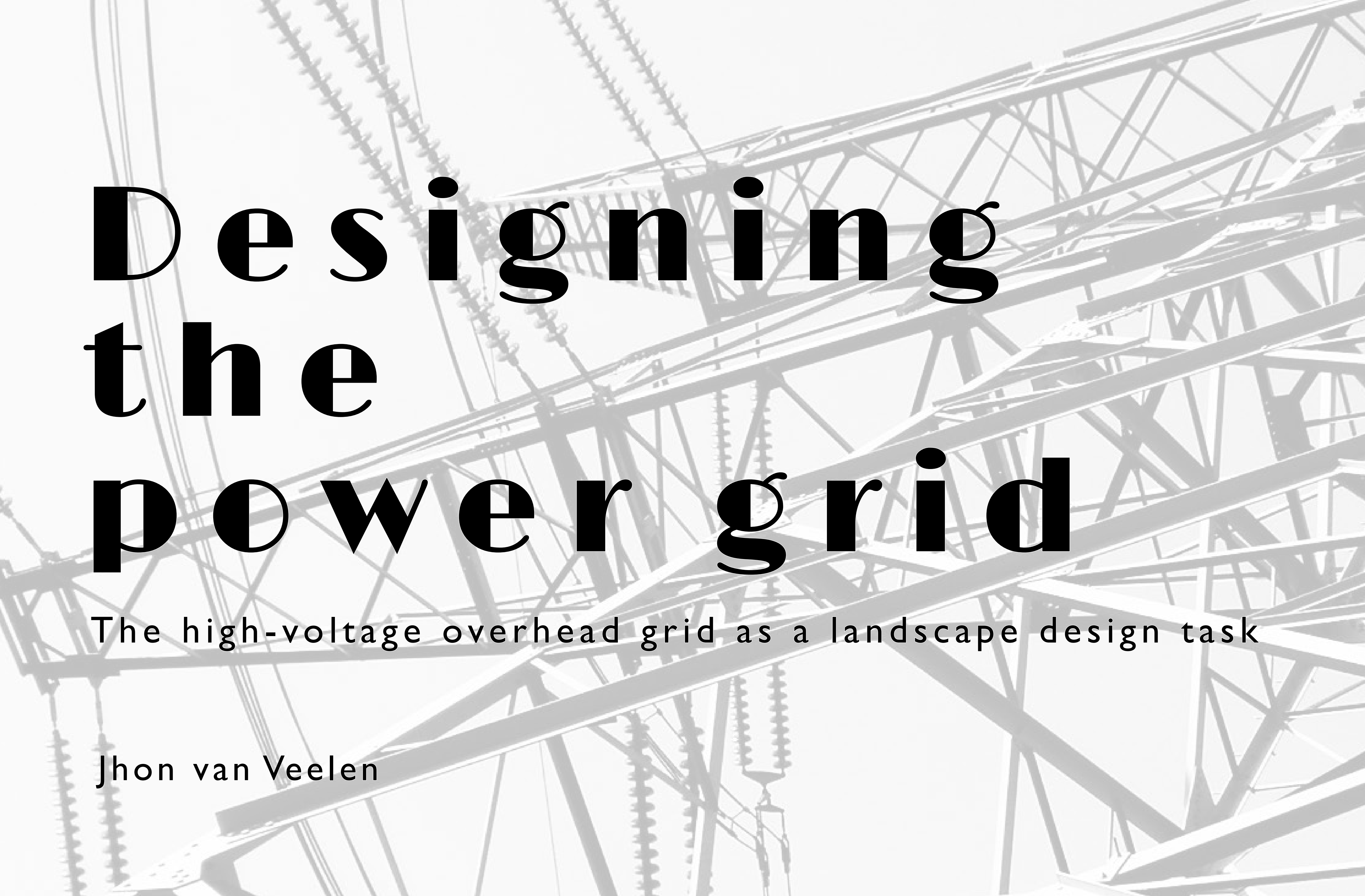

Designing the power grid

The high-voltage overhead grid as a landscape design task

Jhon van Veelen

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2023

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1. Preface

Transport of electric energy is an essential component in societies. The indispensable overhead power grid always plays a prominent role in the perception of the landscape. The landscape architectural aspects are always important to considered when planning new spatial parts of the power grid.

This document gives guidance to the integration of new parts of the overhead grid in the landscape.

The most important issue in the approach of landscape integration as presented here is the search for the most beautiful overhead line, the best way in which new parts of the electricity grid can be integrated into any landscape.

It is a positive approach that can best be summed up with: 'a quest for beauty'.

I have developed this approach in my work as a landscape architect and as a senior advisor to the Dutch Grid Operator TenneT TSO in particular.

Jhon van Veelen

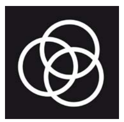
2. Summary / Guidelines

Strive for beauty

Design with a positive approach, strive for the best possible integration of all technical elements of the power grid into the landscape. It is a quest with the aim of realizing spatial quality.

Landscape integration is dealing with the relationship between scale levels

Landscape integration is always about different scale levels:
The central design level, the actual spatial parts and technical elements of the network itself: the overhead lines, the substations, transition installation/point and the landscape.
one scale level higher: The entire connection, the power grid level, which responds to the Regional Landscape Pattern
one scale level lower: The plot where a pylon or substation is located, the spot in the local landscape.
Coherence between these levels is a precondition for the development of spatial quality.



Integration is a threefold mission: designing the power grid, finding the right location in the landscape and adjustments to the landscape

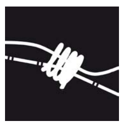
Good integration consists of:
Design parts of the power grid itself from within their own nature, meaning and form;
Correctly locate these elements in the landscape. That is to say, using an integrated approach in which all relevant aspects such as landscape, nature, soil and water are involved. This is a process of designing in conjunction with and following from other spatial plans in the region concerned.
Take advantage of opportunities to strengthen the landscape structure, creating a better balance between the landscape and a new power line or new substation.

Implement landscape design in early and all project phases and ensure a good transfer between all process steps

Guaranteeing spatial quality in any landscape requires coherence between different phases in the total planning and construction process.
A landscape design approach must be included in every phase, from the first high level corridor study or a location study, through detailed routing, environmental impact assessment, Landscape plan to realization and final maintenance.

Connect to the Regional Landscape Pattern (RLP)

The national power grid is a supra-regional and national infrastructure. Make sure to match it with the Regional Landscape Pattern (RLP) as much as possible. The RLP consists of those physical elements and patterns that determine the specific character of the regional landscape. The scale level of the RLP corresponds to the scale level of the national power grid.



Bundle with infrastructure of a similar structure and scale

Bundling with other infrastructures is pursued only when it leads to better landscape integration. This means that bundling with a winding small brook is not the right choice to make, while bundling with patterns of a comparable scale level, such as other overhead lines or large waterways leads to recognizable landscape integration.

When bundling with other overhead lines, preferably keep the pylons "in step"

Bundling with other overhead lines creates a calmer image when the distance between two pylons in both overhead lines is the same. In this way the pylons of the separate lines are aligned.

Pay attention to the area where part of the existing power grid is being demolished

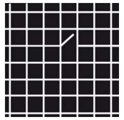
More and more parts of the power grid will be placed underground in the future. This may create "empty spots" where above-ground parts of the power grid have disappeared. To accommodate overhead power lines vegetation such as trees used to be cut. These gaps can be filled with new trees and breaks in ecological connections can be restored.

Design straight and uniform lines, which are best incorporated into the landscape image

Overhead lines may be seen, but it must be prevented from becoming too dominant in the landscape. Simple straight lines of long rows with uniform pylons quickly fade into the background of human observation.
The rhythm of rows of pylons with "wavy" wires in between, gives the power line its own specific spatial quality. Therefore, design straight lines as much as possible.

Design lines autonomously, separate from the local landscape

An overhead line must be as separate as possible from the small-scale elements in the local landscape, because these lines form part of the national power grid.

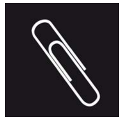


Avoid deviations from the standard; locate necessary deviations away from objects in the local landscape

Simple shapes ensure that objects disappear into the background of our human view and do not disturb perception. Deviations however seek our attention. For example, corner pylons that are necessary to make angles in a line must be located separate from objects in the local landscape, such as sheds and houses,

Avoid disturbing contrasts

The position of each element of the power grid - a pylon or a substation - determines the spatial quality of that location. It is precisely at this local level that a new element is experienced up close. This implies dealing well with the contrast difference between technical grid elements and local objects. The local spatial construction with ditches, roads, bridges, trees, houses, businesses and barns requires an accurate approach. It is essential to take into account the visual influence at eye level and the contrast with the immediate environment

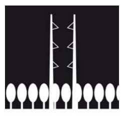


Design installations in a functional and sober way

Simple design of the power grid, limiting visual complexity at every scale level is the starting point. The design of installations must therefore be modest and functional. The different parts of the power grid may be seen, but must not be unnecessarily dominant.

Make a Landscape plan

It is necessary to draw up a landscape plan for every project. It contains all the measures that are necessary for proper integration. These are design measures derived from all relevant environmental aspects: landscape, cultural history, nature, living environment and water. Where possible, the measures are to be combined and integrated. For example, they can simultaneously have significance for the integration of the landscape and for the compensation of ecological values. Landscape is cultural history, that is the starting point for the integration that is the starting point for the integration process.

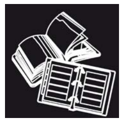


Let the design of the "obstructed" strip of land match the character of the environment

When designing the area under and next to an overhead line – the space where spatial possibilities are limited – strive to maximally connect with the character of the environment and local use. This prevents hard 'denominations' in agricultural, forest and nature areas (Crow 1958). For example, an overhead line is perceived much less as an intersection and is more "taken for granted" in the landscape. Avoid creating a sharply delimited zone with different use and appearance, such as an open strip in a forest. It is also ecologically preferable to avoid sharp boundaries and to allow edges to gradually transition from forest through thickets to open areas as much as possible.

Do not destroy more than is strictly necessary; repair the damage on site as much as possible

Prevent and limit damage to ecology and landscape. Repair and compensate for unavoidable damage by taking measures, such as planting, appropriate vegetation and attaching bird flaps, placing nesting boxes, etc.



Connect with local agendas, engage in active dialogue with residents

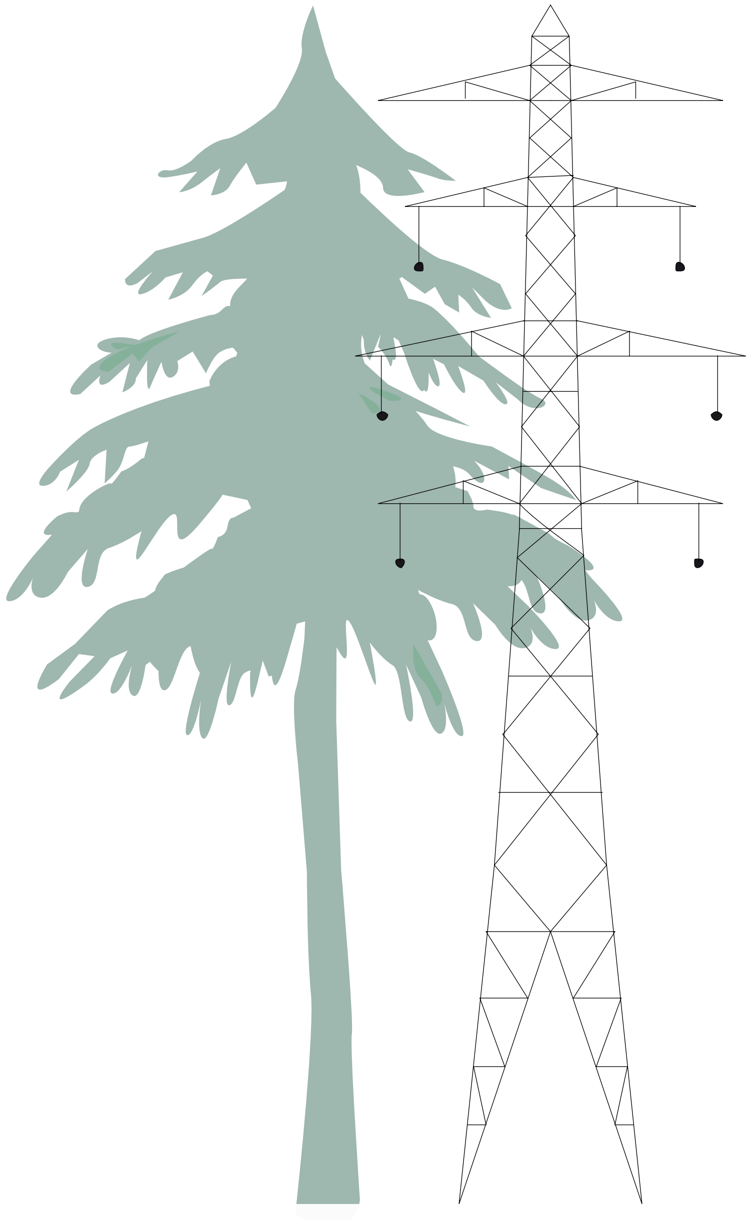
Connect with local agendas, engage in active dialogue with residents
In all projects, seek alignment with local and regional spatial plans. Actively consult with the environment: be situationally sensitive. Where possible, additional nature and landscape values are created in collaboration with local groups. This approach must also be used in areas where parts of the power grid are demolished or put underground.

3. Approach

Sidekick 1 *Why shouldn't a cell tower be just as beautiful as a tree?*

Bas Haring, philosopher (Haring 2009)

A gigantic conifer stands between the bushes and some low pine trees in a grove near the village. A very strange thing. I didn't know that conifers grew wild in the Netherlands. When I was little, I thought that conifers couldn't grow at all; that they were a kind of fake trees for the garden.
This conifer actually turns out to be a fake tree. It's a cell phone tower. A camouflaged tree-shaped mobile phone mast; so that it stands out less in 'nature'.
Apparently, we think trees look nicer than cell towers. Fortunately, because there are more trees than those towers. But instead of camouflaging those towers, you can also try to see the charm in them.
I know someone who did that: a certain Martin.
Martin lives near Amsterdam in a rural area. By the water. He just looks over high voltage pylons; they are right in front of his house. What bad luck. He would rather have had trees in front of his house. Until he realized that trees are only trees. Large brown-green stakes with leaves on them. Really not specially designed to be found beautiful by us. And yet we don't mind. In fact: 'we enjoy it' But if those trees were not specially designed for us. Just being there.
Can't I learn to see the same beauty I see in trees also in utility poles Martin wondered.
Then he began to study those pylons. There seems to be a lot to know about it. They come in all shapes and sizes. With different voltages. You have them at 50 thousand volts, 380 thousand volts - those are the largest. You have them in 'tree form': one trunk with side branches. But they are also available in the form of an arch: two high masts with one thick pole in between. Martin now knows all about those things, and they're getting more and more exciting for him. Now he is no longer annoyed by it, but sees a kind of beauty in it. And why not? It's just a shame that those electricity pylons don't grow and change, they are quite static. Fortunately, a control team comes regularly to maintain the place, and electricity pylons are painted every five years.
So now and then something happens.
Maybe we can learn something from Martin.
Can we learn to see beauty in the things that exist?
As we have seen the beauty in trees for centuries; also just things that are there.



3.1 A quest for beauty

Landscape and ecology play a prominent role in the planning, construction and management of the power grid, as do the electrical and health aspects. Preventing and limiting damage to the environment is often paramount. Health aspects mainly concern possible harmful effects of electromagnetic fields. The precautionary principle sets reasonably clear rules for this in Dutch national policy. Ecology is about possible damage to plants and animals and their living environment. Both national and European laws and regulations provide a reasonably clear framework for the protection of flora and fauna and when nature values are affected. In case of damage - for example loss of habitat or bird collisions - there are rules for determining the damage and the required compensation.

The effects of overhead lines on the landscape are much less clearly described. After all, the meaning and value of the landscape is not unambiguously laid down in legislation and regulations. It is also not clear when damage will occur to 'the landscape', let alone how to deal with it.
Often every change in the landscape is seen a priori as negative, with concepts such as 'horizon/visual pollution' or 'cluttering' the landscape being used to describe effects.

Planning authorities have indicated in memorandums and regulations what they consider to be valuable landscapes. But the backgrounds and criteria as to why certain landscapes are considered valuable are often very different. Cultural-historical patterns are often referred to, in combination with, for example, natural values and recreational attractiveness. Unlike health and ecological aspects, the policy framework of governments for 'dealing with the landscape' with regard to interventions such as the construction of new overhead lines is by no means clear-cut.

Sidekick 2 *You are what you wear*

"Your clothes are part of who you are. With clothing you emphasize your own qualities and distinguish yourself from others. At the same time, you must take into account the written and unwritten clothing laws of your profession and company. That is not always easy, which is why personal clothing and color advice can be a good investment."
http://www.carrieretijger.nl/carriere/zelfmarketing/kleding

The connection between the different garments creates a certain meaning. Sometimes unconsciously, but often precisely designed from specific objectives. The choice of certain color combinations, such as the red tones in combination with the black trim and the black hair of the mannequin, in addition to the fact that the garments have the correct dimensions to suit her body, unmistakably give a specific identity. Giving a certain meaning, appearance has been primary here, the functional plays a less important role.
Functional aspects such as aerodynamics and thermodynamics play a central role in the design of a skating suit. In addition, there must be room for, for example, the recognizability of the sponsor and the identity of the skater. This requires careful choice and placement of the right colors, stripes and texts.
For a uniform, the relationship between form, function and meaning has yet another weight.
One requirement is the immediate recognizability of the role of the person - skater, stewardess, agent - in which the functional aspects, such as safety and freedom of movement of the uniform, are central.

A good coherence between form, function and meaning is a condition, but not a guarantee for beauty.




This makes the design and planning process of such a new large-scale element in the landscape rather difficult. The primary approach is almost always to prevent or limit damage. Basically, a 'negative' approach is often implemented, which means that little or no attention is paid to developing new qualities and values, especially with a positive view to the landscape (Vrijlandt 1984).

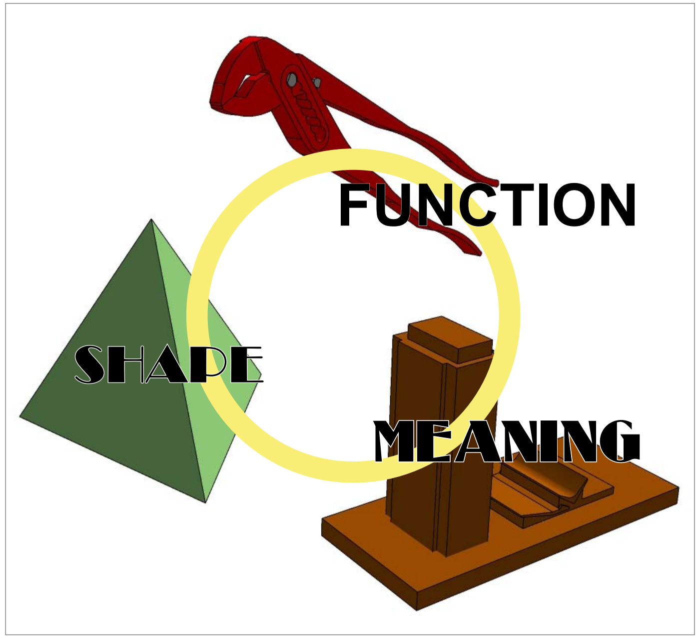
This document provides guidelines for the way in which new quality and value can be developed during the planning and construction of new overhead lines, new stations or the reconstruction of existing parts of the overhead grid.
The integration issue in this approach is a search for the best way in which a part of the power grid can best be fitted into that landscape.

Strive for beauty

Each object has its own beauty (Brochman 1969). So does the power grid. The beauty of an overhead line can be described as its own spatial quality. It is not about the architectural properties of the pylons, but about the interplay of pylons, the conductors suspended between them and the way in which the line 'runs' through the landscape. The way in which the overhead line connects to the specific, characteristic properties of a landscape. This is a spatial-functional approach also used in the design and integration of motorways or series, groups of wind turbines (Feddes 1988, 2010), it means: striving for a good balance between its own specific functional properties and the appropriate spatial appearance of the overhead grid on one hand, and the specific characteristics of the environment, the landscape in its entire spatial, functional, ecological and cultural-historical context, on the other (Armstrong, (2004).

fig. 1 *Consistency of form-function-meaning as a condition for spatial quality.*

Every physical object has a shape, for example a tetrahedron. The shape of an object is related to its function, for example combination pliers. Objects can be assigned a meaning, which meaning becomes recognizable thanks to the specific shape, for example a palace or an office of a regional government



Sidekick 3 *Beautiful'*

Rebekka Reinhard (Reinhard 2014)

"We especially like what we are used to finding beautiful, something we already know. The less we know, the worse we can judge what is beautiful and what is not.
You don't just have good judgment, you have to build it up.

With beauty it is like with food. Or with a poached foie gras terrine with pears, kohlrabi and smoked pigeon breast a beer or a Riesling fits can only judge someone who is culinary experienced. Why a woman doesn't have to have model sizes to be beautiful can explain only an aesthetically developed human being. A culinary artist teaches us to taste, sculptors, painters and architects teach us to see.

The geniuses among them 'give us, as it were, (their) eyes', wrote the philosopher Arthur Schopenhauer (1788-1860) in his Metaphysik des Schönen.
According to Schopenhauer, beauty 'meets us more easily in a work of art than directly in nature or in reality'. Because the genius artist has "distilled beauty from reality with his precise gaze, omitting all kinds of disturbing" coincidences and thus reproduces the essential and characteristic of that reality more purely than reality itself.

Everyone gets a sense of beauty in the crib. In experiments, babies respond positively to the same (symmetrical) faces that adults like too. Some people remain at an infant level for life with their sense of beauty. Others make an effort to refine and further develop.
If you want to learn to see better, you have to borrow the eyes of an artist."

In the search for spatial quality, it is important to gain insight into subjective concepts such as 'ugly', 'beautiful' and 'beauty'.
Beauty arises, for example, when a painter creates such a connection between shapes and colours, between light and dark on a canvas, that a unique composition is created which is a perfect expression of his/her thought. Beauty arises when a couturier arranges different materials, colours, shapes and fabrics in a creation in such a way that the whole gets a certain special expression, a specific meaning (sidekick 2). Coherence between the elements in the painting or between the parts of the garment is not a guarantee of beauty, but it is a condition.

Landscape - cohesion of scale levels

It is essential for this approach that the design issue is approached at different scale levels

Three levels of scale are distinguished.

- Grid level (highest level)
- Line level (middle level)
- Pylon level (lowest level)

For tracing overhead lines, the central scale and design level is the line level, which connects to the regional landscape. A higher scale level is the entire connection as a part of the power grid, the route level, which connects to the supra-regional and national landscape. A scale level lower is the pylon level that connects to the local landscape. The integration issue of, for example a substation takes place at a lower local scale level. The central scale and design level is then the immediate vicinity of the station, the higher scale level is the surrounding landscape and the lower scale level is, for example, the plot.
An important condition for the development of spatial quality is a recognizable correlation between the different scale levels (Alexander1977) (Bakema 1964).

fig. 2 *The spatial connections in the landscape have vertical and horizontal dimensions.*

Each place is embedded in its environment, the patterns of roads and waterways anchors place in the landscape . The properties of a place are built up from a number of layers that have formed mutual connections and that make each place unique, with its own genius loci.

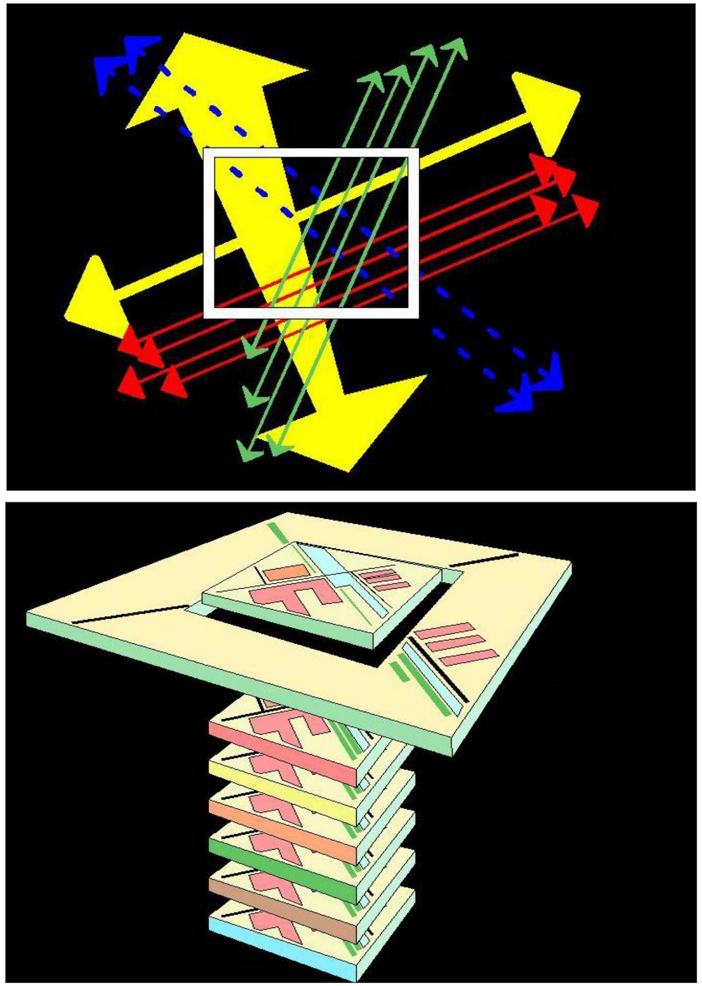
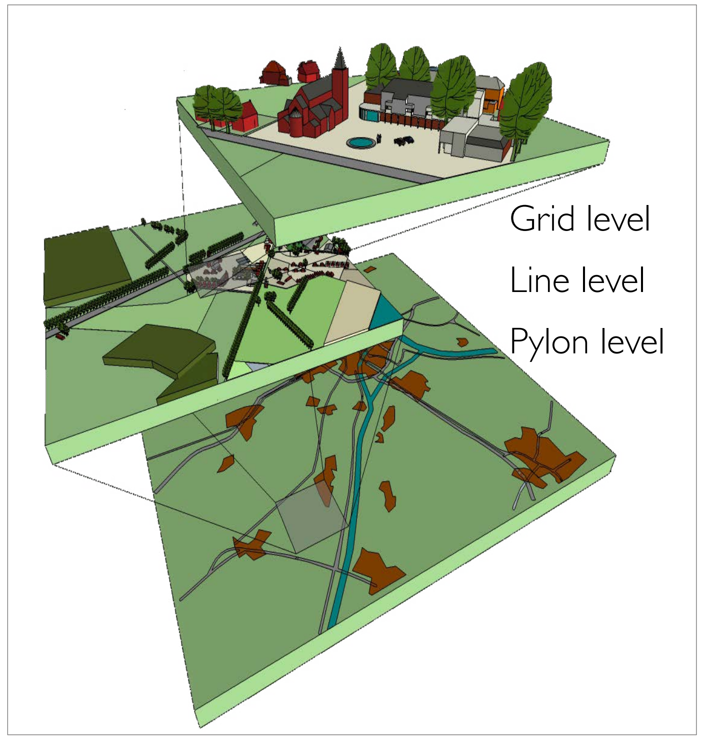


fig. 3 *Consistency between scale levels is the basis for the development of spatial quality*



3.2 What is landscape?

We know the concept of landscape in many forms and meanings. For example, think of geographic landscapes, urban landscapes, office landscapes, natural landscapes, water landscapes.
This guide works from the following description:

> *Landscape is the observable part of the earth, which is determined by the mutual cohesion and mutual influence of the factors soil, relief, water, climate, flora and fauna as well as by human actions.*

In 2000, the Treaty of Florence was concluded, which includes a similar description.

Perception and experience

There is a distinction between sensory and non-sensory perception. The landscape is primarily perceived as sensory: we see, hear (birds and traffic), feel (wind, temperature), smell (blossom, intensive livestock farming) and taste (sea air).
Also important is the interpretation of the outside world, the meaning we attach to it.
You could call that non-sensory perception.
The combination of sensory and non-sensory perception is what we call experience. We make a mental image of our environment. This mental representation is by definition an individual (subjective) one, but can also be experienced collectively, as we will elaborate on below.
Mental Map
The concept of a mental map refers to a person's perception of his geographic environment, the way (s)he structures the spatial environment. (Lynch, 1960)
It is not a geographical map, but the cognitive image an individual has in mind. Although it seems more appropriate in the social sciences, the concept is usually studied by

Sidekick 4 *Consistency between scale levels*

In addition to the relationship between form, function and meaning, the relationship between an object and its environment is important for the emergence of beauty.
Each object is part of a spatial whole. This applies to a chair in a living room as well as a high-voltage pylon in a landscape. Three levels of scale determine the quality of the object and always play a role in the design.
For example, the design of a coffee pot depends on the place of use. Both jugs are functionally suitable: they can hold coffee, have a handle for pouring and a pouring spout is attached to prevent spillage. Yet they are quite different.
The jug on the left is very personal, made for or chosen by a user for the coffee moment in a private setting and probably has a special meaning as part of a Wedgewood or Art Nouveau set. The one on the right is general and anonymous, useful for use in the office or canteen.

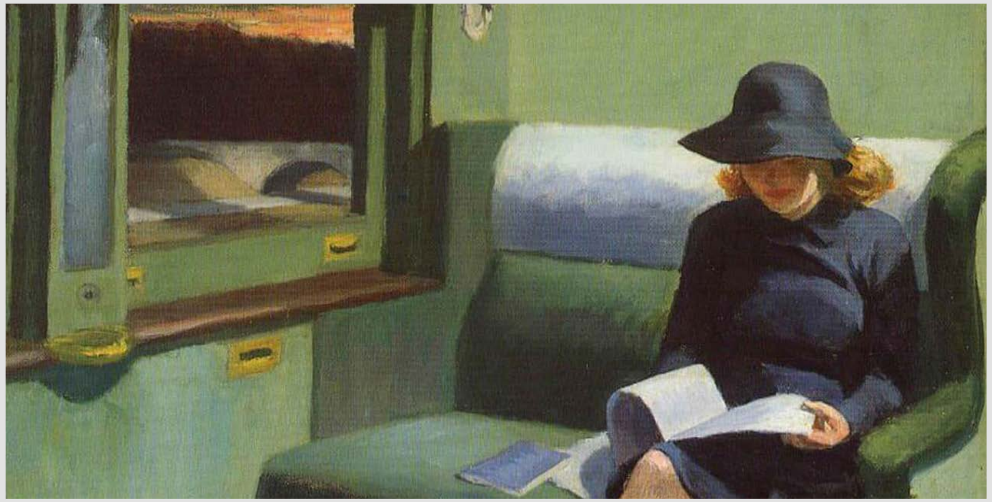
The design of the jug itself, with handle and pouring spout, is the primary central level of scale and design.
On the lower scale, for example, the use of materials and the associated color choice, porcelain or stainless steel, and possible decorations play a role. On a higher scale, the location of use is important and the thermal quality and whether it is dishwasher safe.
The coherence between those scale levels, i.e. whether the design choices between these levels reinforce each other, determines the quality of the object. In the example of the coffee pot: the use of porcelain, decorations and the fragile design, together give a personal appearance. The fact that the jug is not allowed in a dishwasher is less important.

Sidekick 5 *The landscape as an unfinished novel*

Tuesday, June 8, 2004, Venus slowly moved in front of the sun.
An event that only happens once every 112 years, no person alive at the time had experienced this. Very special but also very ordinary. It is unique to us, the living, it is also very common, after all it has happened countless times.

That day, as a result of the events between earth, venus and the sun, I realized that the concept of time is as unclear as it is an important dimension of our earthly existence. By looking at the eclipse and thus at the universe, I realized again that looking at the universe is both looking to the future and looking to the past. After all, the process of "the transit of Venus" lasted several hours and at the start of it we all know, without any serious doubt, that we will see its end, a moment in the future. At the same time we see the sun and know that the light has taken some time (8 minutes and 18 seconds) to reach us. It takes light years for the light from the closest star. In other words, looking at the universe, we look at the past. Without getting into a discussion about the meaning of the concept of time, let alone whether it exists or not, I dare to argue that past and present are close to each other and that "time" is a very essential element for the experience of our environment.

Looking at the landscape, at our environment, I have similar thoughts.
One experience in all kinds of ways that the landscape has a history, has gone through a growth process of many centuries of which you recognize the tangible results. You also see that it continues to develop and that there are opportunities and threats for the developing society. Looking at the landscape you look at the past and into the future.
One we can regard the landscape as a novel. A landscape with quality is like a story that can be read by residents and visitors. A story with exciting and often surprising twists and turns, a story that tells the reader something about his own place within the physical environment, about his relationship with nature, but certainly also about his place within the socio-cultural context and the underlying developments.
The quality of that story exists by virtue of a strong internal coherence, a strong storyline and imaginative passages. Images that are not always immediately recognized, but often only become clear when re-reading.
The quality of the landscape lies in the sometimes recognizable and sometimes hidden connections. Coherences that are often created by very gradual processes, such as with movements of the earth's crust, the erosion of a river or the meandering of a stream. Coherence arises through the interaction between dead and living nature and cohesion that arises through relatively rapid social processes.
The landscape is like a novel (Renes 2004)
A complex but unique system of connections in space and time, together determining the quality of it at this moment and in this place, not in itself but as part of a larger whole. The quality of the landscape is not unambiguous, it is our perception based on our image of the past and with our expectations of the future. The historical perspective, including the visibility of possibilities for the future, is a central quality that forms the basis for the individuality of a region and the feeling of "being at home" of the residents.



The spatial connections in the landscape have, as it were, a vertical and a horizontal dimension. Each place is embedded in its environment, the patterns of roads and waterways anchor the place in the landscape. The properties of a place are built up from a number of layers that have formed mutual connections and that make each place unique, with its genius loci. These connections are not limited to a certain scale level, but move through it. Breaking these cohesion means that the continuity in space and time is broken, a page is, as it were, sanded out of the book, a passage from the novel disappears. When a new element, like a new overhead line, is added to the landscape a new page in the novel is written and it has to be carefully connected to the the existing coherenses.

geographers to determine how the public perceives subjectively. The process of mental mapping relies on perception and cognition. The geographical reality does not correspond to the mental map. There is therefore a lot of difference between the mental maps of different individuals, because everyone forms a different picture of reality. Based on the mental map, the individual moves through the environment.

New overhead lines or new windmills are often referred to as 'visual nuisance' or 'horizon pollution'.
Reality, the actual situation in the landscape, then does not correspond to the mental image.
This also applies to the concept of 'cluttering', which can be seen as misunderstood spatial planning.
Concepts such as visual nuisance, horizon pollution and cluttering have a fleeting character. After all, they depend on the cognitive image of an individual and that can change, and sometimes quite quickly too. The mental image, the experience of the environment, is temporary and therefore not a good design criterion for the location and design of new infrastructure. It is better to connect to sustainable, slowly changing landscape patterns, such as the Landscape Main Pattern.

Genius Loci

The properties and qualities of a landscape are anchored in the coherent system of the various landscape elements. This system forms the basis for the recognizability of a place, for the experience of beauty and the awareness of feeling at home somewhere. It gives every landscape, every place its own unique character, a specific area characteristic-genius loci (Antrop (1999, Vries,2003). If we consider this at the scale level of the national overhead grid, we must seek to connect with the specific character of an area, of a region, visible in the Regional Landscape Pattern.
This consists of all regional and supra-regional landscape elements such as rivers, large infrastructure, villages and towns and area types in their mutual relationship.

Landscape is cultural history

The landscape image must be considered as a "snapshot" of an ever-changing situation. It is the result of ever-changing human use, in relation to various natural processes. Changes in the landscape are in fact inevitable due to continuous, natural processes - which often proceed slowly - and through human intervention. Man deliberately changes the environment and transformes a natural landscape into a cultural landscape. (Antrop (1999, Vervloet 1984)
Social, technical and socio-economic developments are constantly causing drastic changes in the landscape. Just as on a personal level - changed family circumstances, material wealth, taste, fashion - lead to adaptation of the home, changes on a social and socio-economic level lead to adaptation of the place of residence, the cultural landscape. Due to this continuous process of change, the landscape is made up of adjacent - and on top of each other - patterns and remnants of patterns of very different backgrounds and ages. As a result, the landscape reflects history: the landscape is cultural history. Natural and current social development processes are often recognizable in the landscape. Some changes, such as the filling of a riverbed with sand and clay, or the sweeping away of dunes by the sea, happen relatively quickly and can be clearly seen. The revegetation of cut river arms or the afforestation of open heaths are also natural processes that take place within a few decades.
Other changes take place much more slowly and are therefore barely perceptible. Think of tectonics or climate

Sidekick 6 *Treaty of Florence*

The European Landscape Convention;

Landscape is an area, as perceived by people, whose character is determined by natural and/or human factors and the interaction between them.

The Treaty of Florence in 2000 is the first international treaty in which the theme of landscape is treated in an integrated manner. The aim of this treaty is to promote the protection, management and development of landscapes and to organize European cooperation in this area. Among other things, European countries have committed themselves to recognizing landscapes as an expression of the diversity of their common cultural and natural heritage, as well as to have a policy for the protection and management of the landscape.
Each country must take measures, in the areas of:

- *raising awareness among organizations and governments of the value of landscapes,*
- *promote training and education,*
- *to identify landscapes,*
- *identify special values and define quality objectives.*

For implementation, it is mandatory to introduce instruments aimed at the protection, management and/or design of the landscape.

change. The most clearly visible are human interventions. Sometimes making good use of the possibilities offered by nature, sometimes also in contrast to them, man changes the environment and adapts it again and again to his/her wishes and needs. Changes in agricultural methods, for example, lead to a different allotment and therefore often to changes in the spatial structure.

We can therefore regard the landscape that we are currently observing as a phase in a long and continuous development process. We must be aware that the landscape is not static but is constantly changing. That is an essential characteristic of the landscape. It is important that people are able to recognize the interventions, the meaning and the appreciation that people attach to the landscape.

Landscape appreciation

The characteristic of cultural landscapes is formed by origin and the experiential values that are assigned to them. These are closely connected and rooted in a long historical development process (Dauvalier 2008).
Landscapes are given a higher rating if their development is recognizable and 'readable' (Farjon 2004)
That is, if we can see the mining history and the associated use of space, allotment and habitation pattern. The 'readability' of the landscape and of the relationships between different landscape patterns make it possible for people to orient themselves well in space and to feel at home there (Coeterier 1981).

3.3 What is landscape integration?

The design of the components of the power grid is primarily determined by requirements of electrical engineering, choice of materials, maintenance and safety, as well as by electromagnetic fields, network configuration, etc.
This results in choices for e.g. substation type, pylon design and field length, as well as the desired location within the existing network. It is not simply a question of the shortest line from A to B, after all, the design and location of stations and connections in the landscape are strongly determined by aspects of spatial planning, such as living environment, ecology, soil and water, landscape and cultural history.
These factors determine the choice of location for a station or a transition point, the route of a cable or line in the landscape and the decision whether or not to bundle with other infrastructure.
Landscape integration starts with good design.
Within the preconditions set, installations are designed and located in such a way that a natural and relaxed relationship between power grid and landscape is created.

Integration is a threefold mission: designing the power grid, finding the right location in the landscape and adjustments to the landscape

Landscape integration is always about different scale levels:

- the central design level, the parts of the network itself: the lines, the substations and transition points and the regional landscape.
- one scale level higher: the element in question as part of the entire connection, which responds to the Regional Landscape Pattern
- one scale level lower: the plot where a pylon substation is located, the spot in the local landscape.

Coherence between these levels is a precondition for the development of spatial quality.

fig. 4 *Landscape integration is a threefold mision*
fig. 4 a *designing the electricity grid,*

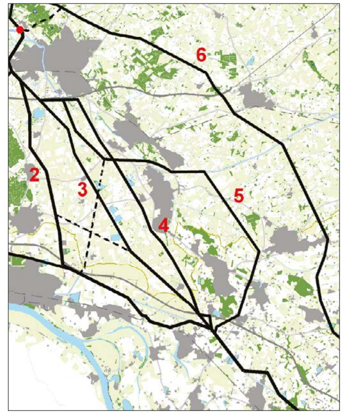


fig. 4 b *location of elements in the landscape*

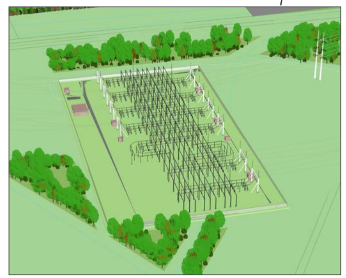


fig. 4 c *adjustment of the local landscape*

3.4 Planning process

Achieving spatial quality requires cohesion between different phases in the entire planning and construction process.
A landscape design approach must be included in every phase, from the first corridor study or a site study, via routing, environmental impact assessment, landscape plan and planting schemes specifications to the final management.

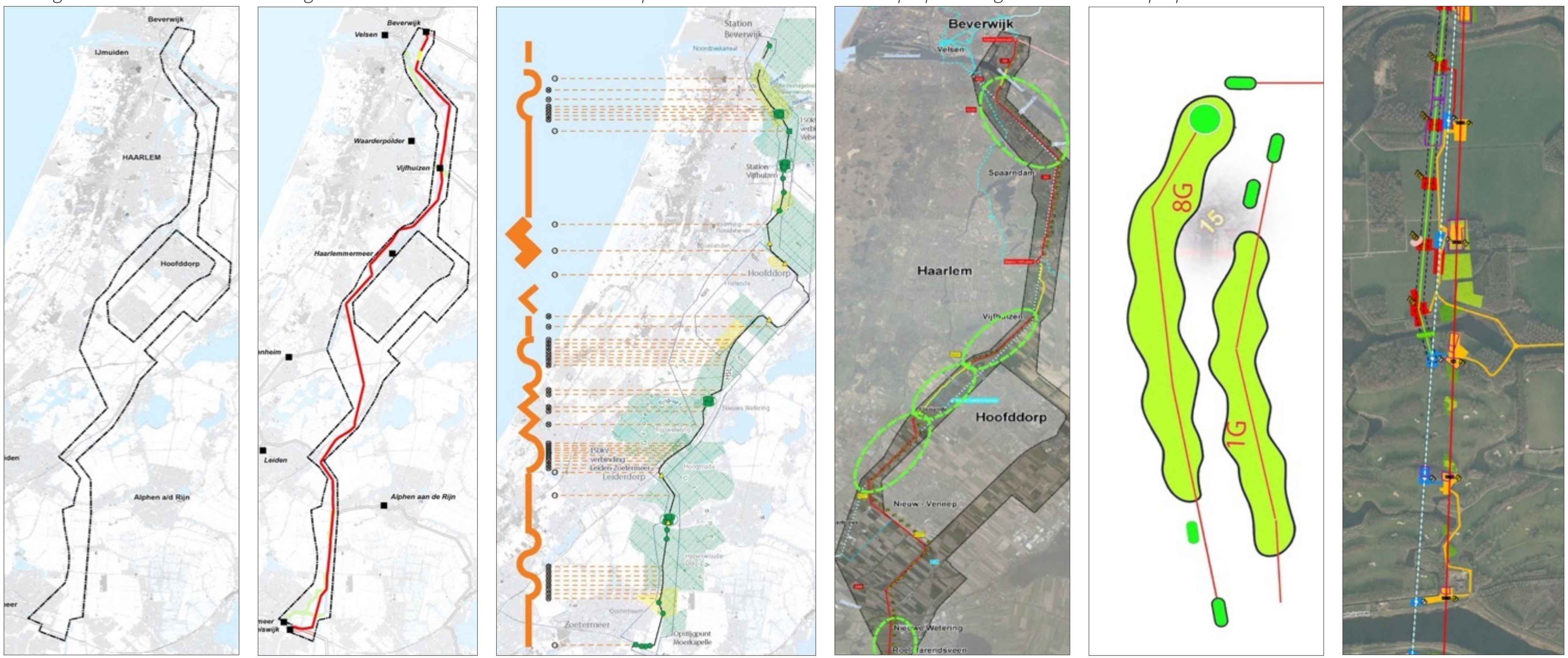


fig. 5 *Landscape design is a important issue in the fases and scale levels of any project: Below how this was done in the Project Randstad 380kV (project 2009-2021)*
finding suitable corridors *finding the best route* *environmental impact assessment* *landscape plan on grid level* *landscape plan at line level* *construction*

Implement landscape design in early and all project phases and ensure a good transfer between all process steps

Each phase should have a specific document in which the design choices are motivated, visualized and anchored.

Environmental Impact Assessments (UVA) on landscape.

This document describes and assesses the environmental impact of a number of project alternatives (routes, location alternatives).

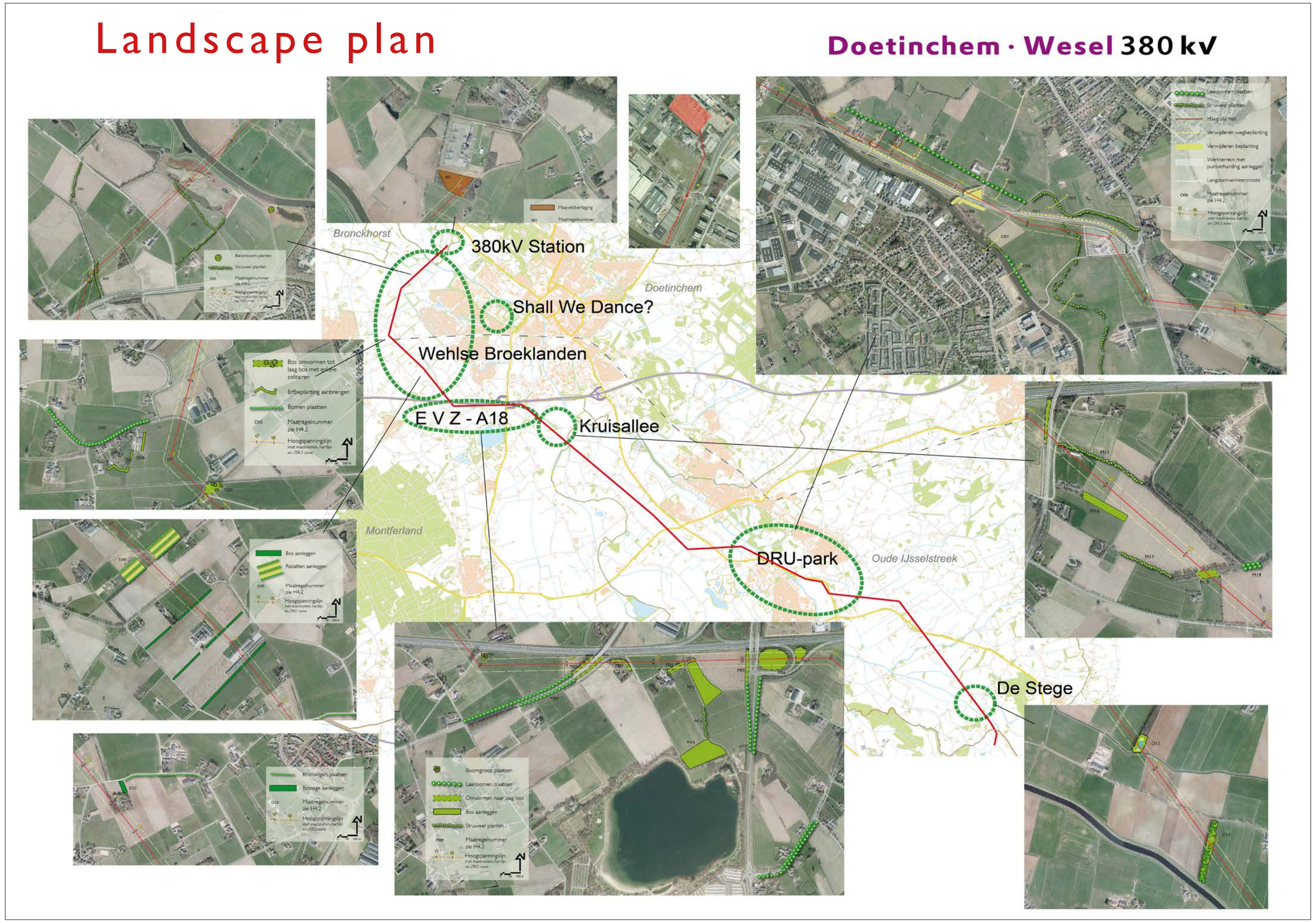
Corridor Study/Tracking Document.

It is recommended to add the corridor study and tracking documents to the Environmental Impact Assessment as an 'Alternatives Background Document'. This document contains a description of all the considered alternatives and the ultimate preferred route.

Landscape plan.

A Landscape plan includes all the necessary design measures for a proper integration of a part of the power grid.
A landscape plan contains all design measures that are necessary for a proper integration of part of the power grid into the landscape and thus for its spatial acceptability. These are design measures based on all relevant environmental aspects: landscape and cultural history, nature, living environment and water.
Where possible and useful, the measures are designed in combination with measures that fulfill a function for, for example, the compensation of damage to nature.
The whole of measures in a landscape plan, together with good routing, form the landscape integration of the new connection.

fig. 6 *A landscape plan primarily is a collection of often relatively small indentations. It is not intended as a conceptual plan, a master plan, for the entire project. Usually, the elements of the plan are carefully locates trees and shrubs whereby the effects of the new overhead line on the landscape are mitigated. (Project 2011-2015)*



The aim of the design measures included in a landscape plan is to mitigate and compensate for the effects of a new power grid element, such as an overhead line.
The effects on the landscape are mitigated by introducing new vegetation, changing existing vegetation and/or strengthening the existing landscape structure. Compensating for the effects on nature is done by setting up new nature reserves.

The landscape plan is drawn up in close consultation with the local and regional authorities involved, residents' groups and relevant land management organizations. After all, drawing up a landscape plan is not an isolated process. It is important to link this assignment as closely as possible to other developments in the plan area, such as the construction of a new highway, new housing developments, an industrial estate or nature development projects.

4. The Dutch national power grid

4.1 Historical overview of the power grid in the Netherlands

The development of the electricity supply in the Netherlands has for a long time taken place at municipal and provincial level. The overhead grid has been built and expanded per province since the beginning of the 20th century. For a long time there were hardly any connections between provinces. Since 1916, a nationwide interconnection network between the main power plants has been considered. With a power grid, the operational reliability of the electricity supply could be increased and the total reserve capacity could be reduced. By connecting more power plants to one joint network, the failure of one of those plants could be absorbed more easily and energy surpluses and shortages would be better distributed.
It was not until after the Second World War that it was decided to install a national 110/150kV interconnection network between the ten largest production companies. An umbrella business organization, the N.V. SEP (Cooperating Electricity Production Companies) was established for this purpose. From the 1960s, work was carried out on a 220/380 kV national interconnection network with a number of international connections. This national interconnection network was completed in 1983. The network activities of SEP were transferred in 1998 to TenneT TSO, the current operator of the national overhead grid.

A glance at the map of the Dutch overhead grid clearly shows that the older lines dating from before 1960 have longer straight lines with fewer deviations than lines built more recently.
This is partly due to the voltage difference. 110/150kV lines were originally regional, provincial transmission lines with local branches, while the 220/380kV lines connected national nodes and power stations. The spatial development of the city and countryside in the second half of the 20th century has a greater influence: expanding cities and villages, more intensive agriculture and the appropriate allotment and development of the land.
An increasingly finely meshed infrastructure network has also been constructed in recent decades.
In particular due to these spatial developments and the associated legislation and regulations, the installation of an overhead line is increasingly deviating from the straight line.

4.2 Spatial Constraints

The overhead grid imposes spatial restrictions on the environment. These influence the route choice of a connection and the location of installations, such as stations

fig. 7 *Overview of pylon types in used The Netherlands*

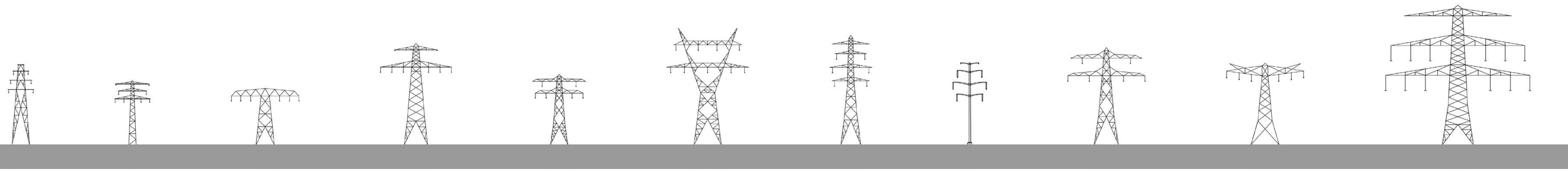


fig. 8 *The power grid of the Netherlands*

fig. 8 a *1900 to 2015 (Tennet GIS 2018)*

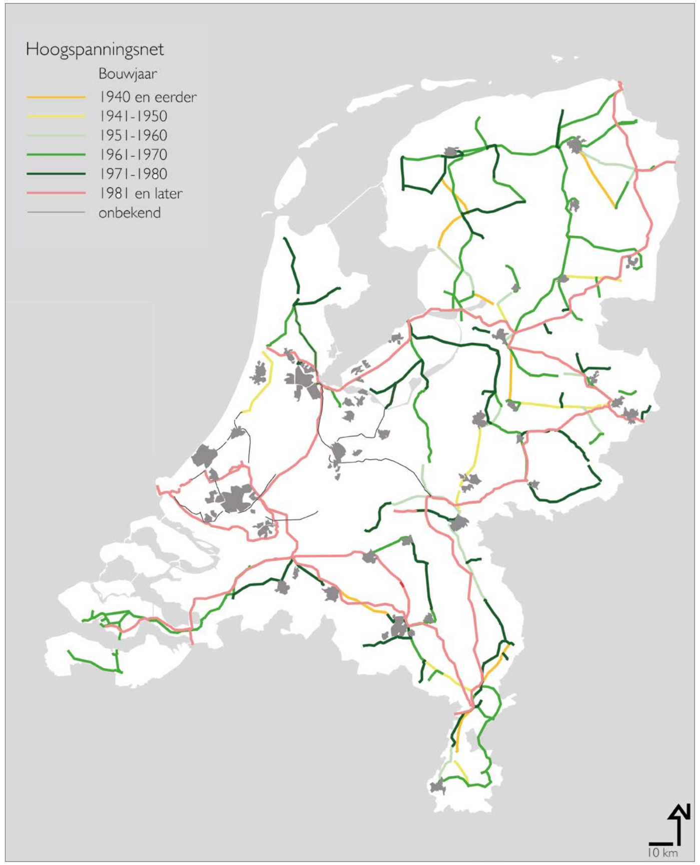
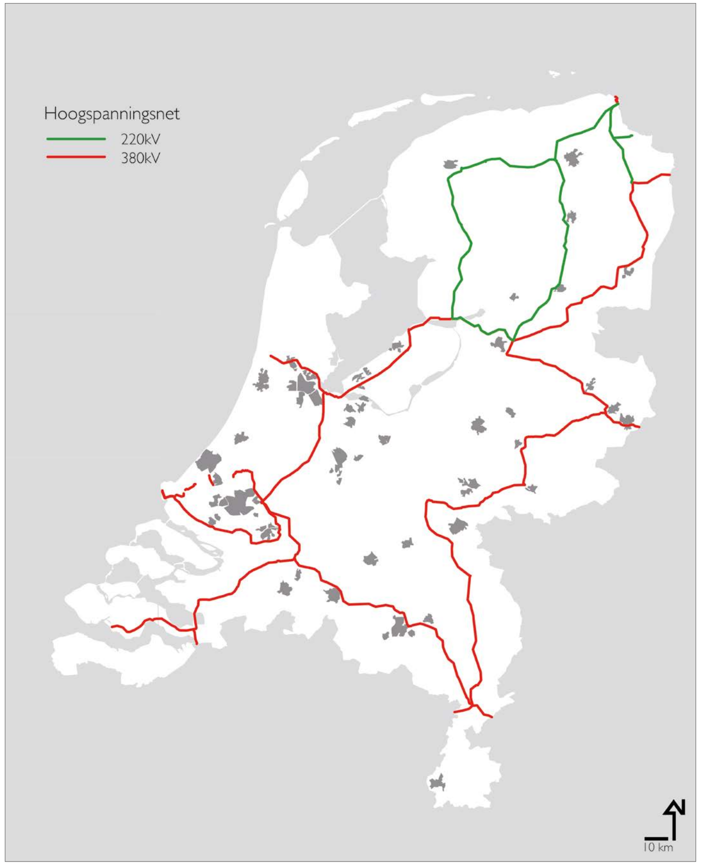
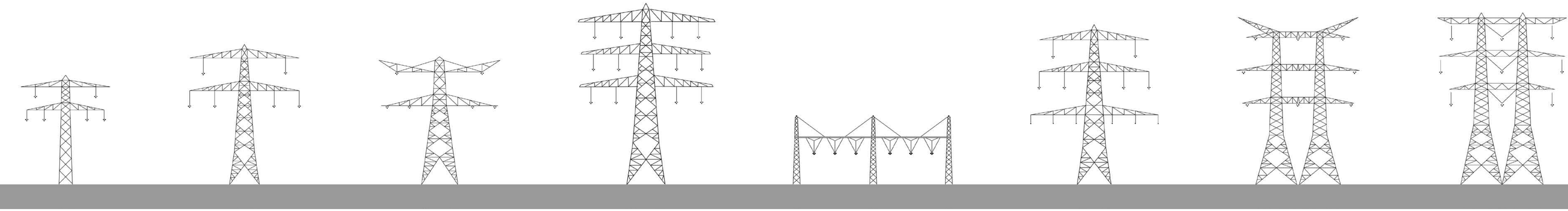


fig. 8 b *110kV and 150kV in 2015 (Tennet GIS 2018)*

fig. 8 c *220kV and 380kV in 2016 (Tennet GIS 2018)*





and transition points. Consider the distance to residential buildings. Such spatial constraints are decisive in the design process.

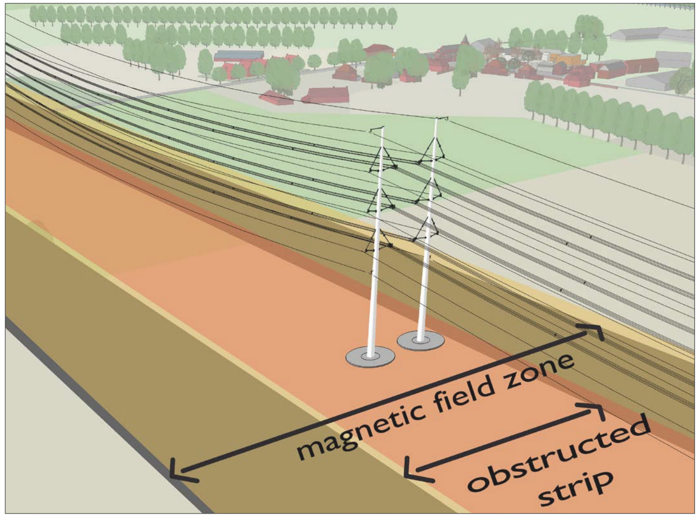
4.3 Magnetic field zone

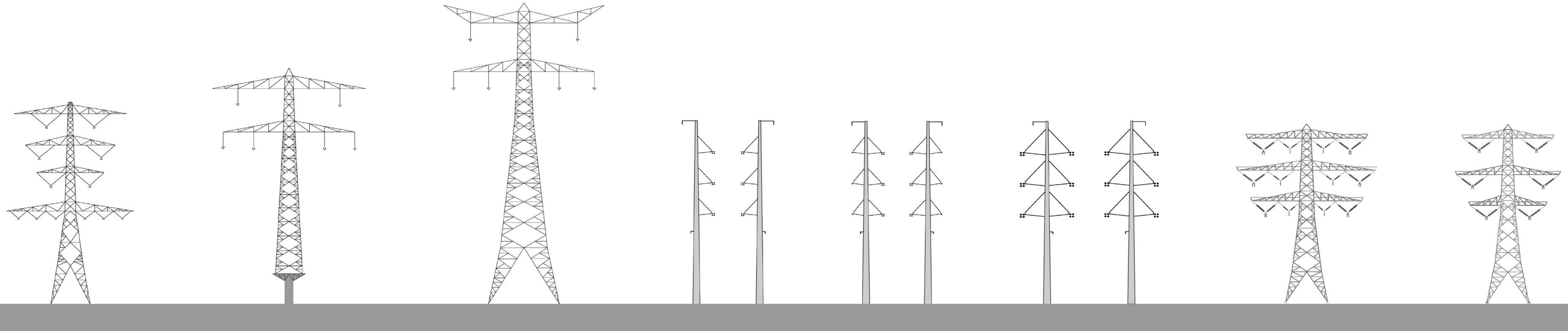
A magnetic field is created during the transport of electrical energy. The strength of this magnetic field is expressed in 'Tesla'. There is always a magnetic field around an overhead line, cable or station. The magnetic field zone is the area around an overhead grid element.
In The Netherlands a zone has been agreed on in national precautionary policy. In this zone the annual average strength of the magnetic field is greater than 0.4 microTesla. This means that when constructing a new connection or modifying an existing connection, it must be avoided as much as reasonably possible that new situations arise in which residential buildings, schools, crèches/nurseries and childcare centers are located within the magnetic field zone.
With a 380kV overhead line the indicative magnetic field zone is approximately 100 m wide depending on de pylon design.

4.4 Obstructed Strip of land

Every overhead line or cable in the Netherlands has a strip of land where obstacles apply (Tennet 2016, 2020).
In this strip of land, buildings and vegetation are subject to strict rules, because there must always be a minimum distance between the conductors and, for example, roofs or trees, and for cables, for example, roots of trees must be prevented from causing damage.
When designing new parts of the power grid, it is good

fig. 9 *Obstructed strip of land and the magnetic field zone*





to think about management and maintenance costs in the longer term by means of design. Think for example of converting forest to heathland.
For companies, the proximity of a new overhead line is therefore a limitation for the expansion. New residential buildings must also keep their distance.
All existing spatial functions are permitted under a overhead connection. There are, however, restrictions on the use of space, accessibility, and safety within the strip of land. The width of the obstructed strip of land depends on the type of connection and the type of pylons used. For an above-ground 150kV connection, the strip has a total width of approximately 40 m to 50 m. For a 380 kV connection, it is approximately 50 m to 75 m wide. Depending on the location of the conductors, the obstructed strip of land connected to an underground 150 kV connection has a width of approximately 10 m and a 380 kV cable approximately 35 m.

4.5 Sound

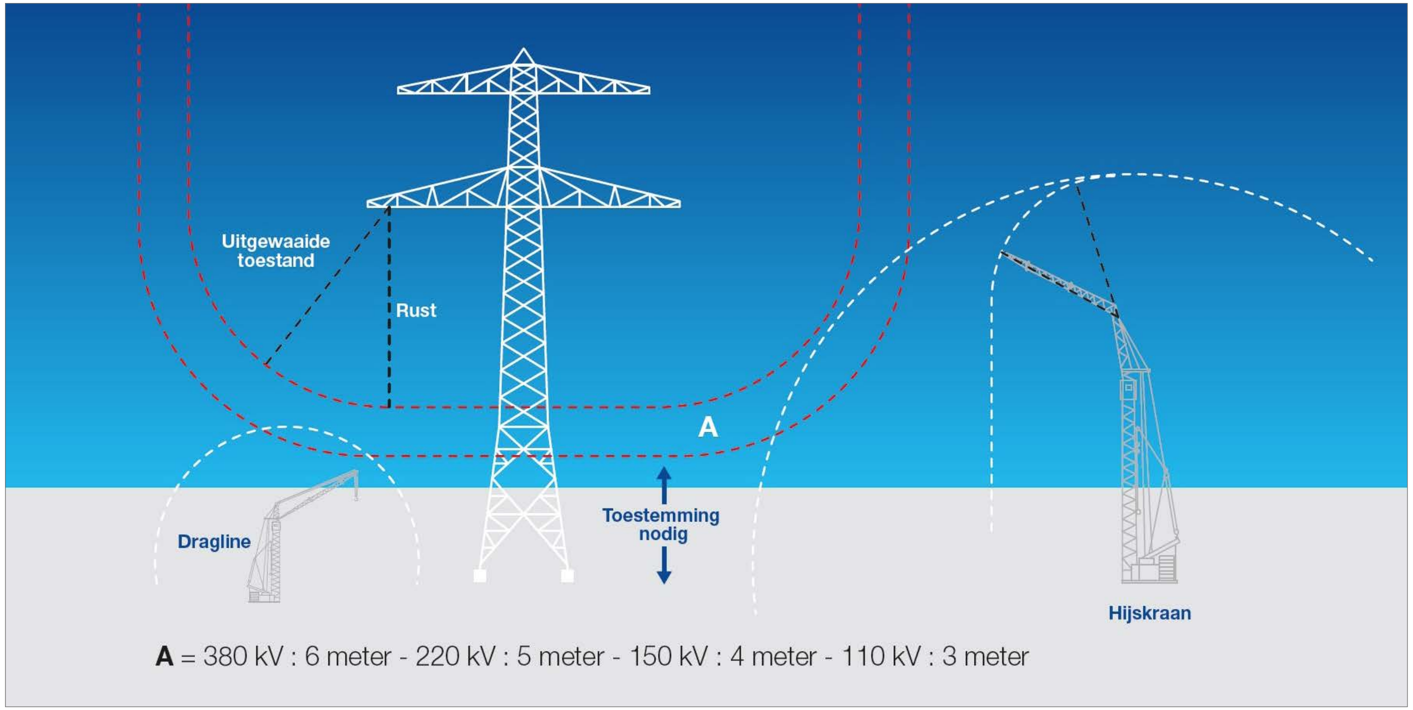
The overhead parts of the connection may cause sound effects. There may be 'wind whistles' and especially in humid weather conditions a crackling sound can occur due to electrical discharges (corona noise). This happens around conductors that are contaminated or have irregularities. There is for the specific corona noise and wind whistles - other than for industrial, rail or road traffic noise - no (legal) assessment framework nationally or internationally. This means that there are no legal distance requirements to, for example, homes.
A substation also causes noise. In addition to the corona sound, a transformer produces a small distortion with every change in the magnetic field (at 50 Hz that is 100 times per second), which creates sound.
A transformer can cause a transformer hum, a heavy, penetrating hum of 100 Hz (Low Frequency Noise) that can be experienced as a nuisance for people living nearby.

4.6 Falling distance

Although the chance of overhead pylons falling over is very small, it cannot be ruled out. That is why falling distances determine the distance between bundled overhead lines and the distance to other infrastructure, such as underground cables and pipelines, railway lines and highways.

The falling distance is primarily determined by the height of the pylon. The risk of falling over in relation to the average weather conditions (wind speeds, ice formation, etc.) on site plays a role in the risk assessment, as does the possible damage. The damage caused if a pylon falls against another 380kV connection is different than if a pylon falls on a national gas pipeline or on a railway line. The falling distance therefore differs per project and per situation. The falling distance plays a major role, especially when bundling with other linear infrastructure.

fig. 10 *Schematic representation of the danger zones at overhead lines (TenneT 2020)*



5. Design with landscape

The main task is to find the best way in which the overhead line connects to the specific, characteristic properties of a landscape. This means striving for a good balance between the specific functional properties of the overhead grid on the one hand, and the specific characteristics of the environment, the landscape in its entire spatial, functional, ecological and cultural-historical context, on the other.

5.1 Regional Landscape Patern

The Regional Landscape Pattern (RLP) can be seen as 'the fingerprint of a landscape'. The RLP consists of elements and patterns in the landscape that determine its specific character of the landscape and have a comparable scale as the power grid.
So it has a regional scale and even a national and supranational scale. Whether this large scale landscape pattern is recognized as such depends on the observer. After all, each individual perceives mostly only parts of the whole, as a more or less targeted excerpt of information available to him about an area. That depends not only on the knowledge of that individual, but also on the purpose with which one looks at the landscape. It matters a lot whether one has lived in the area for decades, is a bird watcher or a casual and "commuter" passer-by.

The question is which elements and patterns in the landscape determine the character of that landscape and have a comparable scale as the power grid?
These landscape patterns have their origin in

- Geomorphology;
- Historical-geographic aspects;
- Infrastructure.

Geomorphology

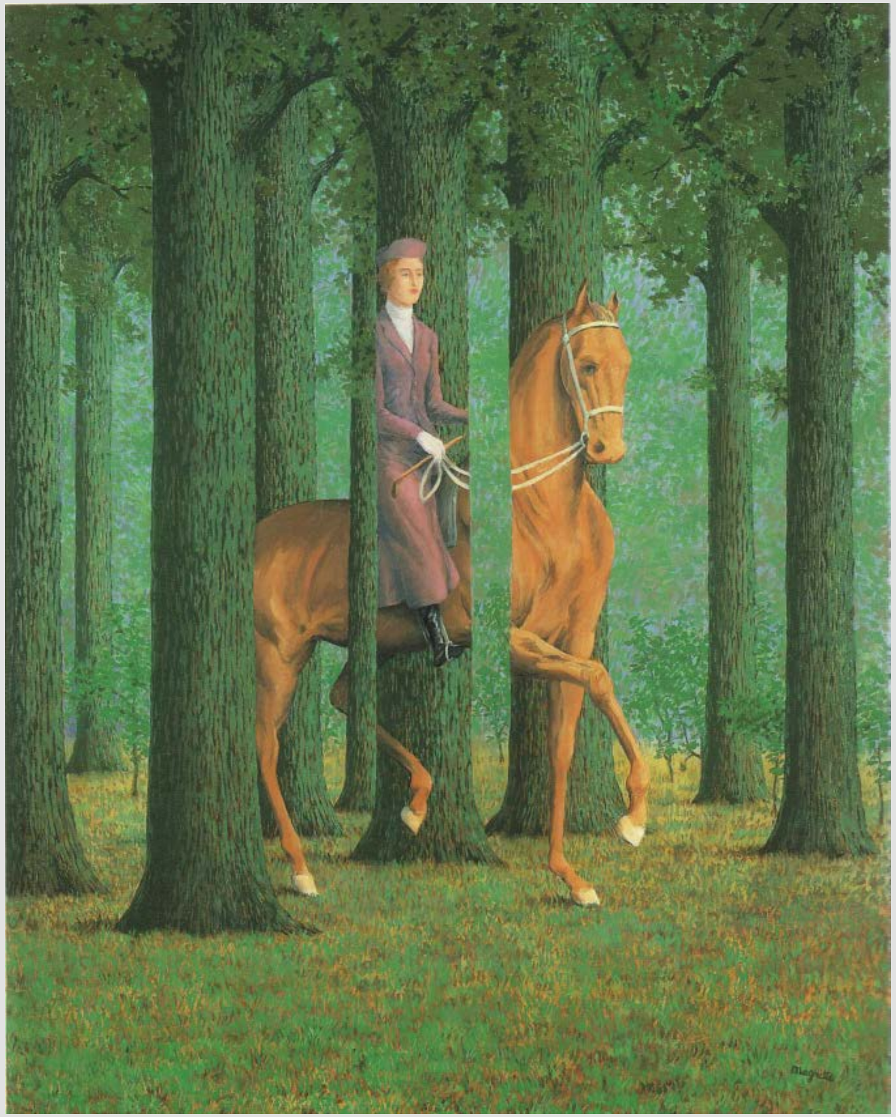
Geomorphology is the "Explanatory description of the shapes of the Earth's surface in relation to the mode of their origin". (Van Dale dictionary). A geomorphological map shows the appearance of the earth's surface, with its differences in height, in 'wet and dry', flat and sloping. It is largely a result of geological processes such as tectonics, erosion and sedimentation by water, land ice and wind. As a result, the Netherlands has hills, moraines, stream valleys, cover sand ridges, stream ridges, and river terraces. Human intervention also leaves its mark on the appearance of the countryside, with dikes, dams, mounds, polders. Terrain shapes and relief of natural origin are considered valuable, they promote the 'legibility' of the landscape, they are authentic and have meaning for people. These geomorphological patterns and elements can serve as a starting point for landscape designs and the location of new elements in the landscape. The geomorphological patterns are closely related to the development possibilities of nature as it took shape on a regional and national level and are protected in the nature networks. The geomorphological map is an important basis for the Regional Landscape Pattern .

Historical Geography

Historical geography is concerned with studying the spatial patterns on the earth's surface and their development over time. It describes the historical development of what one could call the natural landscape into the cultural landscape. The emphasis is on the role of humans in that development, the cultural history, with an emphasis on the morphology of the landscape. A historical-geographic map often shows a division into areas, each with its own area characteristic (Vervloet 1984). This does not only concern historical occupation and allotment patterns, but certainly also recent urbanization processes.

Infrastructure

The infrastructure at regional, national and international level has in most countries developed into an important part of the landscape in a relatively short period (the past two centuries). Waterways, railways, motorways, bridges, dikes, both above ground and underground facilities for the transport of energy and even aviation have a major influence on the appearance and development possibilities of the landscape. In particular, the centuries-long struggle against the water in the Netherlands has left countless traces in the landscape.



Sidekick 7 *Le Blanc-seing*

With 'Le Blanc-seing', René Magrltte takes us into a dense forest, an Amazon rides alone between the trees. But the view of the rider is interrupted: you and your horse disappear partly in front of, partly behind the tree trunks - we seem transported into a picture puzzle in which the front and rear planes jump back and forth and show different images. But it's not like that. The two levels are shiftes - the picture puzzle sticks (Benesch 2005)

This painting by Magritte is a good inspiration for how an overhead line could fit into the landscape.

fig. 11 *Three basic building blocks for the Regional Landscape Pattern (RLP)*

fig. 11 a *Geomorphological map, (Steur 1990)*

fig. 11 b *Historical-geographical map (Bos 2007)*

fig. 11 c *Infrastructural map (drawn to gridmap Tennet 2020)*

6. Designing at grid level

The design challenge at the power grid level lies primarily in the search for the right location in the landscape.
For a new overhead line it is the route, for a substation it is the construction site.
Overhead lines, especially the 380kV overhead lines, are regional, supra-regional, national and increasingly international facilities. They connect power plants and sub stations that are often located at great distances from each other.

Connect to the Regional Landscape Pattern (RLP)

They pass the local landscape but have no functional relationship with it. The route of an overhead line must have such a course that a logical and relaxed relationship is created with the landscape (Vrijlandt 1980). This means that a connection must be sought with other landscape elements of a comparable level: Regional Landscape Pattern
The power grid level can be recognizable when we move through the landscape. Not just once, but regularly, for example in commuter traffic or in cycling routes to school. Based on experiences, but also if we consider the development over a longer period on maps and images. We build up knowledge and insight into the landscape patterns that determine the unique character of the landscape at regional and supra-regional level.
At the power grid level, for example, an issue is whether or not overhead lines are bundled with other infrastructures.

6.1 A new route

The aim is to find new routes for overhead lines and also to find the relevant knowledge. Find the 'story' of the local

fig. 12 *The routeing principle of an overhead line, fttb:*
- *Autonomous route, independent of patterns and characteristics of the landscape on a lower scale;*
- *If angles are unavoidable, ensure consistency with the Regional Landscape Pattern;*
- *If a line bends in places that are associated with elements of the local landscape, this detracts from the supra-regional character of the line and creates clutter: unnecessary, incomprehensible visual complexity.*

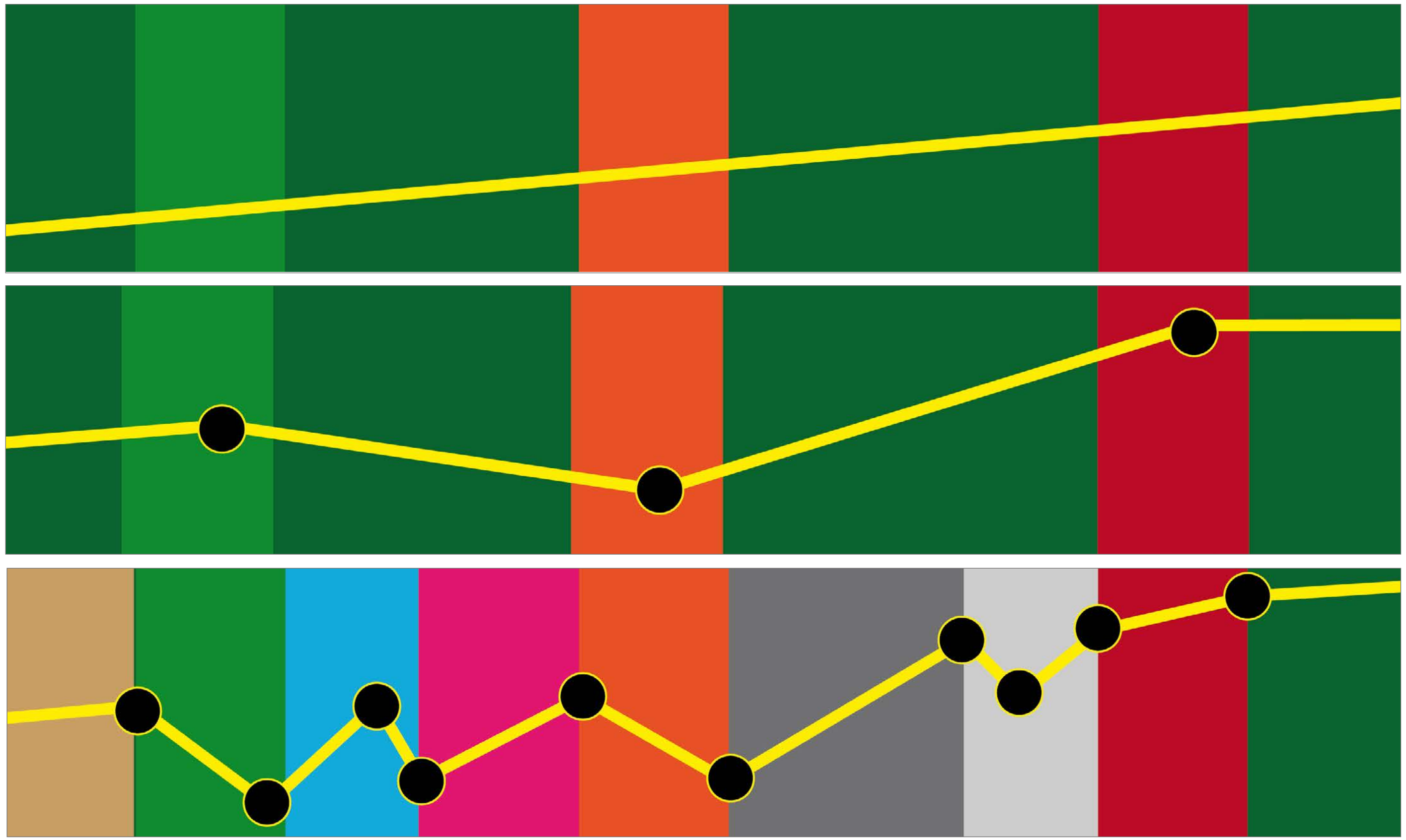
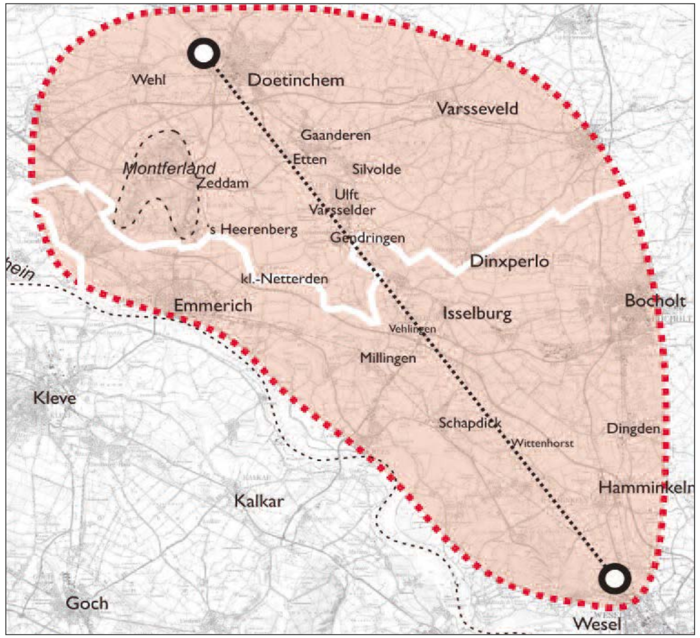
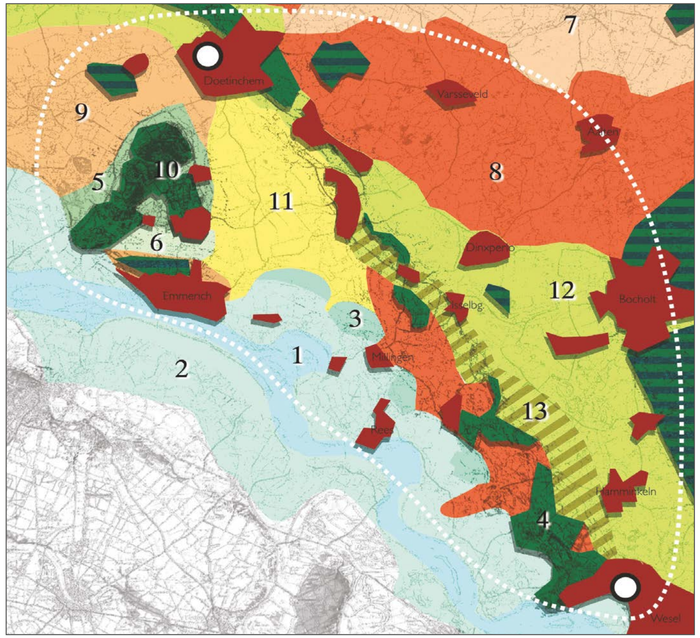


fig. 13 *Project Doetinchem-Wesel 380kV (DW380) on grid level (Project 2009-2011)*

The DW380kV project was started in 2009 with the aim of realizing a new interconnector between the Netherlands, TenneT (Doetinchem) and Germany, RWE (Wesel).
The process started with an international study to determine the correct location of the NL-D border crossing. Subsequently, it was investigated which route was most suitable for the Dutch part.
The connection was put into operation in 2018.
International study DW380kV

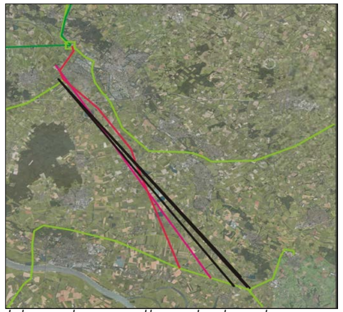
fltr:
Research area DW380kV, Regional Landscape Pattern
below:
Research design finding the most suitable route in



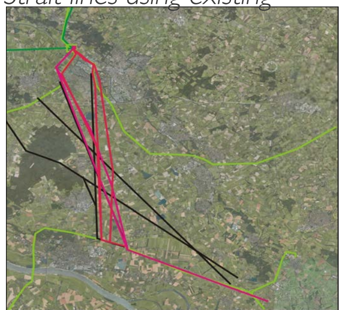


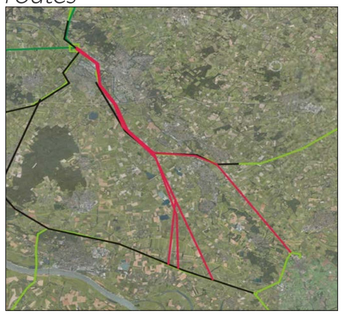
Sortest line

Strait lines

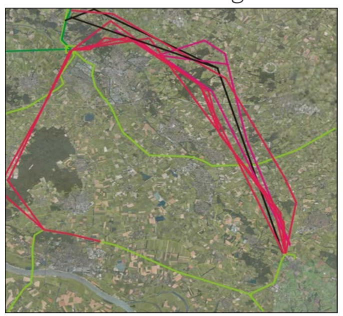


Strait lines using existing routes

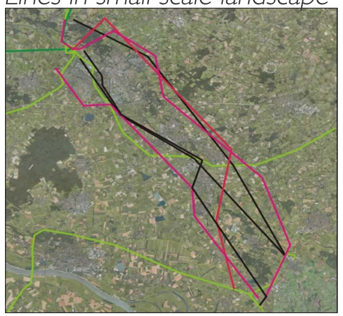




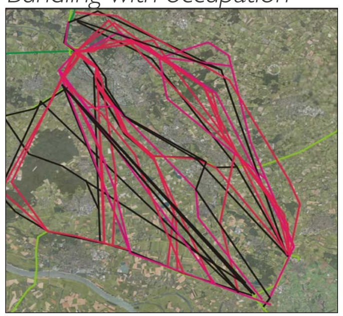
Maximum use exiting routes

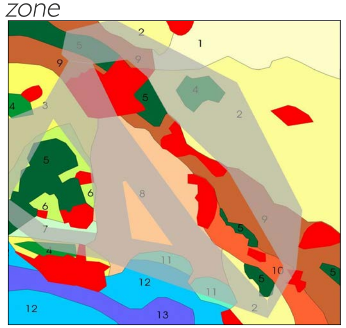


Lines in small scale landscape



Bundling with occupation zone





Lines
Suitable zones fitting in the RLP
Chosen alternative (xxx-lines are to be removed 150kV lines)

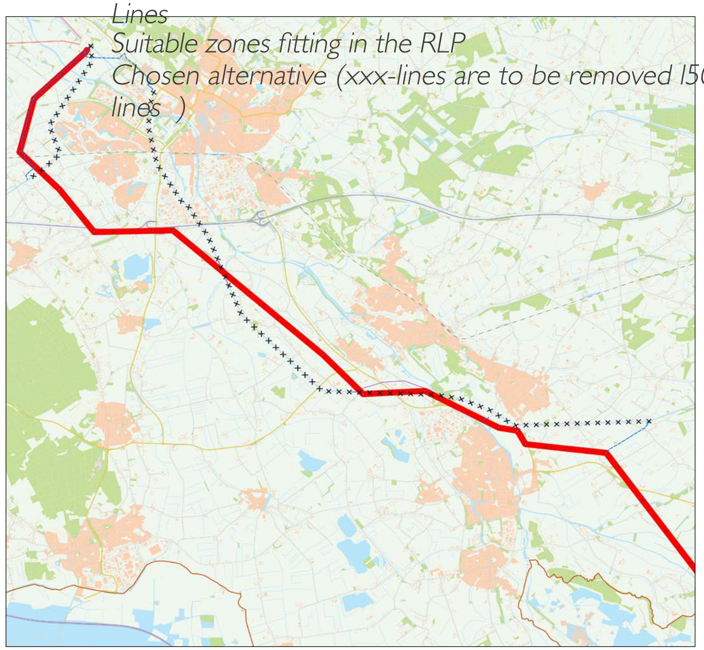


fig. 14 *Project Doetinchem-Wesel 380kV (DW380) (Project 2009-2011)*

Bundling with a motorway
The route of this overhead line includes a junction with a motorway. A choice had to be made between two alternatives. A straight route and a route that bundles with the motorway over a length of approximately 1.5 km. The bundled route has two sharp angles These angles are understandable for users of the motorway, but from the landscape it is not clear why the route has the sharp angles because the highway is not visible.

fig. 14 a *two alternative routes*

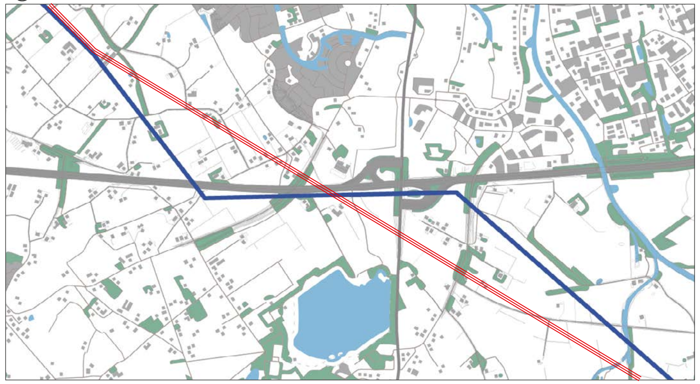


fig. 14 b *the strait overhead line (red)*

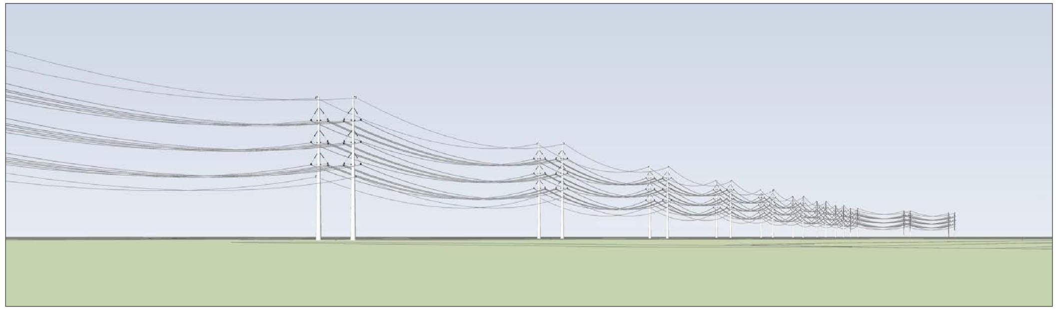


fig. 14 c *the overhead line with two angles (blue)*

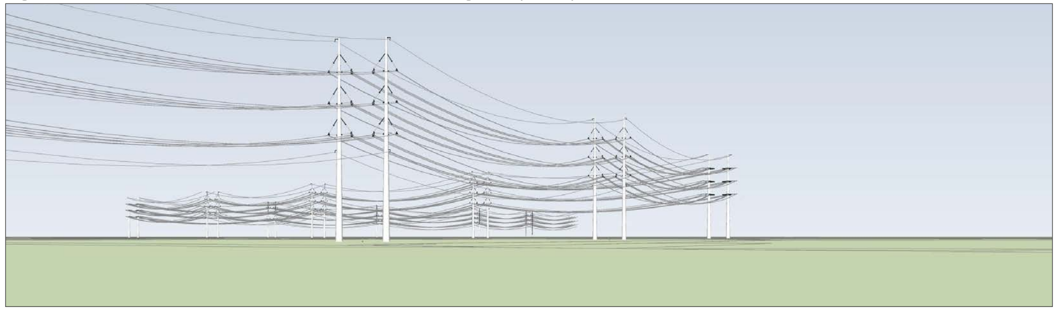


fig. 14 d *View along the motorway*

fig. 14 e *View from the landscape, the motorway is not visible*

fig. 15 *Project Doetinchem-Wesel 380kV (DW380) (Project 2011-2015)*

The route of this overhead line passes through a manifestation site. Instead of crossing the terrain (red dashed line), a route (blue line) has been chosen that bypasses the terrain with two extra angles. From the landscape, this has resulted in a visual complex and incomprehensible appearance.

fig. 15 a *Situation of the two alternative routes near the manifestation site 'DRU-park'*

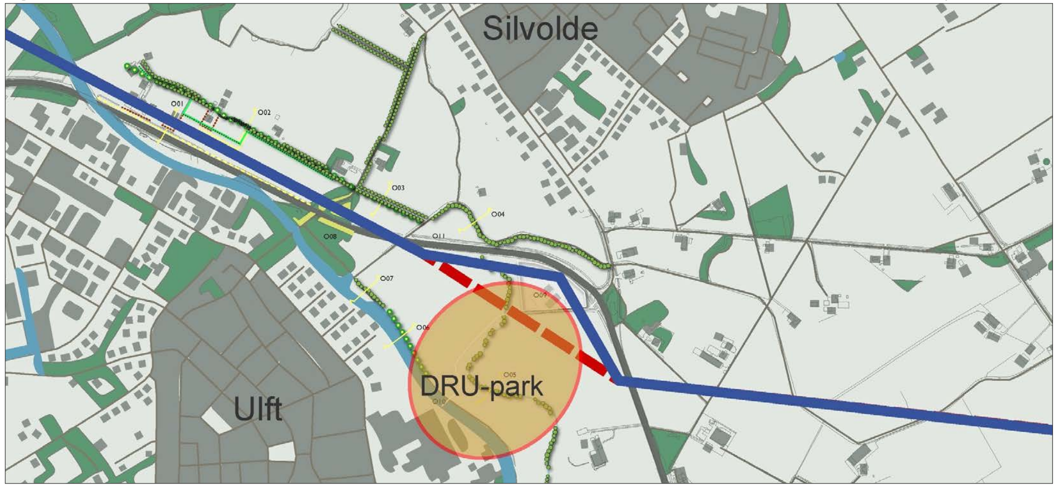


fig. 15 b *View from the landscape with the blue line, as build*

fig. 16 *Autonomous route*

below :
380kV overhead line in a small-scale landscape.
The land use, the historic allotment with characteristic plots and road planting continues 'undisturbed' below the line.

right :
150 kV overhead line in a suburb.
The residential buildings remain at a distance, but the design of the park zone, of the edges of the buildings, of the road and path pattern remains independent of the overhead line.

landscape. This story determines the specific characteristics of the landscape in which a new connection or substation will be built.
Landscape research by design is a cyclical process in which that information is processed pragmatically. It starts with a positive approach to the specific characteristics of the landscape on site, in which the usual planning exclusion criteria are consciously set aside in the first instance. Think of protected landscapes or nature and recreational areas.

In the first stage of a project for a new overhead line, this leads to the drawing of all kinds of routes based on the Regional Landscape Pattern. It is a search for routes that fit into the landscape.
Bottlenecks and gaps in knowledge will arise, which will be followed by further research. This can be detailed research into, for example, the landscape obstacles of a route or route bundle, but also into the backgrounds of the structure of the landscape. This then forms the basis for new alternatives or improvements to routes.

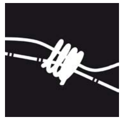
This research leads to a search area or corridor for further route development. The research can also lead directly to a limited number of route alternatives that are further investigated and elaborated in an Environmental Impact Assessment (EIA).
In this phase of route development, it is recommended that various alternatives be classified thematically. Organizing can be done according to certain groups of tracking principles, such as

- a group bundling alternatives,
- autonomous alternatives
- alternatives that combine maximally with existing connections.

Such a thematic approach helps in the search for meaningful alternatives and therefore makes the whole range of effects on the environment visible.

6.2 Bundling linear infrastructure

In the densely populated and completely subdivided countries such as The Netherlands, the construction of new overhead lines is a difficult task. Bundling with other linear infrastructure such as highways, canals, railway lines, overhead lines and underground pipelines can reduce the negative effects on the environment (Willems 2001).



Bundle with infrastructure of a similar structure and scale

By bundling, parts of the rural area remain free of new linear infrastructure and the associated installations.
Bundling prevents fragmentation of the landscape.
A first obvious option is bundling the overhead lines themselves by combining new ones with existing lines. More lines can be hung upon one special designed pylon, the combination of 150kV and 380kV is common. The combination of two heavy transport connections of 380 kV is often not desirable, because of the network strategic disadvantages.
The design of a new combined connection is comparable to that of a 'normal' new connection.

6.3 Aspects of bundling

Fragmentation and barrier effect
The general idea is that bundling leads to less fragmentation. Linear infrastructure sometimes breaks up large units in the landscape into small, spatially separated units. A distinction is important here between functional, ecological and visual/spatial barrier effect.
For example, bundling can have advantages such as the

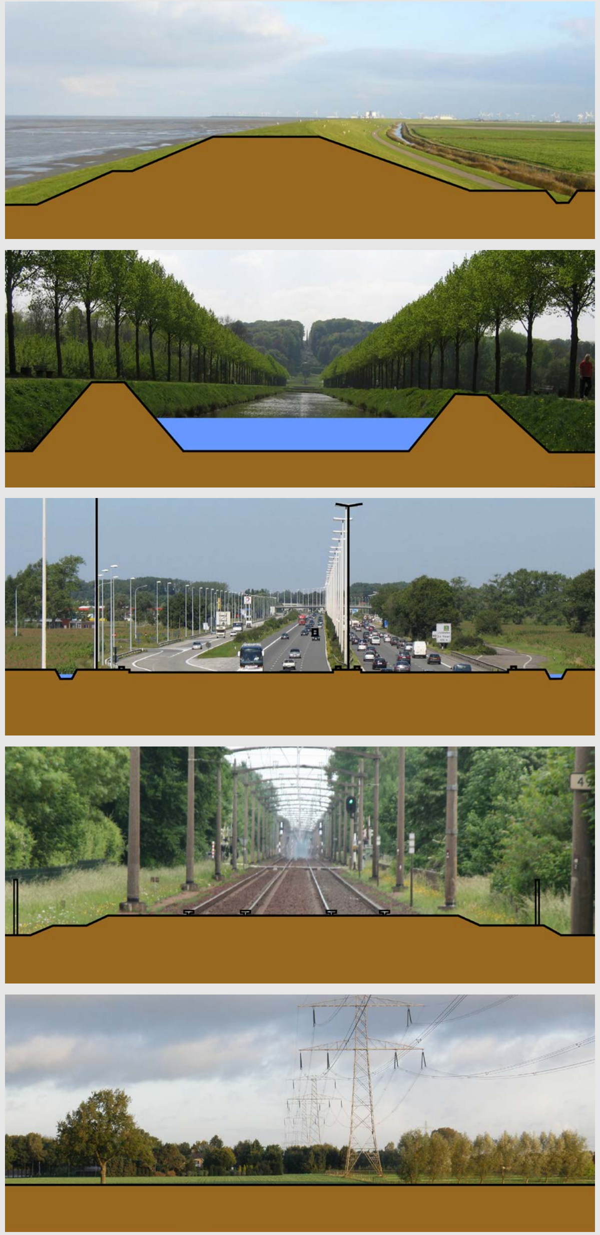
barrier effect of two bundled infrastructures that are comparable and partly coincide, as in the case of railway or the highway. The barrier effect of high-voltage lines is mainly visual, and therefore very different from that of the railway or the highway.

Space occupancy

There is direct and indirect use of space due to linear infrastructure. The direct space requirement is the surface area required for the primary functioning of the infrastructure. The indirect land take is the area, the zone in which other forms of use are possible, but that are influenced by the line infrastructure. This zone is generally equal to the obstructed strip of land.
The impact of bundled line infrastructures can overlap, whereby the question is to what extent the space occupancy of an infrastructure is 'monopolistic', in other words does one function exclude another? The asphalt of a motorway is only suitable for traffic and cannot tolerate secondary use for other functions. But the verges and verge ditches of that motorway can serve as an ecological connection. Under an overhead line cows can graze and the farmer can plow his land.
There is also a downside to bundling. Bundling a new one with an existing line infrastructure often means that a detour is made, which always means a larger space requirement. The shortest route is the cheapest and takes up the least space.

Visibility

The visibility of an infrastructural element from the surrounding environment depends on its elevation relative to ground level, the height of the infrastructural element itself and the number and the appearance of the vertical elements of the element in question. A elevated railway or motorway has a completely different influence on the spatial structure of the landscape than one on ground level.



Sidekick 8 *Linear infrastructure, land use and fragmentation*

Depending on its function, each linear infrastructure has a specific use of space, a related barrier effect, which determines the degree of fragmentation of the landscape.

From top to bottom:

In addition to its flood defense function, a dyke is to a limited extent suitable for other functions, sometimes recreation or road traffic is possible. Due to its function, barrier effect is leading, after all, it must separate the land and the water.

A canal has a function for water management, water traffic, nature and recreation. The barrier effect is great for other traffic functions.

Railways and motorways are almost monofunctional. The space between the verge ditches is almost entirely suitable for the traffic function only. The barrier effect is huge and they therefore have a strong fragmenting effect. Sometimes the verges of a road can also have a function for nature. Increasingly, however, railway lines and motorways are bordered by fences, which increases the barrier effect.

The space required by the overhead grid is very limited. Only the pylon feet, the transition points and substations are monofunctional, the rest of the obstructed strip of land (approximately 90%) is also suitable for other functions. There are only height restrictions.

fig. 17 *Examples situations of bundling with different types op infrastructure*

fig. 17 a *150kV and local road.*
Tight bundling with full overlap.
The restricted strip of the line overlaps 100% with the usable space of the road.

fig. 17 b *150kV and regional road.*
Tight bundling with partial overlap.
The 150 kV overhead line is located in the verge of the city motorway.

fig. 17 c *2x150kV overhead lines*
Tight Bundling with full overlap.
The two 150kV overhead lines are only 20m center to center of each other. The city has grown below the lines the bundle has been incorporated in an informal park zone.

fig. 17 d *380kV overhead line and canal*
Zone bundling.
The 380kV overhead line bundled with a regional canal over a great length. Sometimes very close, sometimes hundreds of meters apart. Along the channel, there are accompanying trees in a number of places, creating a recognizable spatial coherence locally.

A railway has an overhead wire with portals, a motorway often has lighting, signage and noise barriers. Often image-defining linear vegetation is planted alongside. The pylons of power lines are usually between 30 m and 60 m high and several hundred meters apart. In between, the conductors hang against a predominantly blue-grey sky, in short, a transparent image and no visual blockage.
When combining different types of infrastructure, the differences in vertical dimensions are particularly important and how they work out visually together.

Horizontal alignment

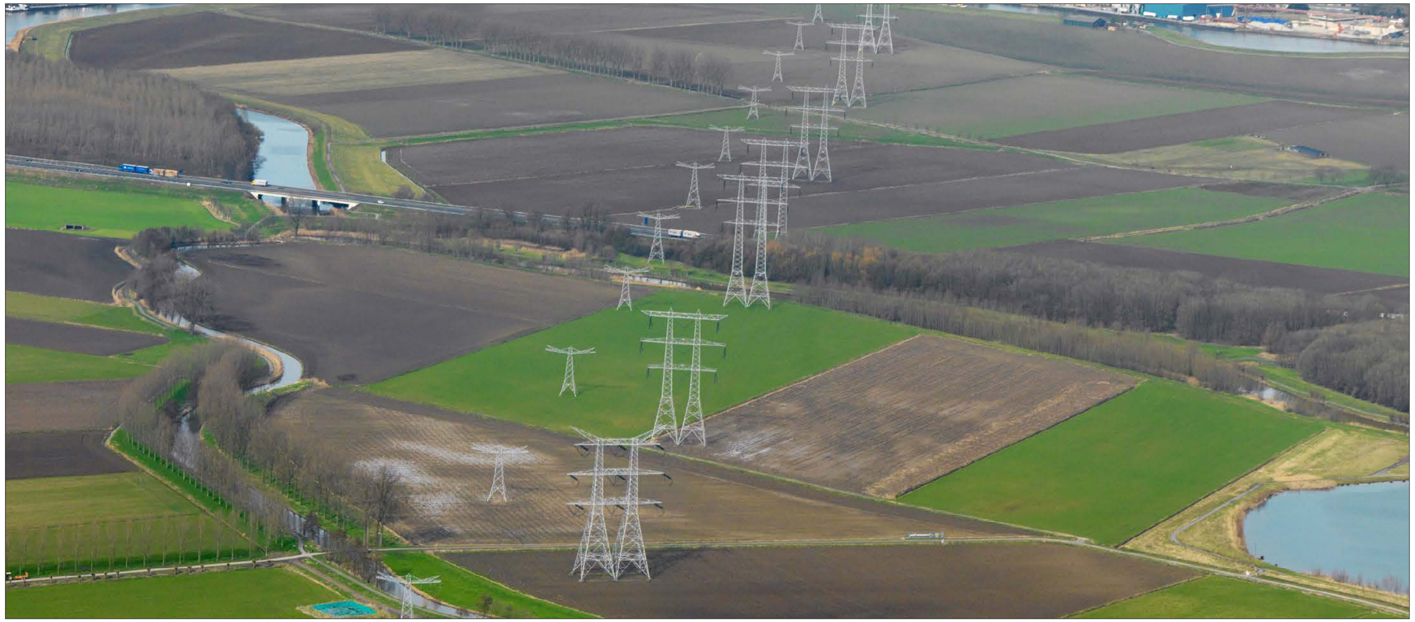
Each type of infrastructure has its own optimal horizontal alignment, its own design language. Motorways are winding, railway lines and canals have long straights and gentle bends that have little influence on the image from the surrounding environment.
Pylons in an overhead line stand neatly in a long straight line with the occasional sharp angles. These angles have a major influence on the image of the overhead line. When bundling different types of linear infrastructure, it must be examined whether the horizontal alignment fits together. Adjusting the route of an overhead power line by bundling with other infrastructure because of the horizontal alignment causes deviation from the straights and determines the number of corner pylons which have another appearence. Thus, the image of the line itself is changed.

Sound

Sounds can be pleasant like the rustle of trees and birds or very annoying like a train rushing by. Overhead lines can also produce a light crackling sound (Corona) in certain weather conditions. The advantage of bundling an overhead line with a motorway is that the noise of the line is masked. Overlap of noise zones thus leads to a reduction of the total noise nuisance, because the total noise from two different sources together is always less than each noise source separately next to each other.

6.4 Methods of bundling

fig. 18 *Bundling small and large*



There are three types of bundling:

- Tight bundling;
- Remote bundling;
- Zone bundling.

The advantages and disadvantages of bundling become more clear when tight bundling is subdivided into the degree of overlap of the use of space.

Tight bundling with full overlap

In this case one infrastructure line is completely covered by the physical space requirement (obstructed strip of land) of the other. This is only possible if the vertical dimensions of the lines differ from each other. The lines are very strongly physically linked and run completely parallel in the vertical and horizontal plane.
In principle, overhead lines can be bundled with other infrastructures in this way.
After all, the conductors are for the most part 10 m or more above ground. Only the pylons have a direct space requirement, the conductors only have an indirect space requirement. For example, an overhead line could theoretically be located in the central reservation of a motorway.
However, such a tight bundling is often not desirable from the point of view of maintenance and management of the line and because of the obstacles to car traffic in the event of a wire break.
An important disadvantage is the difference in horizontal alignment of the road and the power line.
Due to negative interference (electromagnetic fields) between the conductors of the railway and those of the overhead line, this method of tightly bundling overhead lines with railways and underground pipelines (pipeline corridors) is in fact highly undesirable.

Tight bundling with partial overlap

With this type of bundling, the total space taken by the bundle is greater than that of each infrastructure line individually, but less than the sum of the individual lines. There is also a very close relationship and parallel development. However, it is possible that the infrastructure lines are in the same vertical plane when some parts are shared. In most cases it concerns embankments and ditches. The same applies here for overhead lines as for tight bundling with full overlap.
Tight bundling without overlap
In this case the infrastructure lines are placed as close to each other as possible, but no common parts are used. The zones of indirect land (obstructed strip of land) connect to each other. The space occupied by the bundle is equal to the sum of the space occupied by the individual lines. Another important characteristic is that there is residual or intermediate space between the parallel lines. Overhead lines can easily be bundled in this way. Significant drawbacks associated with interference remain here. The disadvantages for the difference in horizontal alignment are less significant.
Tight bundling with functional spacing
Sometimes the interspace contains functional objects that are necessary for functioning, such as maintenance facilities and substations. Then we are still talking about tight bundling, albeit with a functional space in between.
Remote bundling
In this case, two or more elements are at a greater distance from each other than is minimally necessary. In the interspace there is room for many functions such as habitation, industrial activity or nature.
Overhead lines can easily be bundled in this way. After all, the direct space requirement of a line is limited to the surface of the pylon feet. Most forms of land-use pass under conductors, there are only restrictions in height. The interspace is therefore often not recognizable as such. With remote bundling, the basic principle remains that the bundled elements run more or less parallel.

Zone bundling (Kerkstra 1981)

At first sight, remote bundling and zone bundling show many similarities in terms of maximum mutual distance and in terms of the functional use of the space between the infrastructure lines. The difference lies in the manner of route planning and thus in the horizontal alignment: with zone bundling, each line is individually optimally planned from its own functioning and appearance.
The mutual distance varies and there is no constant parallel course. This makes the bundling more difficult to recognize as such. With zone bundling, each infrastructure line has its own optimal route, so that they are largely not parallel.

6.4.1 Bundle length

The length of a bundle must also be at the correct level. A motorway and a 380kV overhead line must run parallel for much longer than, for example, a neighborhood road and a bicycle path. A bundle that is too short is disadvantageous. An overhead line that only bundles for a few field lengths with a motorway means a short straight stand with two heavy corner pylons close to each other, which are also in the direction of view of the traffic on the motorway.

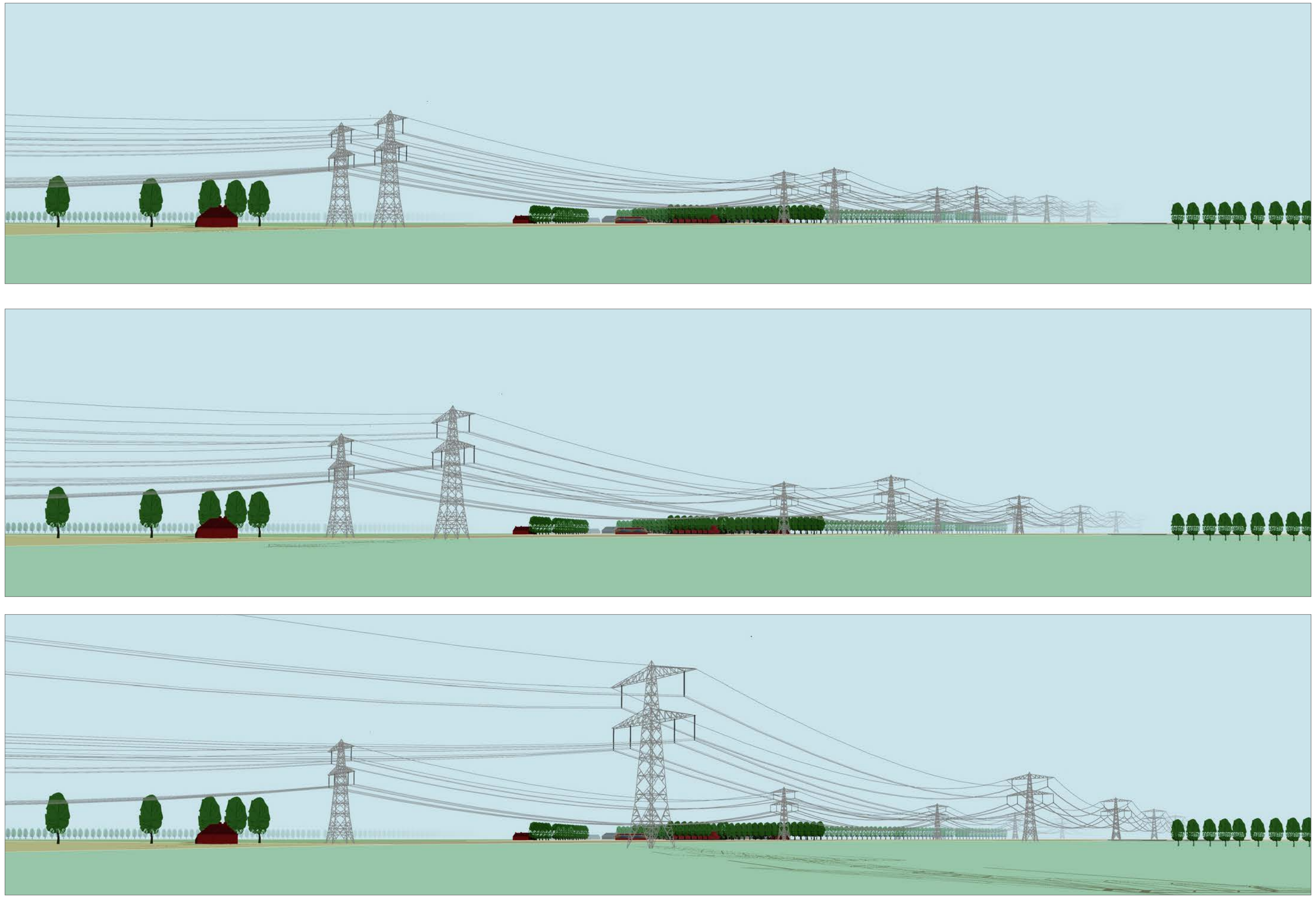
'In step'

When bundling with other overhead lines, preferably keep the pylons "in step"

If it is possible to bundle two overhead lines tightly it makes sense to equalize the field lengths of the two lines. This 'in step' routing of lines gives a calm appearance which is preferable. At a greater distance however, routing 'in step' is less useful. Due to perspective distortion, the calm image then disappears and there is little difference between the image of 'in step' and 'out of step'.

fig. 19 *Bundling of 2 overhead lines*

At a larger bundling distance, keeping two connections 'in step' becomes less effective as a result of the perspective distortion.
Bundling distance
top: 50m,
center: 100m,
bottom: 200m



7. Designing at line level

7.1 The straight line / Visual complexity

Simple autonomously designed lines - that is, designed separate from the local landscape - are best incorporated into the landscape image. Simple straight lines, consisting of long series with the same pylons are the least noticeable. To understand this better, a comparison with the frames of glasses is useful.
When someone buys a new pair of glasses, the frame will be conspicuous during the first few days.
Pretty quickly, however, the frame disappears from our view, not because it is no longer there, but because in fact the brain filters out the frame.
The glasses are always in the same place in the person's field of view, always provide the same information, which after a while adds nothing to the perception and can therefore be disregarded and thus the frame disappears into the background of our observation. In a similar way, the guide rail next to the motorway is filtered out of our observation. It is almost always there, but we seldom perceive it consciously. The frame of glasses and the guide rail next to the highway form simple visual information for the observer that can be 'skipped'.

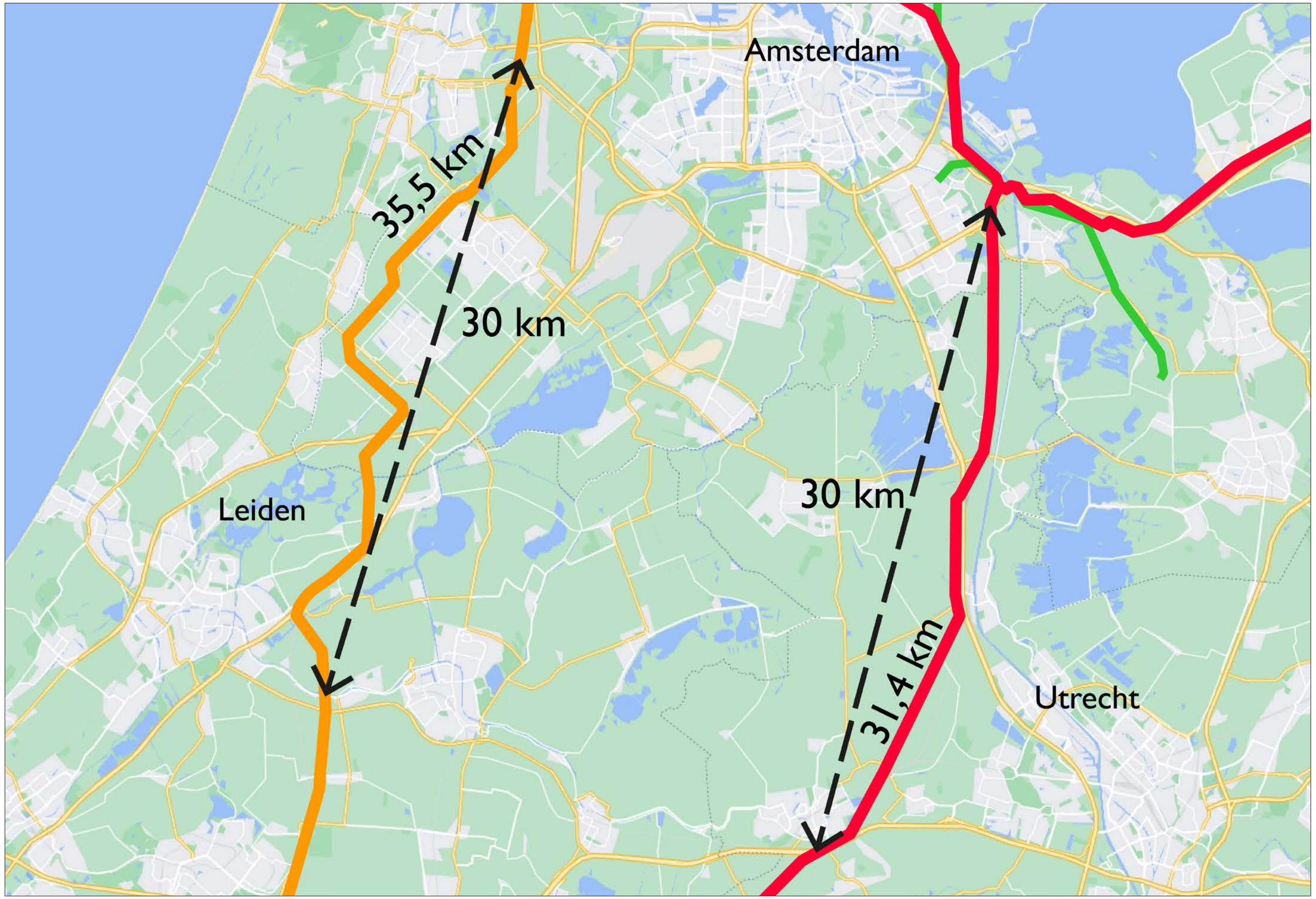
The low visual complexity, simple shapes, always in more or less the same place in the field of view, ensures that these objects disappear into the background and do not disturb the observers perception. A parallel can be drawn here with the design of overhead lines. Simple lines with the same pylons in a clear rhythm, without deviations in direction or height, disappear into the background of the observation.
In the event of unavoidable changes in direction or differences in pylon height, the route should preferably be associated with similar elements of the the Regional Landscape Pattern . For instance the supra-regional, large-scale infrastructure such as a motorway or other elements such as rivers, ridges, forests and urban zones. Simple design of the overhead grid, limiting the visual complexity at every scale level, are central to the design.

The straight line is the most obvious route for an overhead line after all: a straight line is the shortest connection between two points (Holford 1971).
Unfortunately, a straight line is usually not possible, so the challenge is to find the correct locations of the angles and their coherence with other elements in the landscape.
Overhead lines pass the local landscape but have no functional relationship with it (Vrijlandt 1984). The route of an overhead line must therefore be defined in such a way that a logical and relaxed relationship is created with the landscape. This means that a connection must be sought with other landscape elements of a comparable level.
Depending on the openness of a landscape at this level an overhead line can be clearly surveyed over a long distance from different locations in the landscape and certainly when one moves around.
An overhead line must be as separate as possible from the small-scale elements of the local landscape. The rhythm of rows of pylons with the wavy wires hanging in between give the overhead line its own specific spatial quality.

fig. 20 *The strait line*

Basic design principle, "a straight line is the shortest connection between two points", already stated in the study by Vrijlandt (Vrijlandt et al., 1980).
It is under all circumstances most beautiful solution because it reflects the main function of electricity transport in the most efficient and effective way.
However in most situations it is not possible to make a straight line.

A straight overhead line is the shortest connection and therefore has the least impact on the environment.
A straight line has the smallest carbon footprint, the amount of material to build the connection is the smallest, less steel for the masts and conductors, less concrete for the foundation.
Fewer masts means fewer foundations and therefore less influence on the soil. A shorter length means less ecological and functional impact. Less chance of bird strikes



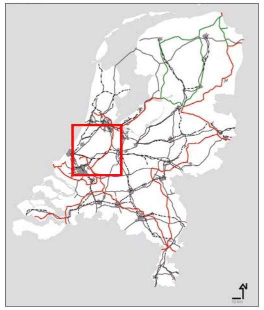
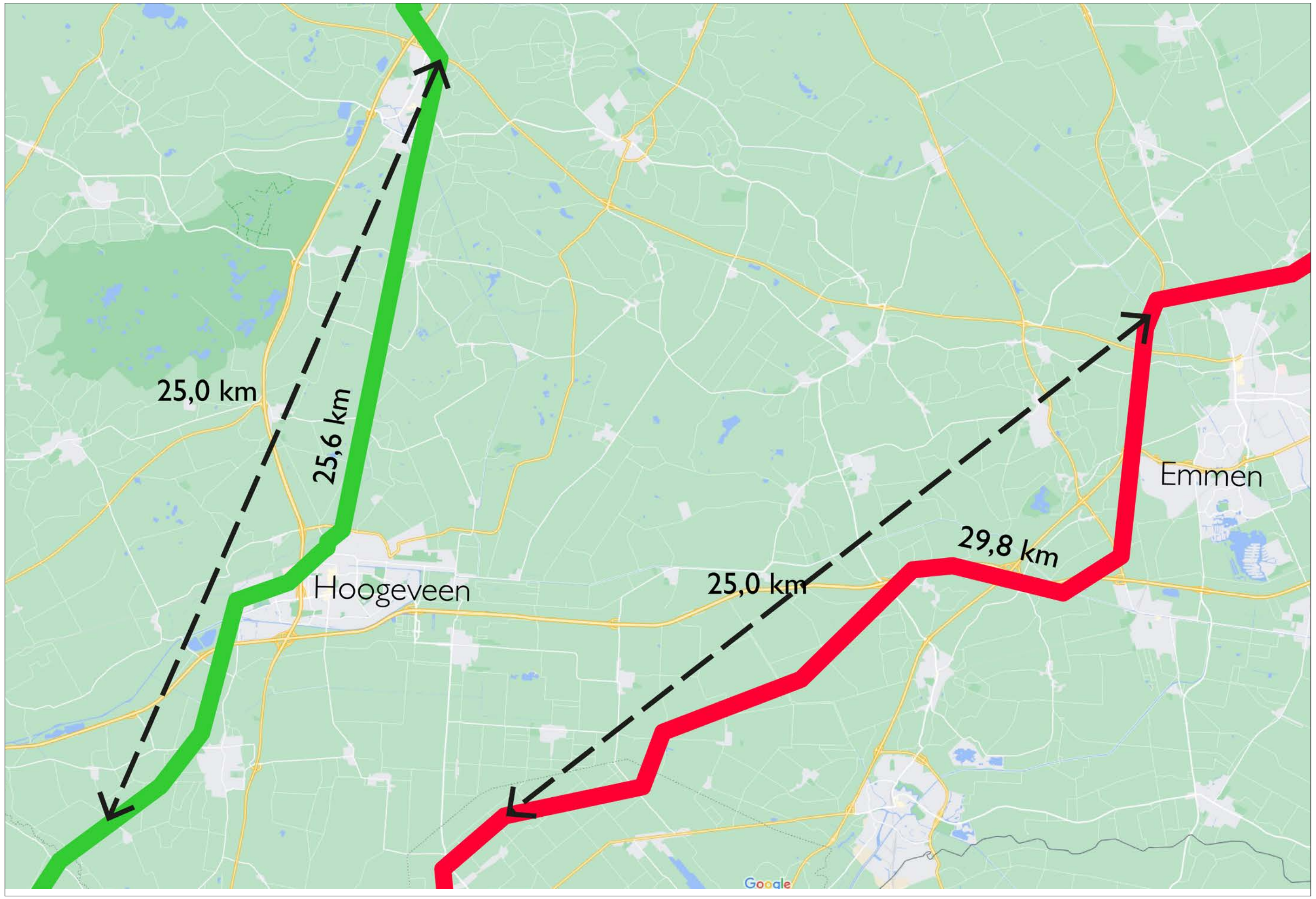


fig. 21 *Example of overhead lines before and after planners participate in the planning and realization of new overhead lines.*
Two connections in the west part of the Netherlands. The red line (right) was developed in the 1970s, the influence of environmental planners on the design process was very limited. The shortest line (black dashed line) would have been approximately 30km, the realized connection is 31.4 km, which is a difference of 5%.
The orange line (right) was developed between 2009 and 2019. The influence of environmental planners, local and regional stakeholders was great. The shortest line (black dashed line) would have been approximately 30 km. The realized overhead line has a length of 35.5 km, which is a difference of 18%.

and less negative impact on nature under the conductors and masts as a result of the necessary maintenance.
A short connection has fewer restrictions for the land use under the conductors. The shortest connection means the lowest energy transport losses.
After environmental planning started playing a role in the proces of planning and realisation the power grid, overhead lines were build less straighter and therefore longer.
In Nederland that is that case since the 1970s.



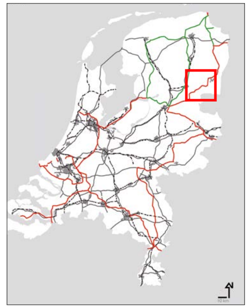
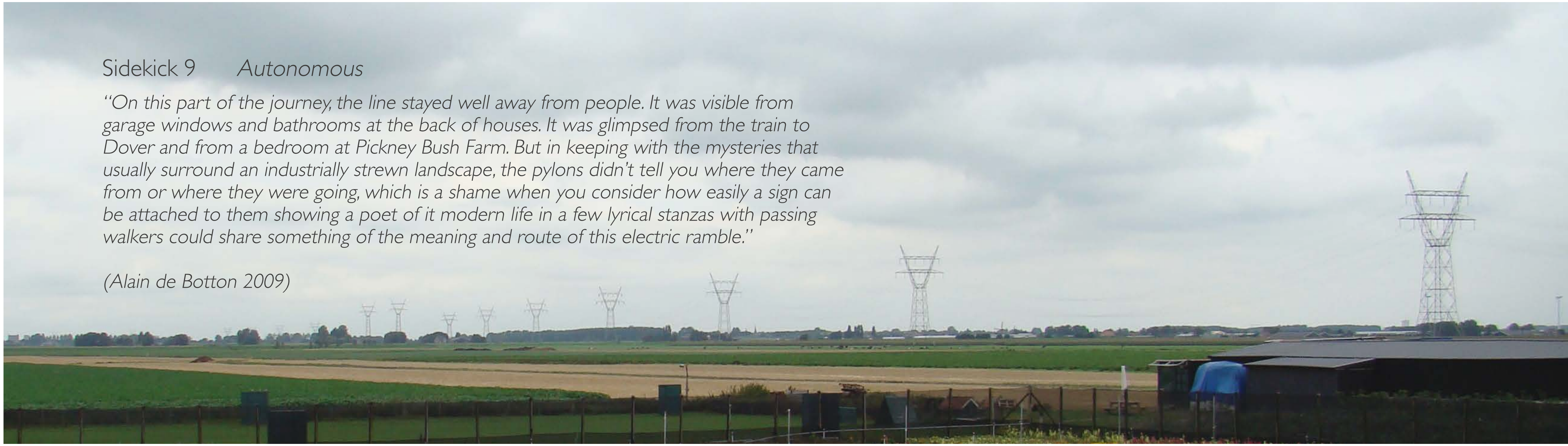


fig. 22 *Example of overhead lines before and after when planners participate in the realization of new overhead lines.*
Two connections in the north east part of the Netherlands.
The green line (left) was developed in the 1950s, the influence of environmental planners on the design process was very small. The shortest line (black dashed line) would have been approximately 25 km, the realized connection is 25.6 km, which is a difference of 2%.
The red line (right), was developed in the 1990s. The influence of environmental planners and local and regional stakeholders is considerable. The shortest line (black dashed line) would have been approximately 25 km. The realized connection has a length of 29.8 km, which is a difference of 19%.



Sidekick 9 *Autonomous*

"On this part of the journey, the line stayed well away from people. It was visible from garage windows and bathrooms at the back of houses. It was glimpsed from the train to Dover and from a bedroom at Pickney Bush Farm. But in keeping with the mysteries that usually surround an industrially strewn landscape, the pylons didn't tell you where they came from or where they were going, which is a shame when you consider how easily a sign can be attached to them showing a poet of it modern life in a few lyrical stanzas with passing walkers could share something of the meaning and route of this electric ramble."

(Alain de Botton 2009)

Design lines autonomously, separate from the local landscape

At the line level it is important that one investigates how an overhead line or a technical installation is perceived. The issue is finding the correct location of changes in direction and the relation with, for example, agricultural plot directions, variations in the distance between the pylons and the space required?

'The simpler the better' is the main assignment when designing an overhead line in the landscape.

Design straight and uniform lines, which are best incorporated into the landscape image

In most rural and suburban areas which are often highly divided, relatively small-scale areas, a straight overhead line is in fact not possible.
There are always necessary deviations from the ideal straight line. That requires paying attention to the design.

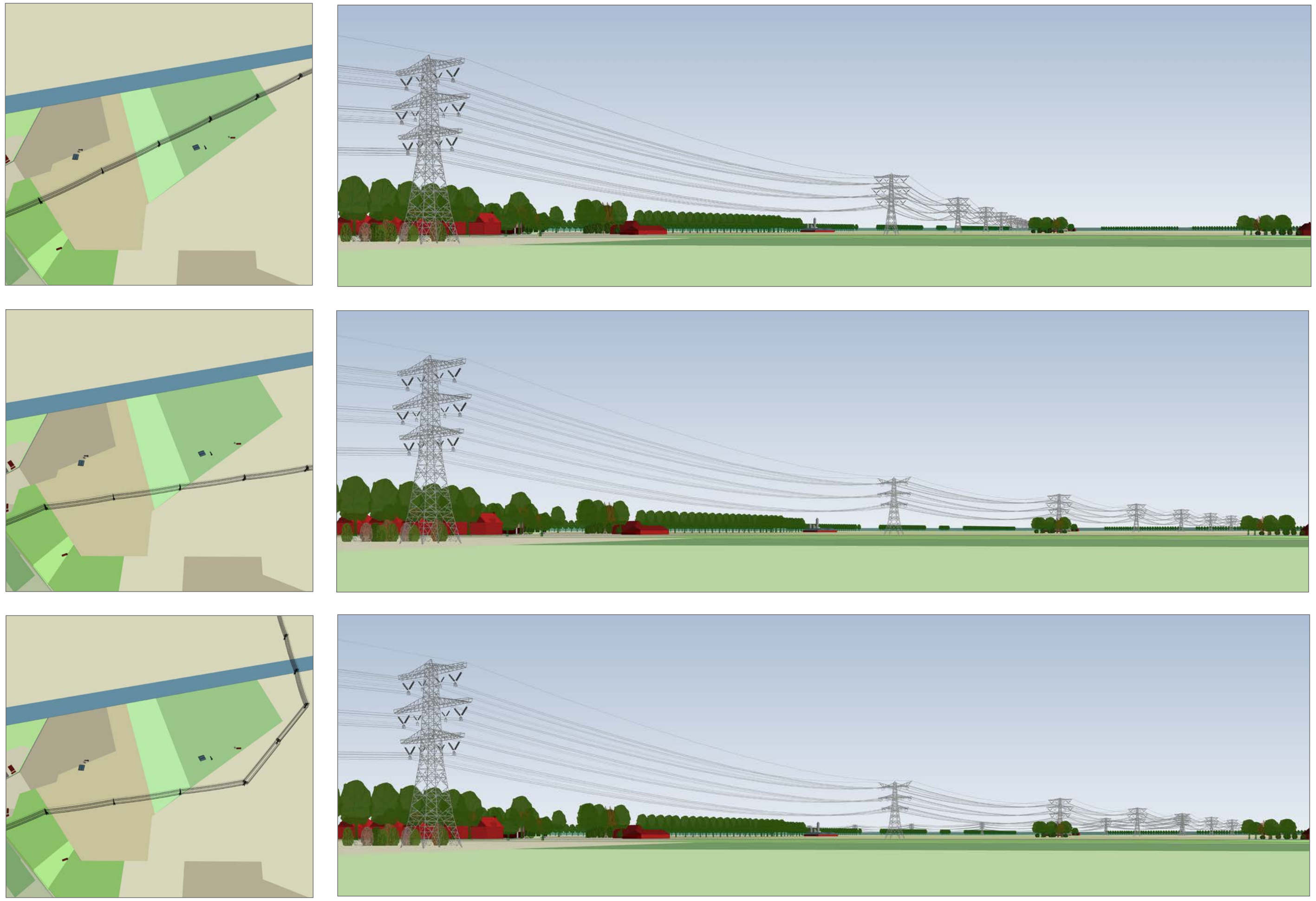
We distinguish deviations in:

- Direction;
- Pylon height;
- Field length:
- Pylon design.
- Aboveground-Underground

7.2 Deviations in direction

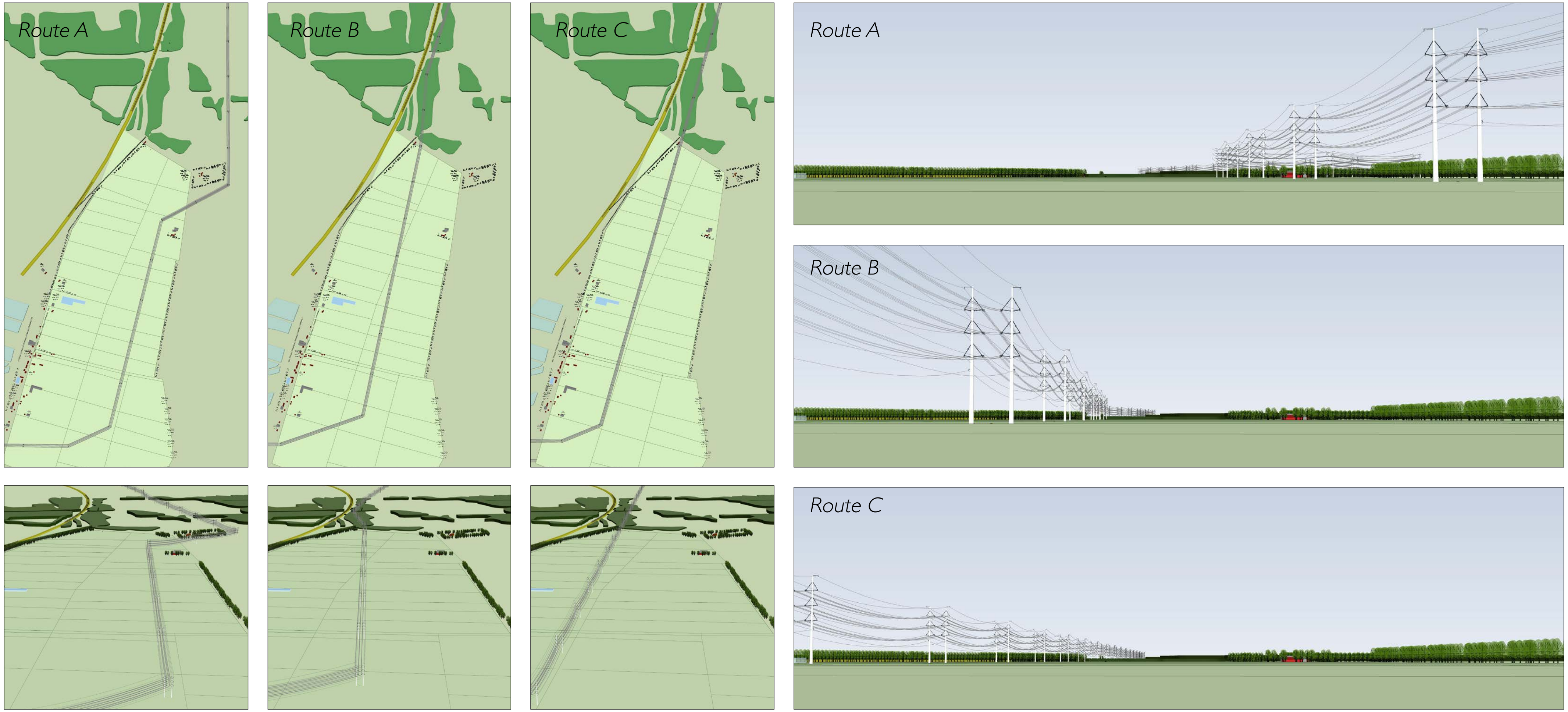
An angle or change of direction strongly determines the appearance of an overhead line. At the angle, the image changes but also the shape of the pylon, because a heavier and depending on the pylon design a lower corner pylon is

fig. 23 *Deviations in direction*

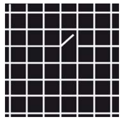


fttb: Straight line, a 5 degree angle, a 30 degree angle, several angles

fig. 24 *Project Randstad 380kV (Project 2009-2021)*
In this route, 3 alternatives were considered for crossing a newly created recreational forest.
The images clearly show that deviations in direction, often



needed to make the angle.
From the environment, the image changes because the angle between the viewing direction (the optical axis) and the centerline of the overhead line is different on both sides of the angle. For the observer, the optical distance between the pylons before and after the angle changes, with the result that the rhythm of the pylons and conductors is disturbed. The magnitude of this disturbance depends on the sharpness of the angle and on the position of the viewer. For example, with a small change in direction of 5 degrees, the change in rhythm is more limited than with a sharp angle of, 40 degrees.



Avoid deviations from the standard; locate necessary deviations away from objects in the local landscape

If you stand close by and look almost along the center line, the optical difference on both sides of the angle is much clearer than when you stand at a distance and look more or less at right angles toward the overhead line.
Sometimes it might be better to divide a sharp 40 degree angle into a few less sharp angles, so that the optical difference between the pylons changes step by step.

The location, the sharpness and the mutual distance between different changes of direction strongly determine the image of an overhead line. If a angle is unavoidable, the precise location of the angle deserves special attention. It is important to ensure that there is coherence with elements in the landscape of a comparable scale level so that the line remains independent of the local landscape.

When a angle is made to avoid, for example, a farm in an open agricultural area, a visual-spatial connection is created between the line and a local object. This harms the supra-regional character of the high-voltage connection.
If a change of direction in a line is necessary to avoid an underground archaeological monument, for example, then an unclear situation arises. Not only does the line take on an appearance that is not appropriate for a national infrastructural element, but it also creates an incomprehensible situation. The line takes on an additional visual complexity, the cause of which is unclear, something that will quickly be perceived as cluttered.

7.3 Pylon height deviations

In order to pass objects, it is sometimes necessary to increase the height of the conductors above ground level.

necessary to solve a local problem, have a large influence on the appearance of the overhead line at a great distance.

fig. 25 *Pylon height deviations*

For example, when crossing a dike with a road, a river that is navigated by large vessels, or a building. In such a situation a choice for higher pylons is sometimes made in combination with a shorter field length.
High pylons strongly determine the appearance of a line. It is important that a visual recognizable connection is created between the high pylons and the reason for them in the landscape.

7.4 Field length deviations

As many equal field lengths as possible seem sensible, both from electrical considerations as from the pursuit of a simple, calm appearance of the overhead line.
Sometimes shorter field lengths arise in places where the conductors must be higher above ground level.
Another common reason is local land use. For example, it has practical advantages for the farmer to situate a pylon on the edge of a plot. Small variations in field length of a few meters are barely perceptible, larger deviations of tens of meters clearly influence the appearance.

7.5 Pylon design deviations

Each power connection is generally built with one pylon design. For each project, an optimum between pylon height and field length is chosen, based on electrical requirements and, for example, climatic conditions in the region concerned.
The standard pylon in a connection is a support pylon, a pylon that holds the conductors and lightning wires in the air.
Tension pylons are placed at a certain distance to keep the conductors at the correct tension. Because of the pulling forces, these are slightly firmer than the standard pylon. Depending on the design of the standard pylon the

fig. 25 a *Overhead lines crossing a large channel with high pylons*
fig. 25 b *Overhead lines with high pylons*

suspension of the conductors also has a different shape. For instance, in case of a lattice pylon the insulators will hang horizontally as opposed to the insulators at a support pylon that hang vertically. The result is that a pull pylon is lower than a support pylon.
A corner pylon is needed for a angle. Due to the tensile forces – in both directions – this one is also stronger than the support pylon and also has a different suspension of the conductors. The image of this pylon is very different from the standard pylon.

Due to height restrictions around an airport with its take-off and landing runways, lower pylons are often used in the vicinity of airports. As a result, the field lengths are shorter. In addition, the application of color markings and lighting may be necessary.

7.6 Underground construction

If a bottleneck in a route is identified and there are no options for optimizing the route or solving the bottleneck by applying technical measures or adapting or buying out existing functions, underground construction (cabling) can be considered.

Underground construction, cabling, can be done with two methods:
- with open excavation
- drilling.

In open excavation a trench is dug in which the cables are laid; the existing vegetation is cleared beforehand. The trench is filled with sand, on which only shallow rooting plants are allowed. This creates open grass, meadow and

fig. 26 *Field length deviations*
Very short field length so the conductors can be kept high

fig. 27 *Pylon design deviations*
fig. 27 a *Red mark near an airport (Project 2009-2021)*

fig. 27 b *Corner lattice pylon with different design, wider and heavier, insulators are horizontal so the pylon is lower*

field strips.
Open excavation is not always possible, for example at a junction of a road or canal, or if there is not enough space. Then it is possible to drill, whereby the cables are laid in pipes. Fewer restrictions apply to vegetation on top or besides the cable route.

When choosing an underground route, existing valuable vegetation or greenery is avoided as much as possible. Such as culturally or historical trees or avenue planting. If a cable route realized with 'open excavation' method and ot intersects groves an unplanted strip is created above the cable route. The aim must then be to ensure a good transition from the open zone above the cable route to adjacent forest or groves.
In such a situation, a drilling can also be chosen in order not to damage the vegetation. Both ecologically and in the landscape it is preferable to avoid tight denominations.

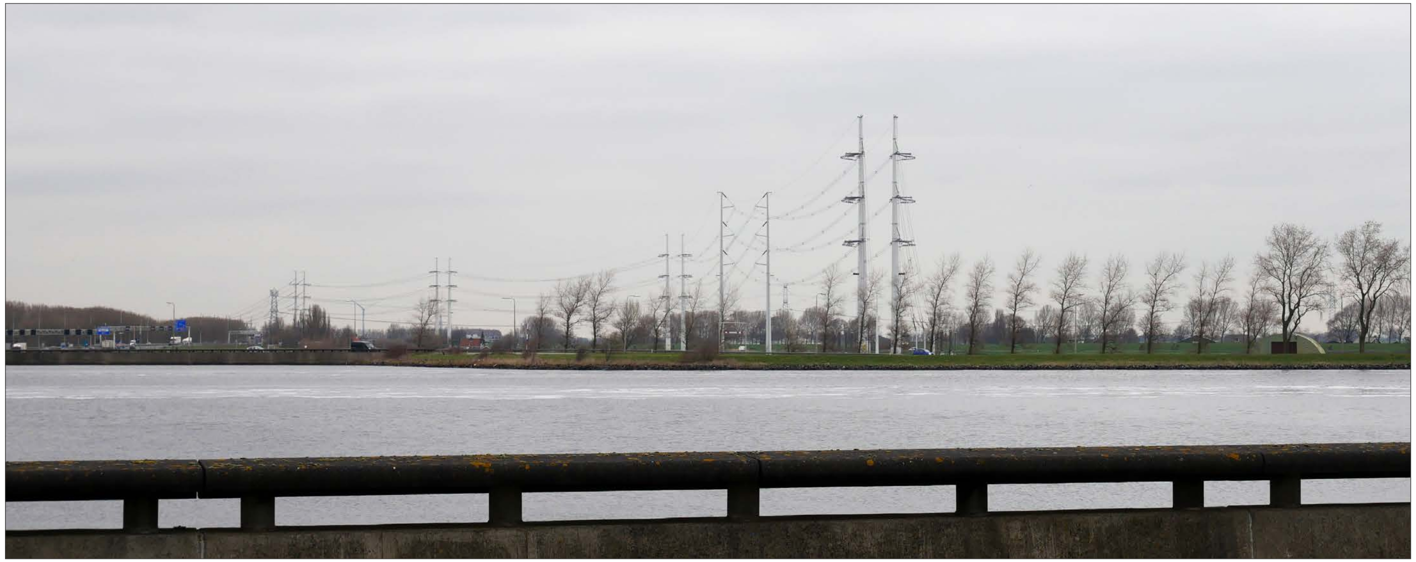
The following aspects play a role when cabling (parts of) a connection:

- Cable length
- Number of cabled route sections
- Location of transition points
- Change in land use on the cable bed

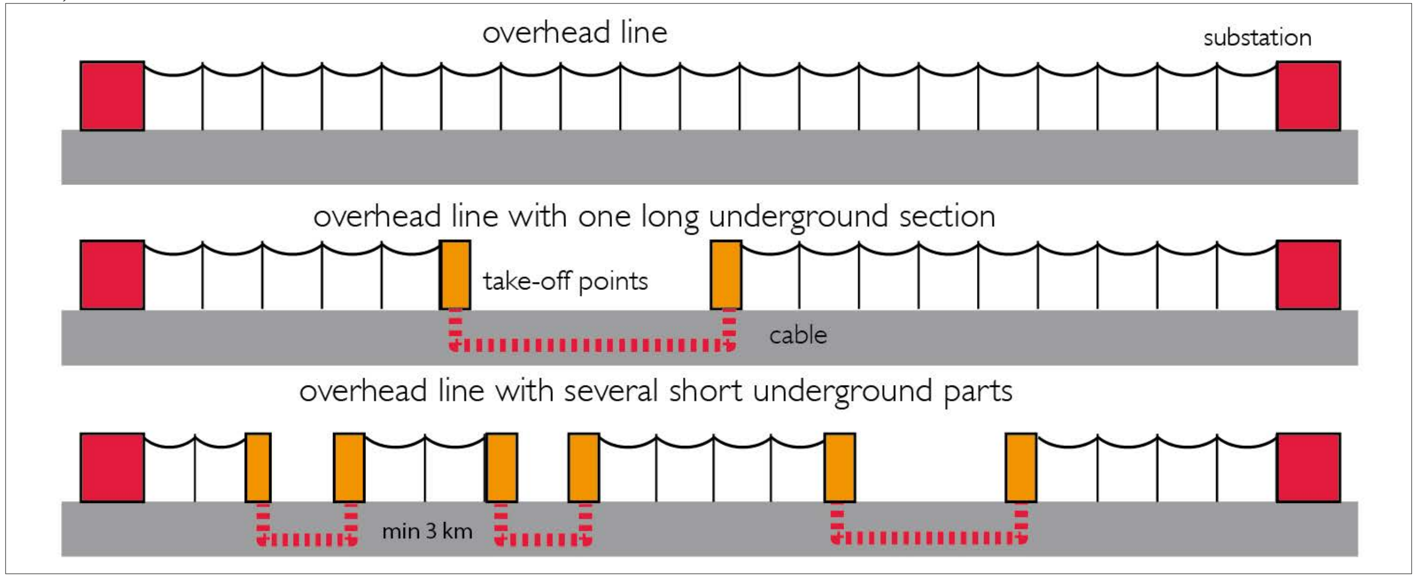
Length of cable section

The length of the cable section partly determines the spatial quality of a route. Keep the recognizability of an electricity connection as a whole and of its supra-regional significance intact as much as possible. This depends, among other things, on the degree of openness of the landscape. Choose the location of a cabling in conjunction with the Main Landscape Pattern.
Coherence between cabling and the local landscape
Make sure that the reason for a cabling (section) is recognizable. A short cabling should be seen as a 'local

fig. 27 c *Corner bi-pole pylon with different insulaters (Project 2011-2015)*
fig. 28 *Channel crossing:*



The coherence between the underground section, its necessity and the location of the transition point is clear. (Project 2009-2021)



deviation' comparable to the use of extra high masts when crossing a river or channel with a large vertical clearance. The interruption of the overhead line and the transition point strongly determine the appearance of a connection. It is important that there is a recognizable correlation between the use of shorter cabling sections and the functional reason for this in the landscape.

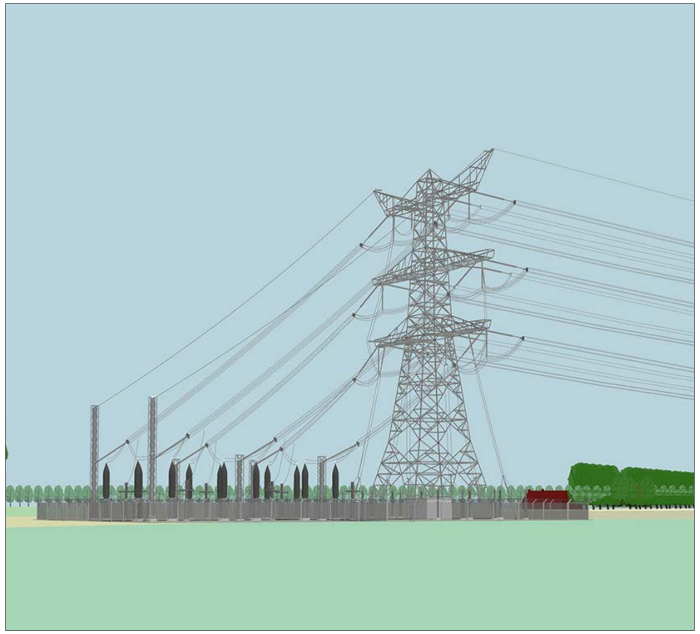
Number of cabled route sections

Short cabling sections are primarily used for solving bottlenecks such as the presence of a waterway with a high vertical clearance, when route planning is very close to a residential area, or at the location of an ecological highly valued area. If several cables within a short distance from each other are unavoidable within a connection, a messy and visually complex appearance quickly becomes fact. This is not only caused by the interruptions in the line, but also by the relatively large transition points. This obviously this depends on the degree of openness in the landscape.
This aspect plays a role at line level as well as at mast level. In general:

- If cabling at a short distance from each other is necessary, combine them into one long cable section
- The minimum distance between two cables is approximately 3 km (depending on landscape structure).

fig. 29 *The recognizability of a power connection as a whole and its supra-regional significance depends on the number, length and distance off the cable sections*
fig. 30 *Examples of transition installations*

fig. 30 a *transition point bipole pylon 150+380kV (Project 2006-2016)*



8. Designing at pylon level

The position of a pylon must do justice to the specific characteristics of a location. It is precisely at this level that a pylon of an overhead line is experienced fairly directly. This implies good handling of contrast differences between the new, large vertical steel pylon and local objects. The spatial structure with its ditches, roads, bridges, plants, houses, businesses and sheds also requires an accurate pylon position. Especially important is the visual influence at eye level and the contrast with the immediate environment.

Avoid disturbing contrasts

The overhead grid is an autonomous system, without a direct functional relationship with the local landscape. However, at the lowest scale level, i.e. the pylon level, the station location or the fencing around an installation, there is indeed a direct physical connection with the landscape.

The challenge is to design practical solutions at pylon level that both fit within the concept of an autonomous electricity system and that also do justice to the local situation. The elements of the power grid are large technical objects in the landscape with dimensions that far exceed human size.
For example, the pylons of a bi-pole pylon are large solid elements with a distance (center to center) varying from 7.5m for a 2x380kV corner pylon to more than 24 meters for a 4x380kV corner pylon. The diameter of the base of this pylon varies from 2.2 meters for a standard support pylon of a 2x380kV pylon type to a diameter of more than 4 meters for a 4x380kV corner pylon.
The distance from the pylons to homes and other buildings is of great importance for the perception of the overhead line by people who live, work or recreate there. The situation is similar for substations. An installation

fig. 30 b *transition point lattice pylon 150+380kV (Project 2017-2022)*

behind large fences - albeit not as high as a pylon - is also a technical object that people like to keep their distance from. There is no general recipe for designing at pylon level, every situation requires a specific, location-specific design.

8.1 Distance to a road

Determining the optimal distance from a pylon to a road is a point of attention. The main design aspects here are the (often agricultural) use of the plot on which the pylon is to be located and the view from the road on that pylon. The user/owner of the field usually wants the pylon at the edge of a field. In this way, land use is least hindered. However, a pylon close to a road is dominant for the road user. Planting along the road can 'soften' the confrontation with the pylon here, the observers view is led elsewhere. A pylon that is situated in the extension of a road at a bend also plays a prominent role in the image from the road. A simple solution is to shift this pylon in the center line of the crossing connection slightly to the left or right so that it disappears a bit more from the observers view.

8.2 Distance to planting

There are height restrictions for vegetation under the power lines. Close to the pylon the conductors hang high and in the middle between two pylons the conductors hang relatively low. Therefore, vegetation close to a pylon can grow higher than in the middle between two pylons. If a power line crosses valuable linear landscaping, such as woods or road plants which often are important as bat migration routes, the height restriction can be minimized by placing a pylon close to this linear planting.

fig. 31 *Avoid disturbing contrasts*

fig. 32 *Coherence between pylon location and a road.*

fttb: Pylon as an extension of the road results in a dominant appearance, below: Pylon in the field. less dominant

fig. 33 *Close to the pylons the conductors of an overhead line hang high and are lower in the middle between two pylons. By locating a pylon close to an avenue planting the damage to trees is limited.*

8.3 Urban situations and special views.

When locating a new overhead line close to a residential area, it must be prevented that pylons are in line with residential streets. As a result, the pylons will become too dominant in the streetscape and unnecessarily determine the urban character of the district.
We also see this when a connection comes close to a recreational resting place or when the view from, for example, a historic estate or monument is affected. Carefully locating pylons, possibly in combination with specific vegetation, is very important in these situations.

8.4 Integrating substations.

There is a big difference between integrating overhead lines and installations, such as stations and transition points or substations. Overhead lines have no direct functional relationship with the local landscape, they just pass, while substations do have such a relationship. The substations and other installations such as transition points (hereinafter only 'substations' will be used for readability) are the functional links between the national/regional overhead grid and the local underground power grid, which links to the electricity users in the region.

In addition, substations take up much more space than pylons and they have other specific dimensions and shapes based on their function.
The integration of substations is therefore a more specific, location-related design issue of the installation itself and of the immediate surroundings. It makes a big difference whether the station is located in a rural or urban area.

fig. 34 *Pylons can, intentionally or unintentionally, play a dominant role in the residential environment.*

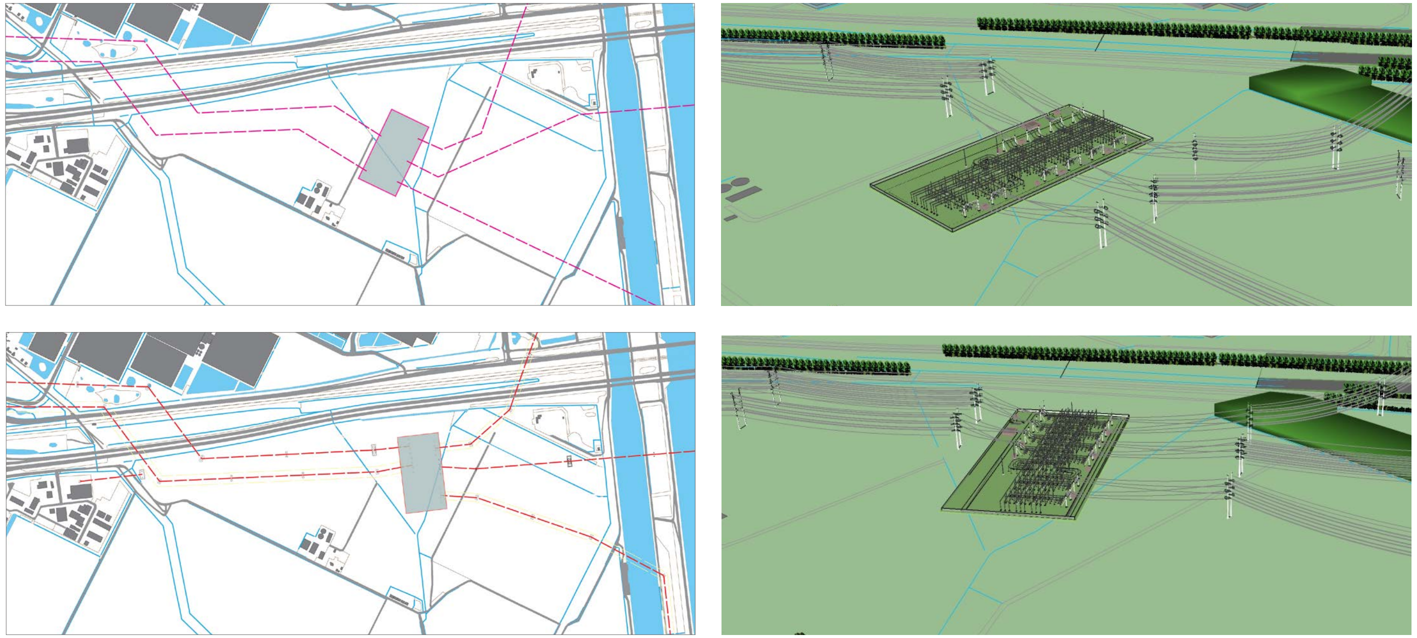
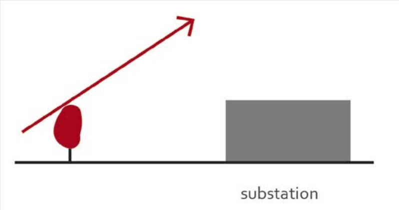
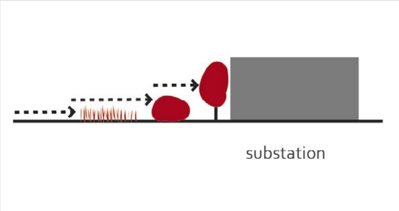


fig. 35 *Project Substation Rilland (Project 2014-2017)*
The new substation (completed in 2017) is a link between various existing and new 380kV connections.
If the station is oriented fitting in the historical plot pattern (top images), many angles would have been necessary in the overhead line, resulting in a visually complex situation.
With an orientation of the installation perpendicular to the main direction bundle of overhead lines, there are fewer deviations in direction necessary.

Sidekick 10 *Guidelines for specific approaches substations (Oudes 2013)*

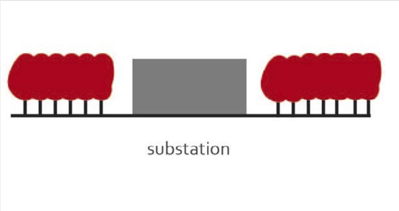


Trees close to the point of perception:
By placing trees close to the point of perception, high vertical elements can be hidden if they are placed at a distance from the tree. As a result, this will have an effect on a local scale, while the vertical elements (such as the substation) can be visible from a larger distance.

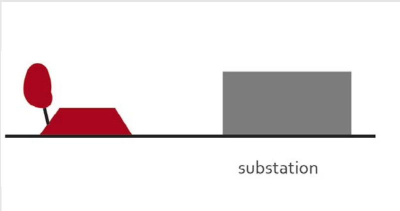


Using vegetation of different heights
Trees, shrubs and grasses have different structures and dimensions and can therefore be used to reduce the visibility of the substation in different degrees. Combining trees with undergrowth can be used to preserve the visually blocking effect, even in autumn and winter.

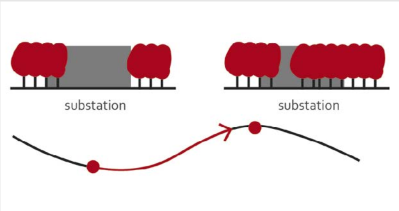
Changing surrounding land-use



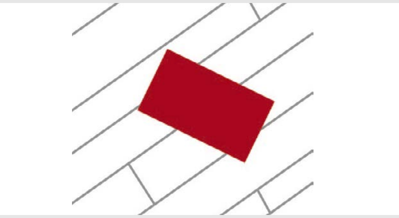
By altering the land use around the substation, the substation can be made less conspicuous. In this way, the visually blocking element has a main function, besides the visually blocking function. Examples are a leisure forest and a tree nursery.



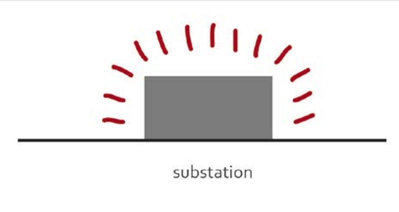
Using the existing landscape
By using the existing landscape, the view towards the substation can be differentiated. Existing vegetation structures can be emphasized or extended to show or obscure (certain parts of) the substation.



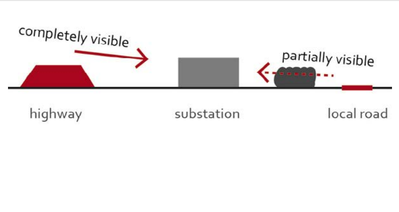
Discontinuous view towards substation
By looking at the main points of perception towards the substation, and positioning certain objects (such as clumps) on specific positions, and interesting view towards the substation can be directed.



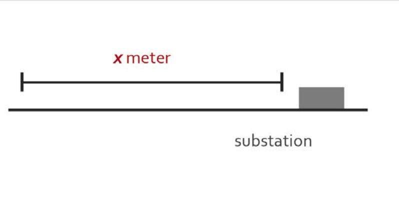
Contrasting orientation
By contrasting the substation with the underlying parcel structure, the substation is better understandable as a part of the electricity grid. This will work best if the parcel structure is dense.



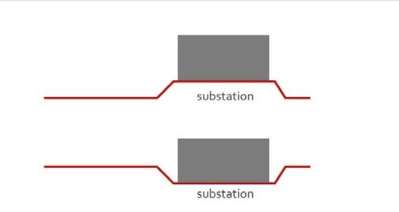
Color of the substation
By altering the appearance, and especially the color of the substation, different effects can occur. If unsaturated colors are used the substation can recede to the background. Furthermore, coloring specific parts can be used to show functioning of the substation.



Different experience on different levels
If a substation is located e.g., near road structures of the same hierarchy, this can be a motive to design conditions for different experiences on different levels.



Large distance from point of perception to substation
By ensuring a large distance between the point of perception and the substation, the scale of the substation is less conspicuously experienced and the functioning of the substation better understandable.



Altering height
Heightening the substation, it will attract more attention. It could even be perceived as emphasizing the functioning on a large scale. This effect can also be reversed: by lowering the substation into the ground, the substation will become less visible.

The primary challenge lies in creating a good connection between the station and its surroundings.
How is the substation orientated relative to the overhead lines that have to be connected to the substation from different directions?
How does the substation fit in with the local lot patterns?

In terms of size, substations can be compared to large sports areas, so cutting through plot boundaries is almost impossible to avoid.
The connection of overhead lines to a substation is preferably done at an angle of 90 degrees, because otherwise additional pylons or yokes are needed. The pylons and/or yokes (with the associated conductors and lightning wires) are higher than the station installations and thus determine the image from a distance.
The aim is to provide a simple and clear appearance
At a substation that does not match well with the orientation of the overhead lines that connect to it, extra yokes or corner pylons are often necessary, which often results in a complicated and visually complex situation.
The substation itself is relatively low and is often barely visible from a distance due to vegetation in the area. The connecting overhead lines are much higher and additional changes in direction with corner pylons play a role in the view from the landscape at a much greater distance.
A substation that connects well to the power grid in its orientation is often simple and less conspicuous.

8.4.1 Elevation

The elevation of a substation also determines the appearance. A sunken or semi-sunken station is less visible from the environment. The overhead lines connected to the station, however, remain clearly visible.
A sunken location has a major impact on the environment, for example on the soil structure, water management and ecology values, so it does not always lead to a better integration.

8.4.2 Combining with other functions.

In urban situations in particular, combinations of substations with existing buildings are possible. This mainly applies to the 110/150kV power grid. The 380kV power grid is generally not located in urban areas. Combinations with industrial buildings or buildings with a cultural-historical significance can contribute to a good integration

9. Landscape plan

A landscape plan primarily is a collection of often relatively small indentations. It is not intended as a conceptual plan, a master plan, for the entire project. Usually, the elements of the plan are carefully locates trees and shrubs whereby the effects of the new overhead line on the landscape are mitigated.
The plan contains all design measures that are necessary for a proper integration of part of the power grid into the landscape and thus for its spatial acceptability.
These are design measures based on all relevant environmental aspects: landscape and cultural history, nature, residential environment and water.
Ecological, landscape and water management measures are integrated as much as possible. For example, necessary water compensation can be combined with improving a wet ecological connection. And necessary forest compensation can be combined with strengthening the landscape structure, as a mitigating measure for fragmentation of characteristic avenue plantings

9.1 Toolkit

The measures in a landscape plan are complementary to the design of the new overhead line after all landscape integration is a threefold mission: designing the power grid, location in the landscape and adjustments of the landscape by taking advantage of opportunities to strengthen the landscape structure, creating a better balance between the landscape and a new overhead line or new substation.
The whole of measures in a landscape plan, together with good route planning, form the landscape integration of the new connection.

Make a Landscape plan

The aim of the design measures included in a landscape plan is to mitigate and compensate for the effects of a new overhead line.
The effects on the landscape are mitigated by introducing new plants/vegetation, changing existing plants and/or strengthening the existing landscape structure.
Compensating for the effects on nature is done by setting up new nature reserves.

Drawing up a landscape plan is not an isolated process. It is important to link this design assignment as closely as possible to other developments in the plan area, such as the construction of a new road or highway, new housing plans, industrial estates or nature development projects. Consultation with local and regional authorities and site management organizations is therefore of great importance.
The entire process of tracing, determining location, integration, detailing and implementation of a project, including the design measures included in a landscape plan, must be regarded as good spatial planning.

It goes without saying that design measures included in a landscape plan are related to the project in question. Usually, the development measures will be located within a zone of approximately 1.5 km wide on both sides of a new connection. This distance is determined, among other things, by the 'Critical viewing distance'. This is a distance of approximately 1200m at which the contours of objects and the distinction of individual objects replace and merge with the background. Beyond this distance, people can no longer see depth. It goes without saying that this is highly dependent on the weather conditions.

Damage to vegetation can occur when a new overhead line is constructed. Sometimes pruning trees or shrubs is sufficient, sometimes felling and grubbing is unavoidable for the construction of (temporary) work roads and work sites.
This damage must be prevented as much as possible and preferably replanted on site.
In this section, an overview of useful and available design measures for integration of the power grid is given. A number of general integration principles are used for the landscape plan.
The primary aim is not to hide the overhead line.
After all, a good coherence of line and landscape requires a balance between comprehensibility - and thus visibility - and the preservation of specific characteristics of the landscape.
Interventions to hide things from view can also lead to extra attention being drawn to them.

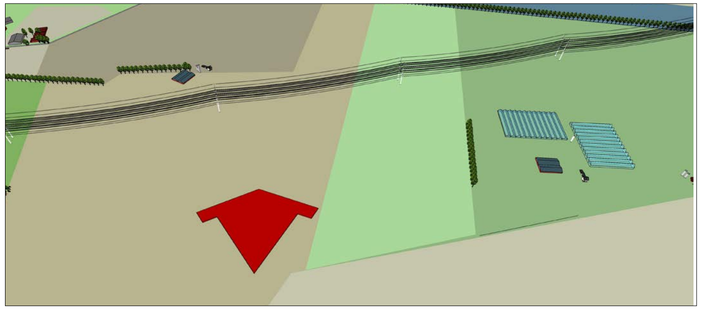
The integration principles are explained on the basis of a number of representative situations:

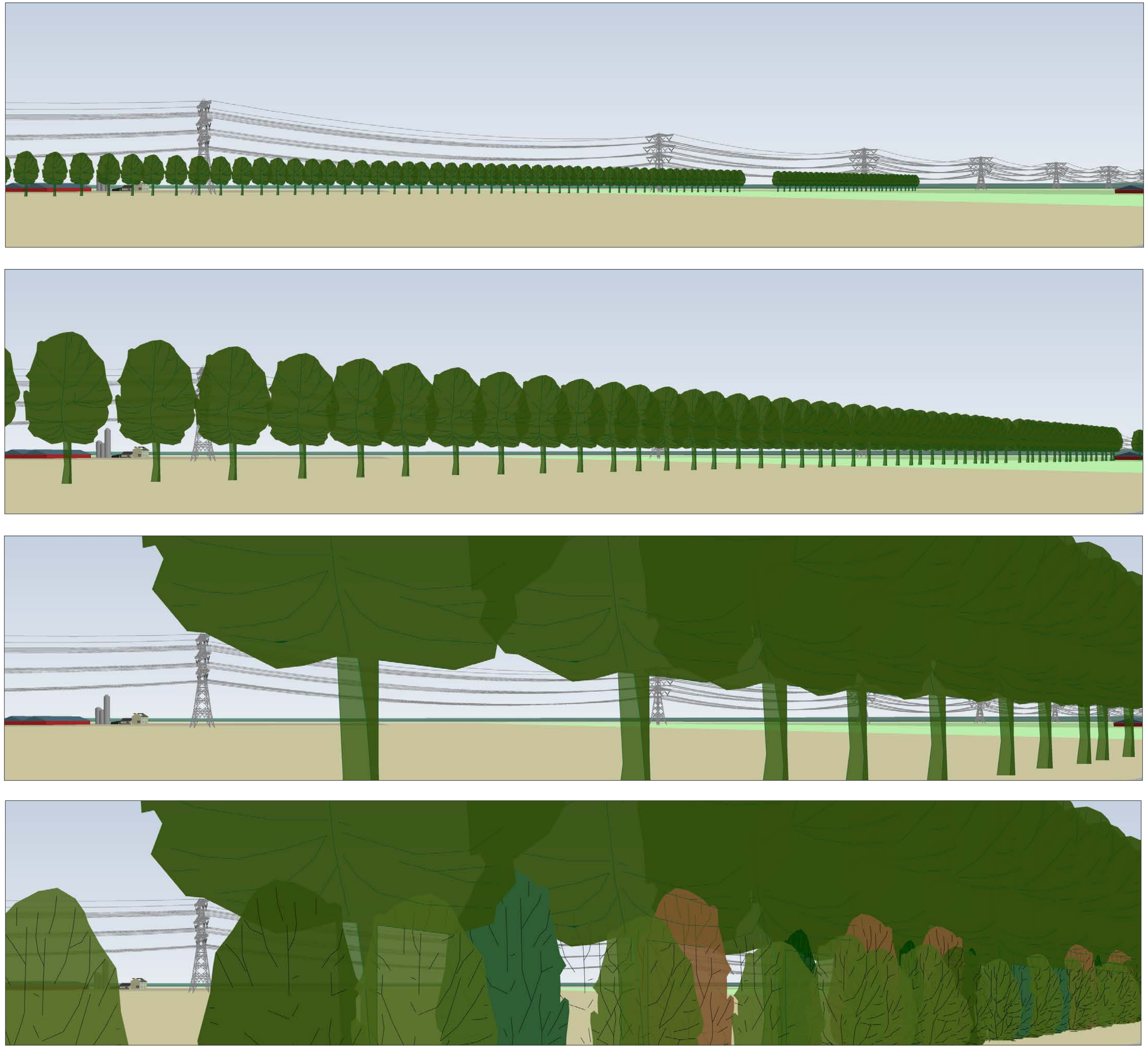
- View on the overhead line;
- Intersection of linear planting;
- Cutting through forest;
- Integration of installations;

The application of these principles in concrete situations is, of course, always tailor-made. Each integration location requires a specific approach and a design tailored to the location.

fig. 36 *Fictional landscape with a 380kV line.*

*The image above is a bird's-eye view,
the images on the right show a view at ground level.
The red arrow indicates the position and viewing direction of an observer at a distance of approximately 400m from the line.*





*The figures illustrate that plants close to the observer limit the view of the line more.
In a number of situations trees will suffice, in other situations the application of shrubs, whether or not in combination with trees, is desirable.*

*fttb:
planting of trees with a height of 20m at a distance of 50m from the line. The line is visible above the plants.*

*planting at 100m from the line. The line is visible above the plants
planting at 300m from the line. The planting blocks the view of the line.*

*planting at 4 00m from the line. The line is visible under the crowns of the plants.
planting 400m from the line. The shrubbery under the trees obscures the view of the line.*

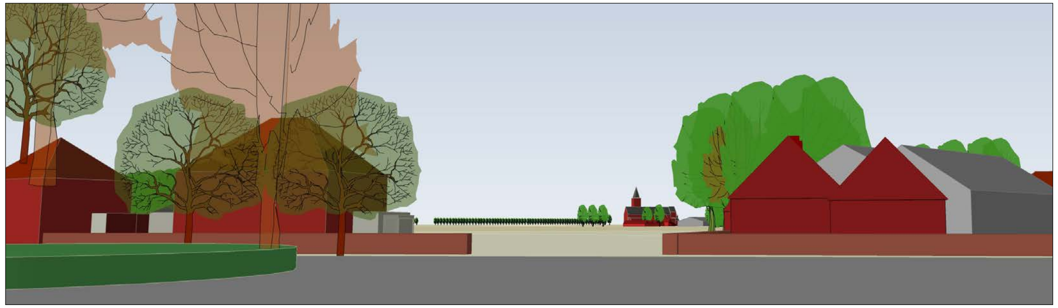
9.2 View on the overhead line

The 'hiding' of the 380kV pylons and lines by planting is practically impossible and not useful. After all, the pylons are considerably higher than most trees and will therefore always rise above them. Planting can make sense in a larger area around the line from the perspective of different observers. Adjusting the spatial structure of the area, for example by planting trees and shrubs along plot boundaries or roads, can be positive for the observer. Such a planting between line and observer changes the orientation to the landscape and thus the view of the overhead line. As a result, the overhead line will be less dominant in the landscape
This principle has a better affect the closer the planting is to the observer.

This integration principle works well in situations nearby a recreational cycling or walking route from which the view of the line is experienced as a nuisance. Trees or shrubs directly along the recreational route direct the viewer's attention to another part of the landscape.
This method also works for locations where an overhead line disrupts a specific beautiful view of the landscape, such as a view to, for example, a village silhouette or a certain landmark.

fig. 37 *High-voltage line near village center. Left bird's-eye views of the situation, the white arrow indicates the position and viewing direction, right image from the village center.*

Situation before realization of the line.



Situation after the line is built.

The pylon is no longer visible due to planting in the edge of the village.

9.3 Intersection of linear planting

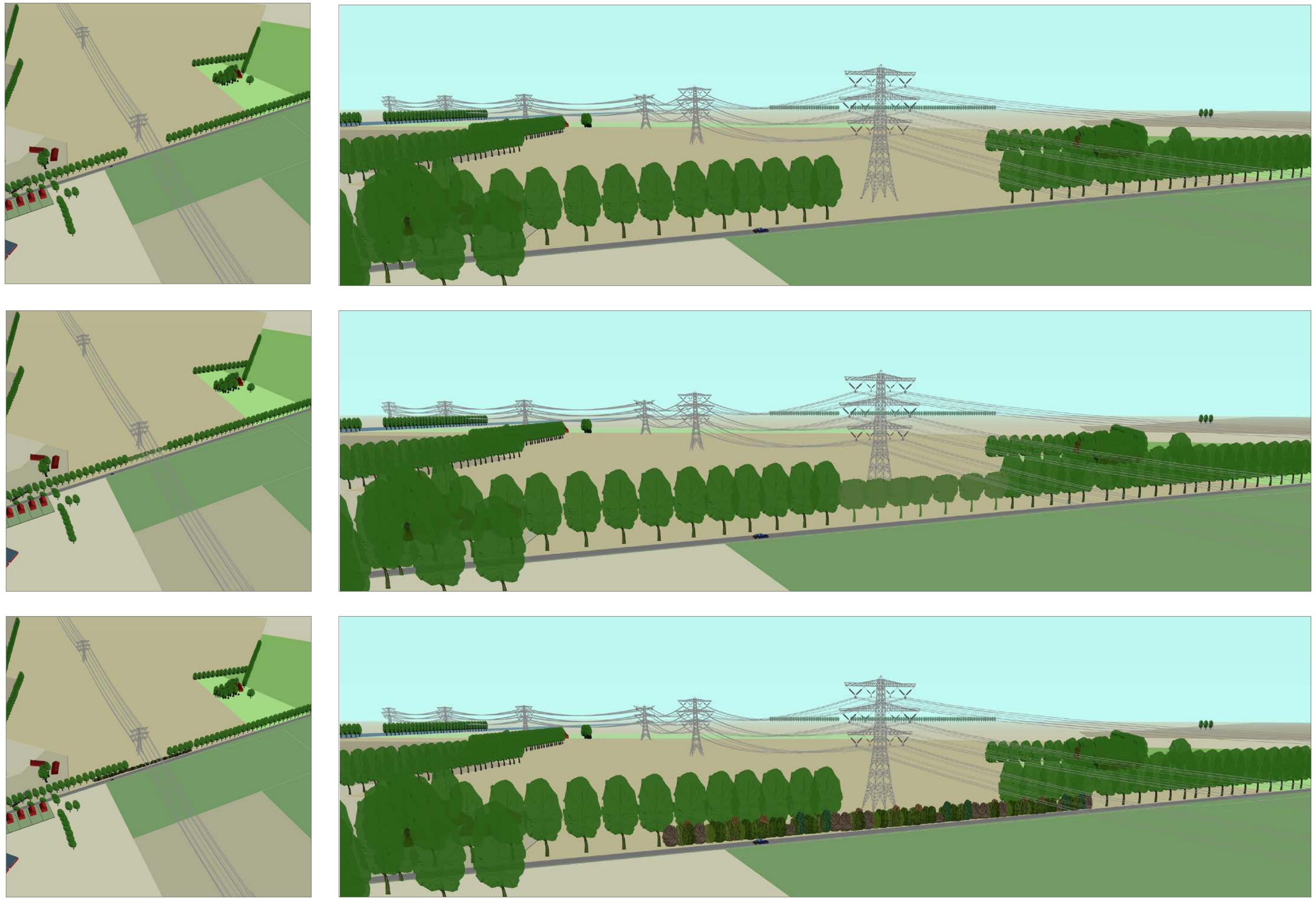
Planting under an overhead line must remain limited in height for reasons of safety. Interruption of avenue plants is sometimes unavoidable when crossing avenues. This can have a negative impact on the landscape as well as an ecological impact.

Planting under the conductors can be limited in height, by regular pruning or by planting types of shrubs or trees that naturally only reach a limited height.
Interruption of the continuity of the avenue image can be partly 'softened' by pruning the treetops under the conductors to a safe height. The crowns become lower, but the rhythm of the trunks is maintained.

The conductors of an overhead line hang high close to the pylons and lower in the middle between two pylons. By locating a pylon close to an avenue planting when tracing and optimizing the connection, the conductors at the site of the avenue planting hang fairly high. This limits pruning damage to treetops.

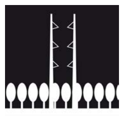
Plants such as hedgerows and avenues of trees often also have an ecological significance, for example as guidance for the flight paths of bats.
Interrupting this planting by an overhead line sometimes affects the habitat of protected animals. This damage can be prevented or limited by shrubbery under the conductors. This keeps or restores ecological continuity in the planting. In order to restore the unity of such a planting, this thicket planting can optionally be arranged over a greater length.

fig. 38 *Intersection of overhead line with linear vegetation*
fttb:
- *The line crosses the planted avenue halfway between two pylons, where the conductors hang low, an interruption of the row of trees is necessary.*
- *The line crosses the avenue near a pylon, the trees can be maintained but must be pruned.*
- *At the location of the interruption, to ensure the continuity of a route of bats low shrubland is planted.*



9.4 Cutting through forest;

Careful route planning will prevent cutting through forest areas as much as possible. Where this is unavoidable, a denomination is created in the forest or an edge of the forest is 'cut off'.
This has an important ecological and visual impact. When integrating the overhead line, from a landscape point of view, an attempt should be made to prevent a sharply delimited, open strip in the forest from being created. A sharp cut creates an unnecessarily large contrast between the area next to and below the overhead line.
It can also be beneficial from an ecological point of view to avoid sharp boundaries and to allow edges to transition gradually from forest through shrubbery to open area as much as possible. It is also possible to consider converting part of the forest into a semi-open landscape.
The new overhead line is then less profoundly experienced as a strong intersection of a forest, but as a line at the edge of a forest at the transition from a closed to an open landscape. The line is thus more 'naturally' incorporated into the landscape.



Let the design of the "obstructed" strip of land match the character of the environment

Carefully arranging the obstructed strip of land in line with its surroundings can also be seen as a form of nature inclusive design, whether or not to compensate for a loss of habitat for flora and fauna due to the construction of the overhead line (Crow 1958).
From an ecological point of view, a succession of forest elements, as an ecological connection, can provide significant added value.
When cutting through an existing forest, it can make sense both from an ecological and landscape point of view to convert part of the forest into an agricultural area and

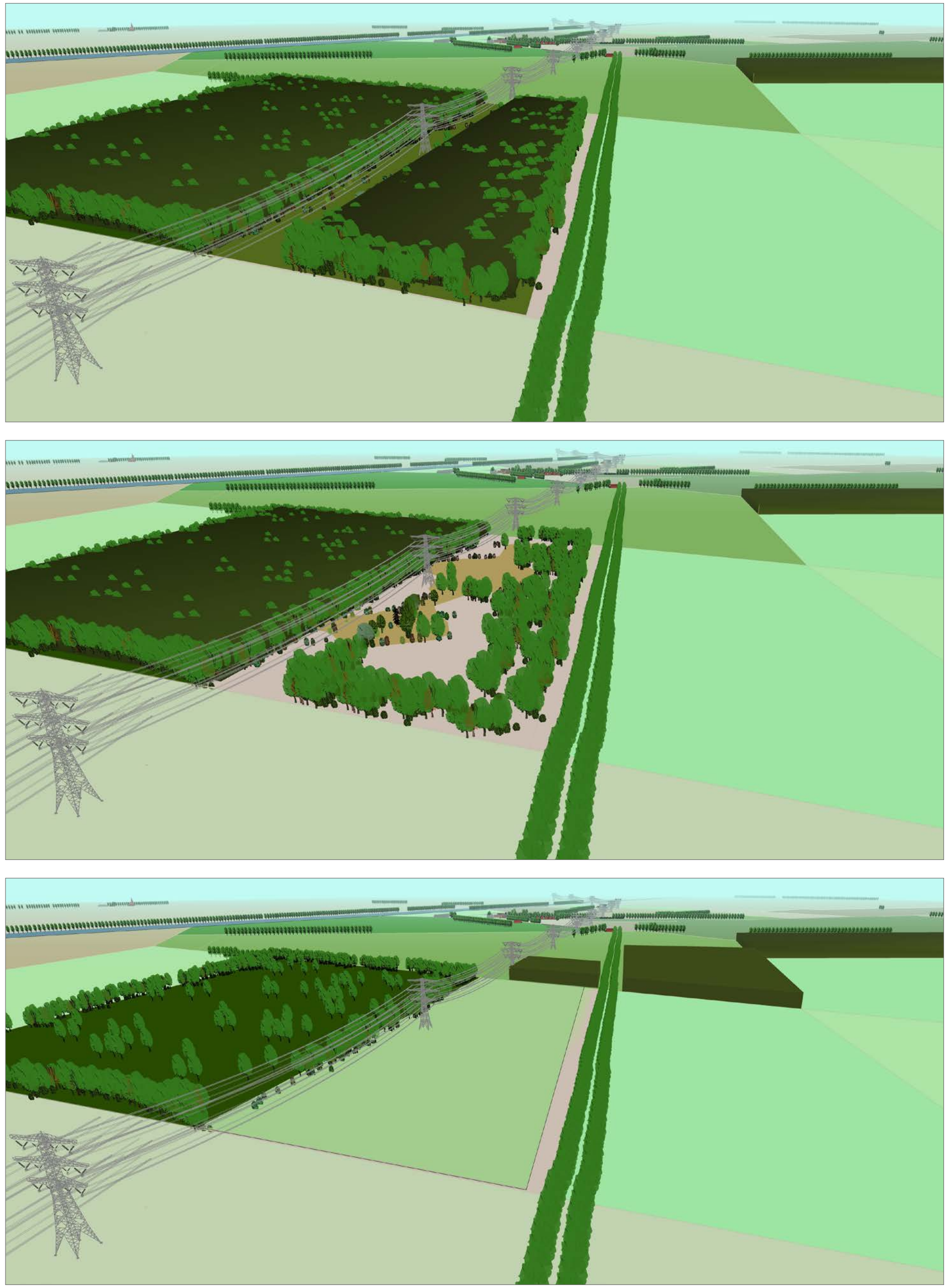


fig. 39 *Cutting through a forest. Sometimes cutting through a forest with an overhead line unavoidable.*

fttb:
The obstructed strip of land is subject to height restrictions due safe distances from the conductors. That means that it is not possible to maintain the existing forest but that it will be
transformed into low forest with more clearings and gradients to the nearby forest.

Another possibility is to transform a part of the forest into, for example, a half open moorland. The new connection is then more or less self-evident on the transition of two landscape types.

It is also conceivable that part of the forest is transformed into agricultural land and that the forest compensation is used for the construction of new forest that can play a role as an ecological link and
thereby strengthening the nature network.

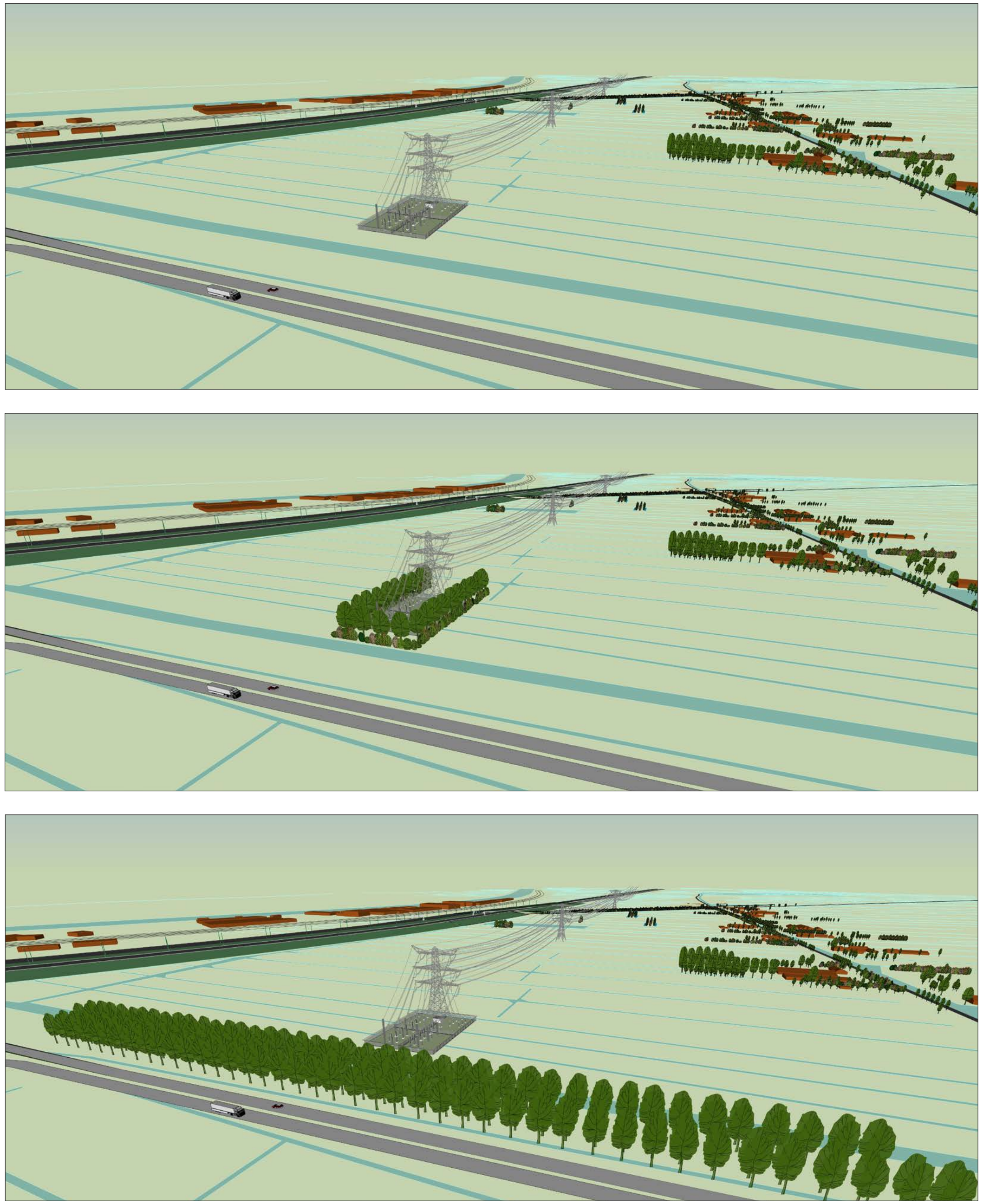


fig. 40 *principles for integrating installations in open landscape.*
fttb:

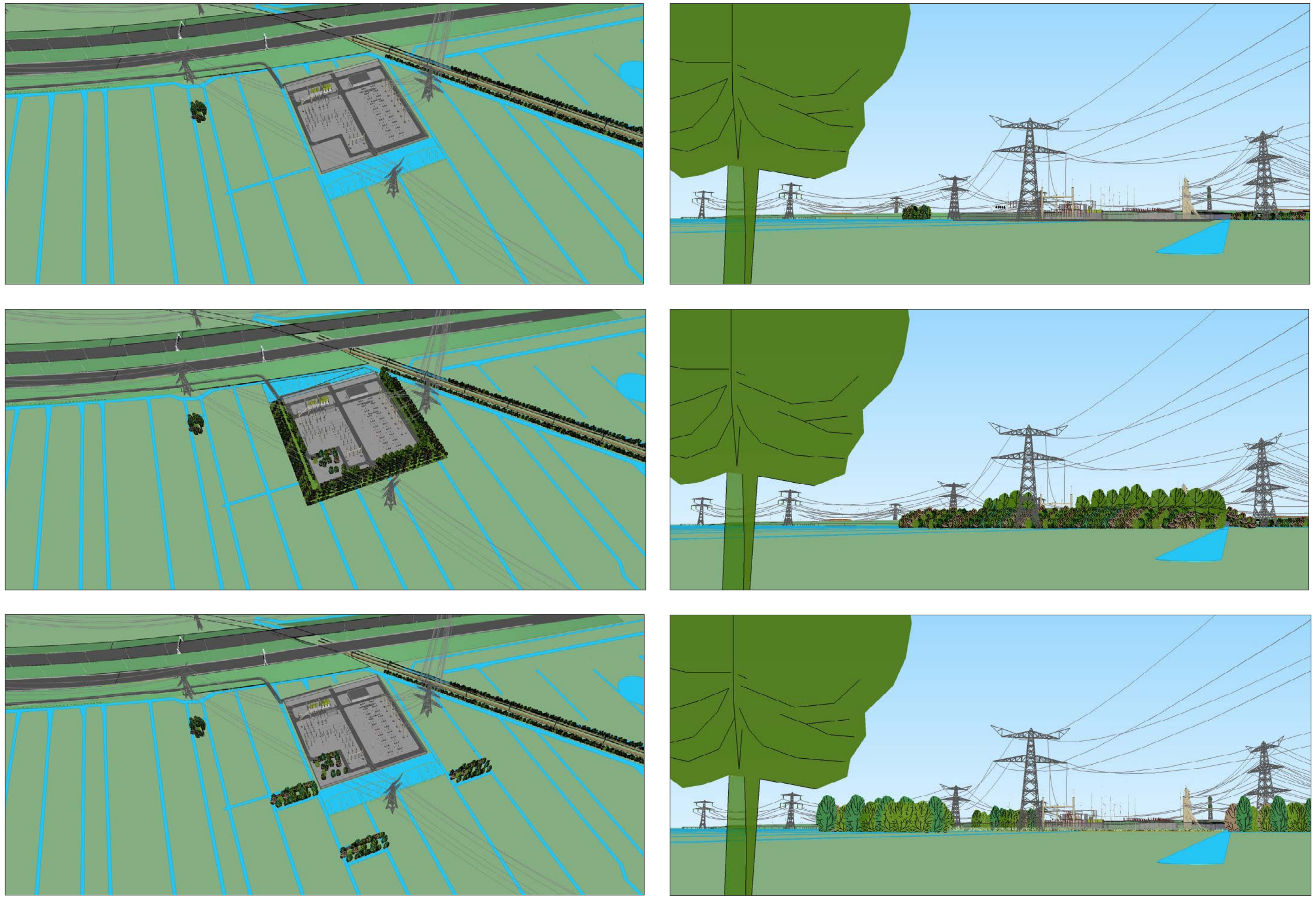
- *Transition point without integration measures*
- *Integration by planting trees around the installation*
- *Integration by applying road planting consisting of avenue trees*

subsequently create new forest, resulting in a series of forest elements. Such more structural measures must be in line with and fit in with the existing spatial plans in the area.

9.5 Integration of installations;

High-voltage substations are mainly located in (semi) industrial areas, urban fringes and rural areas. Close to residential areas, an attempt is usually made to hide the installations as much as possible. Isolated in rural areas, showing the installation correctly results in a low impact. Planting to hide installations can be useful; after all, switching stations and transition points are not as high as pylons.
This does not lead to a better situation in all cases, however. An isolated transition point in an open area with plants is more dominant than one without plants. With a businesslike, restrained design and use of materials, these installations are often best integrated into the landscape. In specific situations, however, the cohesion with the environment can be improved by means of vegetation and earthen walls. This works best in more (semi) enclosed areas, where the view of the environment from specific locations is changed by these measures. The 'green clad' installations can thus have less influence on the genius loci. Due to the use of paved ground surface in stations, water compensation is often required. This offers good possibilities for a combination with nature inclusive design.

fig. 41 *Integration 380kV substation (Project 2012-2018)*
Above: The substation was connected to existing 380kV lines. It is precisely located between into the existing cultural-historically valuable ditch pattern.
Middle: Variant as suggested by residents in the vicinity. The substation is hidden from view by a high embankment with trees and shrubbery. The substation, including the embankment, does not fit within the cultural-historical pattern of ditches. The effect of the embankment and planting in the open landscape is that extra attention is drawn to the substation.
Below: Variant 'Landscape': Commodity woods. These are characteristic elements for this historic landscape. These groves have little influence on the openness due to their limited size and because they are scattered in the landscape as separate elements. By carefully locating them the view of the station will be limited without seriously affecting the openness of the landscape.



9.6 Art, architecture and urban planning

In exceptional situations, added value arises if one or a few pylons are given a very specific design, or if special architectural elements are added.

fig. 42 *Art as a means of integration*

The Source
The artwork 'Source' is unique because of its concept and its dimensions. It is a monumental art installation on a 225 kV overhead line 'Amnéville - Montois' France. Four high-tension towers and 1.5 kilometers of the line where transformed into works of art. www.art-elena.com

fig. 43 *Integration 380kV transition installation in suburban area*
The intergration is achieved by the realization of a park, with play grounds and walking opportunities for the residents of the nearby suburb. (Project 2006-2016)

fig. 44 *Substation Tanthofdreef Delft (2013-2014)*
Links fttb:

- *situation befor: to the left of the substation there is an 150kV overhead line in the park;*
- *after the demolition of the 150 kV connection, a small pond has been realized in the park;*
- *on the foundation of the removed mast an island has been created with 4 trees on it.*

fig. 45 *Cross-sections at the location of the pond*

- *above situation before*
- *below situation after realization of pond with island*

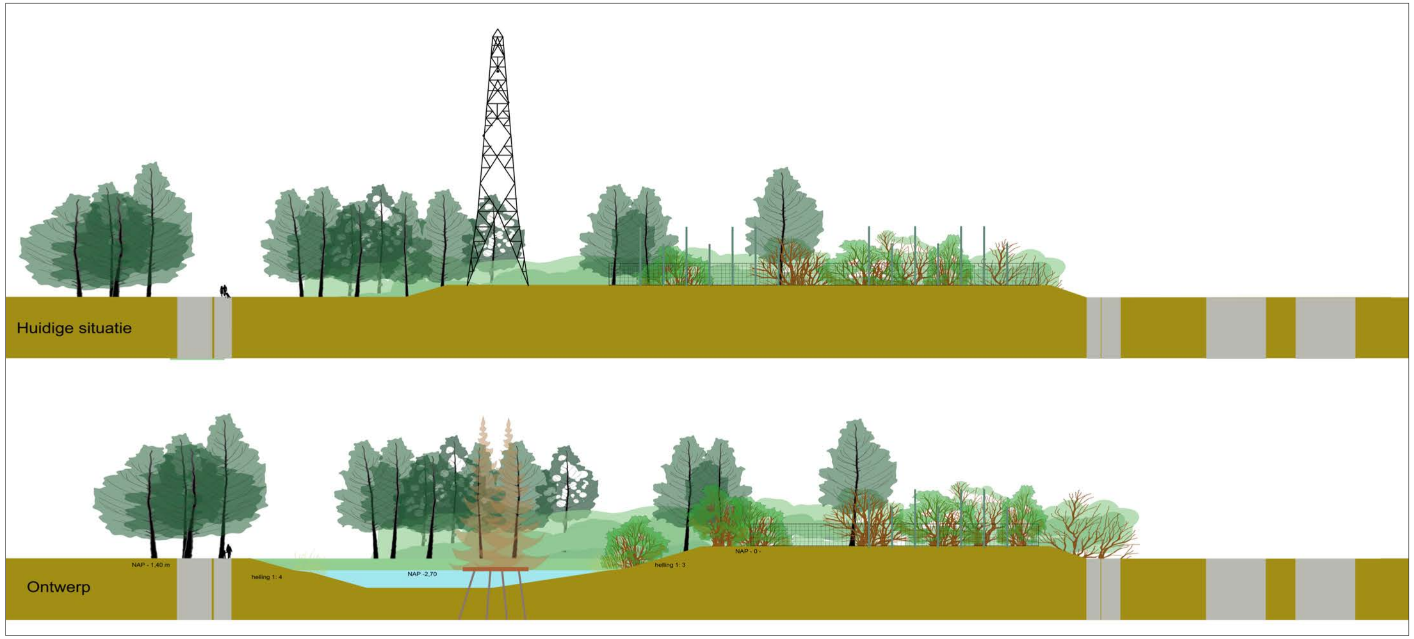


fig. 46 *Aerial view after realization of pond with island and group of trees*

10. Environmental Impact Assessment

With an Environmental Impact Assessment (EIA), all information is presented that is necessary to be able to fully consider environmental interests in the decision-making process.
The assessment framework included here is a method of impact determination and assessment developed in the period 2006-2020 in a number of 380 kV power projects:

10.1 Assessment framework

An important part of the planning process is the question of how plans for building new parts of the power grid should be assessed on the Landscape aspect. Based on the description of landscape quality included above, this assessment framework is also made up of three levels
- Grid level
- Line level
- Pylon level

The central issues are:
- What are the effects of the various investigated alternatives on the previously chosen scale levels: grid, line, pylon?
- How are those effects assessed and with what criteria? Are the effects temporary or permanent, is it only negative or can it also have a positive effect on the landscape?

The starting point for route planning and designing the alternatives is a systematic, integral approach outlined above for good landscape integration. Moreover, the alternatives are based on different tracing principles, such as bundling or an autonomous line.

The different alternatives are assessed with the criteria:

Grid level
- Influencing existing relationships that determine it
- Route quality: Design of the route of the line (e.g. pylon types, tracing principles)

Line level
- Influencing existing cohesion that determines the genius loci of areas.
- Influencing coherence between specific elements and their context.

Pylon level
- Influencing coherence between specific elements and their context.
- Physical influence on specific elements

Temporary and permanent effects

During construction, excavating will take place and construction sites will be set up. This has a temporary, relatively small effect on the landscape. This effect will differ slightly per alternative and is therefore often not included in the impact assessment.
For cable routes, which are realized in open excavation, there is no planting possible on top of the cables after construction. In densified green areas, unplanted zones therefore appear above the cable route.
In some areas with peat in the ground due to the settling of the cable a 'mound' will be installed along the length of the cable route, which will settle to ground level after a few years. During this settlement period there is therefore a very limited landscape effect, which is often not included in the assessment, but can be mentioned.

Research area per (sub) criterion

For all criteria, the study area is determined by the distance at which an effect can be observed and experienced, in other words: the scope of the landscape effects

Cultural history

Cultural history is an integral part of the landscape assessment. After all, landscape is regarded as a process of which the current situation is a snapshot, a moment in time. The current cultural landscape is the result of years of development. The cultural-historical aspects thus form an integral part of the characteristics and quality of the landscape. The landscape assessment is therefore automatically also a cultural-historical assessment. If cultural-historical aspects are influenced, this directly affects the landscape.
Archeology is part of cultural history, but is mostly investigated as a separate study on Archeology, Soil and Water.

Operationalization the assessment criteria

The effect determination for the landscape aspect is done by assessment based on 'expert judgement' on a seven-point scale.

Impact assessment scaling	
+++	Very positive effect
++	positive effect
+	Slight positive effect
0	Hardly any effect
-	Slight negative effect
- -	Negative effect
- - -	Very negative effect

Limits of the scaling

The description and assessment of the environmental consequences (in addition to landscape and cultural history, also nature, soil and water, spatial functions, etc.) in an Environmental Impact Assessment (EIA) aims to enable a proper assessment of the route alternatives and to facilitate decision-making regarding the substantiate preferred alternative.

Class boundaries can be used when translating quantitatively described effects (such as, for example, the use of footprint pylons in an archeologically valuable area). These class boundaries are project-specific, since project-specific circumstances such as route length, implementation, area properties, etc. must be taken into account. For each project, the class boundaries are defined in such a way that relevant differences between the alternatives become clear and traceable, as well as the absolute size or severity of the effect. This approach makes it impossible to compare the qualitative impact assessments of different projects: each project is in fact unique.
This is no obstacle for a responsible assessment of the route within a specific project.
Supplementary to the table, the influence of the genius loci can be assessed as positive at line level, if the line adds something to the specific landscape appearance, or if the genius loci is positively influenced by the disappearance of an existing overhead line.

10.2 Effects at grid level

- Quality of the route
- Influence on Regional Landscape Pattern

The grid-level rating is only used on the full route alternatives, not on sections or details.

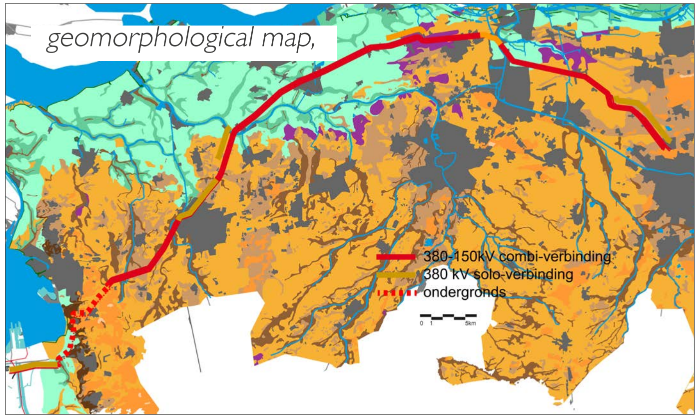
10.2.1 Quality of the route

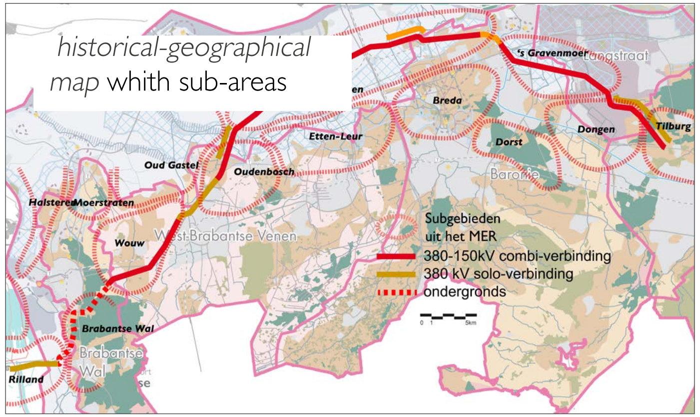
This assessment criterion looks at the recognizability of an overhead line as a supra-regional infrastructural element. Which route planning principles are applied and is this done consistently, is there a fragmented image due to, for example, underground parts with transition points?
The combination of these factors determines the quality of the route. This means that a connection that scores very unfavorably on one of these aspects does not automatically score very negatively when taking the whole route into account. It also means that a connection that scores well on one aspect does not automatically score very well for the whole route.
On the basis of this criterion, it can be assessed whether a route design does full justice to the character of the line as supra-regional infrastructure in conjunction with the Regional Landscape Pattern. This pattern is mainly formed by the variation of open and closed landscapes, the urban and rural areas and the supra-regional infrastructural networks – roads, railways, rivers, canals, dikes, etc.
The degree of recognizability of the connection as a supra-regional infrastructure determines the score.
It is also important that a connection is clear and understandable and recognizable as an infrastructural entity. A connection that is strongly fragmented by, for example, underground parts, lacks this clarity, comprehensibility and unity. The number of underground parts, their length and the location of the transition points determine whether a connection scores neutral to negative.
Creating a route plan in which the new connection follows local infrastructure with many angles, can lead to a very large visual complexity. This is assessed as 'very negative'.
It is important for the quality of the route to use as few different routing principles as possible; straight lines over longer lengths are preferred. The uniform use of a tracing principle in the route will ensure a smooth line.

Effect Quality off the route	
Effect	*Description*
Very positive effect	n/a
positive effect	n/a
Slight positive effect	n/a
Hardly any effect	The route is easily recognizable as supra-regional infrastructure and does not respond to local phenomena
Slight negative effect	Route is moderately recognizable as supra-regional infrastructure and reacts only slighly to local phenomena
Negative effect	Route is poorly recognizable as supra-regional infrastructure and reacts quite a lot to local phenomena
Very negative effect	Route is not recognizable as supra-regional infrastructure and reacts strongly to local phenomena

10.2.2 Influence on Regional Landscape Pattern

The route of an overhead line can influence the existing Regional Landscape Pattern.
This happens when the recognizability of it changes, for example because the connection forms a completely new visible line in the landscape. The seriousness of the influence strongly depends on the local landscape and is therefore location specific.
The degree of influence on the Regional Landscape Pattern determines the impact assessment. A neutral score (0) is assigned to an alternative that does not cause changes in the Regional Landscape Pattern.
Influencing the Regional Landscape Pattern could take place in very open areas where no overhead line exists yet.
Effect Influence on Regional Landscape Pattern (RLP)





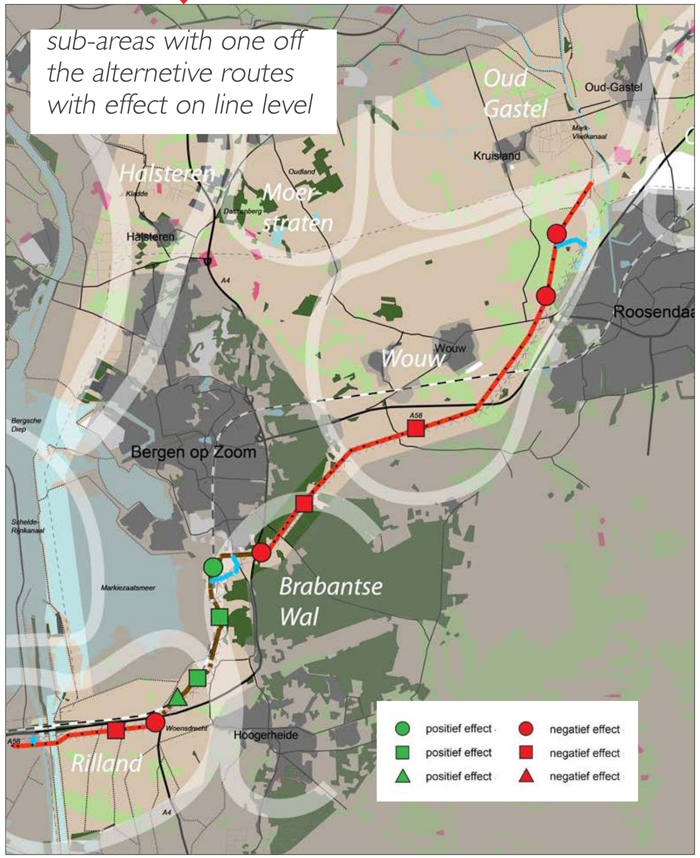


fig. 47 *Project 380kV ZWO (Project 2017-2022)*
Example of using maps in an Environmental Impact Assessment.
The Regional Landscape Pattern here represented by the geomorphological map, the map with sub-areas that give a picture of the historical-geographical situation and the overview of the regional infrastructure are the basis for the effect description at grid level.
The landscape on the scale of the sub-areas are the basis for the effect description at line level.

fig. 48 *Example of photo manipulation of a new connection to provide insight into the effects on the landscape image.*
Above situation before, below after realization

Effect Influence on Regional Landscape Pattern (RLP)	
Effect	*Description*
Very positive effect	Major reinforcement of the RLP
Positive effect	Reinforcement of the RLP
Slight positive effect	Some reinforcement of the RLP
Hardly any effect	No reinforcement of the RLP
Slight negative effect	Some weakening of the RLP
Negative effect	Weakening of the RLP
Very negative effect	Major weakening of the RLP

Effects visualized on a map

Effects must be displayed in map images in addition to a description.
Attention could be paid to a schematic representation of the tracing principles and implementation methods, for example by indicating the succession of the interruptions through underground parts, and the different pylon types and bundling methods.

10.3 Effects at line level

At line level, the following two assessment criteria apply:

- Influencing genius loci
- Influencing coherence between specific elements and their context at line level

10.3.1 Influencing genius loci

The genius loci is determined by the appearance and meaning of an area. A landscape around a highway has a completely different character than a semi-natural peat meadow landscape with a lot of water. An overhead line has a completely different influence in an area with a highway than in a more natural landscape.
Depending on the characteristics of an area and the construction of the overhead line, there is a strong or less strong contrast between the overhead line and the character of the landscape.

(Sub)areas

In an Environmental Impact Assessment (EIA) a division into sub-areas is often used to apply a clear structure to the process and the document(s). The genius loci's are described and assessed on the basis of sub-areas. These are geographic units with their own genius loci that distinguish them from the surrounding area. Areas with a recognizable character of their own. A division into sub-areas can mean that effects can be cross-border. For example, positive effects as a result of the demolition of an existing connection can occur in one sub-area and the effects of the new connection in another sub-area. In addition, sub-areas often have a different surface area. This must be taken into account in the overall assessment.

Visual complexity

In assessing visibility, the visual complexity of the connections plays an important role. This is determined, among other things, by the rhythm of the pylons, the visibility of the deviations therein, such as angles, different technical constructions such as crossings and transition points, unequal field lengths or differences in height of the pylons. The linear perspective of the connection also

plays a role in relation to other elements in the landscape. Local deviations in the design of the overhead line partly determine the quality of a connection and its visual complexity.
Alternative routes are initially designed on the basis of certain principles: such as bundling or making a line as straight as possible. Deviations from these principles occur, such as with local changes of direction, a angle to avoid a building. There are also deviations in height and field length.

Deviations in order from severe to less severe:

- Directional changes
- Height deviations
- Field length deviations

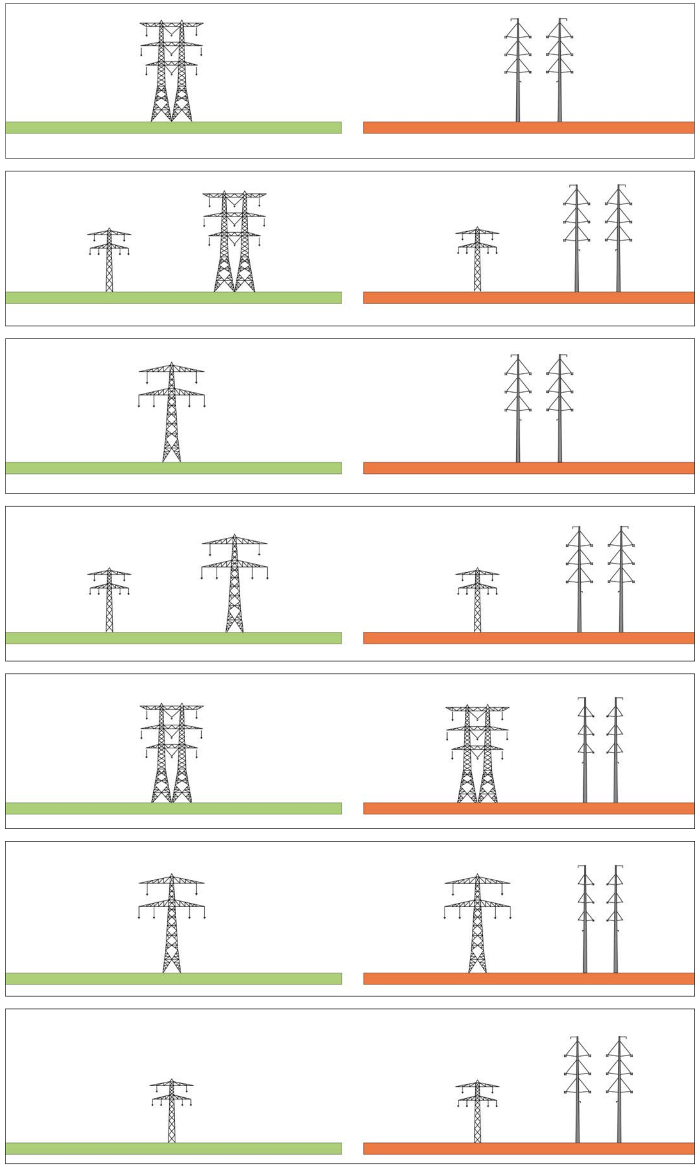
The combination of the deviations in number, type and mutual distance determines the visual complexity of an overhead line. The seriousness of the deviations depends on the landscape situation, for example the degree of openness of the area on site.
Sometimes local deviations show a clear connection with the, for example high pylons with a short field length when crossing a river. The logic of such deviations is understandable and so strong that it does not have a negative effect on the landscape.
The influence on the genius loci depends on;
number and severeness of the deviations the resulting in visual complexity.
In those cases where the new connection is built next to an existing connection, it is also important to what extent the two connections run exactly parallel or slanting.

Specific situations

Due to their height, overhead lines can disrupt landmarks. These are striking high elements in the landscape such as church towers, which can be seen from a great distance. This effect is highly dependent on the observation position.

fig. 49 *Photo manipulation of with bundling off an existing overhead line with new line to gain insight into the effects on line level (Project 2017-2022)*

fig. 50 *Different forms of possible bundling of existing overhead lines (left) whith new ones (right) to gain insight into the effects on grid level and line level (Project 2015-2022)*



Sufficient space must be left under the conductors of the overhead line and there must be no deep-rooted plants on a cable bed. As a result, it is possible that planting structures, such as characteristic rows of trees along avenues of an estate have to be interrupted.

Effects of bundling

Bundling with other overhead lines
The influence on the genius loci depends on the extent to which an overhead line is present in the landscape, the extent to which a new connection fits into the landscape, fits with the genius loci or contrasts with it.

In The Netherlands where bundling is an issue a number of combinations may occur:

- an existing 150kV overhead line with lattice pylons
- an existing 380/220kV overhead line with lattice pylons
- an existing 380/220kV overhead line with pole pylons

These can be removed, bundled or combined with:

- a new overhead line with pole pylons
- a new overhead line with lattice pylons

New connections can be made in the landscape:

- Bundled with existing connections;
- Located at some distance from the existing connections;
- Located in an area where there is no connection yet.

An overview has been drawn up of various combinations for the purpose of a careful and understandable impact assessment. The purpose of the overview is to define a limited number of terms that can be used and with which the impact assessment can be drawn up in an understandable manner.
The overview provides insight into the differences between a number of existing and new situations on the basis of different pylon types. The impact assessments are based on a connection or part of a connection performed with these pylon types and the effect of deviations such as changes in direction, deviating field lengths, deviating pylons or pylon heights.

A limited number of categories have been used which do not indicate absolute but relative values within the relevant scope: Neutral; Firm; More Firm; Very Firm.
Firm is intended to be an indication of the degree of presence, the degree to which a connection in the landscape is striking.

The effect on the genius loci is qualitatively described and visualized on the basis of projections on the map, cross sections, perspective drawings and photo montages linked to the scoring method. The specific landscape and cultural-historical characteristics of an area ultimately determine the effect.

If the appearance and thus the perception of an area does not change and no contrast is created, there is no effect. There is a positive effect when the individual character of the line adds something to the genius loci, for example because the line provides perspective in an open landscape. If an existing line is removed, this can have a positive effect on the genius loci. Slight influences on the character and/or slight contrasts form a minimal negative effect. When the character changes and/or there is a contrast, this leads to a negative score. A strongly different character and/or a strong contrast leads to a very negative score

Influencing Genius Loci	
Effect	*Description*
Very positive effect	Major reinforcement genius loci
positive effect	Reinforcement genius loci
Slight positive effect	Some reinforcement genius loci
Hardly any effect	No influence on genius loci
Slight negative effect	Some weakening genius loci
Negative effect	Weakening genius loci
Very negative effect	Major weakening genius loci

10.3.2 Influencing coherence between specific elements and their context at line level

This criterion concerns landscape elements such as village and city silhouettes, distant features, a row of houses and buildings along a road or special groves or avenues. When an intervention, such as building an overhead line, disrupts the cohesion between these elements and the landscape, or impacts landscape elements, there is a negative effect. This kind of disturbances will make a gap in the 'story' of the landscape. An example of a landscape element at line level is a row of houses and buildings lining a road. If such a spatial element is passed at a short distance or is crossed by an overhead line, this has a negative effect.
Positive effects can also occur with this criterion, for example if a gap in the 'story' of the landscape is restored by removing an existing connection.
For the assessment of the effects on elements in their landscape context, the local situation (where, which elements, which relationship) is decisive for the impact assessment in all cases.

Examples of elements at line level are a row of houses/ buildings lining a road or an estate with avenues and sight angles. A new connection has a negative effect if at line level there is a change to the coherence of a (cultural-historical) element with the environment. This is done, for example, by passing a row of houses/buidlings at a short distance or crossing it at a slight angle.

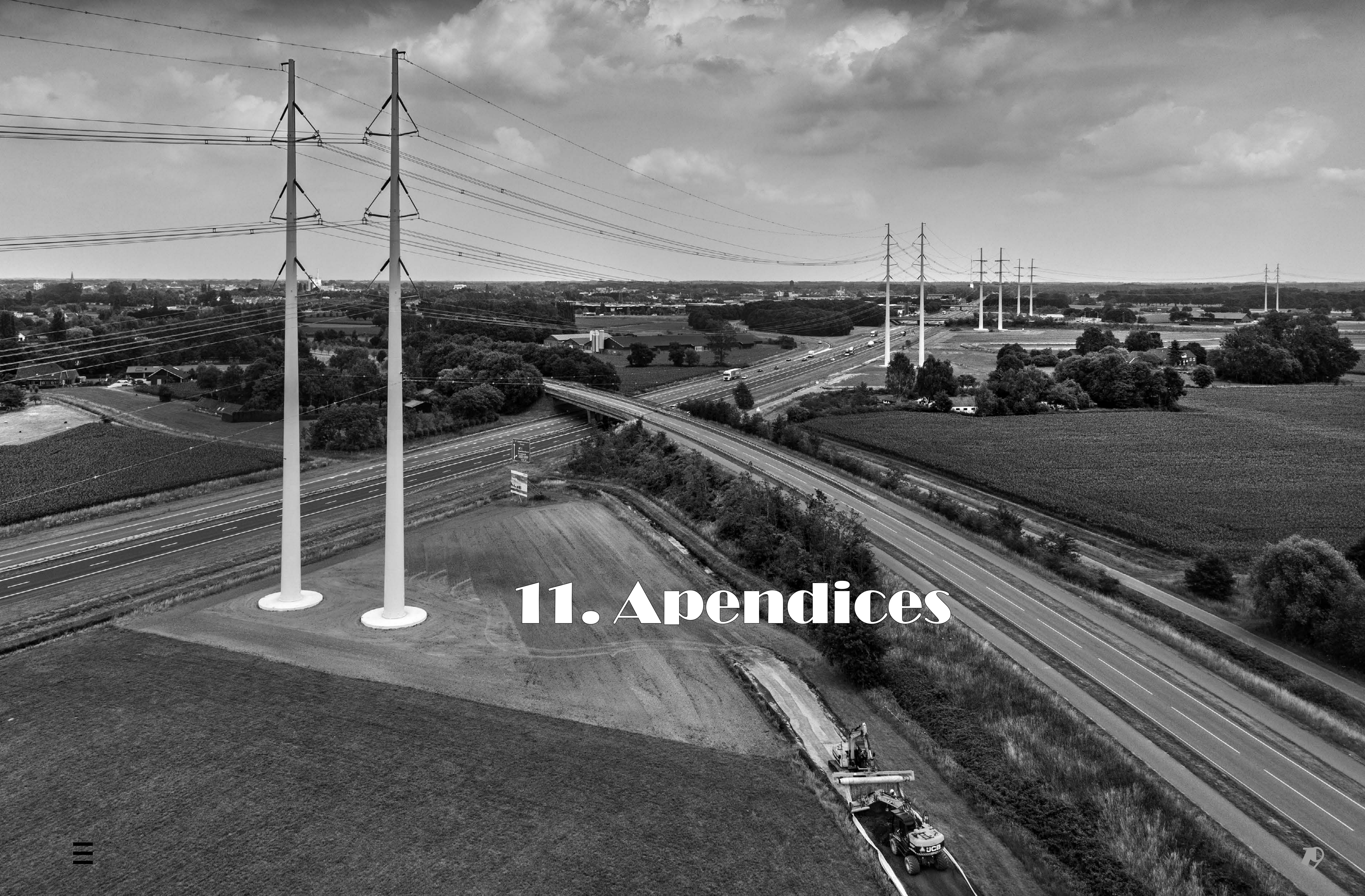
Influencing coherence between specific elements and their context at line level	
Influencing coherence between specific elements	
Effect	*Description*
Very positive effect	Major reinforcement coherence
positive effect	Reinforcement coherence
Slight positive effect	Some reinforcement coherence
Hardly any effect	No influece coherence
Slight negative effect	Some weakening coherence
Negative effect	Weakening coherence
Very negative effect	Major weakening coherence

10.4 Effects at pylon level

Influencing coherence between specific elements and their context at pylon level.
Placing a pylon or transition point or digging a cable trench close to historical architectural monuments or other historically important elements, such as solitary trees or remnants of former fortifications, can have a negative effect.
When pylons are close to special landscape elements, such a quay, a watercourse or a monumental building, the specific spatial coherence between that element and its environment changes. There is also influence on city/ town edges or in recreational green areas. For example, seen from playgrounds, sports fields, residential streets and paths, pylons can be confrontational and thus influence the landscape and urban cohesion.

Physical damage to specific elements is not relevant because in the routing phase a pylon is never placed on a monumental building or element. It is possible, however, that a pylon, transition point or cable route is placed in the vicinity of protected objects or protected historical geographical elements. In such cases, the effect is described on the basis of the known pylon positions, cable routes or transition points. The locations concerned are drawn on a map on the basis of which the effects are described. This is done qualitatively, whereby attention is paid to the cohesion between elements and their context as well as to the physical influence of the specific element or object.

fig. 51 *Photo manipulation of a new overhead line in a cultural-historical valuable situation to gain insight into the effects on pylon level (Project 2008-2019)*



11. Apendices

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11.2 list of projects

1981, 380kV overhead line Bemmel-Doetinchem

1981, 380kV overhead line Goor-Hengelo

1992, 330kV overhead line Zwolle-Eemshaven

2006 - 2016, 380kV overhead line Zuidring Randstad Zoetermeer -Bleiswijk

2008 - 2019, 380kV overhead line Eemshaven-Vierverlaten

2009 - 2011, 380kV overhead line Doetinchem-Wesel (D)

2009 - 2021, 380kV overhead line Noordring Randstad Bleiswijk-Beverwijk

2011 - 2013, 380kV substation Wateringen

2011 - 2015, 380kV overhead line Doetinchem-German border

2012 - 2018, 380/150 kV substation Breukelen-Kortrijk

2013 - 2014, 150 kV substationTanthofdreef Delft

2013 - 2016, 110kV substation Emmeloord Zuidervaart

2014 - 2017, 380kV substation Rilland

2014, 380kV substation Oostzaan

2015 - 2023, 380kV overhead line Borssele-Rilland - Zuid-West 380kV West

2017 - 2023, 380kV overhead line Rilland-Tilburg - Zuid-West 380kV Oost

2017, 220kV substation Oudehaske

2018 - 2022, 380kV substation Tilburg

2019 - 2020, 110kV substation Bolsward

2019, 150kV substation Etten-Leur

11.3 Origin of images

Author

- cover
- fig.: 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16a, 18, 19, 20, 21, 22, 23, 24, 25, 26c, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
- all icons
- Sidekicks: 1, 8, 9,

TenneT TSO

- fig.:10, 11, 17, 19b

Chris Pennarts commissioned by TenneT

- 16b, 26a,26c
- all photos at chapterpages

Sidekick 2, 4: Internet anonymous
Sidekick 3: Albrecht Dürer, Self portret 1500
Sidekick 5: Edward Hopper, Compartment C, 1938
Sidekick 8: René Margritte, Le Blanc-seing, 1965
Sidekick 10: Dirk Oudes 2013: