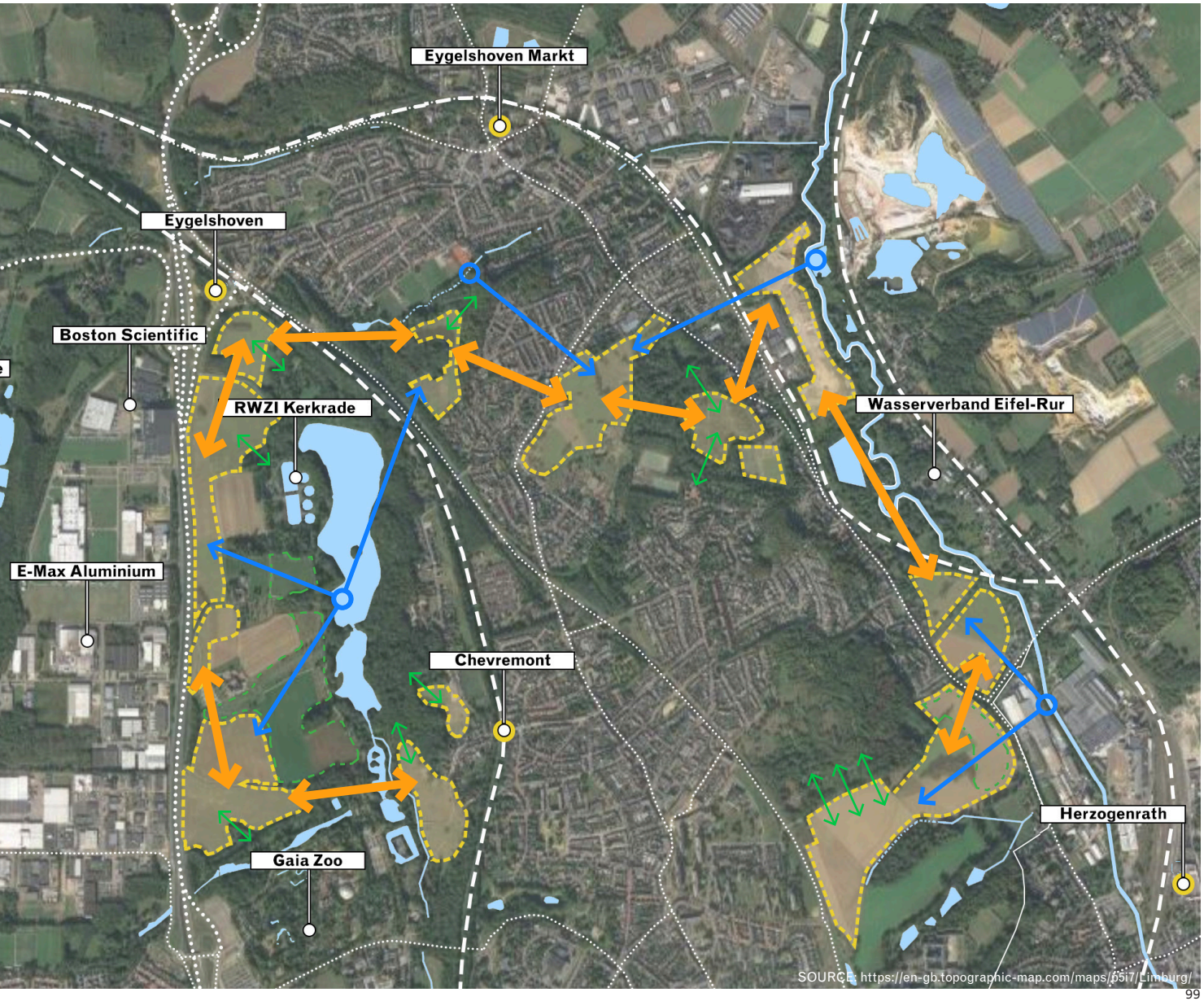
The area along the Wurm configures as the most fitting choice. This river marks the border between The Netherlands and Germany, and its flanked on both sides by residential and industrial areas.

Many industries with differentiated production are clustered above a flattened plateau. On its East, another plateau with a more natural morphology and a residential use.

The overall accessibility to this portion of the city is high: five train stations, one highway and multiple regional roads are found.

Leisure-wise, the site presents multiple activities such as Gaia Zoo, Mondo Verde, the Wurm river itself and several gardens and playfields, all surrounding the central, overlooking element of Whilelminaberg.

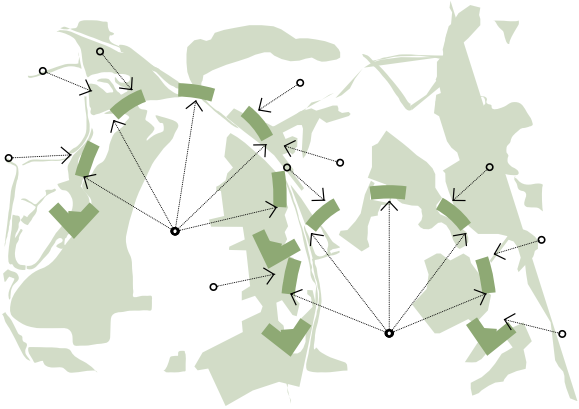



Eygelshoven Markt
Eygelshoven
Boston Scientific
RWZI Kerkrade
Wasserverband Eifel-Rur
E-Max Aluminium
Chevremont
Herzogenrath
Gaia Zoo
SOURCE: https://en-gb.topographic-map.com/maps/65i7/Limburg/

Urban vision - Kerkrade and Landgraaf

Reforestation

To provide the native species of the area with a set of ecological stepping stones throughout the region, new forested patches are designed. These are planned along the plateaus' ridges in emptying neighborhoods and constitute both the backside forestry and the horizon line for the estate-carbon plant.



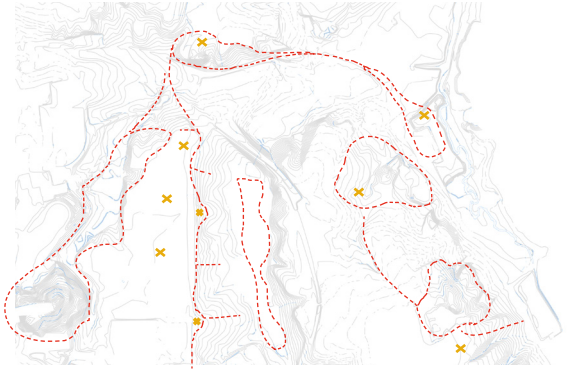
Restoration and expansion of the water system

Water streams, basins and ponds are extremely important elements both for the carbon recycling plants and for ecological purposes. For this reason, the existing water system is restored and several pools are planned along it.

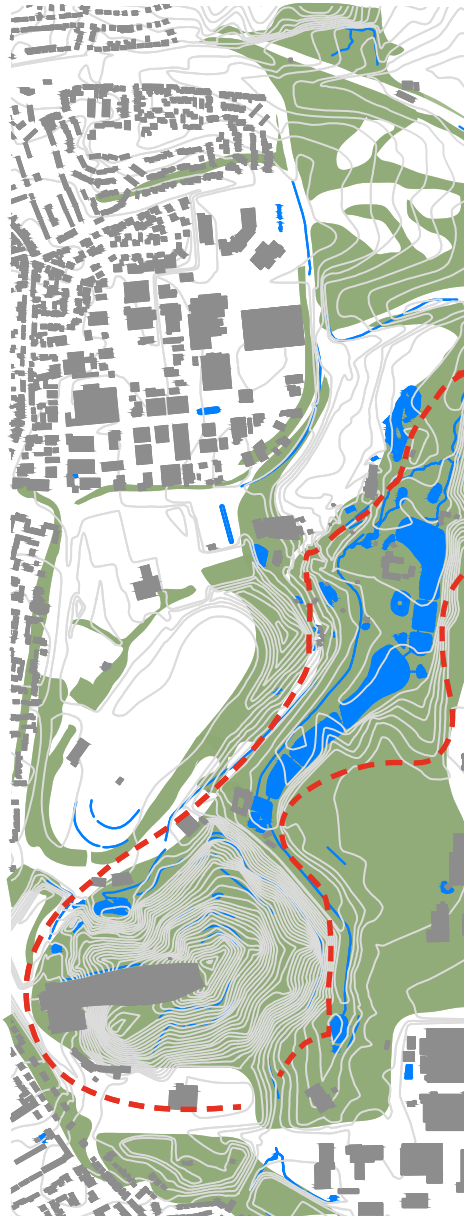


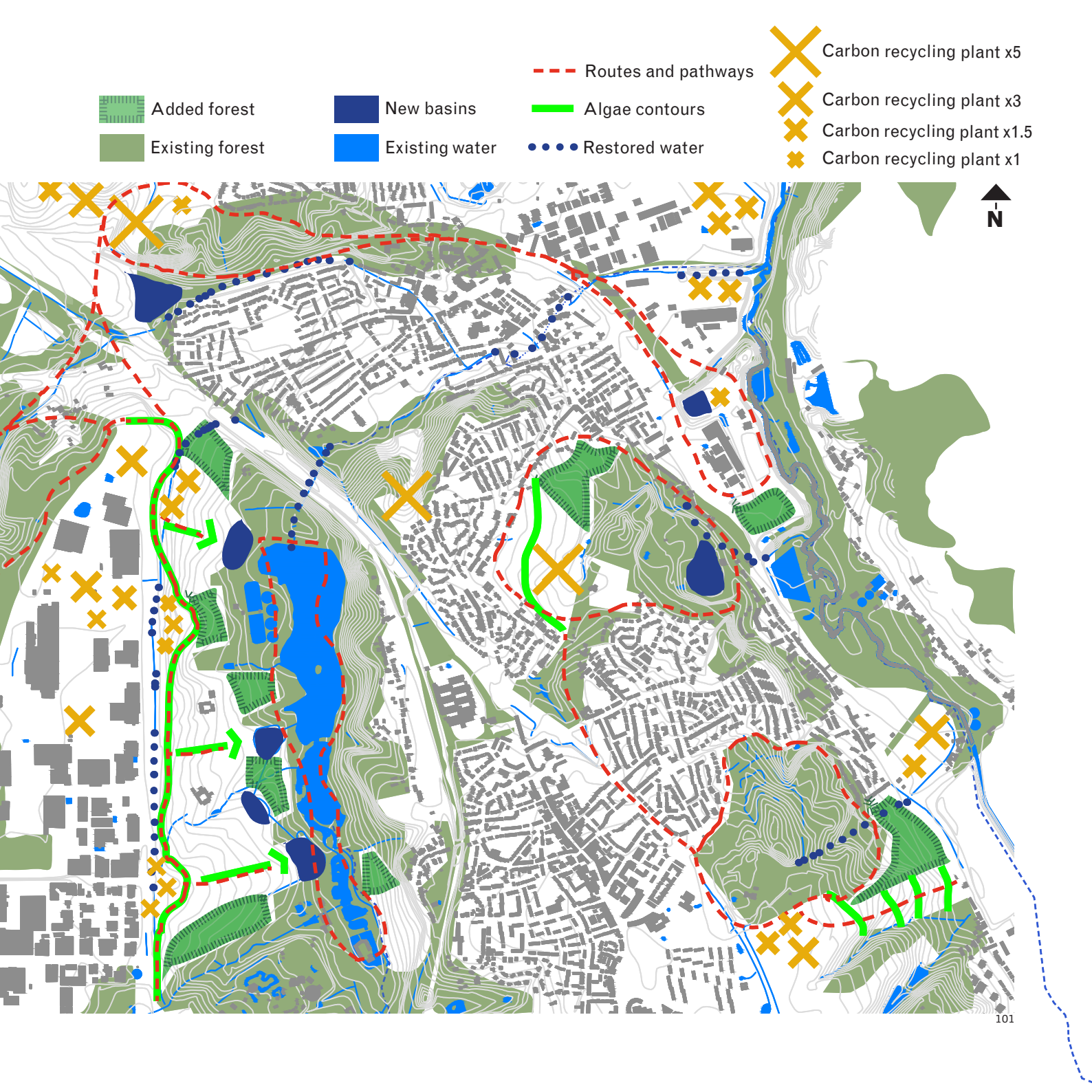
Paths and territory

The morphology of the area and the staging of the several energy objects revolves around a set of loops which outline the brook valleys areas. In here an access to the artificial mining basins is provided, rendering these elements into leisure areas within the ecological context.



Source: All diagrams by author




Added forest
Existing forest
New basins
Existing water
Routes and pathways
Algae contours
Restored water
Carbon recycling plant x5
Carbon recycling plant x3
Carbon recycling plant x1.5
Carbon recycling plant x1
N

Conceptual design principles

"Throughout human history, there has been a notable **interaction between the use of energy and the use of space**, between the production of energy and spatial design."

"In the reciprocal relationship between space and energy, it cannot unambiguosly be said which is leading, and which is following : it might be both."

"**Space is also charged with values, meanings, symbols, memories and emotions**. The landscape is therefore full of formal and informal agreements that do not make way for major new additions without a fight."

"This is where the key spatial challenge lies: **not simply the "integration" of a new facility, but rather a reorganization** that does justice to all of landscape's ingredients".

"Our energy supply is embedded in a global system in which we do not have to know the origin of the oil or coal that drives our way of life, or the effects that mining has on the scenic qualities of those faraway places. **Thanks to this concealment, our landscape is largely an illusory one**."

"**The energy supply will become visible** in our own everyday environment, **audible and tangible**. The concealment will be over; we will e directly confronted on a daily basis with the production that is necessary for our consumption."

Dirk Sijmons - Landscape and energy

Spatial design principles

Direct relation between landscape/ environmental characteristic of the site at different scales and form of objects of energy: Protect, Imitate, Expand.

Link of the developed power park's image and structure to the regional identity of energy artifacts and production landscapes.

Synergetic clustering of divesified objects of energy.

Infiltration of energy production landscapes within the urban an ecological environments.

Estate landscape structure

Once defined why power parks can represent a positive tool for ecological and social regeneration of Parkstad, where shall these systems be placed within its landscape structure and which elements match best both the atmospheric conditions and the regional identity, an internal sequence for the power park itself needs to be defined.

In order to achieve this, this research looks once again at the local landscape, seeking elements that combine diversified production and harvesting of resources, while providing the region with ecological areas which have a clear identity. These criteria are all met in the estates, which characterised the region long before the coal mining did and still today represent the iconic image of Parkstad in terms of tourism, leisure and production. The typical structure of an estate in the landscape is here analysed in terms of its spatial organisation, kinds of production and staging of the elements.Estates often are divided into three zones, which have identifiable thresholds, keeping however a smooth transition in their sequence.

In the foreground are found the most regulated and maintained elements, mostly related to leisure, agriculture and display of wealth. These are for instance formal gardens, bee hives and both flowers and vegetables gardens, natural pools, terraces and playgrounds, all of which revolve around the main building of the estate: the castle or villa.

On the threshold between the foreground and the middleground can be found fruit orchards and secondary structures such as barns or storage buildings that serve the livestock. This happens in the middleground, usually characterised by open grasslands and agricultural fields. These productive landscapes allow in fact to have a wide view over the extent of the estate, which is usually marked by wilder, forested areas on its background. These, historically, represent the main source for logging and hunting.

0 **Entrance / Gates**

1 **Villa / Castle**

2 **Terraces**

3 **Fruit orchard**

4 **Formal gardens / Mazes**

5 **Playgrounds**

6 **Ponds and landscaping**

7 **Bee hives**

8 **Barn**

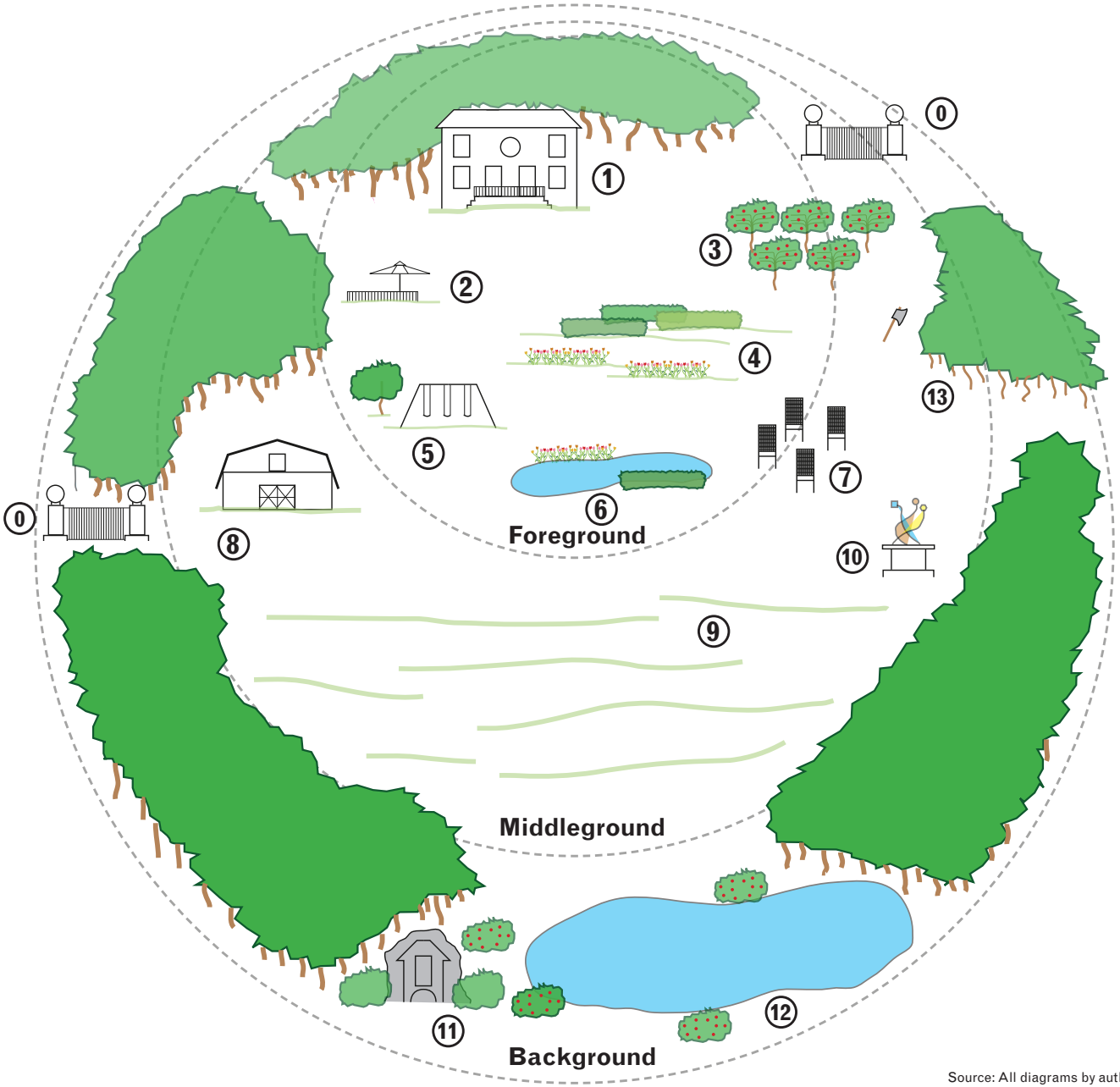
9 **Open grassland**

10 **Sculptures / Landmarks**

11 **Caves / Sanctuaries / Sculptures**

12 **Water basins**

13 **Woodland for production**



Source: All diagrams by author

Power park landscape structure

The structural composition of estates has been used as a blueprint to define the seqeunce of artifacts and their location within the typical landscape of Parkstad. This set of productive landscapes, having their main buildings placed on the upper edges of the ridges of the area and overlooking the lower plateaus and the river valleys is conceptually translated into another productive landscape.The power park is in fact organised around one central built environment, while uses its surroundings to harvest its necessary resources. The carbon plant is placed on the edge between a plateau and a ridge and it has different relations with its foreground, middleground and background.

In the immediate vicinities of the carbon recycling plant are found maintained gardens, formal paths in between solar panels, energy playgrounds and informational and leisure areas.These are the spaces for social interaction, where the human intervention is most visible and regulated.

In the middleground are found several flowerbeds, working as ecological steeping stones for insects and small rodents, and savonius wind turbines, which require an open ground to harvest as much wind as possible. This area is kept wide open and allows for panoramic views of the valley while one's descends towards the basins.

In the background are found forestry and water basins, either historic or newly dug. Within the several pools and floating solar panels are also found.

The sequence of elements composing this energy harvesting landscape structure is built after the concept of integrazione scenica, lacking though the mirror axis typical of the baroque villa and embracing more the english landscape concept of flowing space as described in "Architecture and Landscape" by C. Steenberg and W. Reh, 2010.

0 **Entrance / Gates**

1 **Carbon recycling plant / Biorefinery**

2 **Terraces / Horeca / Amine scrubber**

3 **Solar gardens**

4 **Formal gardens**

5 **Playgrounds**

6 **Algae pools**

7 **Insect hotels**

8 **Fuel storage**

9 **Open grassland / Savonius turbines**

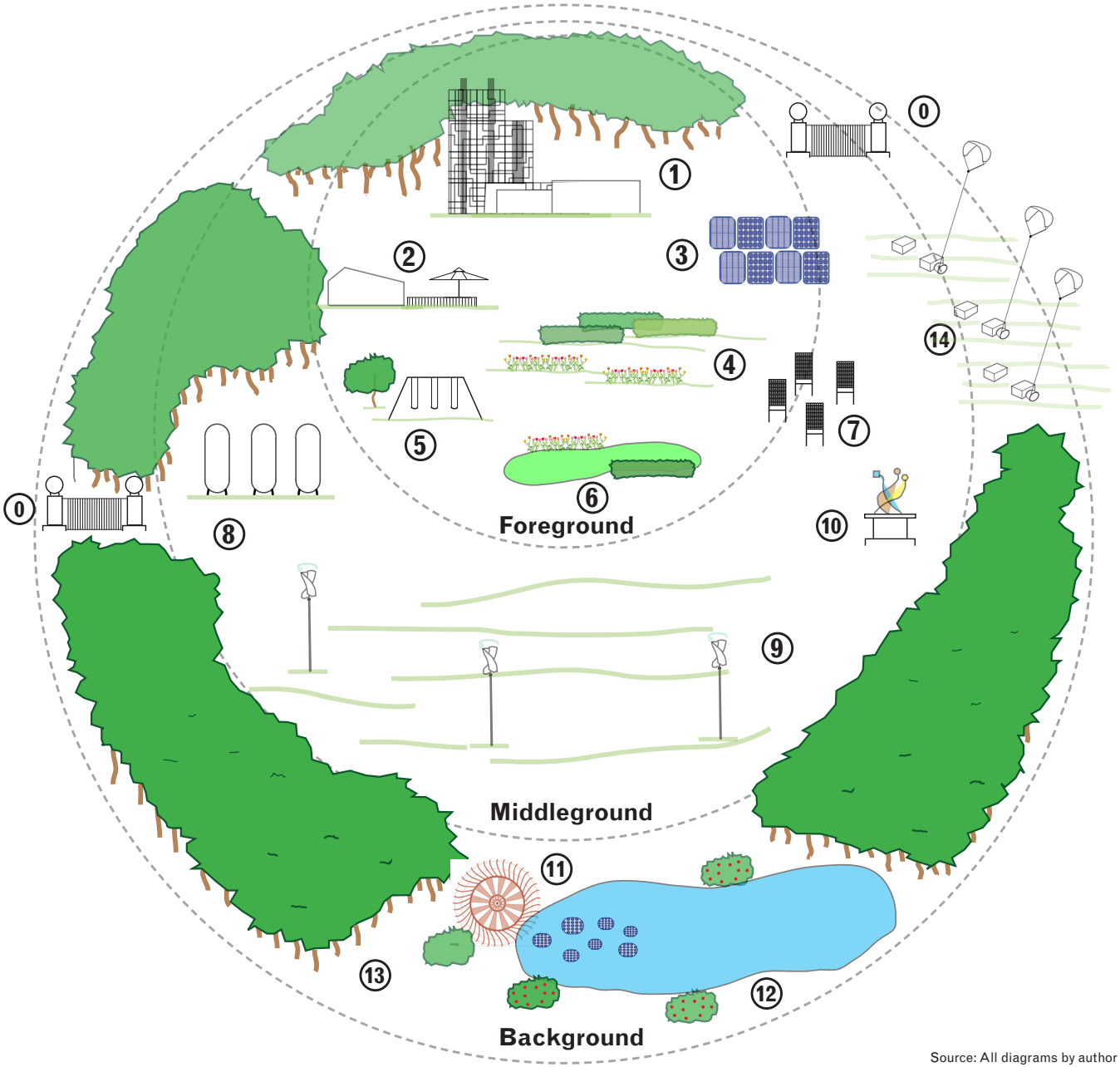
10 **Sculptures / Landmarks**

11 **Water mill**

12 **Solar basins with floating panels**

13 **Background forests**

14 **Kite generators**

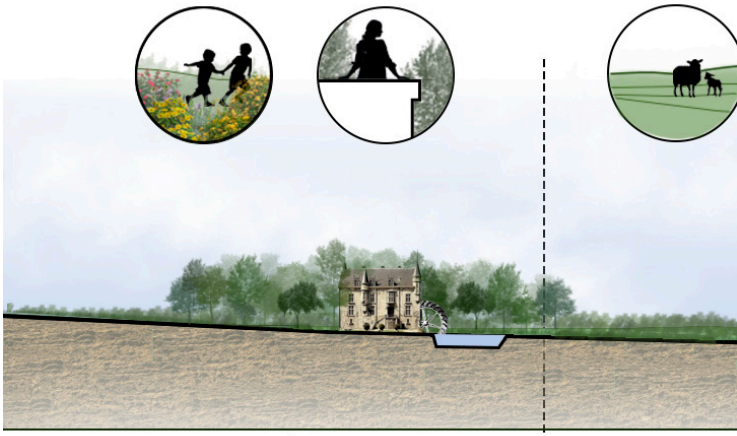


Source: All diagrams by author

Power park - Patterns

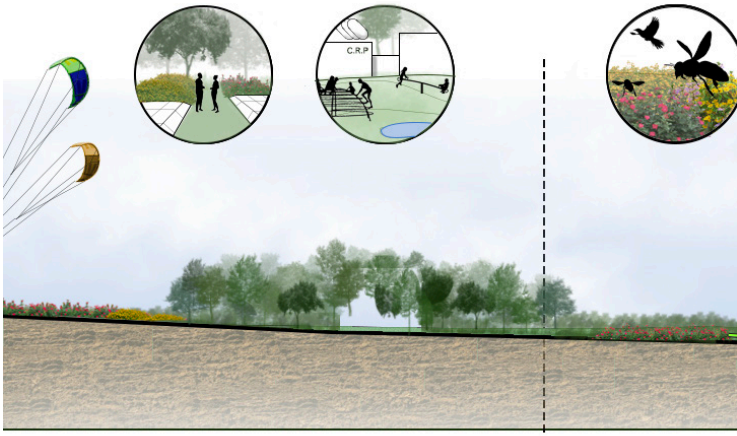
LANDSCAPE CHARACTERISTICS EACH ENERGY ARTIFACT MIRRORS/PROTECTS

- SOLAR FLOATS:
  - day = shimmering over ponds
  - night = stars
- ALGAE POOLS
  - rational pools of the traditional estate
- KITES
  - flight of birds
  - reveal wind direction
- WATERMILL
  - reveal flow of water
  - icon of pre-coal energy period
- WATER LOOKOUT
  - observation over valley
  - landmark within the valley
- CARBON PLANT (C.R.P.)
  - castle / villa in the estate
- SAVONIUS TURBINES
  - need for an open field in the middleground



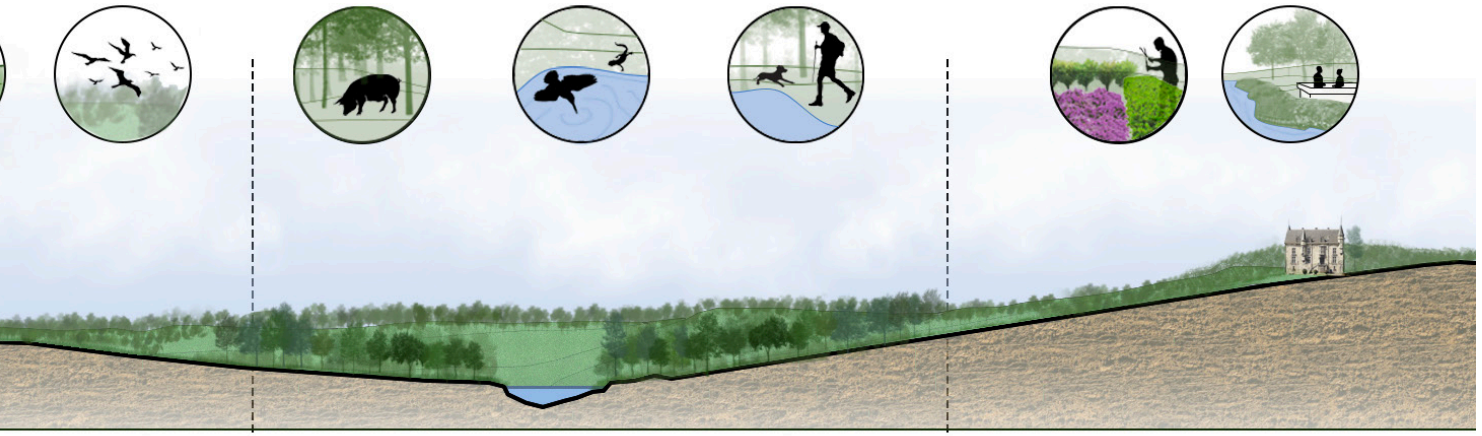
Foreground | **Midd**

Estate and garden | Open



Foreground | **Midd**

Carbon recycling plant and energy playgrounds | Flowery n savoni



lleground

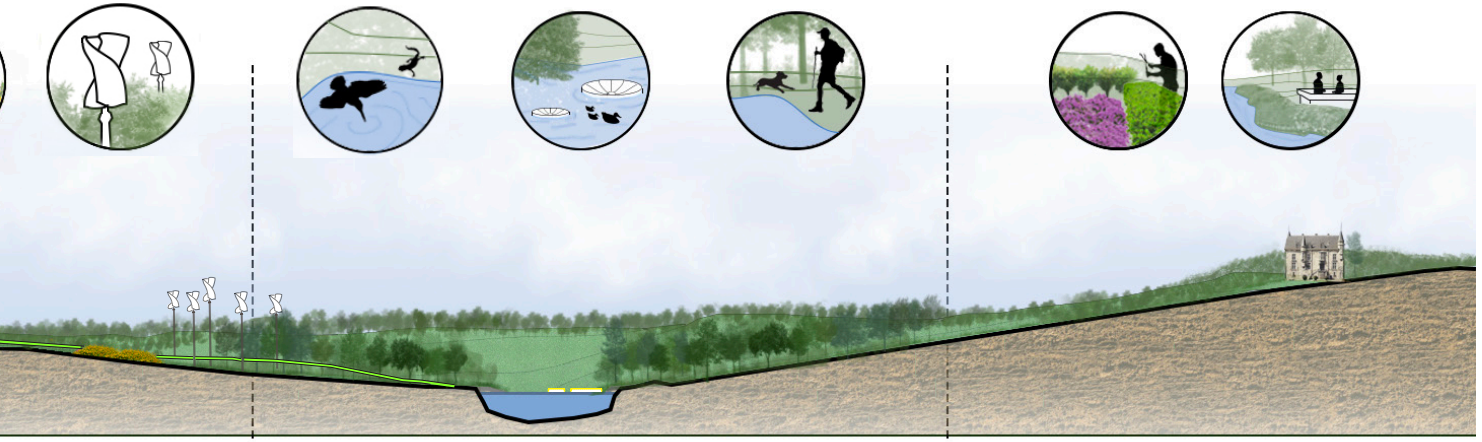
grassland

Background

River and forestry

Panorama

Further estate



lleground

meadows and
us towers

Background

Zodiac ponds and
Water lookouts

Panorama

Further estate

Ecology principles - Indicator species

In order to design an ecologically comprehensive power park and to link specific energy objects to specific biotopes, it has been of prior importance to take into account the local fauna.

Earlier in this report is found a description of the most important biotopes and their inhabitants, however to be able to proceed effectively in the research by design it had been important to narrow the palette of species to a more essential one.

The design approach is in fact based on a small set of more vulnerable or at risk species that generally indicate an healthy ecological environment.

The selected indicator species are here bees, and more generally speaking insects, hedgehogs and salamanders.

These three are in particular chosen due to the worrying drop in honeybees in Europe, the specific needs of sheltered green corridors, proximity to water and fields of the hedgehogs, and again the drop in the population of salamanders in Parkstad. The latter are in fact a specific native specie of the region, and are slowly disappearing.

In the diagram, the habitat conditions needed to be satisfied for attracting the selected species are reported.



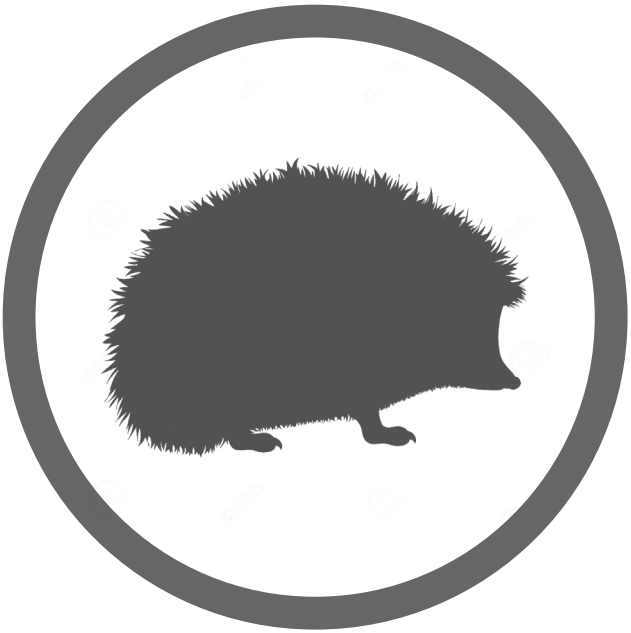
HONEY BEES:

Habitat:

- Forested areas
- Temperate climates
- Gardens
- Orchards
- Flowery meadows

Bee-hotel requirements

- Good exposure to sun
- Protection from rain



HEDGEHOGS:

Habitat:

- Forested areas
- Temperate climates
- Gardens
- Shrubs
- Hedges

Hedgehog home requirements

- Close to water
- Burrowed



Salamanders:

Habitat:

- Forested areas
- Temperate climates
- Water basins
- Rivers
- Ponds

Salamander home requirements

- Presence of fallen leaves and sticks
- Shading and humidity

6.

Design

Project site

The model power park developed with this research by design is located in Kerkrade, East of the industrial site that flanks the green recreational area around the Whilelminaberg.

As it is hinted here, two structures will be discussed in this chapter: the power park as a whole, and its unit element, the carbon recycling estate.




Power park
Carbon estate

Landscape typologies

As mentioned before, the site chosen for the model power park theorised in this thesis is on the border between Kerkrade and Landgraaf. Here can in fact be observed two different plateaus, one characterised by residential areas and a cluster of small city parks, the other by a large scale industrial area and a cluster of leisure facilities.

While the first one, closer to the border with Germany, still presents its natural morphology, the second is greatly modified by human action: not only it has been flattened to optimise the construction of the industries, it also hosts on its ridges the largest inheritance of the mining period, the Whilelminaberg, and a set of artificial natural areas like Gaia Zoo, Snoworld, Mondo Verde and the setting where Pinkpop is held.

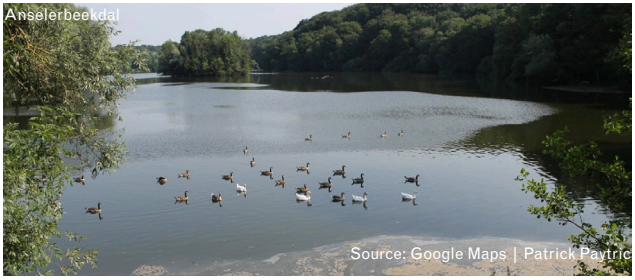
In between the plateaus is found the valley in which the Anstelerbeek historically flowed into the Anselderbeek to then merge into the Wurm river. Today, this valley is almost completely occupied by a large water basin enclosed by dense vegetation, and the two streams are not connected on the surface, in particular due to the highway that cuts diagonally through the northern part of the valley to then climb onto the residential plateau.

The ridges descending towards the waterbody, exactly as the upper part of the plateaus they belong to, present opposite characteristics. The one on the East, connected to the residential areas includes several forested areas, has a sharp drop in height and a rather discontinuous profile. The one on the West, connected to the industrial area, is almost completely composed by an open meadow, on which a couple of farms are located and has a softer section with a more continuous perimeter.

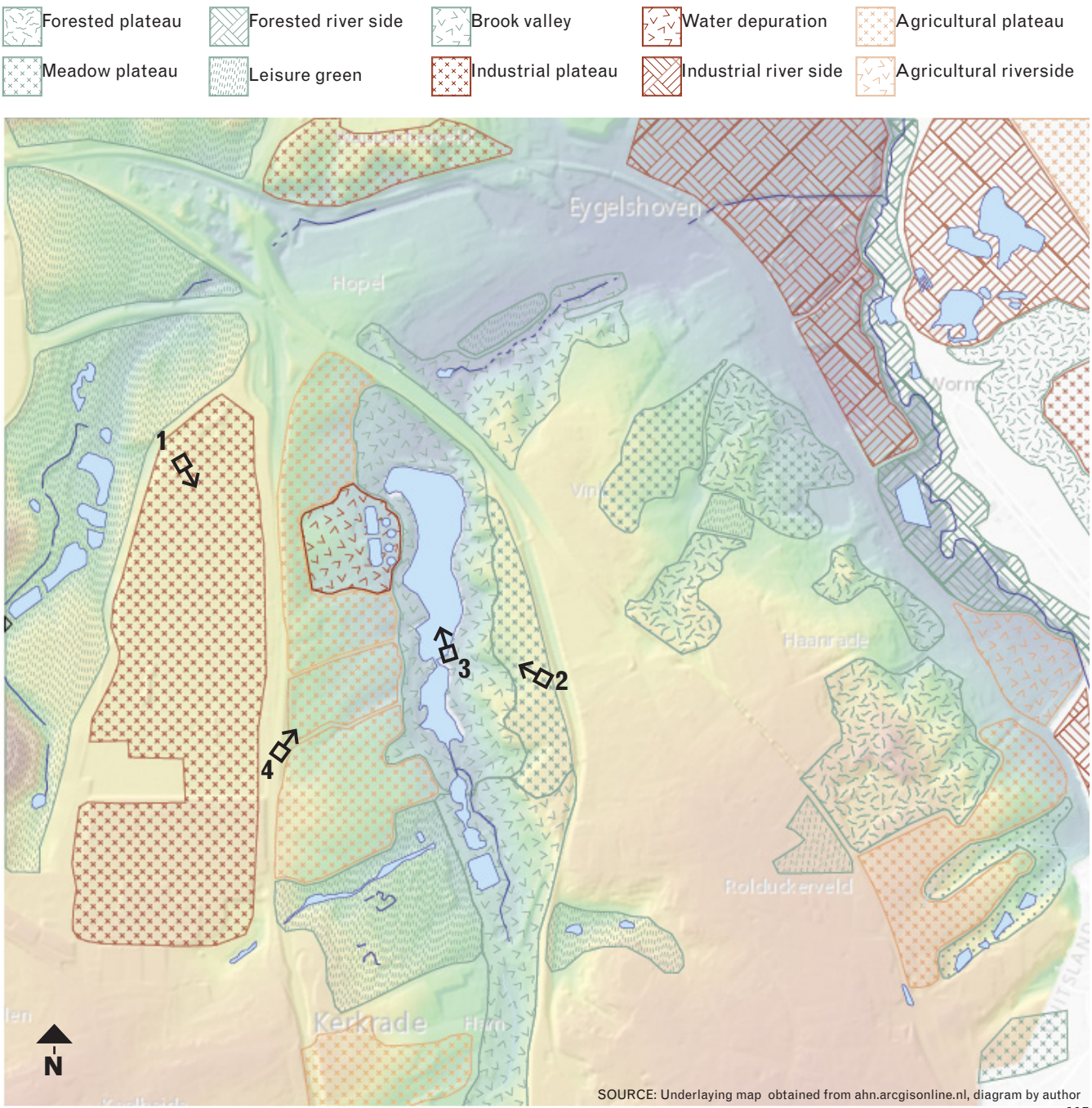
Shown on the map, the points from which the shown pictures are shot, in order of appearance.





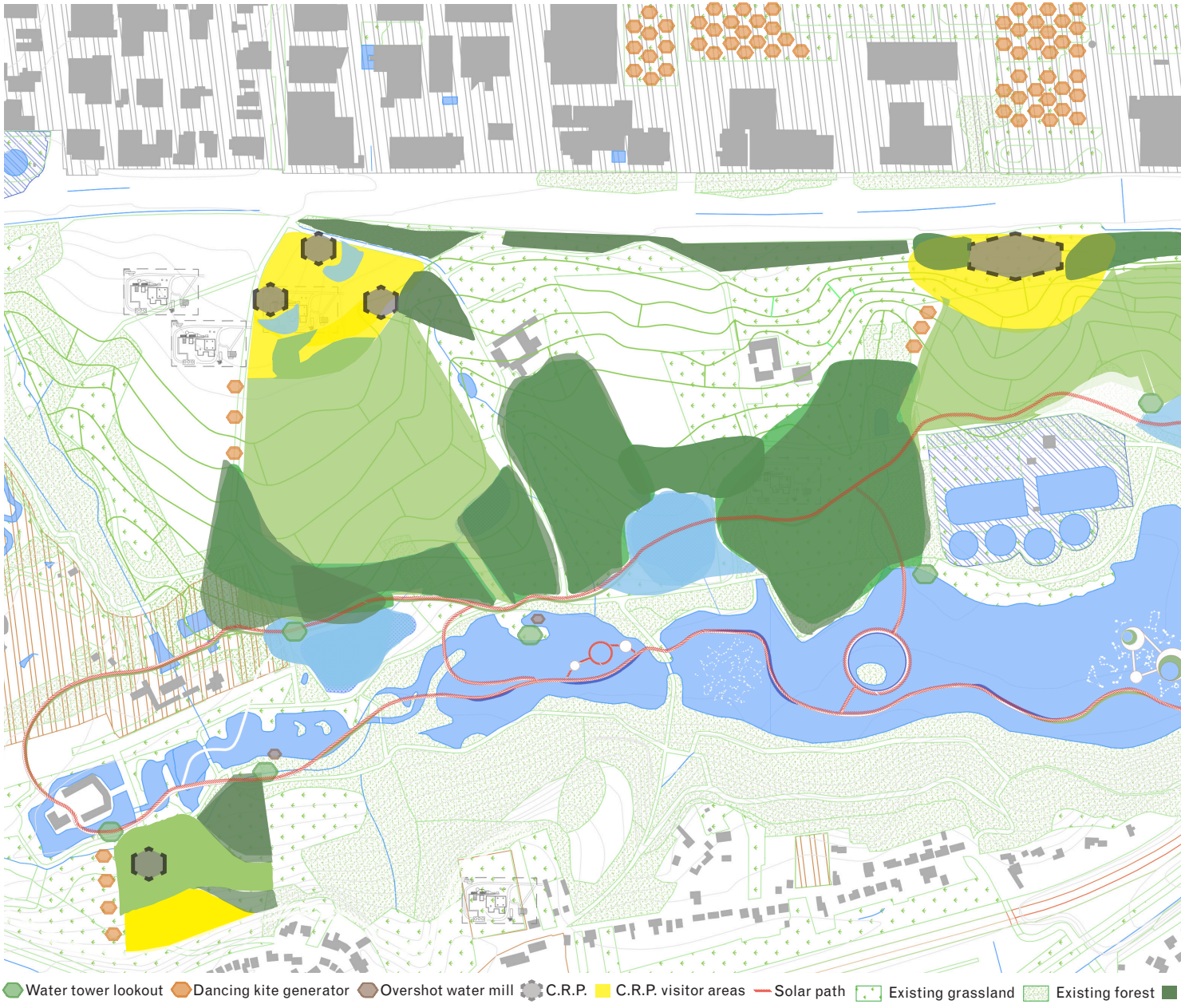






SOURCE: Underlaying map obtained from ahn.arcgisonline.nl, diagram by author

Mosaic, artifacts and synergies - Power park





Added forests Flowerfields and wind meadows

SYNERGIES

Carbonplant
+ Algae pools

excess O2, H2O and heat to feed algae

Algae pools
+ Flowerbeds

excess fertilizer used for cultivation

Water lookout
+ Watermill

excess water over mill

Water lookout
+Solarponds

excess water collection

On the flat top of the industrial plateau, among the factories and offices, kite generator drums are found. These elements, placed on the highest point of the design, would provide the industries with energy. Colored in different ways and operating during determined hours and moments, the artifacts can be seen from the Whilelminaberg, giving a new playful identity to the industrial area. The algae contour outlines the threshold between the plateau and the ridge and enclose the foreground of the carbon estate.

The most human-related portion of these estates will in fact be organised in a set of descending terraces that follow the existing morphology. On these, algae pools are found, separating the flow of visitors from the flow of workers. The rythm of these spaces spans from the upper, most artificial patio with formal solar gardens and infopoints to the most natural one, with informal grasslands, playgrounds and observation pavillions towards the valley found lower down. All of these terraces will host the carbon recycling plants, in a gradually less dense amount.

Moving on, the middleground: here will be found flower beds and grasslands, in this way small rodents, insects and other animals would be allowed to roam freely without being disturbed by humans, who will though still be able to enjoy the scenery from the elevated position. These open fields will also host wind-harvesting technology, which will actually be the defining element to justify the openness of the fields themselves.

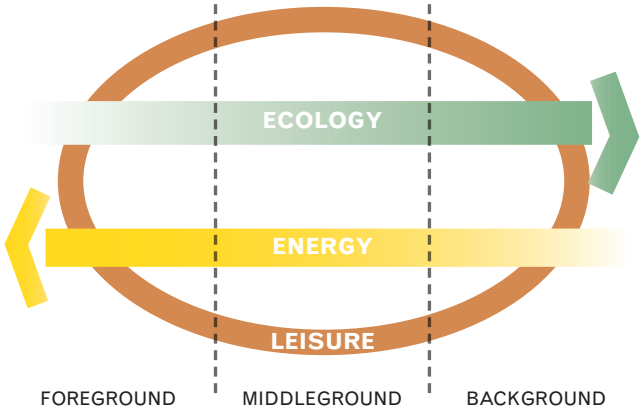
Once reached the valley, passing through the Savonius forests, algae paths connect with another promenade, which encloses and explores the whole valley. In the junction between these two elements are designed algae lookouts, both for the harvesting of the biomass and to function as landmarks and observation towers. These rise in fact over the newly planned water collection basins, in which are found floating, concave solar panels.

Carbon recycling estate - Overview

As it can be seen in the plan, the architecture of this system is all collected into the entrance area, composed of a set of descending terraces and including algae pools. These will in fact serve multiple purposes, such as keeping the visitors at a safe distance from the more technical and inaccessible portions of the power plant, cleaning the air, producing fertiliser and harvesting biofuel. This area is meant to be an industrial zone with nature infiltrating within it.

Moving downwards along the ridge, an open field is found, where several savonius turbines tower above a flowery meadow, designed mainly to serve bees, butterflies and other insects. In this zone, the balance between ecology and energy production is designed to be half and half.

At the bottom of the carbon recycling estate, in its insertion into the wider scale path that spans over the water and connects all the carbon estates composing the power park, the most ecological area of the design is found. The balance is here inverted, being this a nature area with energy objects infiltrating into it.







Carbon recycling estate - Energy production

Being energy production the main focus of this research, an estimation of how much energy can be generated in this Carbon recycling estate is done first.

Knowing that the power plant itself requires a set of artefacts whose total energy capacity is at least 15MW, the amount and disposition of the several objects is based on this requirement, and will shape the immediate surroundings in order to maximise the artefacts' efficiency.

It is interesting to notice that the estimation does not count the amount of CO_2 that will be absorbed by the trees and algae ponds. This means that the overall rate of carbon dioxide recycling of this system would even be higher than the one indicated, however these calculations are kept as they are in order to provide clear data about the potential of the carbon recycling plant unit.

FOREGROUND:

- RECYCLED CO_2 :
  18.000tonnes/year
  = 1/17 Kerkrade emissions

-BIOMETHANOL PRODUCED:
15.000tonnes/year

- ENERGY OBJECTS:

- ALGAE PONDS x4

- RATIONAL SOLAR GARDEN

- BIO REFINERY x1

- CARBON RECYCLING PLANT x3

- GAS TURBINE GENERATOR x1

- ENERGY REQUIRED: 15MW

- ENERGY PRODUCED:
  up to 110˙009 MWh/year
  = 1/16 Kerkrade energy use

MIDDLEGROUND:

- ENERGY OBJECTS:

    - SAVONIUS TURBINES x50
      0.002MW each

    - KITE GENERATOR x3
      3MW each

- ENERGY CAPACITY:

    - 9.1 MegaWatt

BACKGROUND:

- ENERGY OBJECTS:

    - WATERMILL x2
      2.5MW each

    - SOLAR FLOATS x144
      0.02 to 0.04MW each

- ENERGY CAPACITY:

    - 8 to 11 MegaWatt

Carbon recycling estate - Routes

The system of routes and more generally speaking accessibility of the carbon recycling estate is based on the concept of minimising the crossing between the flow of workers and the flow of visitors, while keeping an enjoyable open view feasible to both.

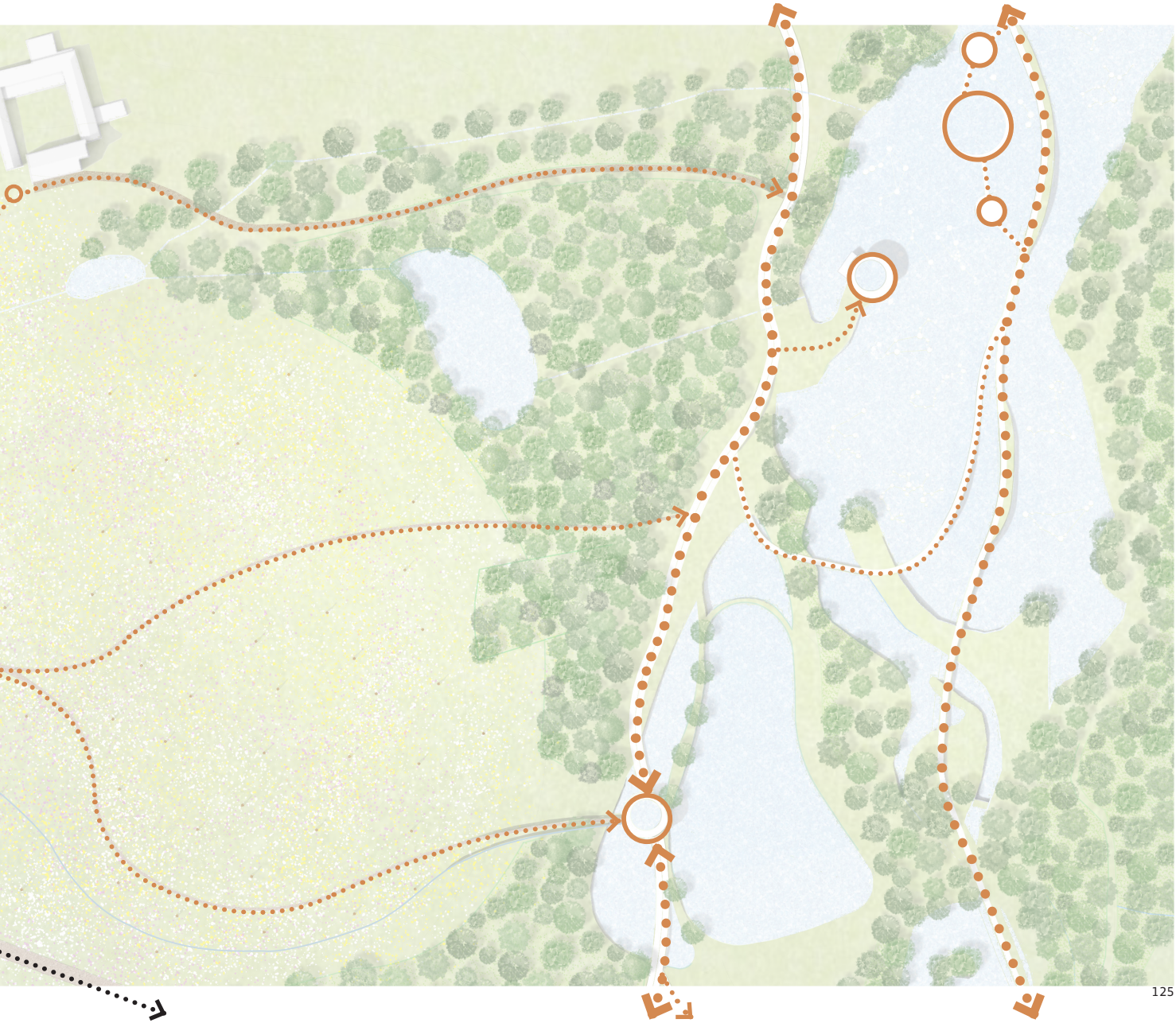
The diagram shows what are the entry points and distribution roads for cars and emergency vehicles, shown with the black dotted arrows, and the set of possible routes that locals and wanderers can follow.

As shown here, the foreground with its terraces configures as the only place fully dedicated to humans: it is in fact only here that they are allowed to roam freely in wide areas.

The middleground is in fact characterised by linear, well defined paths that the visitors can follow, while being surrounded by medium to tall grasses within a flowery meadow.

Finally, in the background is found the larger route that connects all of the carbon recycling plants together, defining itself as the spine of the power park as a whole. This route has a direct connection to the water and is characterised by pin-pointed water lookouts that will allow the visitors to stop, have a chat, sit and enjoy the view.





Carbon recycling estate - Water system

The water system of the design works with gravity. The first element found at the top of the ridge are algae pools, used for the collection of polluted water coming from the industries and from the carbon recycling plant itself.

These element have the role of collecting and purifying the water, to then let it flow in the descending ditches that characterise the middleground. Once reached the height level of the lookout that the collected water is being directed to, the ditches maintain that height by slowly tuirning into small and slender aqueducts, inaccessible to the visitors.

When the water finally reaches the lookout, it is collected there in a open storage at the top of it to be then gradually let flow from above onto a watermill, which will in turn let the water flow into the basins and pools found within the valley.

The core idea of this system is to purify and store water, while using it as a resource to create energy. By defining how this system of technical elements is deeply organised around the flow of water, an impact on the design itself can also be observed.





Carbon recycling estate - Actors

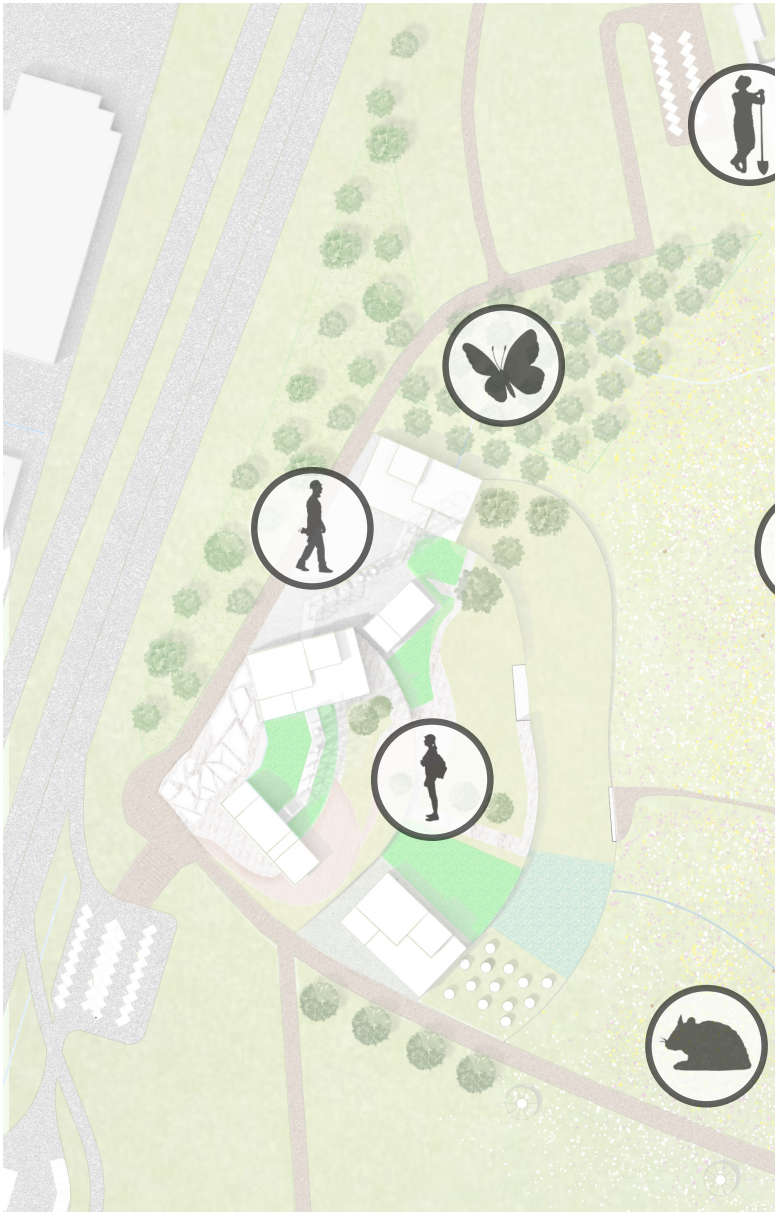
As introduced before, the design is meant to serve a wide spectrum of species, while focusing on a set of indicators ones.

In this diagram are collected the different actors for which different biotopes have been defined, including also humans with different jobs and occupations.

The foreground will be mainly used by workers and visitors, with a most probable interaction with city birds.

The middleground is mainly designed for honey bees, butterflies, and all the birds that thrive on them.

The background is characterised by both wet and dry areas, in order to serve hedgehogs and other wild mammals, while at the same time providing space for insects, reptiles, bats and water birds.





Landscape system - Elements and functions

Foreground

First terrace
Hosting the main methanation units, the formal solar gardens and the infopoint, this terrace is the most artificial and formal of the three. It contains algae pools.

Second terrace
Mediating between the first and the third, this terrace combines paved areas with grasslands and contains playgrounds and a second carbon recycling plant.

Third terrace
Working as the threshold between the foreground and the middleground, this terrace starts merging with the morphology of the area and is completely covered by meadows for informal activities.

Middleground

Savonius towers
This energy artefact shapes and characterises the middleground. This element will also play an ecological role in relation with its surrounding flowery meadows.

Flowerbeds, meadows and vegetation
Aesthetically pleasing and ecologically valuable for the insects and small rodents, these areas are critical in giving a rythm to the carbon estate, especially due to the steep sections that can be found in many of the region's ridges.

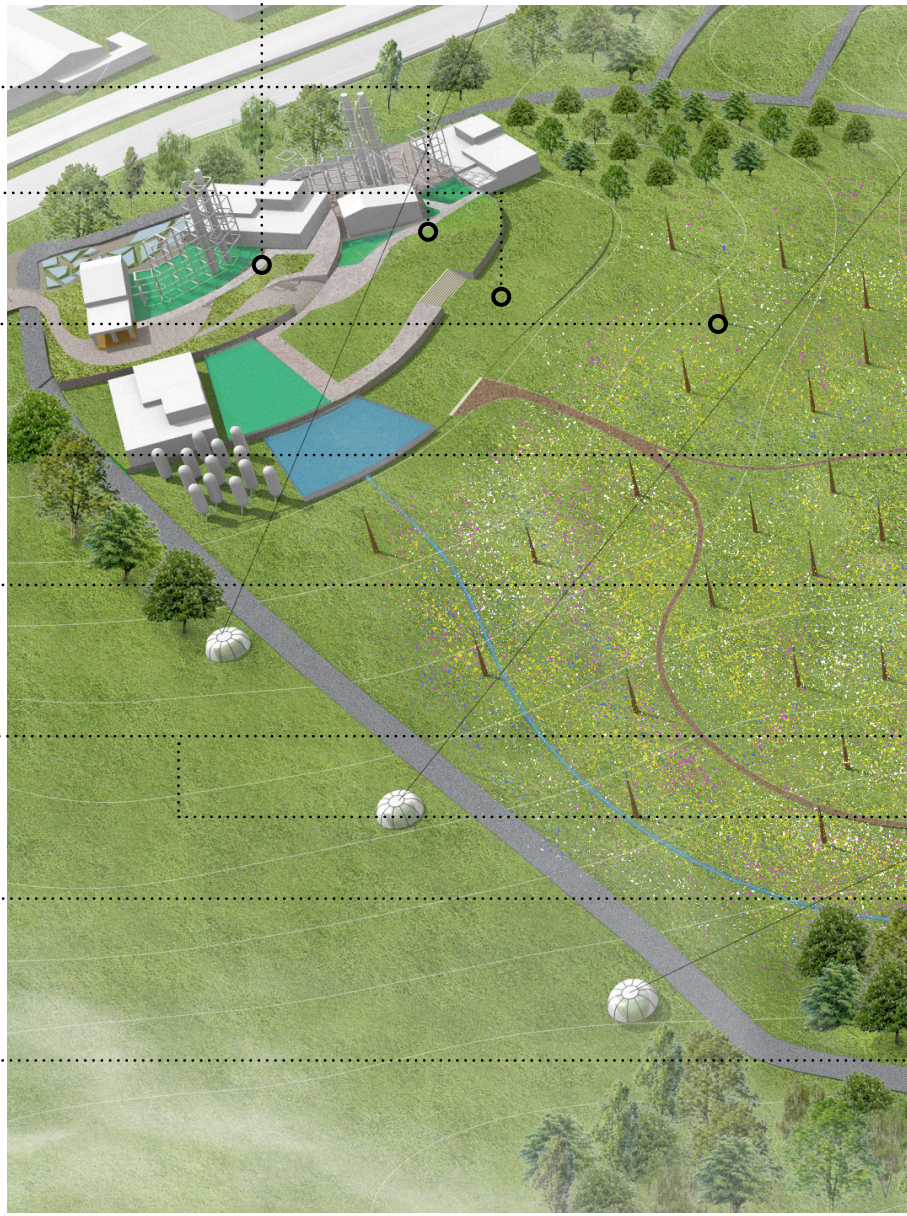
Exisiting farm
Due to the partial land reclamation from the existing farmlands in order to reforest parts of the ridges, and for the need for maintenance of the flowerbeds, the farmers will be offered the retributed job of "guardians" of the restored natural areas.

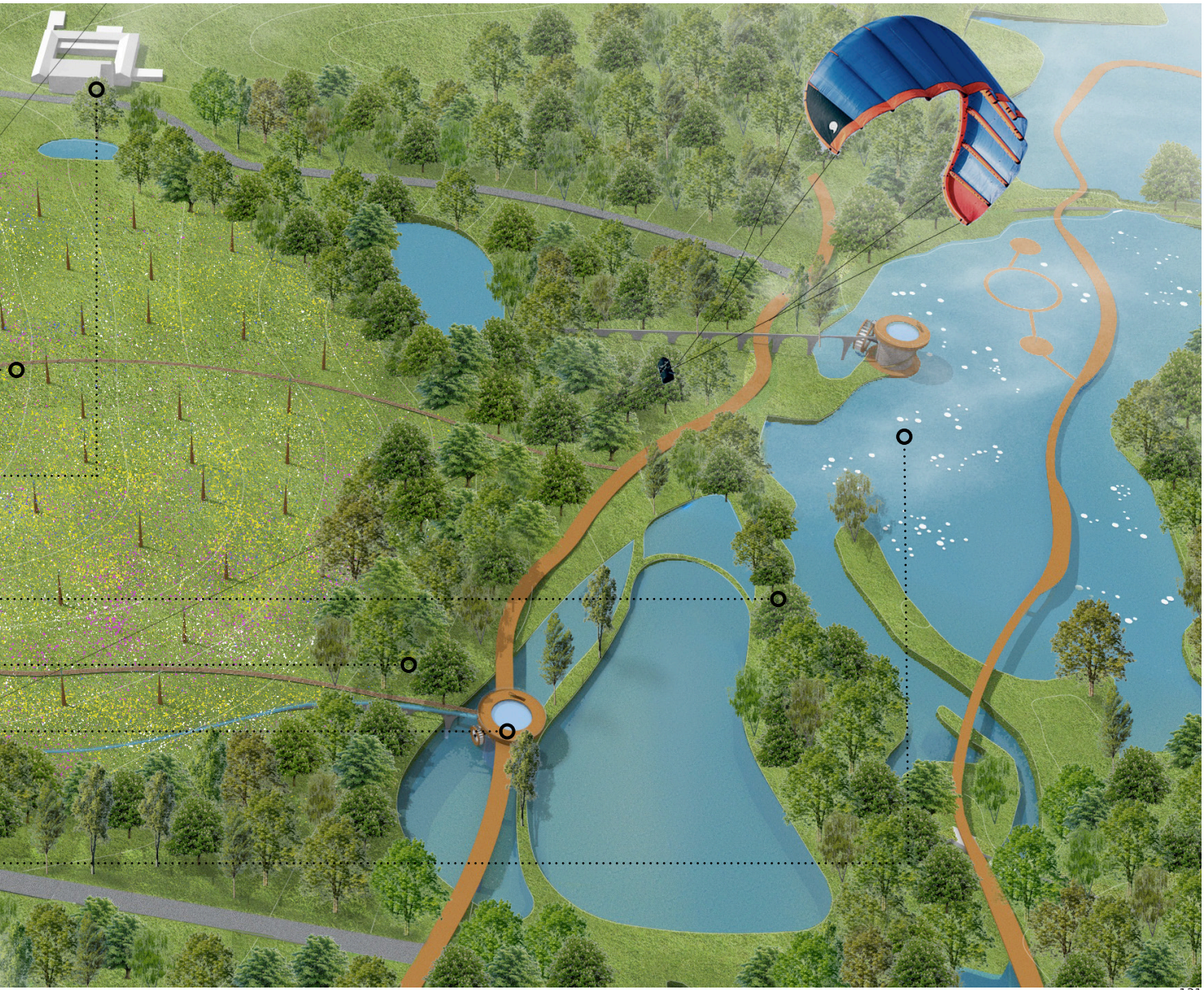
Added forests
Configuring as the ecological heart of this project, these patches of forest will be added along and on the lower borders of the ridges. Integrated with generators and transformers designed as small sheds, these areas will effectively serve the double purpose of the powerpark.

Background

Water lookout
The observation tower serve multiple purposes: it collects the purified water running off from the algae pools, provides an elevated point to let this water fall onto a watermill, and finally it provides an architectural standpoint from within the waterbody.

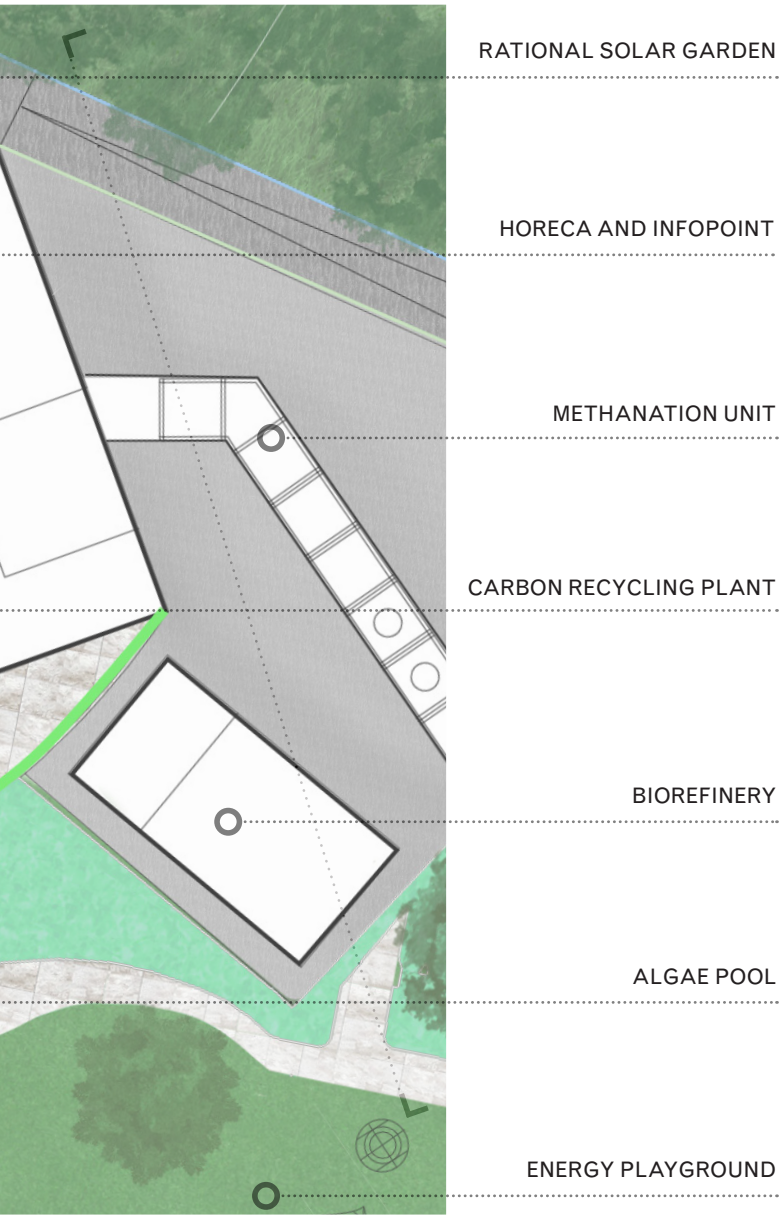
Water basins and solar floats
These elements also serve a double purpose: on the ecological level, they provide drinking areas for the animals that inhabit the forests and a place to live for the reptiles of the area, while on the energetic/educational one they produce electricity while giving the chance to the visitors to learn about constellations and the sky.





Carbon recycling plant





The designed carbon recycling plant is organised along a set of descending terraces, with each being characterised by a different area and activity.

At the very top is in fact foun a more paved space, with the infopoint and a rational solar garden. These artificial elements are directly serving the carbon recycling plant, and organise around the first of several alage pools.

The second terrace is more characterised by mowned grasslands and less rational elements, with trees starting to appear and a wide set of energy-producing playgrounds.

Savonius flowery meadows

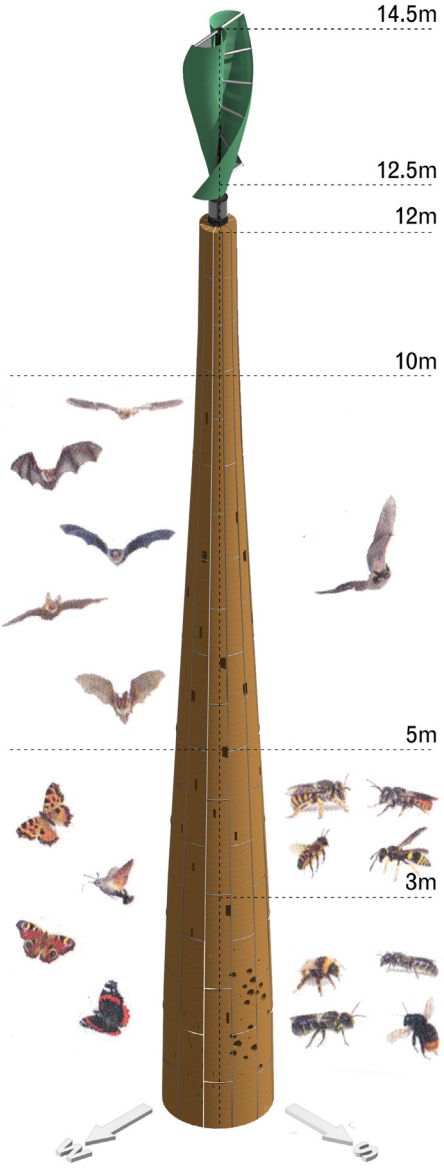


The middleground is characterised and defined mainly by the Savonius turbine energy artefact.

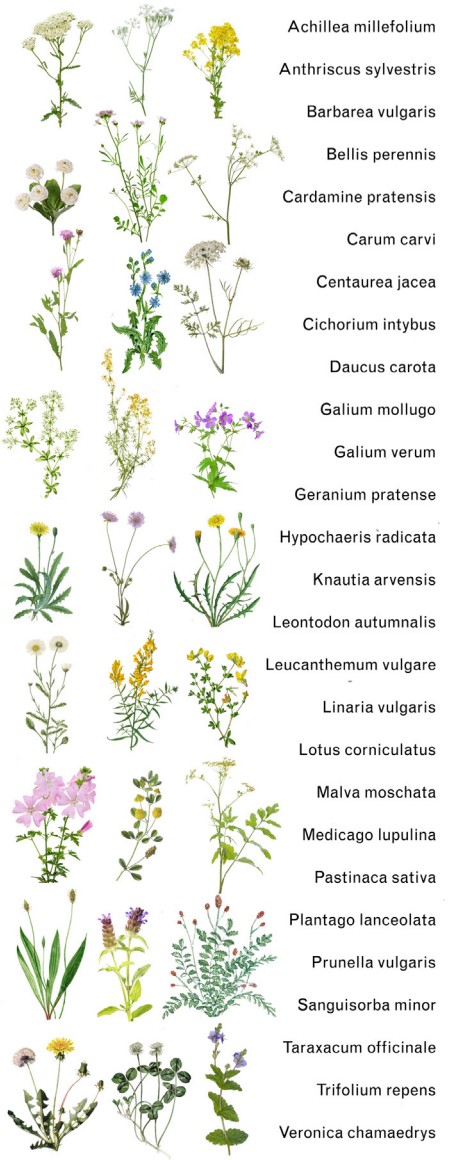
These elements require in fact an open field to best operate, thus influencing the landscape and kind of plantation.

This requirement is here treated as an opportunity by turning the openfield into a flowery meadow, feasible for rodents, horses, birds and most of all honey bees. A list of plants that will guarantee this result is included here. The meadow would be in some parts grazed by horses and in other mowned annualy, in order to maximise its attractiveness for the insects.

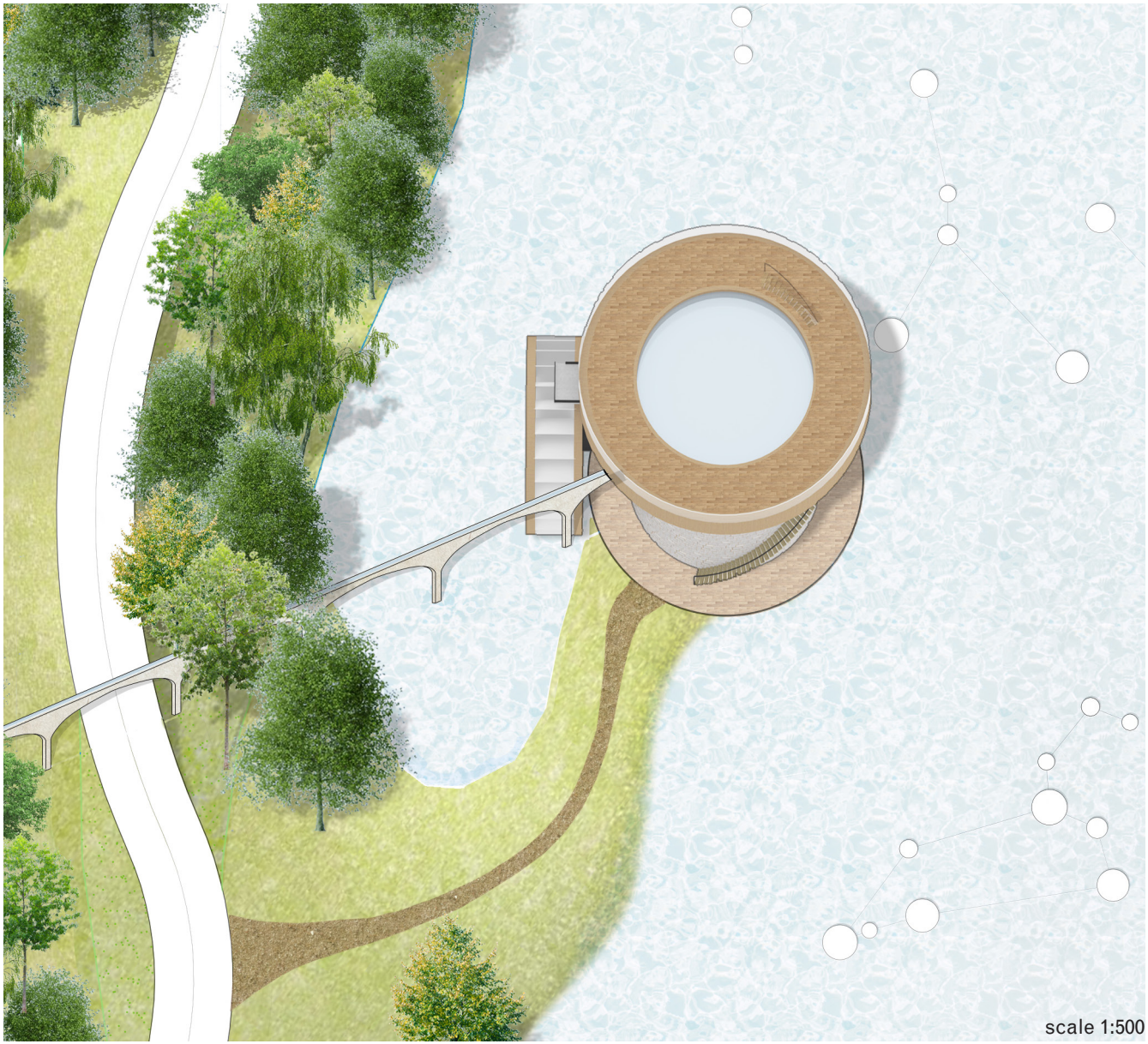
In order to deeply connect the energy object to the landscape, the shaft of the turbine is here enlarged and made porous, thus creating insect hotels and bat houses.



PLANTS PALETTE

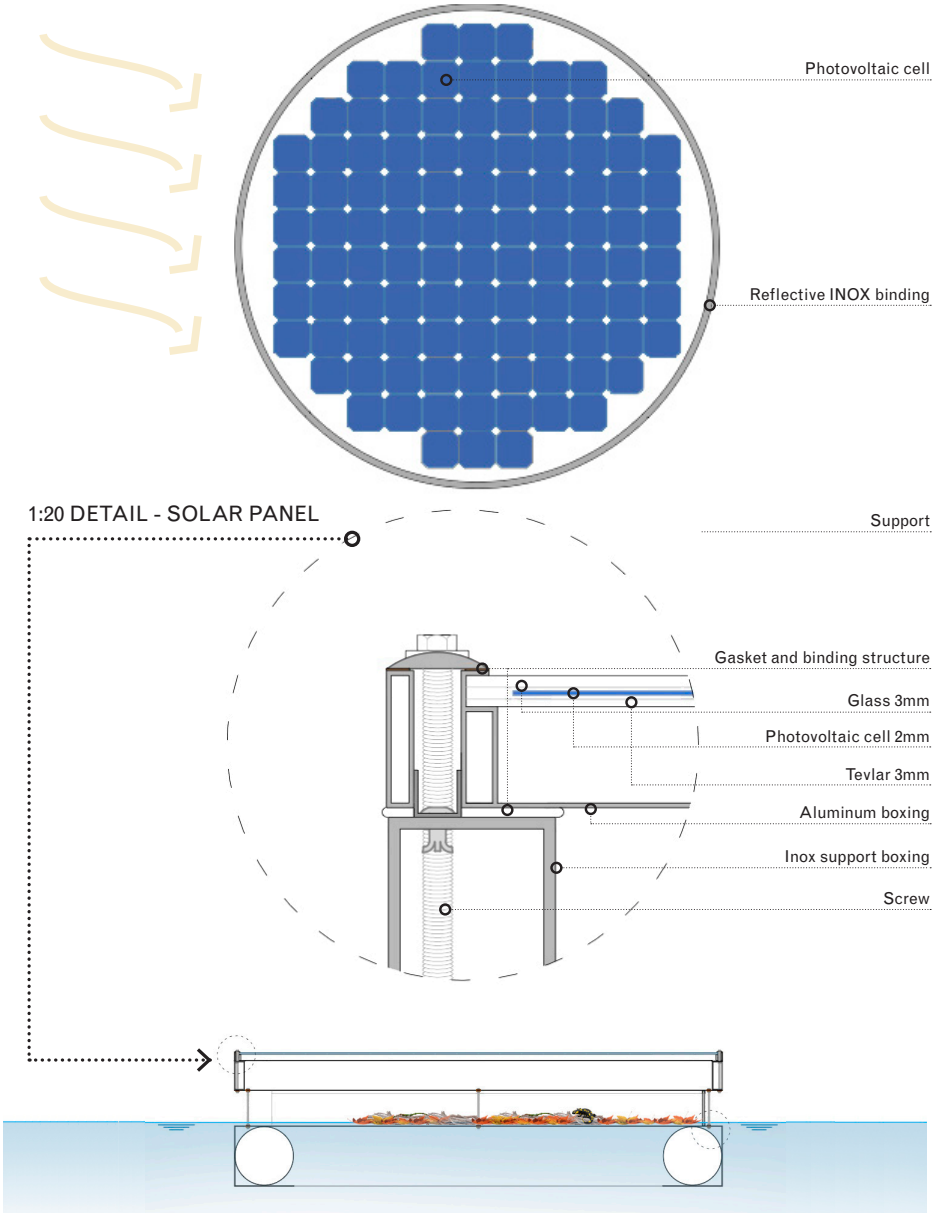


Zodiac floats - Energy

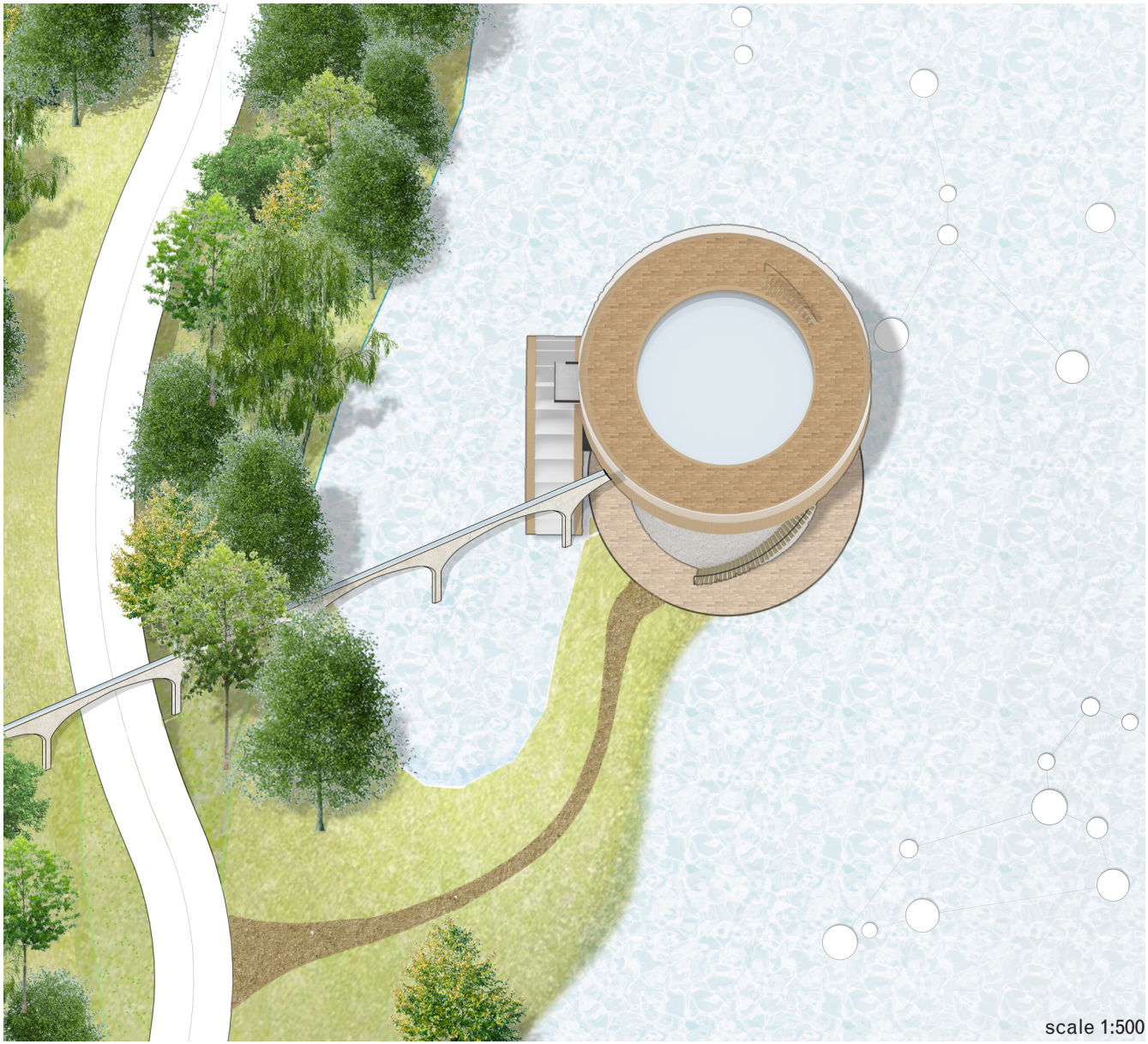


The background is mainly an ecological area, and both forestry and water will characterise most of it. For this reason, its main energy objects are watermills and a constellations of floating solar panels. In order to best integrate the artefact with the natural landscape, I followed a logic similar to that of the wind turbines. The solar floats are in fact designed as a set of horizontal layers, where the top one creates energy, the middle one is used as a reptile chamber, and the lowest one works as structural support. The top layer is covered with solar cells.

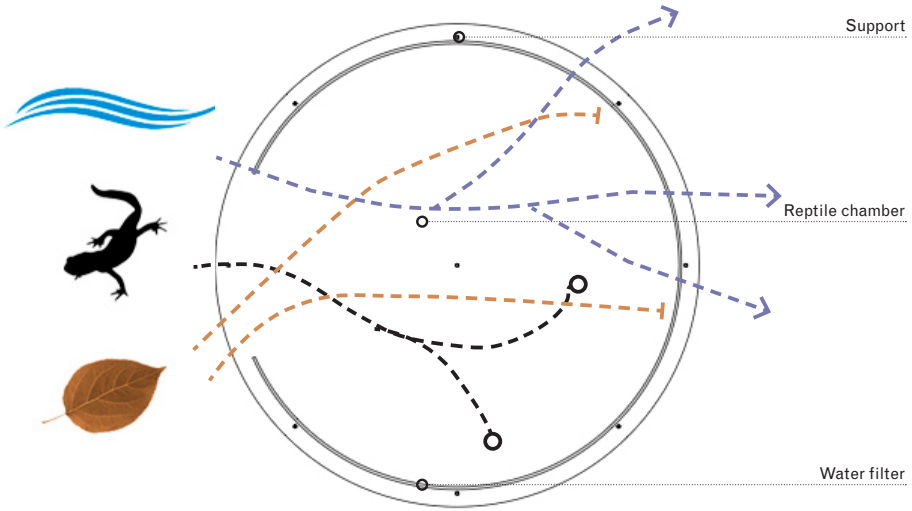
These are kept together by a reflective, water resistant binding, which during the day will play and imitate the shimmering of light on the water's surface. At night, by looking at the solar floats as an ensemble, they will reveal their disposition as constellations and zodiac signs. In this way one can learn to read the night sky by looking at the water.

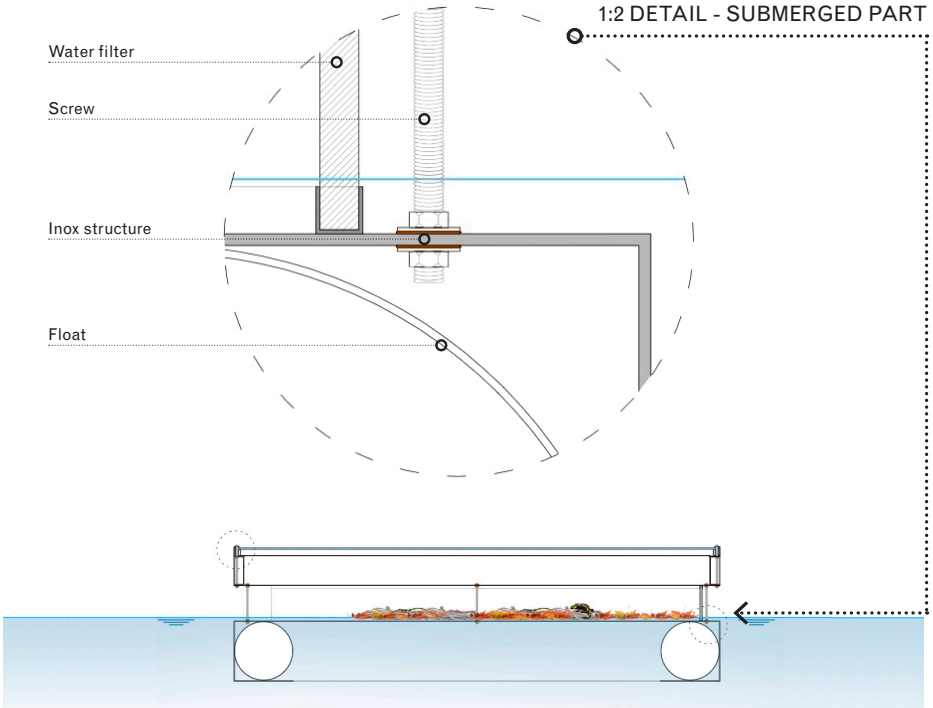


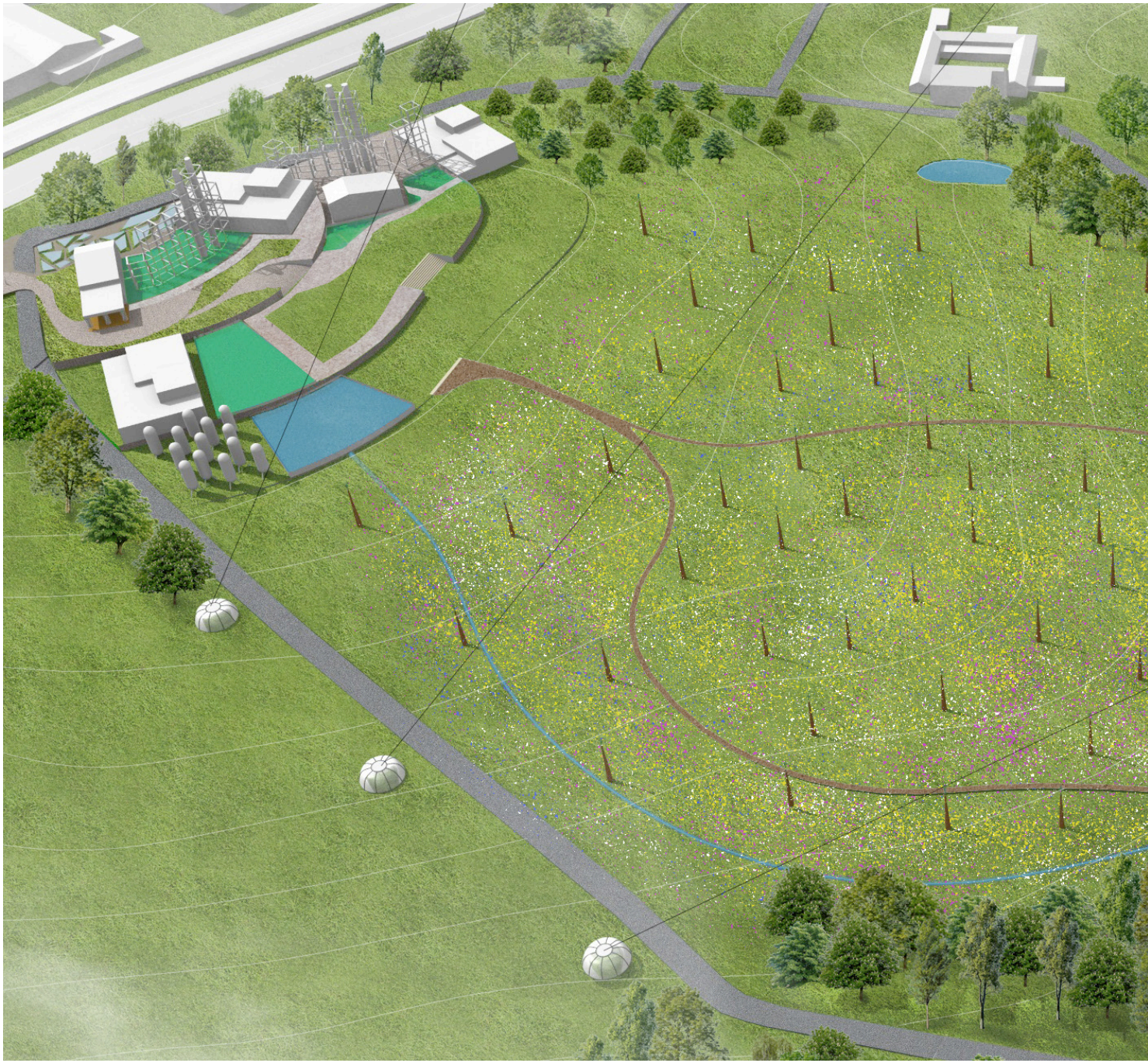
Zodiac floats - Reptile chamber



The lower level is a reptile chamber, where the ideal habitat for salamanders is created by adding a semi-open water filter. This will retain leaves and twigs while letting the water go through, and salamanders love wet, shaded areas filled with fallen leaves to hide and reproduce. In this way, the artefact will produce energy, host vulnerable species, clean the water, and teach people how to read their surroundings all at the same time.









7.

Reflection

Reflection - Conclusions

The researched and developed graduation topic connects to the theme of production landscapes by means of goals and world views. This is due to the direct relation with a solid agenda (Palet 3.0) proposed by the very region in which the project is based and to the interpretation of Nature and Landscape as Cultural and Emergent as presented in Drenthen, Keulartz and Proctor's "New visions of Nature" in 2009.

Nature is treated here as a complex set of systems that unfold through time, in relation to the resources and needs of a society. The individuals that compose said society in turn, as a reaction to the resources and processes they can find in Nature, define a concept of what Nature is. This concept evolves with society and its emerging assets, addressing elements and tools of the contextual landscape either as natural or artificial and constantly questioning the threshold between the first and the second ones.

The presented research by design finds its foundation in the theme of "Landscape as infrastructure" and "Infrastructure as Landscape", which is TU Delft's Landscape architecture's master track Flowscapes studio main topic. In this sense, in accordance with professor's F. Palmboom definition of space, Landscape can be understood as the infinite container in which different species settle and thrive, and its components as the key resources and infrastructures that said species use and interact with. The physical manifestation of Nature. Bearing this in mind, this research mainly addresses Landscape as scale continuum, investigating ways to integrate the harvesting and distribution of energy, the key human resource, with ecologic and societal contexts, from the global necessity to the personal interface with the energy objects.

Blending the energy infrastructure with the green and blue ones in order to reduce its impact on the species that inhabit a territory means making it more Nature inclusive, which includes also making it more human inclusive.

The theorised landscape of technical objects which mirror, cooperate with and protect what is usually called the "natural" landscape aims in fact at providing a unique solution to multiple issues. The main concerns are in fact here to counter the slow decline in social economy of Parkstad, to enhance its ecological system and biodiversity, to strengthen its leisure opportunities and general liveability and to counter the climate crisis, which is a threat for most of the species of our planet.

All these issues might seem unrelated, however this research proved that they all stem from energy production and its impact on the landscape throughout history. Energy is indeed harvested from the Landscape and its natural resources.

According to the calculations, fifty carbon recycling plants having the same dimensions and requirements as the icelandic one taken as model would suffice in turning Kerkrade, the chosen site for an example implementation of the power parks system, into energy neutral. In the urban vision, fifty of these have been strategically located around within the municipality and on its border with Landgraaf. It is important to underline that the carbon recycling plants alone would not meet the energy demand of the region, as shown in the calculations, however the proposed power park includes a large amount of energy objects, which will produce enough energy for both the carbon recycling plant and the local surroundings.

Approaching this issue on a temporal level, the more carbon plants will be built and integrated with sustainable energy artifacts, the lower the amount of emissions that need to be countered will be. The implications and the outcomes of this research present themselves as both a toolbox for sustainable energy parks that react to specific natural settings and a different concept of energy production landscapes, here reintegrated at the core of the urban living, instead of keeping them alienated from the everyday life.

The topic of energy transition has been quite a difficult one to deal with, in particular due to the technical aspects of the energy artifacts. Collecting datas about the spatial qualities of these objects and understanding how these function in order to be able to elaborate on their shape and inclusiveness proved itself to be a difficult task.

The language and theoretical background needed to understand most of the articles and publications that interest energy artifacts and processes rarely match with the ones a designer develops through his or her education.

One of the main conclusions drawn from the analysis is that multidisciplinarity is essential in designing the future. Fortunately, TUDelft is composed of many different faculties and departments and the fact that the content of courses of different schools is openly accessible by everyone enrolled made this research more solid.
One of the main limits of the presented project is that, also due to the presented vision of Nature and the fact that individuals are temporary, it is completely top-down and it does not directly involve the inhabitants of the area in the decision making.

Concepts as experimental as the one presented here are often critiqued and it takes time to accept, if ever, technological innovation. In this sense, a region that is slowly losing most of its inhabitants and that has thus an abundance of places to be recovered like Parkstad presents an ideal, yet unique context for the design.

Energy transition is though a necessity, and the positive aspect of this research by design is that it proves that it can be treated as a spatial, ecological, even artistic theme. In addition to this, it underlines how productive systems should also be evaluated in terms of inclusiveness and social and ecological impact instead of keeping it limited to efficiency an profitability. For this reason, a local energy landscape is preferred. Forcing awarness through inclusive design is here intended as an investment on the future, for the generations to come. This research's relevance for the profession of Landscape architecture lays exactly in its questioning which should be the boundaries between production and ecology, which expertise and criterias should be adopted in the design of technical places, to which extents these can be integrated in the urban fabric and wether these artifacts can be treated as landscape-reactive artworks, not only tools.

With the limitations given by the fact that this research's results are theoretical, how effective this method still remains a speculative answer. However, it has been proven that an energy transition in which production landscapes could be nature inclusive and with energy artifacts that can be treated as elements which dialogue with the environment can be conceived, that spatial and ecological criteria can be defined for it and that designers should be involved in the planning of energy production.

Reflection - Personal growth

Dealing with an issue as critical and vast as energy transition changes the way one looks at his or her surroundings, habits and activities. It is indisputable that without energy, humans would not be where they are now, nor would be able to remain there. Every single action and choice is somehow related to energy, either by the impacts it has on the world or by its dependency on it.

The deeper I moved in this research, the more it became important to me to live more responsibly and in a energy-wise sustainable way. There is still room for improvement, and as this research taught me there always will be.

The second lesson I have learned from this research by design is the importance of a continuous review and questioning of present systems, along with the implementation of state of the art technology with identities and dynamics from our past. Without the first, we would not be able to move forward, however the second one is critical in understanding towards what shall we move.

Having to analyse a territory, identify its problems and propose solutions that span from the regional to the human scale to then reconnect the conclusions obtained to a global situation provided me with new skills and new visions. The importance of presenting this research on an academic level, with the relevance of a scientific method, allowed me for instance to improve my story telling abilities.

The impact of this lays not only in the way one presents a topic to a third, but mainly on how one understands and develops the story that he or she is trying to enrich. For this I really need to thank my mentors.

It has been extremely challenging, but thanks to this I now try much more than before to "step out of my own head" to see if what I am presenting is understandable and how dependent is it to me. I now think that a good story should be as good without its storyteller.

As a designer, I have found a new interest and lexicon on how to deal with artifacts and more generally singular, prefabricated elements, and how to read landscapes on several levels, from understanding them as geometric configurations of space to analysing them as sources to satisfy our needs.

Reflection - Coronavirus, considerations

Graduating during the Corona crisis has been difficult.

On a professional level, it erased the chances to do site visits and interviews that were planned, making the presented solution more speculative. This triggered moments of insecurity and stress, especially due to the uncertainty of both the situation and one's own work, which could only be validated by digital means.

Another great impact this emergency had on me is that it prevented from meeting with fellow students, sketching together, presenting one's own work to each other. This is what I missed the most, because those moments and dynamics are a great source of inspiration and knowledge exchange.

The lack of facilities and resources has also been hard to deal with, especially due to the fact that inspiration can be found in materials and in changing methods.

It is true that reviews and meetings could and have been done anyways on a digital level, but in my experience the genuinity typical of a face to face meeting was lost. I enjoy presenting, and in my experience having to do it through a screen took the adrenaline away.

This situation had however its upsides. The most important and immediate one, in my opinion, is that we had a chance to prove ourselves how resilient we can be, and that it forcefully taught us how to work and present from a distance, which would be extremely useful in a professional environment where it is normal that projects built in a continent are often developed in another one.

On a personal level, the lockdown instantly changed the extents of our worlds.

Having to live with the fear that a relative could get in serious conditions, which fortunately in my case didn't happen, and not being able to be there made me feel powerless, and trapped.

Graduation became the only thing going on in my life, and that did not help on a psychological level. Especially due to the not being able to relieve the stress that a work as immense as graduating inevitably generates.

However, the digital tutoring really helped having a schedule and I found very interesting and thoughtful that TUDelft and its professors organised side activities and meetings to help the students dealing better with this period, even if I have not actively participated to them.

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Appendix 1 - Flora and fauna

Animals	Plants	Insects
BIRDS:	TREES:	BUTTERFLIES:
Athene noctua	Fagus sylvatica	Argynnis paphia
Eurasian eagle owl	Quercus robur	Limenitis camilla
European green woodpecker	Quercus petraea	Nymphalis antiopa
(Eurasian woodcock)	Quercus rubra (non native)	Large tortoiseshell
Rook	Robinia pseudoacacia (non native)	OTHER:
Red kite	Acer pseudoplatanus	Apis mellifera
Eurasian treecreeper	Carpinus betulus	Bombus terrestris
European honey buzzard	Fraxinus excelsior	Myrmica rubra
Common wood pigeon	Prunus avium	
MAMMALS:	Tilia cordata	
Daubenton's bat	SHRUBS:	OTHER::
European badger	Corylus avellana	
Eurasian hedgehog		
Garden dormouse	ANNUAL & PERENNIAL:	
Sus scrofa (Wild boar)	Narcissus pseudonarcissus	
Hazel dormouse	Blechnum spicant	:
Euopean wildcat	Pyrola minor	
Roe deer	Viola canina	
Yellow-necked mouse	Oreopteris limbosperma	
European pine marten		

Animals	Plants
BIRDS:	TREES:
Yellow wagtail	Alnus glutinosa
Yellow hammer	Fraxinus excelsior
Grey heron	Betula pendula
Grey wagtail	Betula pubescens
	Prunus padus
Sand martin	SHRUBS:
White-throated dipper	Salix cinerea
Kingfisher	Salix aurita
(Otter)	ANNUAL & PERENNIAL
Eurasian water shrew	Chrysosplenium oppositifolium
REPTILE/AMPHIBIAN:	Thelypteris palustris
Northern crested newt	ANNUAL & PERENNIAL NUTRIENT POOR
Palmate newt	Hypericum elodes
Fire salamander	Viola palustris
Great crested newt	Menyanthes trifoliata
European tree frog	Lysimachia thyrsiflora
FISH:	
Brook lamprey	ANNUAL & PERENNIAL NUTRIENT RICH
Common minnow	Limosella aquatica
Cottus perifretum	
River lamprey	

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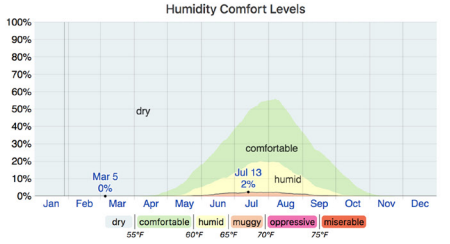
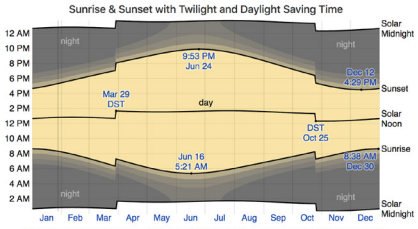
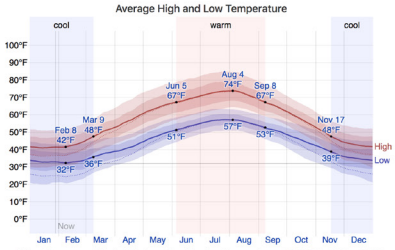
Appendix 2 - Parkstad atmospheric data



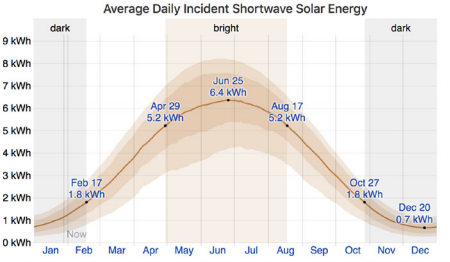
The percentage of time spent at various humidity comfort levels, categorized by dew point.



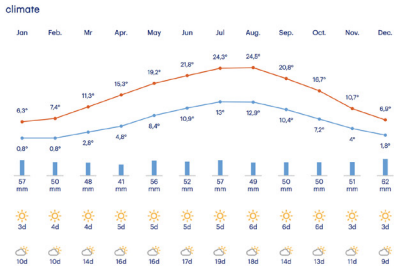
The solar day over the course of the year 2020. From bottom to top, the black lines are the previous solar midnight, sunrise, solar noon, sunset, and the next solar midnight. The day, twilights (civil, nautical, and astronomical), and night are indicated by the color bands from yellow to gray. The transitions to and from daylight saving time are indicated by the 'DST' labels.

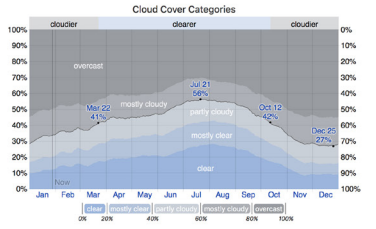


The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

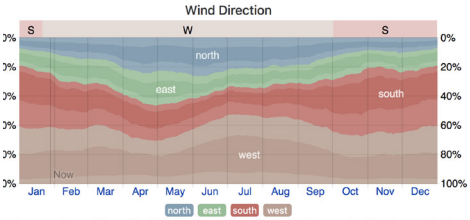


The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands.

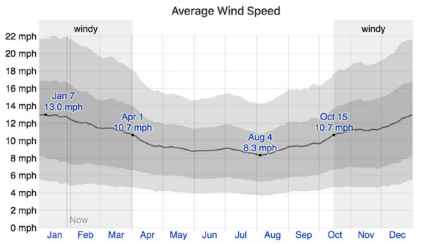




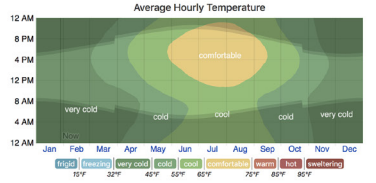
The percentage of time spent in each cloud cover band, categorized by the percentage of the sky covered by clouds.



The percentage of hours in which the mean wind direction is from each of the four cardinal wind directions, excluding hours in which the mean wind speed is less than 1.0 mph. The lightly tinted areas at the boundaries are the percentage of hours spent in the implied intermediate directions (northeast, southeast, southwest, and northwest).



The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.



The average hourly temperature, color coded into bands. The shaded overlays indicate night and civil twilight.

Sources:
https://weatherspark.com/y/54299/Average-Weather-in-Kerkrade-Netherlands-Year-Round
https://www.buienradar.nl/weer/kerkrade/nl/2752923/klimaat

Appendix 3 - List of industries

E-Max Aluminium Remelt
// Metal processing company

Anstelfood B.V.
// Food producer

Burrows Netherlands B.V.
// Manufacturer

ADJ Supply Europe B.V.
// Electronics manufacturer

Jindal Films Kerkrade B.V.
// Chemical plant

EKK Eagle Simrax
// Auto parts manufacturer

BTC BV
// Industrial gas supplier

Mayfran Limburg B.V.
// Machining manufacturer

Medtronic BV
// Medical technology manufacturer

SIBELCO Sibelco Benelux B.V.
// Masonry contractor

Trommelen BV
// Earth works company

Source:
Google maps

Appendix 4 - Artifacts' technical foundation

CARBON RECYCLING PLANTS

"It is actually possible to chemically combine hydrogen gas with CO2, again from the exhaust of fossil-based power plants. This process is based on the so-called Sabatier reaction, and it can be used to produce, among other things, methane and methanol. Methane is the main ingredient of natural gas, and because it has a higher energy density and is less reactive than hydrogen gas, it is somewhat easier to store and transport. National gas distribution networks are actually excellent energy storage facilities, generally able to store more than a year's worth of a country's energy use. And the Sabatier reaction can also produce Methanol, a liquid fuel that is basically a toxic variant of alcohol. This can relatively easily be stored for longer periods. Long-term storage using methane or methanol produced from hydrogen and CO2 may not have a high efficiency, as storage goes. But it does offer something that batteries or pumped storage cannot: the possibility of seasonal-scale storage. This way, an energy surplus produced in summer by solar PV, can be stored and used in winter. It is certainly an interesting option to combine coal-based based electricity production with carbon capture using fuel cells and/or the Sabatier reaction*. It would be a win/win situation, drastically reducing the CO2-emissions of coal power plants without reducing their efficiency too much, and offering options for long-term storage of renewable energy." [Source 1]

A "Large commercial facility is the George Olah carbon dioxide recycling plant in Grindavík, Iceland. This commercial plant uses around 5 MW of electricity from the 75 MW Svartsengi Geothermal Power Station to produce hydrogen. The hydrogen is then combined with CO2 from the power station exhaust, to make methanol. The facility has a maximum production capacity of around 13700 L methanol per day (equivalent to roughly 59 MW·h of stored energy). The methanol is currently blended with gasoline and used as transportation fuel." [Source 1]

Sources:
[1]Energy storage and the Tesla battery, Levien van Zon, (jun 3, 2015), published onto "The substance of sustainability".
[2] Carbon recycling international, https://www.carbonrecycling.is/
[3] Wikipedia, https://en.wikipedia.org/wiki/Sabatier_reaction

WIND TURBINES

"Wind turbines produce no greenhouse gas emissions during their operation. It takes a turbine just three to six months to produce the amount of energy that goes into its manufacture, installation, operation, maintenance and decommissioning after its 20-25 year lifetime. During its lifetime a wind turbine delivers up to 80 times more energy than is used in its production, maintenance and scrapping. Wind energy has the lowest 'lifecycle emissions' of all energy production technologies. The output of a wind turbine depends on the turbine's size and the wind's speed through the rotor." [Source 3]

"An average onshore wind turbine with a capacity of 2.5–3 MW can produce more than 6 million kWh in a year – enough to supply 1,500 average EU households with electricity. An average offshore wind turbine of 3.6 MW can power more than 3,312 average EU households. Wind turbines start operating at wind speeds of 4 to 5 metres per second and reach maximum power output at around 15 metres/second. At very high wind speeds, that is gale force winds of 25 metres/second, wind turbines shut down. A modern wind turbine produces electricity 70-85% of the time, but it generates different outputs depending on the wind speed. Over the course of a year, it will typically generate about 24% of the theoretical maximum output (41% offshore). This is known as its capacity factor. The capacity factor of conventional power stations is on average 50%-80%." [Source 3]

"Ninety percent of a turbine's parts can be recycled or sold, according to Van Vleet, but the blades, made of a tough but pliable mix of resin and fiberglass — similar to what spaceship parts are made from — are a different story." [Source 2]

Horizontal axis wind turbines are generally preferred for large scale construction.

Sources:
[1]https://greenliving.lovetoknow.com/Efficiency_of_Wind_Energy
[2]https://www.npr.org/2019/09/10/759376113/unfurling-the-waste-problem-caused-by-wind-energy?t=1587541312689
[3]https://www.ewea.org/wind-energy-basics/faq/
[4]Landscape and Energy, Designing Transition; Dirk Sijmons, Jasper Hugtenburg, Fred Feddes, Anton van Hoorn; Published by NAI010 Publishers, Rotterdam, 2014

Appendix 4 - Artifacts' technical foundation

KITE GENERATORS

"Gliders can also be used as GG aircraft. Like delta kites, their wings are subject to bending moment during the tethered flight. Gliders, and more generally rigid wings, have excellent aerodynamic performance, although they are heavier and more expensive. Lifetime with regular maintenance is several decades."
[Source 1]

"Repeated in continuous cycles, this procedure results in positive net energy output.
The type of wing used by the system is a Leading Edge Inflatable (LEI) kite."
[Source 2]

"This type of kite is affordable, easy to transport as well as maintain and upgrade. Tube kites for kite surfing developed quickly over the past years and by choosing this concept Kitepower has further developed it for the power application."
[Source 2]

"On the ground, the drum/generator module is responsible for traction power conversion while constantly monitoring and adapting the force in the tether. The separation of wing steering and power conversion at the ground allows for optimised functional designs. The control software includes two alternating autopilots, one for the lying figure eight maneuvers during tether reel-out and one for the reel-in phase."
[Source 2]

Sources:
[1]Airborne Wind Energy Systems: A review of the technologies; Antonello Cherubini, Andrea Papini, Rocco Vertechy, Marco Fontana; published in Renewable and Sustainable Energy Reviews, Volume 51, November 2015, Pages 1461-1476
[2]https://kitepower.nl/tech/

HYDROPOWER

"Compared to alternative (renewable) energy sources, hydropower's potential is quite low in the Netherlands, in 2011 hydropower only contributed to 0.02 percent of the total energy mix; some policy makers expect this percentage to stay low (a perception problem that small-scale hydel entrepreneurs have to handle). As a Rijkswaterstaat officer explains: "there are still a couple of big locations on the Meuse, so the total hydropower capacity can be increased by around 20 to 50 MW.[...] So there are quite a few locations where plants can be established, but I believe this will be a maximum of four to five plants and some smaller ones scattered around. That will be about it."
[Source 1]

"A mill owner converted the facility's old electromechanical equipment into a 6 kW hydropower plant. The owner installed a Mitsubishi FR-A741 inverter drive with power regeneration capability to convert the electricity produced by the Francis turbine into the frequency required by the main transmission grid. At the same time, variable-speed operation of the turbine is increasing the efficiency of electricity generation at this facility. Since the conversion, the plant has provided a reliable supply of power for the owner's consumption, as well as about 12 MWh of electricity annually that is fed to the grid."
[Source 2]

Sources:
[1] Small-scale hydropower in the Netherlands: Problems and strategies of system builders; Tanja N.Manders, Johanna I.Höffken, Erik B.A.van der Vleuten; published in Renewable and Sustainable Energy Reviews, Volume 59, June 2016, Pages 1493-1503
[2] Converting a Watermill into a Hydroelectric Plant; Daniel Lehmann; published in Renewable Energy World, March 2012, Issue 2 and Volume 20.

Appendix 4 - Artifacts' technical foundation

PHOTOVOLTAIC

Thin-film technology has always been cheaper but less efficient than conventional c-Si technology. However, it has significantly improved over the years. The lab cell efficiency for CdTe and CIGS is now beyond 21 percent, outperforming multicrystalline silicon, the dominant material currently used in most solar PV systems.[1]:23,24 Accelerated life testing of thin film modules under laboratory conditions measured a somewhat faster degradation compared to conventional PV, while a lifetime of 20 years or more is generally expected. [2] Despite these enhancements, market-share of thin-film never reached more than 20 percent in the last two decades and has been declining in recent years to about 9 percent of worldwide photovoltaic installations in 2013. [Source 1]

From a regulatory aspect, PV panel waste still falls under the general waste classification. A sole exception exists at EU-level, where PV panels are defined as e-waste in the Waste Electrical and Electronic Equipment (WEEE) Directive. The PV panel waste management is thus regulated by this directive, additionally to other legal frameworks.

The solar cells manufacturers are bound by law to fulfil specific legal requirements and recycling standards in order to make sure that solar panels do not become a burden to the environment. That is when technologies to recycle solar panels started emerging. [Source 2]

Sources:
[1] Wikipedia, https://en.wikipedia.org/wiki/Thin-film_solar_cell ;
[2] "Photovoltaics Report". Fraunhofer ISE. July 28, 2014. Archived from the original (PDF) on August 31, 2014. Retrieved August 31, 2014.
[3] "The Real Lifespan of Solar Panels". EnergyInformative. May 7, 2014.
[4] The Opportunities of Solar Panel Recycling, What Happens to PV Panels When Their Life Cycle Ends, Attila Tamas Vekony, 10 March 2020, Greenmatch
https://www.greenmatch.co.uk/blog/2017/10/the-opportunities-of-solar-panel-recycling

GEOTHERMAL - MINE HEATING

"In the last 10 years numerous research and commercial initiatives have been undertaken in Europe to develop abandoned coal mining fields in to low-temperature resources.

One of the most successful is the Minewater project of the municipality of Heerlen, the Netherlands, where a low-temperature district heating system was launched in operation in October 2008, under the European Interreg IIIB NWE programme and the 6th Framework Program project EC-REMINING-lowex. The Minewater project is now being upgraded from a straight forward pilot system to a full-scale hybrid sustainable energy structure called Minewater 2.0.

[...]A straight forward pilot system to investigate how the mine water of the abandoned coal mines of Oranje Nassau could be used as a geothermal source for the sustainable low-exergy heating and cooling of buildings. Five wells were drilled to the stone drifts in the underground (see figure 1). Two hot wells in the northern part of Heerlen with a depth of 700 meters below surface for the extraction of hot water with a temperature of about 28 °C, two cold wells in the southern part of Heerlen with a depth of 250 meters for the extraction of cold mine water with a temperature of about 16 °C. A fifth well in the middle part of Heerlen with a depth of 350 meters is used for the injecting of the cooled hot and warmed cold mine water with intermediate temperatures between 18-22 °C." [Source 1]

Sources:
[1] Minewater 2.0 project in Heerlen the Netherlands: transformation of a geothermal mine water pilot project into a full scale hybrid sustainable energy infrastructure for heating and cooling; René Verhoeven, Eric Willems, Virginie Harcouët-Menou, Eva De Boever, Louis Hiddes, Peter Op 't Veld, Elianne Demollin; https://www.researchgate.net/publication/260043754_Minewater_20_Project_in_Heerlen_the_Netherlands_Transformation_of_a_Geothermal_Mine_Water_Pilot_Project_into_a_Full_Scale_Hybrid_Sustainable_Energy_Infrastructure_for_Heating_and_Cooling

Appendix 4 - Artifacts' technical foundation

ALGAE FARMING

"A model algal biorefinery would have three revenue streams: cellulosic ethanol, renewable diesel or jet fuel, and animal feed. However, the high cost of algal biomass production for these high-volume, low-value commodities challenges the economic viability of an integrated algal biorefinery." [Source 1]

"Like fossil fuel, algae fuel releases CO2 when burnt, but unlike fossil fuel, algae fuel and other biofuels only release CO2 recently removed from the atmosphere via photosynthesis as the algae or plant grew. The energy crisis and the world food crisis have ignited interest in algaculture (farming algae) for making biodiesel and other biofuels using land unsuitable for agriculture. Among algal fuels' attractive characteristics are that they can be grown with minimal impact on fresh water resources, can be produced using saline and wastewater, have a high flash point, and are biodegradable and relatively harmless to the environment if spilled. Algae cost more per unit mass than other second-generation biofuel crops due to high capital and operating costs, but are claimed to yield between 10 and 100 times more fuel per unit area." [Source 2]

Long-chainc EPA/DHA omega-3 fatty acid supplementation can be co-preventative and co-therapeutic. [...] Certain microalgae produce high levels of EPA or DHA. Now, organically produced DHA-rich microalgae oil is available. Clinical trials with DHA-rich oil indicate comparable efficacies to fish oil for protection from cardiovascular risk factors by lowering plasma triglycerides and oxidative stress. [Source 3]

Sources:
[1]Biomass-Based Products and Chemicals; David C. Dayton, Ofei D. Mante, published in Analytical Methods for Biomass Characterization and Conversion, 2020
[2] Wikipedia, https://en.wikipedia.org/wiki/Algae_fuel
[3] Omega-3 fatty acids for nutrition and medicine: considering microalgae oil as a vegetarian source of EPA and DHA.; Scott D Doughman, Srirama Krupanidhi, Carani B. Sanjeevi; Published in Current diabetes reviews 2007

