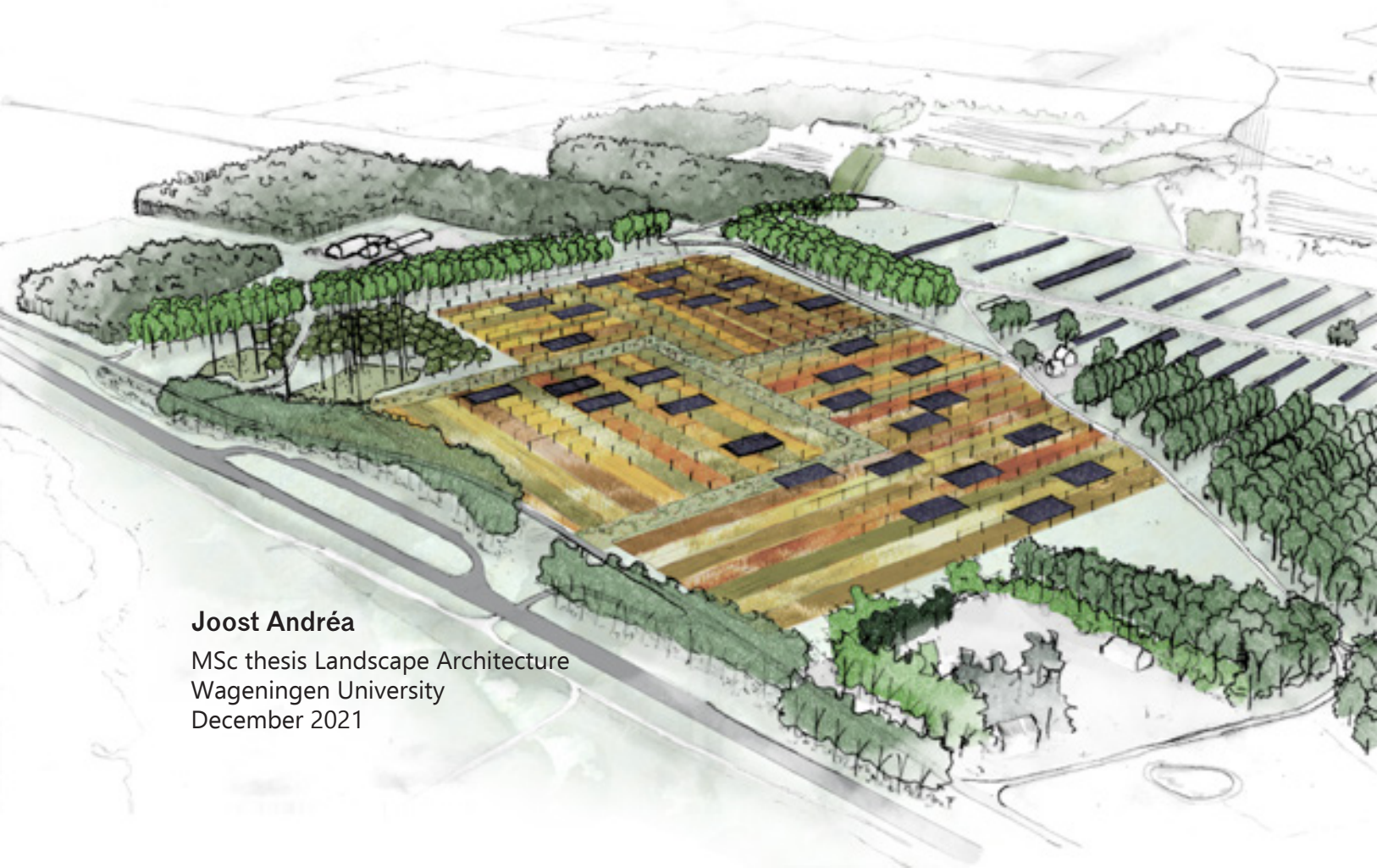
empowering
ENERGY ESTATES

A new estate as a means for sustainable energy in Wijhe, Overijssel



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Abstract

The transition towards renewable energy sources is imperative to establish a low-carbon economy and mitigate climate change. However, the implementation of the required renewable energy technologies in the landscape is often contested at the cost of local landscape quality. In order to realign and better embed renewable energy technologies in the landscape, inspiration is found with the estate (landgoed), as it is an integrative production landscape that unifies agricultural, cultural-historical, recreational, and ecological values. In the last decade several (suggestive) designs were made for the 'energy estates' (energielandgoederen). Although a promising concept, the elaboration into design guidelines for specific landscape types is still lacking.

This thesis has the objective to develop design guidelines for a sustainable energy estate in the landscape context of West Overijssel. It builds upon the existing knowledge of sustainable energy landscape design as well as the activation of the design knowledge embedded in the historical estate type that is found in the region. By a comparative case study, thirteen essential spatial characteristics of the this estate type were identified. These were confronted with a new program that was informed by both the landscape analysis and earlier identified design considerations. This allowed for an evaluation of the estate type characteristics in their applicability for designing sustainable energy estates in this region. Through this process of research-through-designing, several design guidelines were found.

A final design was made for the sustainable energy estate that produced further insights into the effective translation of the estate design knowledge into design guidelines. It is shown that it is indeed possible to employ the estate as a means for designing sustainable energy landscapes and that the estate type characteristics possess enough flexibility to adjust them to the contemporary program.

preface

"Some futures can be predicted, but others need to be designed" De Jong (1992)

Although this was written almost thirty years ago, it still describes the current-day relevance of landscape architecture and other design disciplines. It certainly holds true for the unprecedented challenge of designing the energy transition in the Dutch landscape. It is an undeniable fact that the post-fossil fuel energy systems transcend into the everyday living environment. While technological advancements in generating renewable energy are hard to keep up with, they often remain abstract to the many end users at the power plug. People applaud the transition towards renewable energy sources yet emotionally reject the planned solar park around the corner. This illustrates the existing discrepancy between the goal and the physical means of renewable energy as it is now.

With this project, my ambition has been to address this divergence and seek convergence in between the design of renewable energy landscapes and the appreciated landscapes of estates in the Dutch landscape. It allowed me to indulge in my own interests for the tradition of Dutch landscape architecture and combine it with the fascination for the many new engineering possibilities that are around. Overall, this design research has the aim to inspire and articulate the notion that society ought not be scared of renewable energy technologies, but should find novel ways to co-exist.

This thesis project was executed as the conclusive part of the MSc program Landscape Architecture at the Wageningen University. The independent process of creating, imagining, designing and writing it has been a real challenge. When the physical interactions with other students and teachers were limited due to outbreak of the covid-19 pandemic, my internal motivation and inspiration had to be activated in an unprecedented way. Therefore, my gratitude towards the people that have helped me to complete this thesis is beyond expression. First of all, I would like to thank my tutors, Sven Stremke and Merel Enserink, for their much-valued help in shaping the project during the many physical and online meetings we spent together. Also Rudi, thank you for bringing your expertise to the table by joining as the second examiner. Furthermore, Igor, David, Florian, Sam, Sanne and all of the other students and teachers that have provided helpful feedback in the process. Friends and family, thank you for helping me also to get my mind of the project and regain some sanity. Finally, I would like to make a special recognition of my gratitude towards my girlfriend Sanne, who has been an unmeasurable moral support for me during this thesis.
Dear reader, I hope this report sparks some inspiration, because a successful energy transition requires the minds of many.

Sincerely,

Joost Andrea

Table of contents

chapter 1

Introduction

Rapid action is required to decrease greenhouse gas emissions and mitigate the effects of climate change. As the ambitious goals in the Dutch Climate Agreement show, the transition towards sustainable energy from renewable sources is a crucial part of this challenge (see figure 1.1 and 1.2) (Klimaatakkoord, 2019). Since these renewable energy sources have a lower power density than fossil fuels, the physical energy systems require more space (Gerretsen & Rijpers, 2017; Pasqualetti & Stremke, 2018). Renewable energy technologies and their infrastructure are decentralised and dispersed across the country, as opposed to the mostly invisible infrastructure for fossil fuels (Ford et al., 2017). These spatial implications of the energy transition present an urgent and contemporary challenge in the field of landscape architecture (De Waal & Stremke, 2014; Sijmons, 2017; Stremke & Schöbel, 2019).

The growing number and size of urban and rural sites where renewable energy is being harvested, require the rethinking of their socio-spatial configuration (see figure 1.3). This has led to their recognition as renewable energy landscapes, as they are a subsystem of the larger physical environment (Blaschke et al., 2013; Stremke, 2015). These developments are often met with opposition and resistance from local inhabitants (Pasqualetti, 2011; Sijmons, 2017). Van der Horst

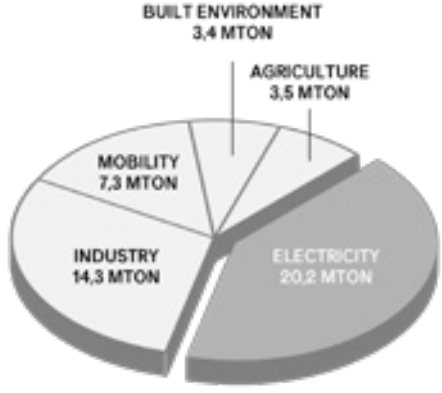


figure 1.1
Electricity takes up a large part of planned reductions in CO2 emmissions

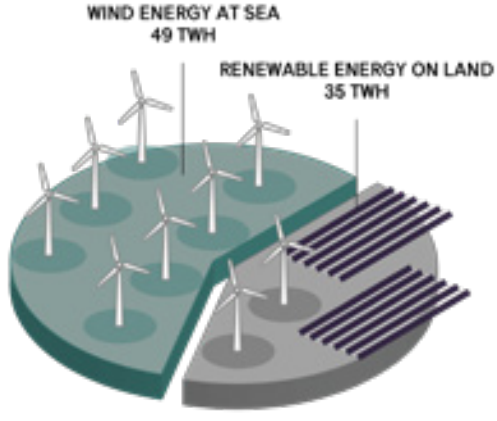


figure 1.2
Most of the required renewable energy is allocated to wind parks at sea, but still a large part must be generated on land

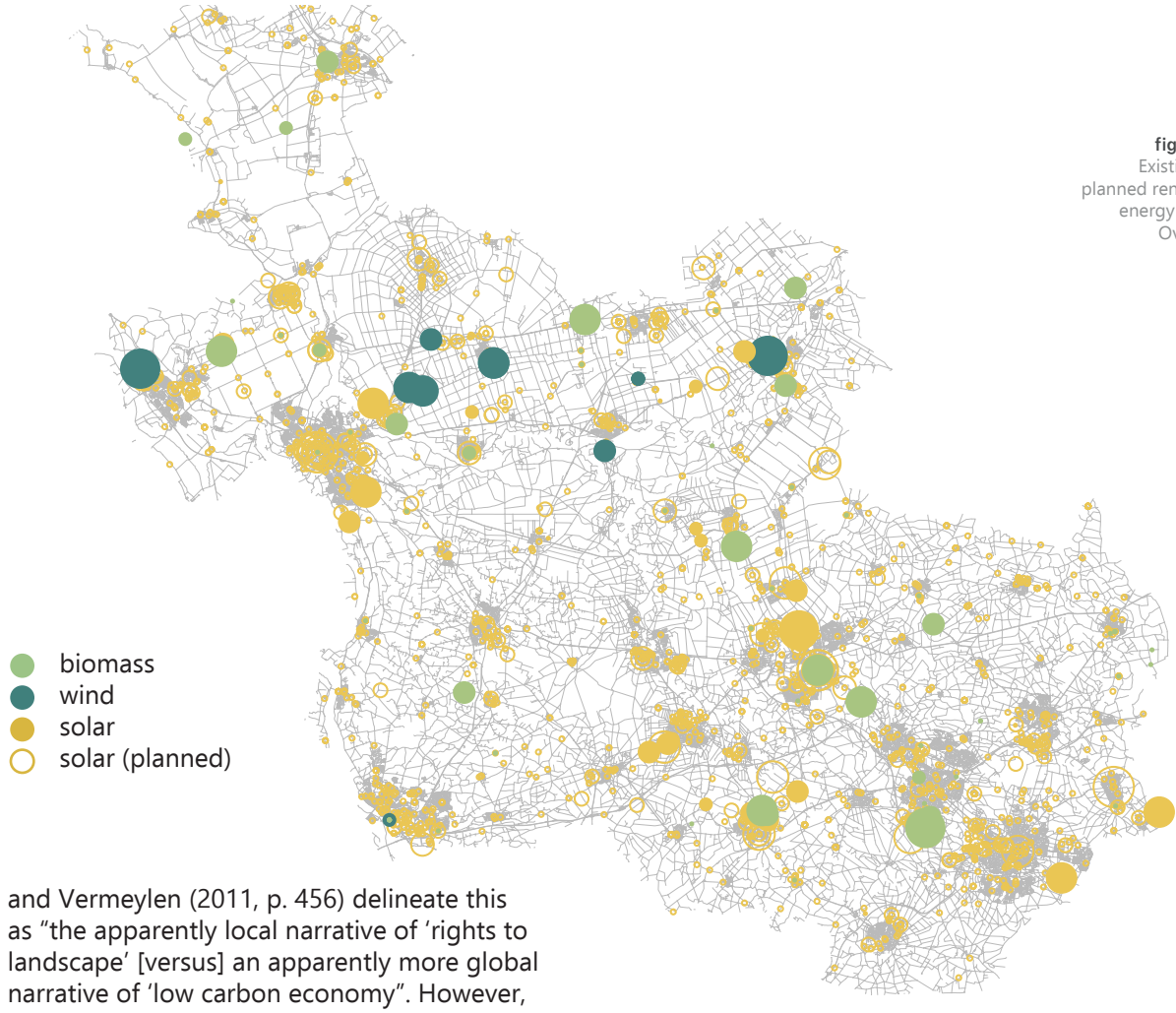


figure 1.3
Existing and planned renewable energy sites in Overijssel

and Vermeylen (2011, p. 456) delineate this as "the apparently local narrative of 'rights to landscape' [versus] an apparently more global narrative of 'low carbon economy". However, the need for these sites is crucial in achieving sustainable energy goals and advancing a low carbon economy in the Netherlands. Efforts to realign these narratives and embed the new renewable energy systems within their landscape context are addressed in academic research (see e.g. Stremke & Van den Dobbelsteen, 2012) and crystalise into local policy guidelines and innovative concepts for energy landscape design inclusive of people, flora and fauna. Hence, in both academia and practice one can observe a focal shift from landscape impact mitigation to the exploration of synergetic relationships between renewable energy infrastructure and other landscape functions and qualities (De Boer, Zuidema, & Gugerell, 2018; Hernandez et al., 2019; Stremke & Van den Dobbelsteen, 2012).

1.1 Energy estates

One of the particular design concepts that has emerged in study and practice in the last few years is the energielandgoed (i.e. energy estate). At first glance, appropriating the estate merely adds to the already many confusing analogies used to describe renewable energy sites in theory and practice (e.g. solar parks, solar fields and solar meadows). However, the energy estate builds upon the rich estate tradition that exists in the Netherlands and employs it as an integrative means for designing and developing multifunctional energy landscapes. The estate has traditionally performed as an integrated system where nature and culture have been interwoven in an innovative design experiment with economic, aesthetic and scientific connotations (Bakker, 2002; De Jong, 2010). If the estate were to be repurposed with renewed interest for these original conceptions, it would thrive as an agent for the confluence of contemporary discourse on technology, culture and nature. This renders the estate as a potential reconciling medium for implementing renewable energy technologies within the landscape. However, it still leaves ample room for speculation on how such an energy estate should be designed. Although the concept has been explored and tested a few times (Dubbelt, 2015; H+N+S, 2019; Provincie Drenthe, 2015), they all show a custom instrumental application of the estate in the project context.

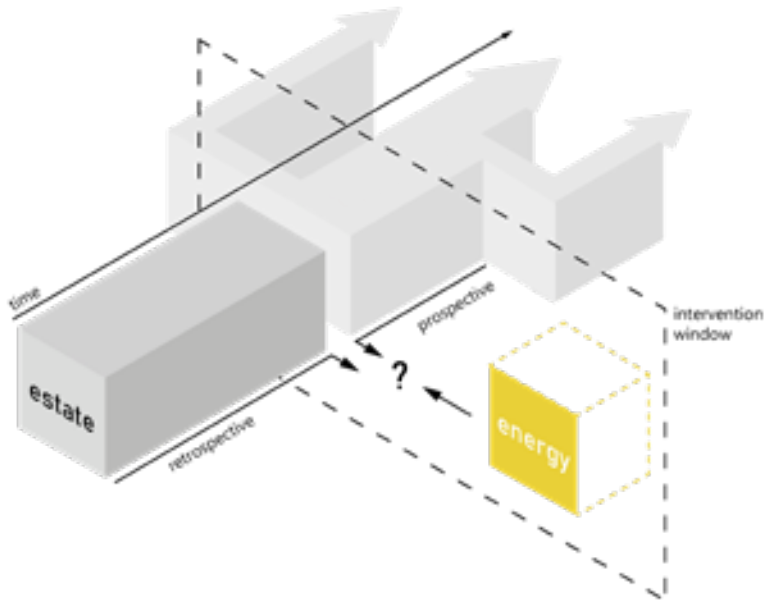


figure 1.4
Illustration of the knowledge gap that addresses two domains

1.2 Research problem

To define the research problem the three preceding energy estates were studied. These abstract explorations and more advanced designs of energy estates illustrate the apparent intersection between energy and estate in research as well as in practice. By studying these precedents, two particular challenges become evident that constitute the research problem. Firstly, although it might not have been the goal of these projects, the findings are only partially consolidated into knowledge that is applicable in the design of energy estates in other similar landscape contexts. Secondly, the translation and transformation of the estate concept into the design for an energy estate seems to be untransparent, implicit, superficial or based on questionable reference estates. The three preceding energy estates in the Netherlands are discussed in detail in the next chapter. Hence, the research problem addressed in this thesis is grounded in the practical and theoretical articulation of the relationship between sustainable energy and the estate concept (for definitions see section 2.1). More specifically, the way in which the estate performs as a means for designing sustainable energy landscapes.

As can be seen in figure 1.4, the knowledge gap is multidimensional. It is clear that the concept of the energy estate draws from both the domains of the estate and the sustainable energy (landscapes). Although the knowledge within these domains is extensive, the knowledge produced via their exchange needs reinforcement and requires more rigorous design research. The temporal dimension also plays a role here, because both a retrospective as well as a prospective stance towards the estate is possible. What lessons can be learned from the historical estates and the wider estate tradition? On the other hand, how does the energy estate take a place in this tradition considering current and future needs? To allow for a more contextual result, these questions are addressed in a particular landscape context.

1.3 The project area

The Noordmanshoek is being developed as a new energy estate. This site comprises 25 hectare of agricultural land directly north of Wijhe in the province Overijssel. As can be seen on figure 1.5, the project site borders various landscape types, like the village edge, the historical estate De Gelder, the river IJssel and floodplains, and the agricultural land to the north east. As the proximity of a historical estate already indicates, many estates can be found in this region. Estates have been extraordinary important in defining the cultural identity of the landscape in Overijssel (Albers & Haartsen, 2011). Building upon this legacy, the site is considered suitable to test the energy estate concept within the landscape context of west Overijssel.

figure 1.5
The Noordmanshoek within the landscape context

chapter 2

Research framework

In this chapter, the scope of the research will be defined. The introduction of the research problem, the knowledge gap and the study location in the previous chapter have given insight into the why and where of the research. However, the what and how of the research need to be further specified. Firstly, the focal concepts and constructs of this research are discussed in the theoretical framework. This framework is not only derived from scientific literature but also anticipates the place-specificness of certain concepts within the site context. The interrelationships between these concepts are summarised into a conceptual model.

Secondly, the specific research activities are further elaborated in the methodological framework. This is initiated with the formulation of the research objective and the general research question. More specific research questions and a design question derive from the links made in the conceptual model and serve to answer the general research question. Lastly, a discussion of the chosen research approach, methods and techniques sheds light on how these questions are answered.

2.1 Theoretical framework

Estates in the Dutch context

The estate can be considered both a conceptual and physical construct. The concept of the estate has evolved as a cultural collection of ideas that has built up from the medieval era until now. The many estates in the Netherlands are each a contemporary product and physical reflection of the estate concept in a specific context. Together, the concept and the artefact make up the estate tradition as brought forward by De Jong (2010). The tradition of establishing estates – in Dutch both “landgoederen” and “buitenplaatsen” – has been a prominent category in Dutch landscape architecture. Together with the polder and the garden, the estate was one of the areas of expertise that matured the discipline of garden and landscape architecture. Estates have been so inherently embedded in the Dutch landscape and culture, that defining it can be ambiguous matter.

There exists much confusion about the terms landgoed and buitenplaats (Bakker, 2002). The crucial difference between the two is the predominance of the economic component.

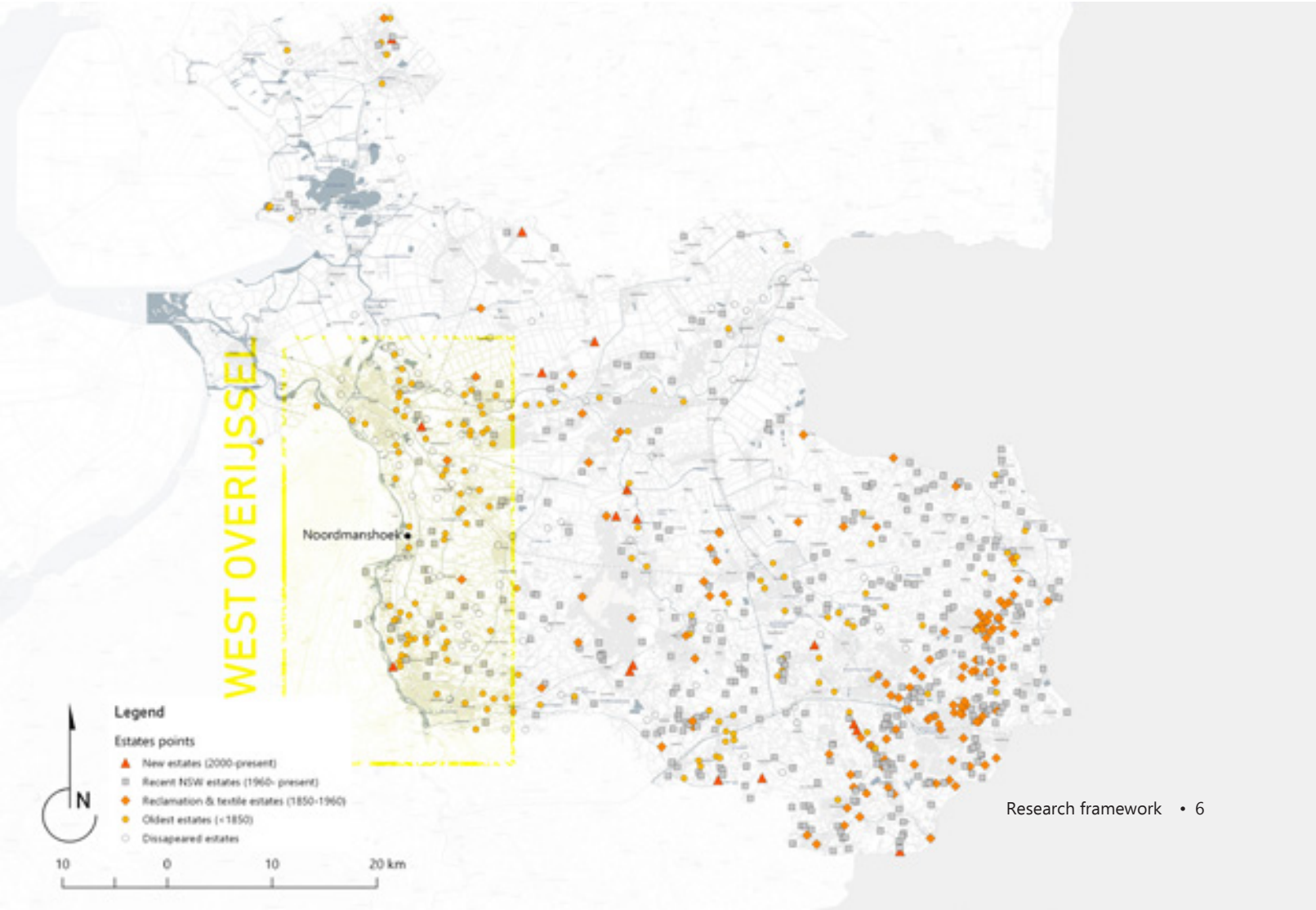
A “landgoed” always contains an essential economic activity or land use; for buitenplaatsen this is only secondary or absent (Bakker, 2002; Dessing, 2019). The Dutch Foundation for Castles and Estates defines a landgoed as “often many hectares in size where agricultural activities take place. The central part of the estate is commonly a ‘buitenplaats’ that may include a historical manor house, one or more annex buildings, and an ornamental and/or vegetable garden. Estates mostly sustained themselves from lease incomes and other land rights” (Stichting Kastelen, 2019). Albers and Haartsen (2011, p. 13) adopt a more holistic and less historical definition of the estate as a spatial entity of terrains and elements that are architecturally, economically and functionally connected. In their definition they also encompass the common spatial hierarchy of the estate, with its architectural core and the surrounding agricultural productive lands. For this thesis, this latter definition of Albers and Haartsen (2011) is considered to be most suitable and workable to refer to a ‘landgoed’ in contemporary sense.

Estates in Overijssel: A typology

The origin and design of estates in the Dutch landscape has been strongly informed by local political, cultural and environmental conditions. Estates have been exceptionally important in defining the cultural and spatial identity of the landscape of Overijssel, since they occupy 10% of the provincial acreage (Albers & Haartsen, 2011). The vast collection of estates in Overijssel has accumulated from the medieval period until now, which has resulted in a distinct typology of estates (see figure 2.1). In their inventory of estates in the province Overijssel, Albers and Haartsen (2011) distinguish four important chronological categories of estates;

- the oldest estates (before 1850)
- the reclamation estates and textile manufacturers estates (1850-1960)
- recent ‘NSW estates’ (1960-present)
- new estates (after 2000)

figure 2.1
The dispersion of different estate types across Overijssel



The oldest estates can be further subdivided into medieval castles, 'havezaten', 'spiekers' and 'buitenplaatsen' (Van der Horst, n.d.). The estates belonging to castles and havezaten originated from strategically defendable noble houses. The spiekers and buitenplaatsen were founded by the wealthy civilians from the larger cities.

The reclamation estates were established by textile industrialists though reclamation of sand-drift areas and heathlands. They were also responsible for the establishment of the textile manufacturers estates that originated from moving industrial activities and their residence into the rural areas. Both these types of estates are mainly found around the industrial nuclei in the east of Overijssel, which makes them less important as a reference regarding the site context.

The many 'recent NSW-estates' in Overijssel are the result of the legal abstraction of the estate in the 'national estate act' (Natuurschoonwet, adopted in 1928) in the 1980's. This allowed for land owners, usufructuary or lease holder to classify their terrains as an 'estate' under certain prescriptive conditions and subsequently enjoy fiscal benefits (Rijksdienst voor Ondernemend Nederland, 2014). These estates are not recognisable as such in the landscape because they have not been designed.

The most recent addition are the 'new estates'. At the end of the last century, the Dutch government has launched a program and policies for the establishment of 'new estates'. The goal behind this plan was to stimulate the planting of forest to aid in afforestation goals in the Netherlands by facilitating private residential developments (Derckx, Kooiman, & Scheffener, 2010b; Stobbelaar, Marcus, & Zwart, 2010). This example shows how estates have transformed into an instrument for spatial planners and policy makers.

This brief history shows that the establishment of estates has been strongly informed by the socio-political conditions throughout history. Political, societal and economic shifts have allowed for the consecutive appropriation of the estate by the nobility, the urban elite, the industrialists, the government and the middle-upper class as displayed in figure 2.2.

figure 2.2
The consecutive appropiaton of estate establishment by different socio-political groups

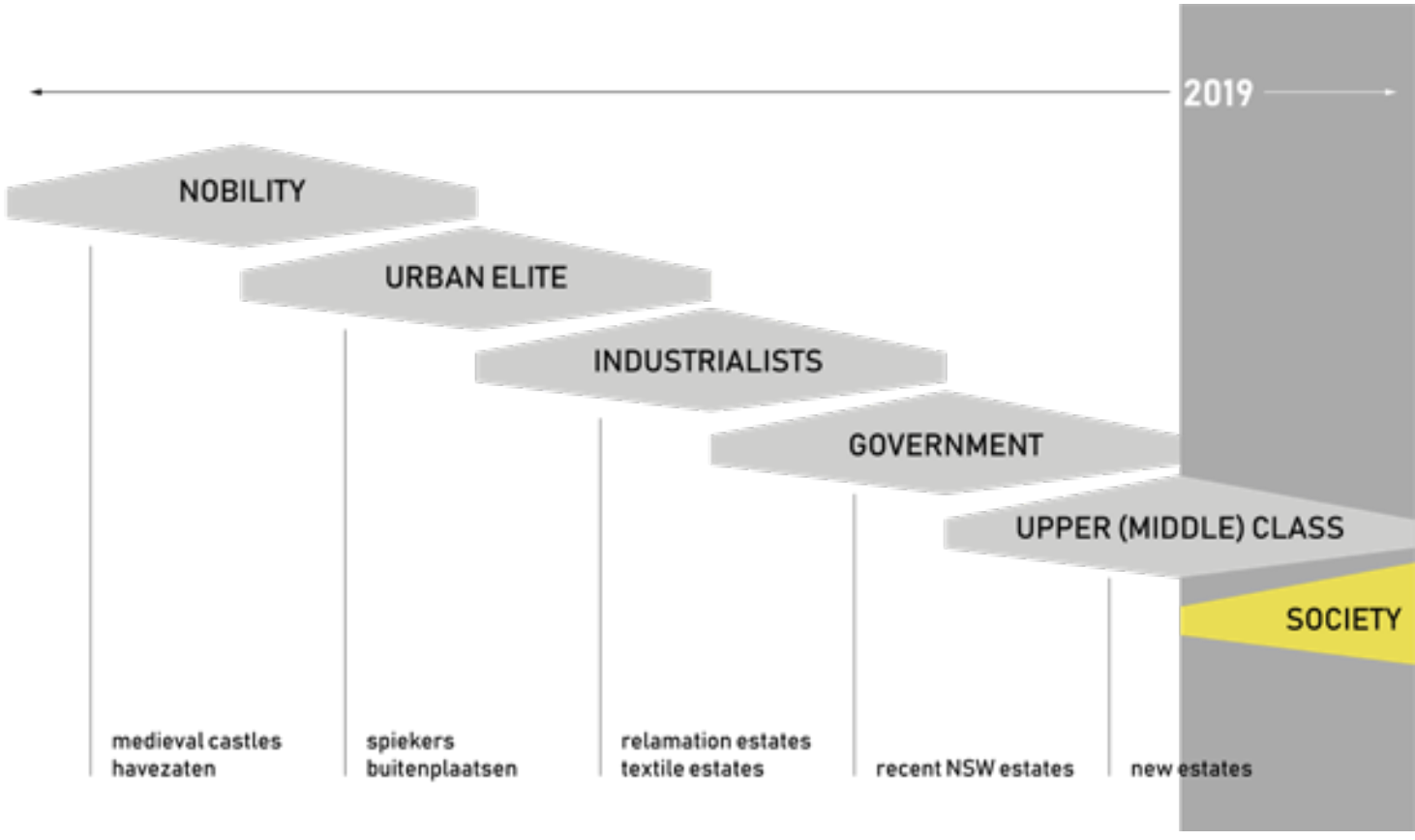
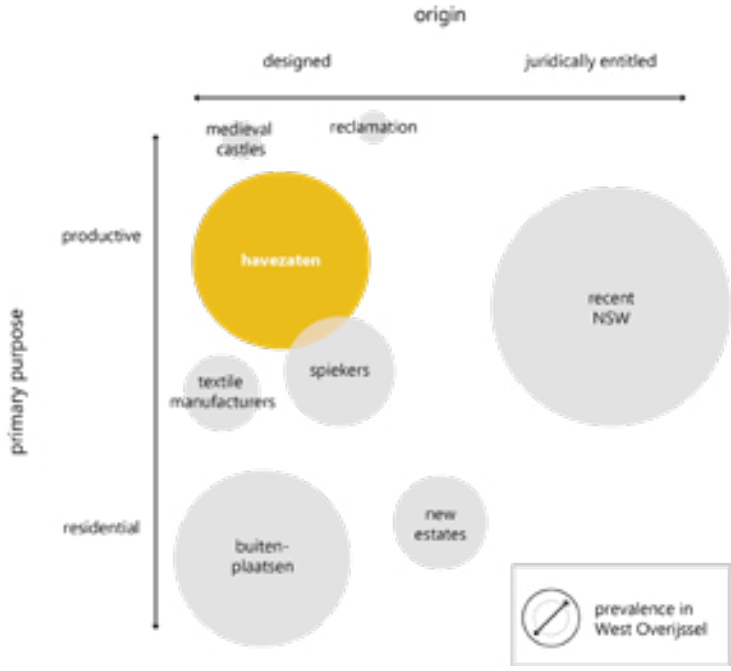


figure 2.3
The designation of the relevant estate type of West Overijssel based on the invetaristaion by Albers and Haartsen (2011)



Estate type of West Overijssel

For this thesis it is not relevant nor feasible to study all the estate types mentioned above. Three criteria were formulated to narrow down the scope to the relevant estate type of West Overijssel that can inform the design of the energy estate. This selection is illustrated in figure 2.3. The first criterion is a focus on estates that were originally productive in nature. This means that the scope is limited to landgoederen and thus excludes buitenplaatsen. The second criterion is that the estate has been the object of landscape architectonic design. The third criterion is a regional focus on West Overijssel, since the design of estates has been strongly informed by local conditions. These three criteria allow for the designation of the relevant estate type of West Overijssel, as can be seen in figure 6.

Contemporary estates: critique and outlook

The ubiquitous reference to the estate in rural developments during the last decades has rendered the term almost meaningless in respect to its original agency. The estate has been resurrected as a model for reuniting agriculture and nature (Van Arkel & Welle, 2016) and as an instrument for achieving ecological objectives through private housing developments (Derckx et al., 2010b). The latter one has resulted in design and erection of 'new estates' over de last two decades. As is exemplified by Derckx et al. (2010b), the design of these new estates has been in the professional portfolio of landscape architects ever since its conception at the turn of the century. Nevertheless, multiple contributing authors in this work criticise the nostalgic motives and cherry-picking ways behind the reuse of historical landscape elements, leading to style forgery and kitsch (Derckx, 2010). Consequently some new estates resemble a catalogue of historical landscape elements, held together by a typical estate element such as allees (Kooiman, 2010, p. 24). De Jong (2010, p. 14) reiterates the architecture of the estate as a complex phenomenon that is informed by more than solely shape. Soil, topography, function, spatial organisation, use and experience direct the design choices and not the other way around.

This critique motivates a revaluation of the estate concept and its design in contemporary culture, for newly designed estates cannot be built upon superficial reference to historical precedents. Therefore, the local prevailing socio-cultural and environmental conditions have to be leading in the design – with a capital D - of contemporary estates, making them more sustainable.

The revaluation of the estate as a multifunctional landscape with both strong functional and aesthetic considerations (Bakker, 2002) can easily be positioned within the wider discourse on sustainable landscape architecture (Musacchio, 2009). This makes it even more qualified to explore it as a new type of sustainable energy landscapes. In her manifest Meyer (2008) advocates the reintegration of beauty and aesthetics into the discussion on landscape sustainability, which has long revolved around ecological health, social justice and economic prosperity. She stresses that designed landscapes should be constructed human aesthetic experiences as well as constructed performing ecosystems. This also pertains to the design of a sustainable energy estate, that should articulate aesthetic experiences as an integral part of its performance.

Sustainable energy landscapes

The academic interest in the topic of energy landscapes has increased during the last decade. (e.g. Blaschke et al., 2013; Howard et al., 2013; Stremke & Van den Dobbelsteen, 2012). Stremke (2015, p. 2) defines the physical energy landscapes as the physical outcome of the energy economies. At the same time, he distinguishes the concept of energy landscapes as "an abstract idea that presents not only the object of philosophical discussion but shapes the way we perceive the physical environment at large". Now that society is becoming aware of the externalities produced by the unsustainable fossil fuel economy, the energy landscape is beginning to shift towards a next stage. Pasqualetti (2012) calls this the 'energy landscape of the sustainable economy' and Noorman and De Roo (2011) a 'third generation energy landscape'. In order to harvest energy from renewable sources like the sun, wind and water, energy systems have to literally and figuratively resurface. This energy transition requires a reintegration of the energy systems within their physical and socio-economic landscape, as was the case before the 20th century (Sijmons, 2017; Zuidema & De Boer, 2017).

The way to achieve this is the focal topic of research and design addressing sustainable energy landscapes (Stremke & Van den Dobbelsteen, 2012). Howard et al. (2013) distinguish form and function as components of the energy landscape. Form refers to both the geographic extent and temporal scale where within an energy system is considered a functional unit. Function refers to the purpose of the energy landscape, where energy may be produced, transmitted, stored and/or used in service of a larger energy system. Sustainable is added as a qualifier to the energy landscape that advocates how certain functions should be accommodated within a dynamic physical form that is the landscape (Stremke, 2015). On that account, Stremke and Van den Dobbelsteen (2012, pp. 4-5) have constructed a workable definition of a sustainable energy landscape as

> "a physical environment that can evolve on the basis of locally available renewable energy sources without compromising landscape quality, biodiversity, food production, and other life-supporting ecosystem services."

Renewable energy infrastructure

In literature, the physical manifestation of the energy transition has been referred to as renewable energy technologies (Picchi et al., 2019), energy infrastructure (Pasqualetti & Stremke, 2018) and energy systems (De Boer et al., 2018). Stremke (2015) positions the physical energy landscapes within the infrastructural layer of the landscape as 'energy networks'. In this thesis, I support the notion that all of the above are embedded in landscape infrastructure, being "the natural or constructed physical or beta-structure of the landscape delivering material or immaterial benefits and services and the recycling of energy and materials" (Picchi et al., 2019, p. 241). Hence, renewable energy infrastructure addresses both the constructed technologies, networks and systems and is regarded as the most suitable term to address the malleable physical construct of the renewable energy landscape.

For a newly designed energy estate in the context of West Overijssel, the integration of renewable energy infrastructure serves two purposes. Its primary purpose is to generate renewable energy from renewable energy sources. This resonates with the estate concept because the production was its primary function (Bakker, 2002). The secondary purpose of renewable energy infrastructure at the energy estate is to provoke an aesthetic experience.

As time has shown the land use of estates has been highly dynamic and subject to change. The physical energy infrastructure that serves the primary purpose of an energy estate must be able to respond to this change. As brought forward by Pasqualetti and Stremke (2018), energy landscapes have a substantive, spatial and temporal qualification. Solar energy landscapes qualify both as dynamic (temporal qualification) and as a component (spatial qualification), so they are considered to be most suitable to facilitate the primary renewable energy generation. The secondary purpose can be facilitated by various renewable energy technologies resulting in a more complex energy landscape (Pasqualetti & Stremke, 2018).

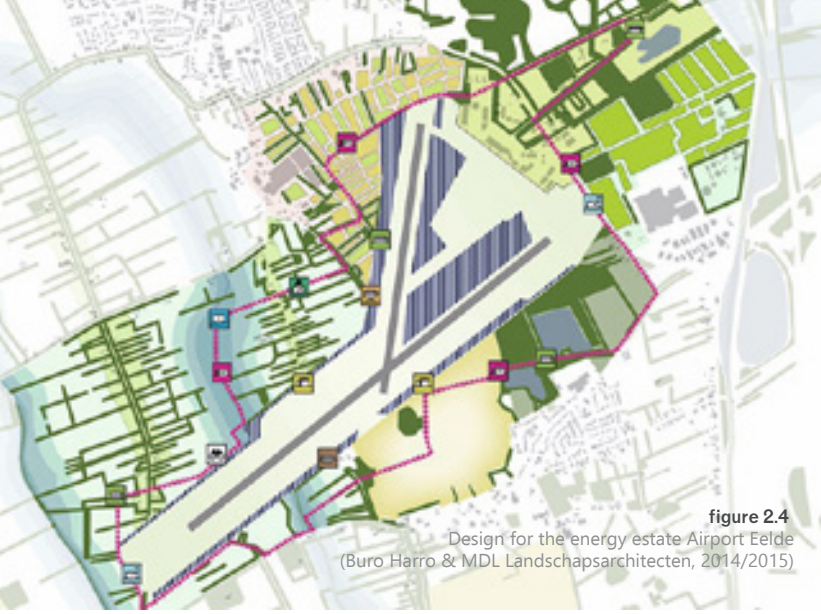


figure 2.4
Design for the energy estate Airport Eelde (Buro Harro & MDL Landschapsarchitecten, 2014/2015)

figure 2.5
Design for the energy estate Zwolle Zuid (Dubbelt, 2015)

figure 2.6
Design for the energy estate Well's Meer (H+N+S, 2019)

Sustainable energy estate

The focal concept of this thesis is not theoretically founded in scientific literature, nevertheless it has been explored a few times in practice and student research at various sites in the Netherlands. Although these projects are just scratching the surface of design research into energy estates, they offer a relevant starting point for the inquiry into this concept. A review of these three precedents derives the motivation behind its application and consolidates a first perspective on the concept.

The design for 'Energy estate Airport Eelde' (see fig. 2.4) was a shared effort by Buro Harro and MDL Landschapsarchitecten (2014/2015). The province of Drenthe commissioned six parties to come up with innovative design proposals for an 'iconic solar field' on the site of Groningen Airport Eelde (Provincie Drenthe, 2015). Two of the six participating firms submitted a conceptual design for an energy estate. Their motivation for employing the concept is founded in multiple desires. Firstly, a physical and metaphorical connection is made with the adjacent estate zone. Secondly, the estate is deployed as a unifying concept for a new landscape park that includes cultivation of energy crops in response to the different landscape types. Thirdly, in both proposals a creative configuration of solar energy infrastructure makes the new energy landscape an iconic feature in the landscape.

'Energy estate Zwolle-Zuid' is an explorative student project by Koen Dubbelt (2015) (fig. 2.5). Also here the energy estate concept is employed as an integrative means for renewable energy from water, biomass and solar sources. A vision that is firmly embedded in the surrounding landscape context combines a robust water structure with a contemporary estate that strengthens the spatial structure and simultaneously addresses hydrological issues. Dubbelt refers to the many estates found in the region, but nonetheless derives design guidelines from classical estates in England and France.

The last and most recent example is the 'Energy estate Wells Meer' by H+N+S (2019) and is the first design for an energy estate that will actually be developed (fig. 2.6). This huge development in Bergen, Limburg, includes the large scale generation of solar, wind and biomass energy

but also generates educational, recreational and natural values through multifunctional use of space. The link to estates is made because a former estate was located on the project site. Although the design is layered and articulated, the motivation for the application of the energy estate concept is largely implicit and builds upon a general conception of what an estate should be or look like.

According to De Jong and Van der Voordt (2002) a new type emerges when the same concept is recognised in different contexts. Through this quick review, the preliminary notion of a new type of sustainable energy landscapes can be witnessed.

Adding sustainable as a modifier to the energy estate has two implications. Firstly, it addresses the purpose of employing renewable energy sources in a sustainable way thus providing sustainable energy (Stremke, 2015). Secondly, it connotes the sustainability of the energy estate as a whole.

The concepts discussed above and the relevant interrelationships are summarised in the conceptual model below (figure 2.7). This research aims to advance the understanding, interpretation and expression of such a sustainable energy estate through the design research at the Noordmanshoek.

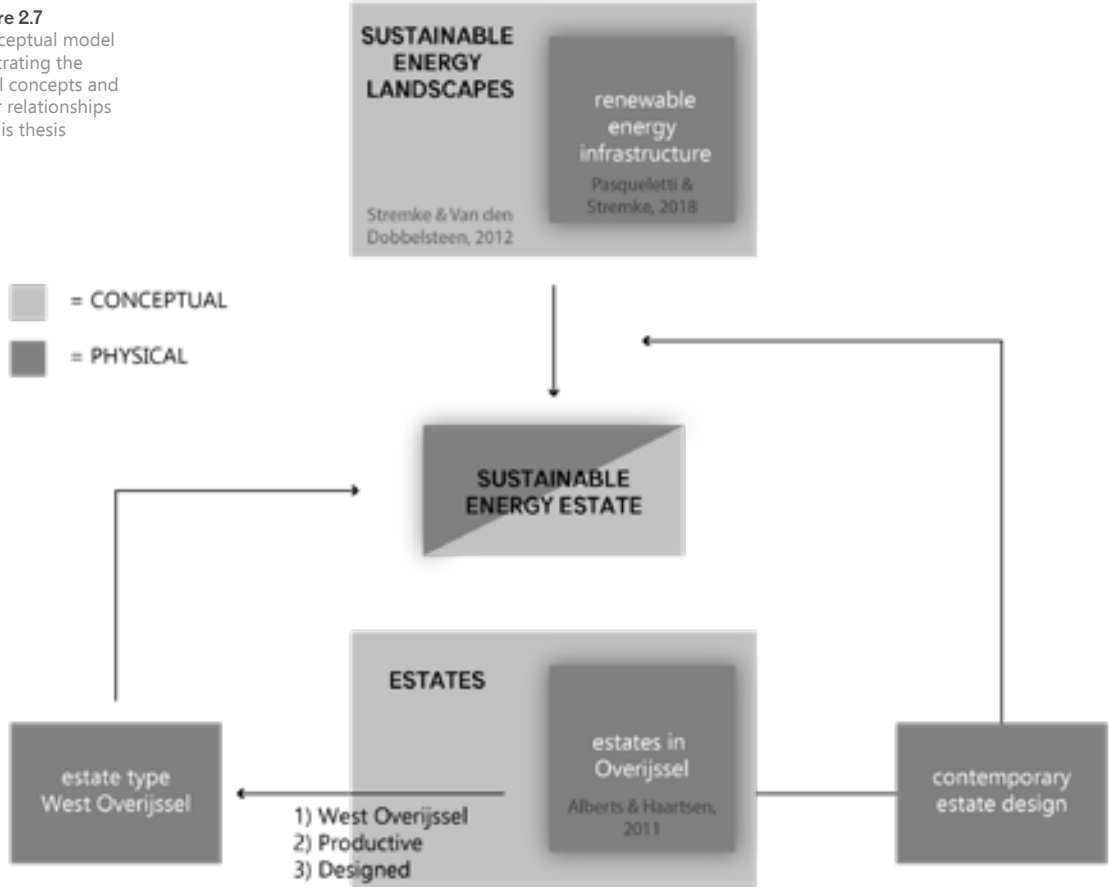


figure 2.7
Conceptual model illustrating the focal concepts and their relationships in this thesis

2.2 Methodological framework

Research objective

As mentioned in the introduction, the knowledge for designing sustainable energy estates is under established. Addressing this deficit, the objective of this research is to develop design guidelines for a sustainable energy estate in the landscape context of West Overijssel. The case at the Noordmanshoek is used as a means to develop and test these guidelines. The research and design activities are oriented at answering the following questions.

General research question
What design guidelines can be developed for a sustainable energy estate in the context of west Overijssel, based on the estate type of this region?

Specific research question 1
What design considerations from sustainable energy landscapes are relevant for the design of a sustainable energy estate in the context of West Overijssel?

Specific research question 2
What are the spatial characteristics of the estate type of West Overijssel that can be employed in the design of a sustainable energy estate?

Design question
How can a design for a sustainable energy estate at the Noordmanshoek look like by means of experimental transformation of the estate type of West Overijssel?

Research methods

It has to be stressed that this research is centred around designing a sustainable energy estate and thus internalises design(ing) as the core component in this thesis. In this case, landscape architectonic design is considered both practical and scientific research, since it is "aimed at the systematic acquisition of knowledge directed to specific practical objectives" (Nijhuis & Bobbink, 2012, p. 240). On the nexus between research and design, this thesis incorporates research on design, research for design and research through design(ing) as they are described by Lenzholzer, Duchhart, and Van den Brink (2016). The additional research methods and techniques per research question are elaborated below.

The overall approach for SRQ1 is research for design (Lenzholzer et al., 2016). Through a literature study, relevant design considerations are synthesised from the existing body of (grey) literature on sustainable energy landscape design. First the sustainable core qualities of estates are condensed from literature. These present an evaluative framework for identifying the substance that is relevant for this thesis and the landscape context (figure 2.8: left column). These insights provide a perspective for study of the (grey) literature on sustainable energy landscape design with a focus on west Overijssel. For this literature study scientific articles and reports, policy documents, but also the preceding projects on energy estates are used. This strategy provides the generation of new knowledge, because the existing knowledge is analysed and translated into meaningful design considerations that combine core qualities of estates and sustainable energy landscape design.

SRQ2 can be considered research on design (Lenzholzer et al., 2016). The second research question has the aim to acquire insights in the spatial characteristics of the estate type of West Overijssel. Landscape architectonic designs embody a great deal of design knowledge that can be activated through study and research (Nijhuis & Bobbink, 2012; Steenbergen, Meeks, & Nijhuis, 2008). By performing a comparative case study, the spatial essence of the estate type can be consolidated and employed in designing a sustainable energy estate (figure 2.8: right column). Three estates of the same type are selected as cases: De Gelder, Windesheim and De Haere. These estates fulfil the criteria discussed in the theoretical framework and share similar topographic conditions as the Noordmanshoek. Hence the choice for these cases is purposive and motivated by the question that relates to a particular landscape setting (Swaffield, 2016). To facilitate the cross-case comparison, each estate has to be analysed with the same analytical framework. There is a myriad of theories and methods to choose from. The method of plan analysis allows for the elicitation of the (latent) landscape architectonic composition of these estates. Besides it has proven its value in analysing historical landscape designs (Steenbergen et al., 2008; Steenbergen & Reh, 2005).

Four layers that constitute and are subject of the landscape architectonic composition are embedded in this analytical framework (Steenbergen et al., 2008):

basic form
The broader conception of site involving a close reading and writing of existing forms, materials and systems

programme form
The choreographing of kinaesthetic perception and materialising spatial (landscape) experience

spatial form
The understanding and designing of site and territory as a systemic environment facilitating infrastructural, human-social and bio-physical processes

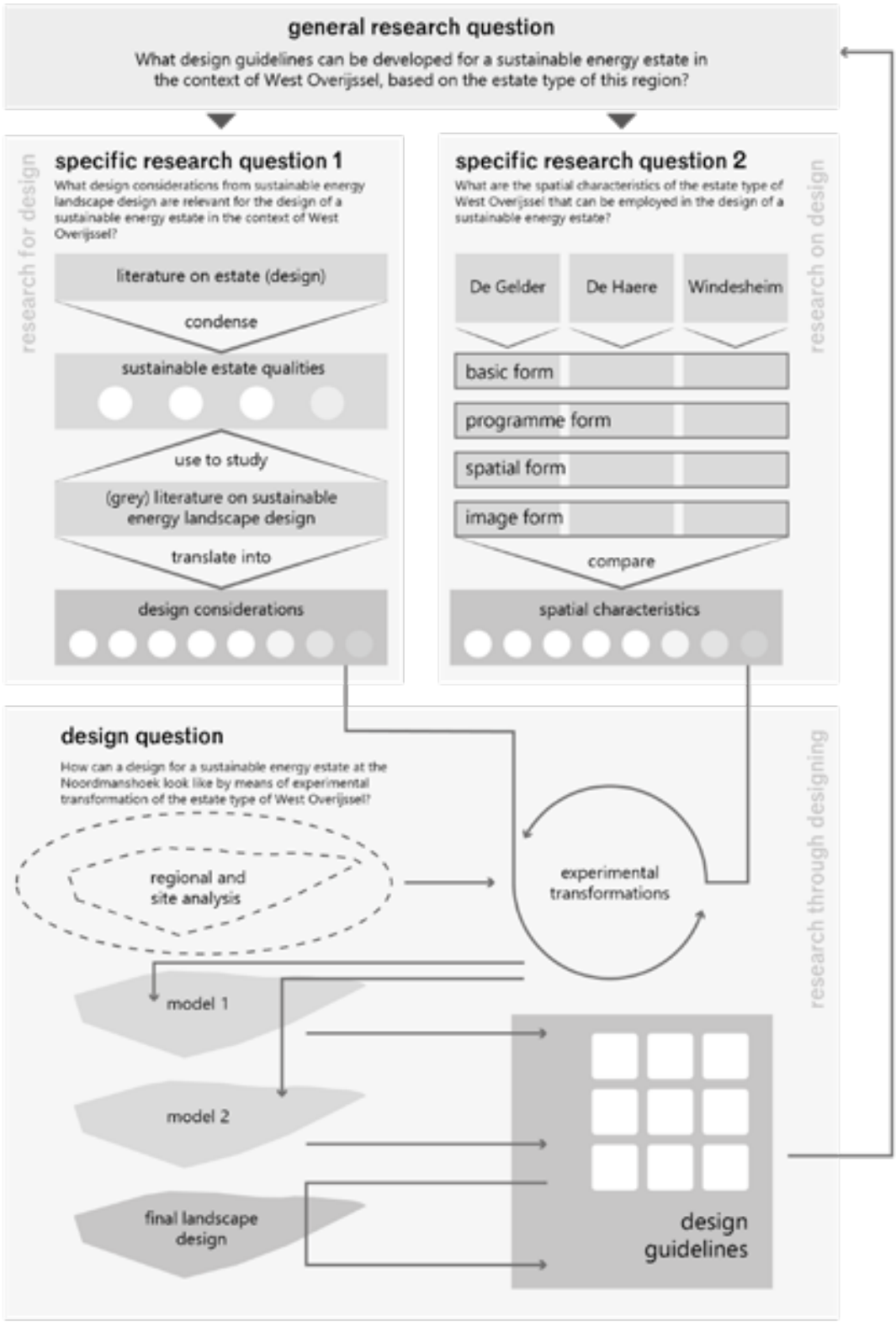
image form
The elaboration of the complex topics of aesthetics (e.g. compound narratives and synaesthetic curation

These four 'operations' of a spatial composition "lay out the relation between the various aspects of the architectonic form and its perception in a systematic way" (Steenbergen et al., 2008, p. 37). A valid critique and a more landscape informed revision to this 'Delft method' for the compositional praxis in landscape architecture was presented by Van der Velde (2018). He reiterates composition as "an apt and relevant concept to delineate the multidimensional praxis of landscape architecture, integrating site-specific, process-oriented and formal 'ways of knowing and doing"(Van der Velde, 2018, p. 303). He proposes a revision of the four traditional static operations into more dynamic 'procedures' which are also summarised above. In order to understand the latent landscape architectonic composition of the three estates in their specific context, each estate is studied from these four procedures. To answer SRQ2, the acquired insights from each case are compared and consolidated into to the most relevant spatial characteristics, that can be creatively utilised in the design of an energy estate.

The design question aims at translating and synthesising the acquired knowledge from both specific research questions into a landscape design for a sustainable energy estate at the Noordmanshoek (figure 2.8: bottom). In this part of the study, the act of designing is actively employed within the research process and can be qualified as research through designing (Lenzholzer, Duchhart, & Koh, 2013). Here, the site of the Noordmanshoek serves as the location for a design experiment, one of the modes of research by design according to Steenbergen et al. (2008). The accent lies on the transformation of the estate type of West Overijssel by confronting it with a new program in a new context and can therefore be considered as an experimental transformation of the type. As Lenzholzer et al. (2013) pointed out, the inherent reductionism in this approach – informed by its urban and architectural origins – renders it only partly qualified to deal with the complex and less positivistic landscape assignment at Noordmanshoek. Therefore the experimental transformations will only be a means of a more 'constructivist research through designing'. This epistemological framework is adopted since the research and designing activities revolve around exploring and generating a new physical construct that is highly contextual (Lenzholzer et al., 2013). In this research, this construct is the sustainable energy estate embedded in the landscape context of West Overijssel. Therefore, a site analysis will be conducted to obtain a spatial understanding of the Noordmanshoek and the surrounding landscape that form the base of landscape architectonic interventions. By performing experimental transformations, two alternative models for the energy estate will be generated. The models serve as a means to develop design guidelines for a sustainable energy estate and apply and review them in the final landscape design.

The research activities within the design question do not only synthesise a final design for the Noordmanshoek but also serves as a means to answer the general research question (figure 2.8: right arrow). Design guidelines for a sustainable energy estate will be developed with the help of the models and designs for the Noordmanshoek. This is a reflexive research mode that allows for a continuous evaluation of the design guidelines. It requires a critical reflection on why and how principles are relevant for designing and why some are only partly or not relevant. A reflection on both the final design and the design process will illuminate the different ways in which the estate type has proven to provide design guidelines for a sustainable energy estate in the context of West Overijssel.

figure 2.8
The research design divided in three main research modules



chapter 3

Design considerations

There is growing body of knowledge on the design and planning of sustainable energy landscapes. This knowledge has accumulated through both academic research as well as applications in practice. These present a valuable source for a more informed allocation and accommodation of renewable energy technologies in the landscape. It is important to build upon the knowledge embedded in the available (grey) literature and use it as a base for developing the design considerations. In turn, those considerations serve the generation of design guidelines for a sustainable energy estate. After all, this thesis aims to make a contribution to the body of knowledge through the development of those design guidelines.

Considering the amount and diversity of knowledge, it is necessary to select and condense the knowledge that is most relevant for designing a sustainable energy estate. This is done through an evaluation that addresses both the thematic challenge of designing an estate as well as the landscape context of the design location. This consolidates the relevant design considerations for a sustainable energy estate, which subsequently give direction to the design process and present an evaluative framework.

3.1 Sustainable estate qualities

The first part of the literature study consists of an assessment of the sustainable qualities of the estate within the Dutch context. As stressed by Derckx, Kooiman, and Scheffener (2010a) not the appearance but the qualities of historical estates should be taken as a source of inspiration in the design of a new contemporary estate. A total of four core qualities of the estate were found, which are elaborated below. These form the analytical framework for reviewing existing knowledge on sustainable energy landscape design in the next phase of the literature study.

Unity

Unity is a quality of the estate that is reiterated by many authors. As emphasised by De Jong (2010, p. 17) the ability of integration and coherence are typical and admirable characteristics of the estate. This criterion can be further subdivided in two dimensions. Firstly, the estate is a coherent spatial composition with one or more climactic features

(Derckx et al., 2010a; Feddes, 2012). This means that the estate is recognisable and distinguishable as a unity in the surrounding landscape. Its scale and spatial composition make the estate an autonomous part of the landscape structure (Feddes, 2012). Secondly, the estate also performs as a stable functional and economic unity (Albers & Haartsen, 2011; Bakker, 2002; Feddes, 2012). It is a landscape within the landscape that is characterised by an internal functional zoning (Van den Heuvel & Wassink, 1994). The preservation, management and development of the estate as a unity has a positive effect on the overall sustainability, including the more (financially) vulnerable parts and natural beauty (Van Arkel & Welle, 2016; Welle & Pastoor, 2017).

Multifunctionality

Another enduring quality of the estate is its multifunctionality. Van Arkel and Welle (2016) praise the power of the estate as provider of a variety of values through multifunctional use of land. In the first place, the estate was a production landscape (Bakker, 2002), but it involved much more than that. As articulated by De Jong (2010, p. 14), the estate was a performative landscape that produced, represented a dynamic culture, was a space of making, thinking, doing and acting, of taste and knowledge, and played a vital role in the social and cultural context. This illuminates the confluence of various tangible and intangible functions and values. In contemporary society this crucial quality of the estate still holds true. Operating as a contemporary societal enterprise, it offers opportunities for recreation and living in a green environment, preservation of cultural heritage, development and conservation of nature and offering the modern farmer the opportunity to run his business (Petter, 2000). In this regard, the multifunctionality is not a static feature but transforms and adapts to societal and cultural change.

Peculiarity

A third core quality that is imperative to the sustainability of any estate is peculiarity. The centuries of interaction between people and nature have made that every estate is unique in its appearance (Bakker, 2002). Due to the vision, ambition and effort of estate owners in the past, people can now appreciate the diversity that can be found within and between all of the estates (Van Arkel & Welle, 2016). As brought forward by De Jong (2010, pp. 13-14) the peculiarity of estates is partly a result of the constant exploration and articulation of tensions within two fields. On the one hand, there is the tension between nature (that bears scientific, aesthetic and functional meaning) and art (involving culture, arts, technology, science and other products of human ingenuity). On the other hand, there is the tension between convention and innovation in practice and design. Of course the physical manifestation of these tensions are subject to the zeitgeist, (landscape) architects and the personal 'touch' of estate owners and managers (Bakker, 2002). For example, estate owners have the ability to apply alternative small-scale nature management techniques that would be too costly and labour-intensive for larger areas, resulting in a peculiar qualities that enhance the identity of the estate (Feddes, 2012). Furthermore, the estate is a breeding ground for innovation because various activities come together in one place (Van Arkel & Welle, 2016). There is a continuous search for ways to exploit the area, in line with the identity of the region and the estate (Vijn & Borgstein, 2014; Welle & Pastoor, 2017). This illustrates that embracing innovation is crucial for the sustainability of estates.

Structurality

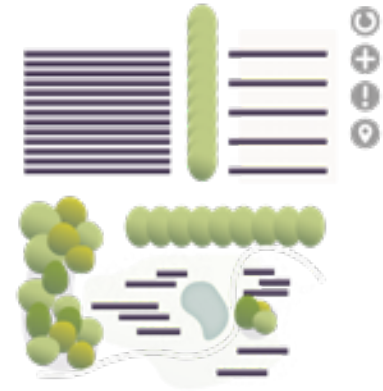
Estates strengthen the structure and bring quality to the surrounding landscape because of their size and scale (Feddes, 2012; Van den Heuvel & Wassink, 1994). Thus, the scope and agency of estates is not limited to their geographical and physical boundaries (De Jong, 2010). As expressed by Feddes (2012), estates give a strong and positive identity to the landscape. The design of estates has always been firmly embedded within the larger landscape context. They were established on gradients in the landscape in which the underlying landscape structure was enriched and made visible. Because of their iconic appearance, estates do not only contribute to their own sustainability but also act as a guardian for the surrounding landscape. They contribute to the identity and recognisability of the region (Albers & Haartsen, 2011). Hence, estates respond to the structure and texture of the existing landscape, but through design they also become a new structural element within this same landscape.

3.2 Design considerations

The four intrinsic qualities discussed above have ensured the enduring value of estates over the last centuries. Due to these qualities, estates sustain themselves within the landscape and thus they define the qualitative sustainability of the estate. It is imperative to consolidate these qualities within the design of a new energy estate to address the long term sustainability of the development. Therefore, the four sustainable qualities mentioned above are used as a qualitative framework to study, evaluate and translate the existent grey (literature) on sustainable energy landscape design into design considerations. A table of the used sources per design consideration is included in appendix A.

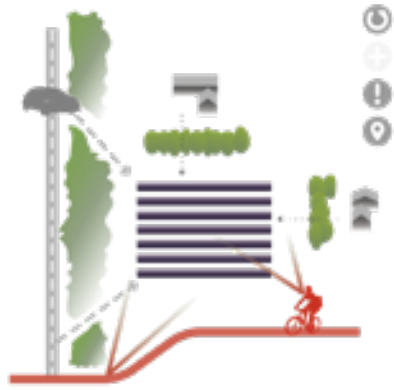
Some of the design considerations are directly informed by the current practices, while others are a creative leap from the existing knowledge. This is indicated for each of the design considerations. Besides, the relevance of each consideration regarding the contribution towards each of the four sustainable qualities is indicated on the right hand side of the corresponding illustration. The considerations contributing to all four qualities are mentioned first, and the considerations contributing to only one of the four qualities are mentioned last. Within each of these four groups, the considerations are then arranged according to the relative physical scale in descending order.

C1. Combine different renewable energy technologies
Combine multiple renewable energy technologies that generate energy from different renewable sources. The scale of an estate makes it possible to concentrate various renewable energy technologies in the landscape, making multifunctional use of scarce space. A technical benefit is that solar and wind technologies can make use of the same power grid connection. Besides, employing different renewable sources makes it possible to achieve a more constant yield of renewable energy, addressing the functional unity of an estate. This consideration also makes an energy estate more peculiar and can provide new structure in the landscape.

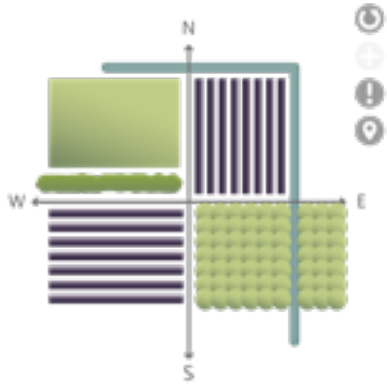


C2. Include intensive and extenstive energy infrastructure
Accommodate both intensive and extensive renewable energy infrastructure within the estate. The design of intensive energy infrastructure should revolve around efficient generation of renewable energy. Extensive energy infrastructure allows for multifunctional land use and combinations with nature ambitions, agriculture or recreation. This coincides with the notion of the estate as a functional and economic unity, where more intensive land uses compensate for the less profitable extensive land uses. Deploying both benefits the multifunctionality, the peculiarity and the structurality of the estate.

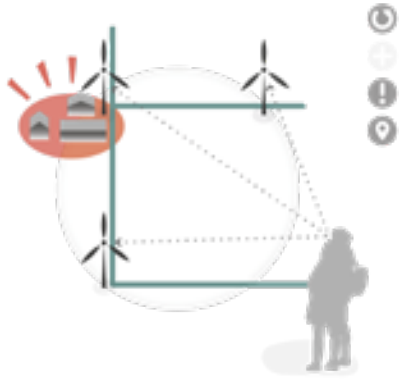
C3. Visibility of energy infrastructure
Make renewable energy infrastructure visible, since energy is the main carrier of the new estate. This provokes curiosity but also serves as an antidote for the common hiding practices. For the on-site visibility, a mix of screening and exposing creates a more diverse and dynamic experience of the landscape. But also the visibility from the surrounding infrastructure should be designed carefully. The field of view and speed of the landscape user should be considered when designing perspectives on this new estate. The visibility from adjacent housing should be designed more careful. This will contribute to the unity and the peculiarity of the estate.



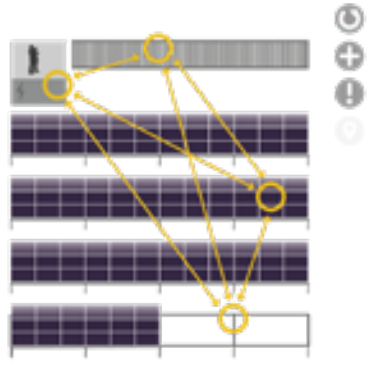
C4. Adopt rational energy patterns
Use the effective orientation of solar energy infrastructure as new ordering landscape structure for the energy estate. This serves two purposes, an efficient and effective generation of renewable energy and a deliberate expressive new cultivation of the landscape. Other components of the estate can respond to this and be designed according the same morphology. This will build a spatial coherence between the different components of the estate. At the same time, it contributes to the peculiarity and the structuring effect of the estate.

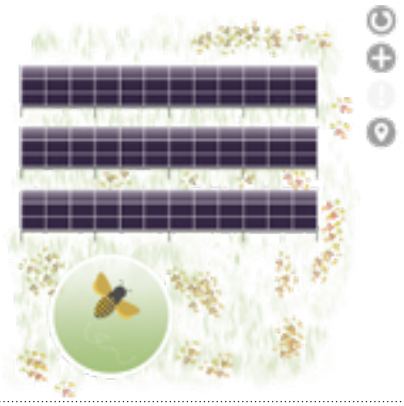


C5. Emphasise landscape features with wind technologies
Emphasise local landscape structures and features within the estate with wind technologies. This can be applied to existing landscape features, but also to newly introduced features that characterise the new energy estate. Employing the height and visual prominence of these technologies, they can contribute to the demarcation of the energy estate within its direct and regional surroundings. This is relevant because it distinguishes the estate as a spatial unity within the landscape. Besides, it aids the structuring ability and the peculiarity of the estate.

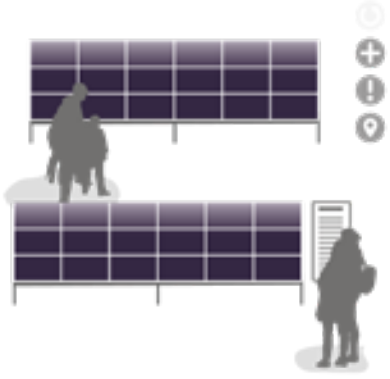


C6. Design all energy infrastructure components
Make all structural and technical components of the new renewable energy infrastructure (transformer buildings, inverters, foundations, et cetera) an integral part of the landscape design. This matters because a sustainable energy estate should be designed as a 'Gesamtkunstwerk'. Establishing a shared architectural language in form and materialisation contributes to the spatial unity of the estate. Additional features and functions can be integrated into these new structures, like furniture, information signs or viewing platforms, which is relevant for the multifunctionality of the estate.

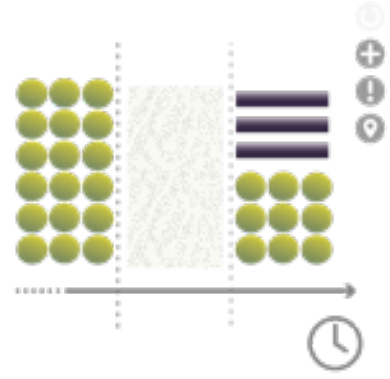




C7. Expand pollinator habitat
Use the space between renewable energy infrastructure to facilitate habitats for bees and other pollinators. This is beneficial for the biodiversity within a estate, but also serves a wider purpose. Wild bees, butterflies and other pollinating insects are of vital importance for agriculture and the regional ecosystem, but increasing pressure on their habitat has caused a rapid decline in their populations. An additional benefit is that this provides another source of income by keeping honey bees at the estate. Overall, this considerations contributes to the multifunctionality and the structurality of an energy estate.



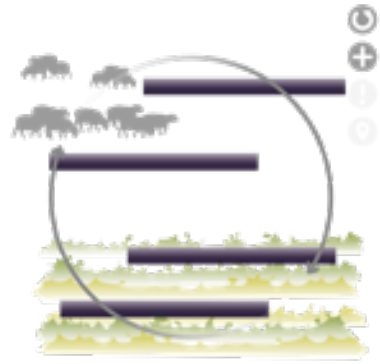
C8. Provide educational value
Design a new energy estate as a landscape with educational purposes. By guiding people along different types, configurations and combinations of renewable energy infrastructure, the new estate will also fulfil an educational role in the wider energy transition. Especially a coherent narrative of sustainable energy generation, storage, distribution and consumption should be conveyed to the visitor. This will make the estate more multifunctional, peculiar and also propagates a message beyond its physical boundaries.



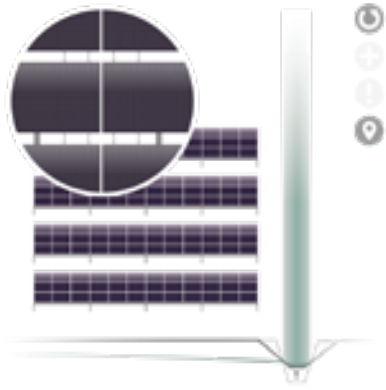
C9. Revive cultural historical landscape elements
Use the development of a new energy estate as an opportunity to revive landscape elements or land uses of cultural historical interest. This is relevant because a contemporary combination with new renewable energy infrastructure emphasises the connection between the historical and the new landscape. These elements should be embedded into the overall economic system of the estate, but they can also bring educational, ecological or other values to the landscape. This enhances the readability of the landscape structure, but also adds to the peculiarity and multifunctionality of the estate.

C10. Consider wider ecological network
Develop new nature in line with the surrounding nature areas and design renewable energy infrastructure accordingly. This is relevant since efforts for nature development at an estate should also strengthen the habitats of the native flora and fauna in the region. If applicable, a new estate can also function as a stepping stone within the wider ecological network and establish a connection between adjacent nature areas. However, new biotopes realised at an energy estate can also facilitate a habitat for rare species. Overall, this consideration contributes to the multifunctionality and the structurality of the estate.

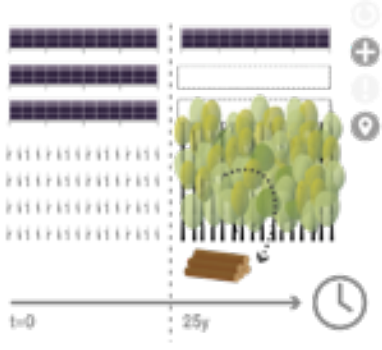
C11. Address broader rural challenges
Seize the opportunity to address regional challenges within the development of a new energy estate. This contributes to the aforementioned sustainability of the estate as a whole because the area is used multifunctionally. An energy estate is a coherent system, where renewable energy is just one of the products that the estate delivers. For example, the development of a new energy estate may contribute to nature developments, landscape restoration or extensification of agriculture. Therefore, sustainable agricultural practices must be applied and the connection between these practices can enforce the estate as a functional unity.



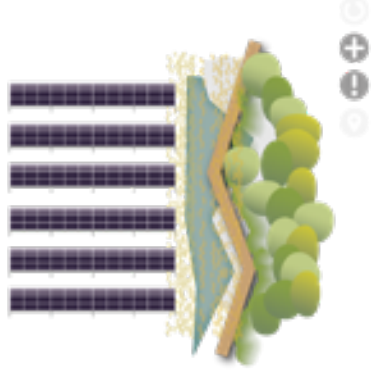
C12. Prevent soil dehydration
Prevent dehydration of the soil caused by the development of renewable energy infrastructure. Instead, the installation of renewable energy infrastructure can have beneficial effects on the regional water balance if designed properly. Extensification of former intensive agricultural land allows for raising the groundwater levels. Also, more spacing between arrays or small spacings between solar PV panels help to equally distribute precipitation across the soil. Another solution is to artificially lead run off water back into the area. This consideration addresses the regional biophysical structure of the landscape.



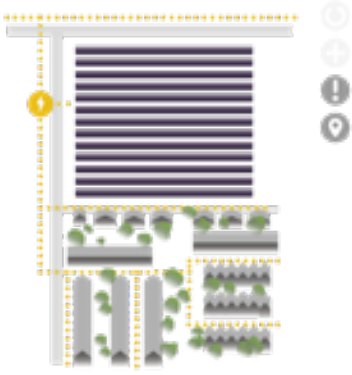
C13. Secure long-term benefits
While other renewable energy projects may be temporary, the development of an energy estate should be considered a long-term investment. Therefore, potential long term benefits should be included in the more permanent structure of the design. This structure keeps on delivering value even when some of the renewable energy infrastructure becomes obsolete in the future. The sequestration of CO2 in trees and vegetation, the production of wood and the development of housing are examples these long-term benefits. This consideration ensures the long-term multifunctionality and structurality of an energy estate.



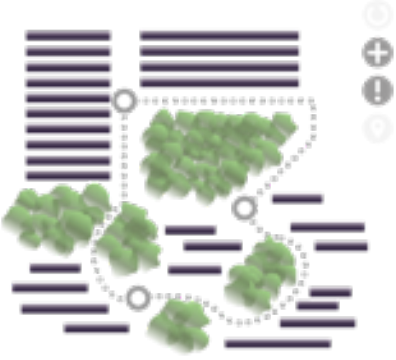
C14. Create diverse and attractive biotopes
Design robust biotopes in combination with renewable energy infrastructure that are also attractive for people. This contributes to the new estate as a because it advances aesthetic experience as another carrier besides the ecological values. These new biotopes should not merely be an expansion of the surrounding nature type, but a newly designed gesture that is not mimicking 'natural' appearance. By deploying small-scale management techniques, a unique collection of diverse and dynamic biotopes can be realised at the estate. This adds to the peculiarity and the multifunctionality of the estate.



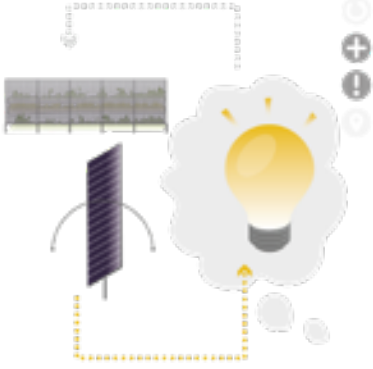
C15. Make biomass multifunctional
Design the cultivation of biomass as a multifunctional component of the estate. Considering the debate on biomass as a sustainable energy source, the energetic value should come secondary to the values for nature or people. The cultivation of biomass can benefit the biodiversity of the area in providing habitat for local fauna or offer cultural value in providing a memorable experience for people. Hence, biomass cultivation can contribute to the multifunctionality of the estate. The site should be chosen according to favourable landscape conditions and make use of native species, enhancing the structure of the landscape.



C16. Cluster intensive energy infrastructure
Concentrate intensive energy infrastructure and locate it close to existing infrastructure or built up areas. Clustering intensive energy infrastructure serves both a technical and an experiential purpose. The technical benefit is that it reduces costs and materials to make a connection with the power grid. On the other side, it makes sense to accommodate the generation of energy close to the consumer. This presents a new energy-conscious structure within the landscape and emphasises the peculiarity of the energy estate.



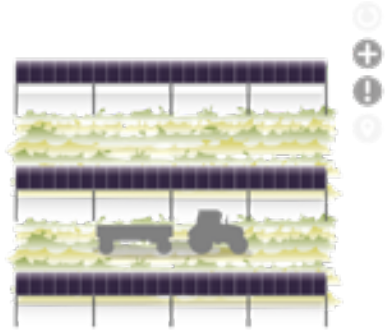
C17. Design accessible energy infrastructure
Make renewable energy infrastructure accessible for people. Designing physically accessible and approachable extensive configurations of renewable energy infrastructure improves the attractivity of the estate and bears educational value. However, not all intensive renewable energy infrastructure needs to be physically accessible all the time. These areas can be closed off during the night or be opened for guided visits. This consideration is relevant because it make the estate more peculiar, but also benefits the multifunctionality of the estate.



C18. Accommodate innovative technologies
Apply innovative and experimental renewable energy technologies within a new energy estate. This contributes to the practice-oriented knowledge generation on innovative and local solutions relating to alternative technologies, configurations or land use combinations of renewable energy infrastructure. The empirical research on this topic is still scarce and as discussed in the previous chapters, the estate has always been the designated place for multidisciplinary innovation. This favours the multifunctionality, but also the peculiarity of the estate.

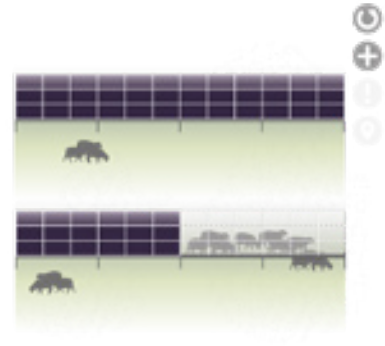
C19. Use alternative solar PV technologies

Make use of alternative technologies and configurations of solar energy infrastructure to make agricultural combinations possible. For example, when PV panels are installed more spaciously on higher installations, light and water can reach the soil for crop cultivation and machinery can pass underneath. Bifacial PV panels in an east west facing array gives more room and light for crop cultivation or livestock farming. Semi-transparent PV panels can also be used to protect crops and create favourable growing conditions. These technologies contribute to the multifunctionality and the peculiarity of the estate.



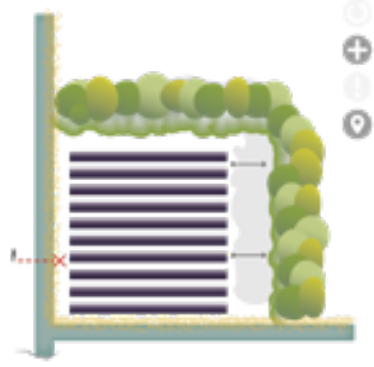
C20. Farm small livestock under PV panels

Combine more intensive solar energy infrastructure with the farming of small livestock like sheep or chickens. This presents a favourable combination, because the animals maintain the vegetation under and in between the arrays and the PV panels provide shelter for the animals. To allow for this double land use, panels have to installed at least 70 cm above the ground and enough space between arrays is important for animal welfare. Farming livestock is essential to close the nutritional cycle within the estate and provides product for the local inhabitants. Hence, it contributes to the unity and multifunctionality of the estate.



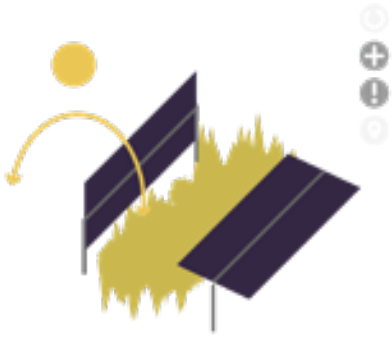
C21. Protect with natural landscape elements

Use natural landscape elements like ditches or dense vegetation to protect renewable energy infrastructure from theft. This matters because they can form an important addition to the larger green blue landscape infrastructure and support in giving structure to the surrounding landscape. New biotopes for local flora and fauna can be integrated into these elements, which is also beneficial for the multifunctionality of the estate. The type of element and choice of vegetation should be informed by the local site conditions and the characteristics of the landscape context. If an artificial structure is required, a custom uniform design should be applied.

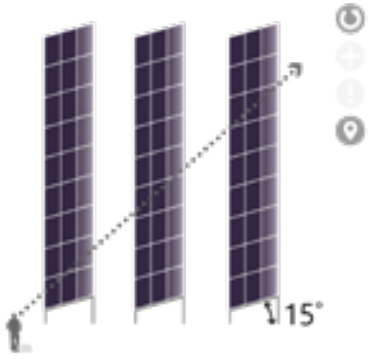


C22. Integrate energy storage solutions

Introduce novel energy storage technologies within a new energy estate to overcome the discrepancy between the supply and demand of energy. This allows for the storage of surplus energy and subsequently a local distribution when demanded. This system also relieves the power grid from processing extreme peaks. The capacity of this battery can also be used to store the renewable energy generated at other sites in the region. This consideration is relevant since it suits the quality of the estate as a functional unity that facilitates sustainable energy generation, storage and distribution.

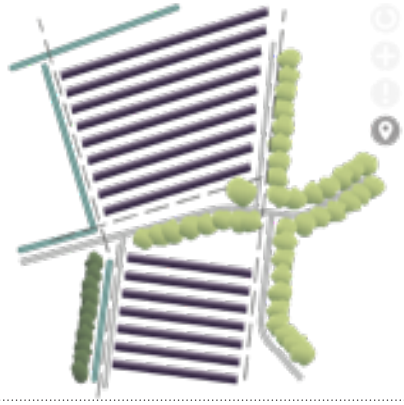


C23. Make solar PV infstructure mobile
Make solar energy infrastructure mobile to increase the flexibility for agricultural practices. This enhances the possibilities for effective crop cultivation in combination with renewable energy generation. This mobility of solar energy infrastructure can be applied at the scale of the panel, the module, or an entire solar field. Mobile PV systems can move along within a crop rotation cycle or can be used to distribute light and rain evenly across the crops. These innovative systems contribute to the peculiarity of the estate but also the multifunctionality and the unity.



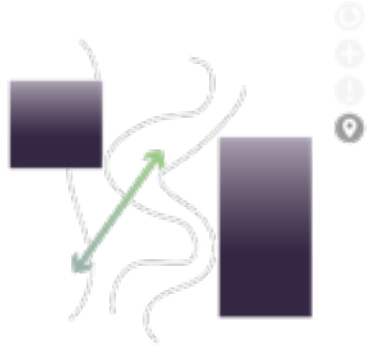
C24. Decline angle of solar PV arrays
Decline the angle of solar PV arrays to make them more recessed in the landscape. A low angle of the PV arrays make it possible to perceive the scale of the landscape. This is a trade-off between efficiency and experience, since the optimal angle of south-facing static solar PV panels is between 30 and 40 degrees. However, installing the panels at a low angle of 10-15 degrees only has a slight implication of the efficiency of the technology, but a huge impact on the perception of the energy landscape. This has beneficial effects on both the spatial coherence and the structuring effect of the estate.

C25. Connect to regional mobility network
Embed a new energy estate within the adjacent and wider regional mobility network to enhance the accessibility. The permeability of the inaccessible agricultural landscape is improved by designing new routes within the estate that are connected to the existing recreational cycling and walking networks. This also increases the attractivity of the estate for regional visitors. Accessibility and infrastructure for motorised traffic is minimised and the connection to the nearest public transport facilities should be considered. This should be consolidated in a new accessible structure for the landscape and improves the multifunctionality of the estate.

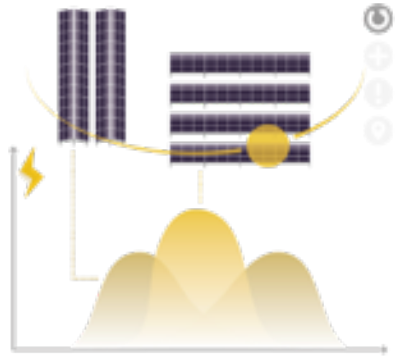


C26. Preserve landscape patterns
Make the size, scale and orientation of renewable energy infrastructure responsive to the existing landscape patterns. This is important because it embeds the new estate within the landscape context and is applicable for more sensitive cultural landscapes. For allocation of intensive solar energy infrastructure, the scale and orientation of the parcel should be compatible with an efficient generation of solar energy. Utilising the existent landscape infrastructure is relevant since it strengthens the landscape structure. Although this notion contradicts with C4 (adopt rational energy patterns), they can co-exist within one energy estate.

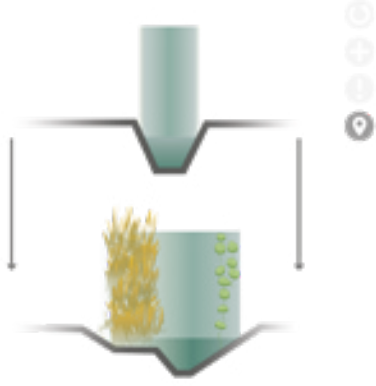
C27. Landscape informed nature goals
Adapt the development of nature to the on-site abiotic and biotic conditions. This contributes to a development of species that sustain themselves. Use and enhance existing gradients in the landscape to create ecologically attractive ecotones and provide diverse habitats. These gradients should only be used in combination with extensive energy infrastructure to maximise the space for nature development. Also, qualitative agricultural land is unsuited for achieving the nature goals. This gives the appropriate texture to the estate and embeds it in the surrounding landscape.



C28. Spread energy yield over day
Because renewable energy sources have fluctuant properties, the production of renewable energy is prone to peaks and bottoms. To evenly spread out the total production of the energy estate, multiple renewable sources and different configurations of technologies should be applied. For example, by deploying an east-west facing PV modules, the production of electricity is spread more evenly over the day and this relieves the electricity grid from digesting high peaks. This consideration is relevant since the energy estate should be designed as a functional unity.



C29. Enhance existing ecological potential
Use existing green-blue elements as the basis for ecological development. Areas with existing ecological values should be preserved, enhanced and integrated into the landscape design of a new energy estate. This matters because the development of an energy estate should not have detrimental consequences for existing habitats. These areas are not suited for allocating intensive renewable energy infrastructure, though they may be combined with more extensive configurations of renewable energy infrastructure. By enforcing the scale and robustness of these elements, it contributes to the structure of the landscape.



3.3 Conclusion

Studying scientific literature, grey literature and the preceding designs for energy estates has provided ample considerations for the design of a sustainable energy estate in the context of West-Overijssel. This list is neither complete nor conclusive and many other design considerations could possibly be identified. However, it has to be stressed that formulating the most inclusive list of design considerations is not the goal of this thesis. As the name suggests, design considerations only have value if they are actually being considered in the process and product of designing. The quality of the design is not determined by applying all of these considerations, but rather the ones that work in combination with the local estate type (chapter 4) and the site characteristics (chapter 5). Therefore, the considerations will be evaluated for their importance via their application at the site of the Noordmanshoek (chapter 6 and 7).

chapter 4

Estate type analysis

In this chapter the results from the second research question are presented. The aim is to get acquainted with the estate type of West Overijssel, as brought forward in the theoretical framework (see section 2.1). Three estates are analysed to consolidate the universal characteristics and spatial qualities that can be employed in the design of a sustainable energy estate in this particular landscape context. The findings of the embedded case De Gelder are discussed in section 4.1 and De Heare and Windesheim are included in appendix B.

The physical boundaries of the study area of each estate are often difficult to ascribe. For this study, the delineated borders, documented for the NSW act in 1928, are chosen as a starting point. These borders are oriented at the spatial unity rather than the land ownership. However, these boundaries are not very accurate if compared with the current situation. Therefore, the NSW boundaries are interpreted and readjusted according to the curent situation and the identified boundaries by Albers and Haartsen (2011). This approach ensures that areas that could be valued as a spatial component of the estate are also considered.

The comparison of the cases and the resulting spatial characteristics are presented in section 4.2. This comparison was only partly performed as a conclusive act of the case study, but also embedded the iterative study of the cases. The found spatial characteristics of one case study were validated in the next case, offering more emphasis on undiscovered features that were subsequently validated in the previous and next case. This led to the identification of … spatial characteristics of the estate type of West Overijssel.

figure 4.1
Historical map of the De Gelder that shows the distinct landscape structure of axes. Source: geoportaal Overijssel

figure 4.2
Basic form of De Gelder in response to the topography of the site

4.1 De Gelder estate

De Gelder is located directly east from the village Wijhe. The history of the estate dates back to the 14th century, when it was part of the bigger 'hofstede Ten Campe' (Landgoederen in Overijssel, n.d.). In the beginning of the 17th century, De Gelder became a separate estate with its own residence. Over the centuries, the estate has been owned by multiple noble families that each made personal changes to appearance of the buildings and landscape (Ottens, Van der Laan-Meijer, & Bevaart, 2019). Currently, the estate is privately owned by the family De Vos van Steenwijk, that acquired the estate in 1906. At that time, the main house was uninhabited for many years and had fallen into decay (see figure 4.9). The building was demolished in 1912, with the intention to build a new house. These plans were cancelled due to the outbreak of the First World War (Hendriks, n.d.). The owner did, however, commission the famous garden architect Leonard Springer to redesign the site around the house and the park (Springer, 1911). A large part of the estate is publicly accessible, as it is protected by the NSW act.

Basic Form

The distinctive layout of De Gelder has been well-preserved throughout its existence (fig. 4.1), which makes it still recognisable as one spatial entity in the current landscape context. De Gelder is an ensemble of productive lands including (production) forest, meadows and arable land. The allocation of these land uses is for a large part informed by the geomorphological and hydrological conditions as can be seen in figure 4.2. Forest is positioned on the higher terrain, meadows and arable land on the lower terrain.

The Zandwetering and the Soestwetering are two water courses that run parallel through the estate. These south-north running 'weteringen' are part of the regional drainage system that was established in the 13th century when the construction of the dikes along the IJssel impeded natural runoff to the river (Haartsen & Storms, 2009). De Gelder has developed in between and around these water courses, making them important arteries and borders of the estate. The main road runs adjacent to the Zandwetering and also the core of the estate is located along this water course.

As displayed in figure 4.2, three axes make up the rational structure of De Gelder. Two of them are oriented east-west, perpendicular to the weteringen. The third axis is placed diagonally and intersects the other two axes. This strong axial structure contrasts with the irregular parcellation patterns of the surrounding landscape and represents a deliberate superimposition of a recognisable landscape framework. This structure dates back at least to the 18th century as can be seen on the "Hottinger map".

Core and park

The core and adjacent park of the estate are located in the south-western corner of the estate, close to the village. This area is situated on a strong landscape gradient that is the result of a river dune (figure 4.2). A detailed analysis of the core and park is illustrated in figure 4.10 where letters A-F correspond with the pictures in figures 4.4-4.8. The central axis physically and visually connects the residential core with the agricultural territory. This axis runs through the centre of the core and extends westwards into a vista on the church tower. To the east, this central axis crosses the entrance gate, two bridges and extends into an oak lane ending in a parcel of production forest. As can been in figure 4.10, the current situation resembles both the older structure and the redesign by Springer (1911). The two remaining outbuildings of the residential core are surrounded by a moat widened and ornamented according to Springers redesign.

The park is positioned directly south and west of the core. The geometric structure of this park dates back to the 18th century and is conserved very well. An orthogonal composition of tree lanes divides the park in rectangular patches of forest. The lanes are mainly planted with oak and some with beech, giving them a stately appearance. Springer introduced more solitary trees in and around the park and accentuated the vista to the church by planting new forest. His design for the two ornamental gardens and the northern extension of the park were never realised.

figure 4.9
Historical picture of the residential core just before the main house (left) was deconstructed (1910).

figure 4.3
The pinetum (collection of coniferous trees) was established in 1909, and featured about 160 trees. It has recently been restored and new species were added to the collection

figure 4.4
The gate at the southern entrance of the park

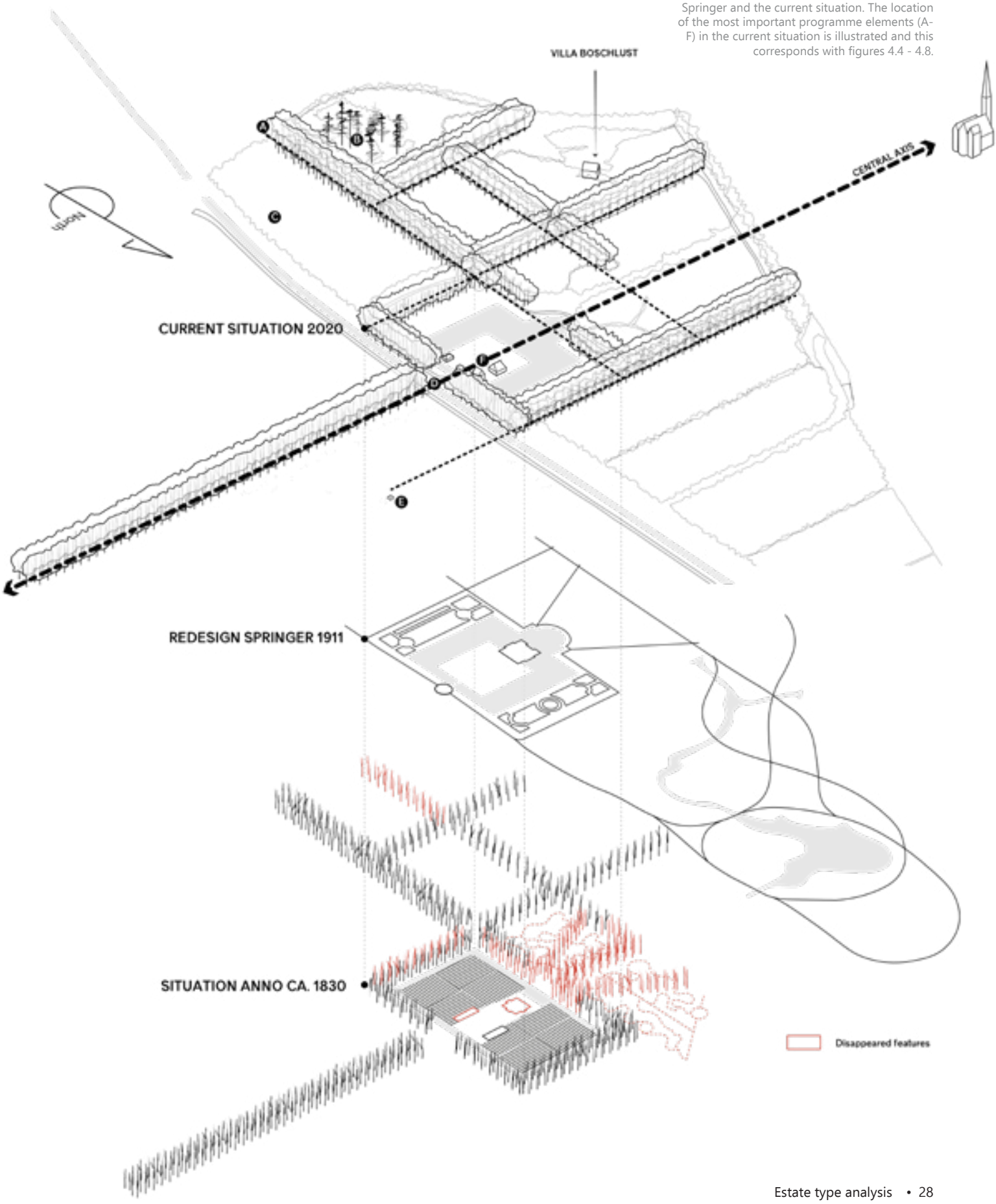
figure 4.5
The recently restored ice house ('ijskelder') was used for conserving ice blocks underground throughout the year. The entrance portal is made of brick with angled buttresses and a front with basket-handle arch and 'fronton'.

figure 4.6
The Leeuwenbrug bridges the Zandwetering and was built at the beginning of the previous century, when the estate was bought by De Vos van Steenwijk. The lions. The lion sculptures were taken from the entrance of the demolished main residence.

figure 4.7
The ornamented dovecote is located in the middle of the field across the Zandwetering. It is a rare and well preserved structure on the estate, featuring the family colours.

figure 4.8
The residential core with the entrance bridge and gate in the foreground, the two preserved historical buildings on the right and the vista on the church in the background. The terrain is designed soberly with hedges that enclose and divide the space.

figure 4.10
Isometric representation of the core and park, showing the historical situation, the design by Springer and the current situation. The location of the most important programme elements (A-F) in the current situation is illustrated and this corresponds with figures 4.4 - 4.8.



Programme form

Agriculture and forestry

The programme of the estate is still mostly dominated by forestry and agricultural programme (see figure 4.11). This resonates with the primary purpose of the estate as a production landscape. As stated before, the spatial organisation of these land uses is quite responsive to the geomorphological and hydrological conditions of the landscape. The forest consists of deciduous and coniferous species within rigidly and less rigidly planted plots, resulting in a patchwork of production plots and mixed forest types. The parcels in between the forest are used for dairy farming and consist of pasture and arable land for fodder production. Another remarkable agricultural activity is the cultivation of various Rhododendron species within the forestry plots

Accessibility and circulation

The larger part of the estate is publicly accessible. As this estate directly borders Wijhe, it is a much valued recreational area for the inhabitants. The main road, 'Onder De Gelder', forms the main access road of the estate for motorised traffic that connects to the Raalterweg in the south. A small parking facility is created where this road intersects the central axis. There are two entrances for cyclists and pedestrians to the park at the southern edge of the park. The orthogonal structure of pathways is accessible for visitors. However, the moated island and the area directly west of the core are not publicly accessible (4.12). On the remaining territory of the estate, recreational infrastructure is limited to the pathways along the weteringen and mainly oriented at pedestrians.

Built structures

De Gelder accommodates multiple residential and farm buildings. The main house in the core has been deconstructed in the beginning of the last century (figure 4.9), but the coach house and one of the annex buildings have been preserved (4.10). These historical buildings currently serve as private residences. Various other farms and residential buildings have been built on the estate, and some have disappeared again. One prominent building is Villa Boschlust (1902) that was built as the mayors residence of Wijhe (Landgoederen in Overijssel, n.d.). Apart from the farm buildings and (historical) residential buildings, there are a few other valuable cultural-historical architectural elements on the estate. These are concentrated around the core and the park (figure 4.10).

figure 4.11
Programme form: Land use

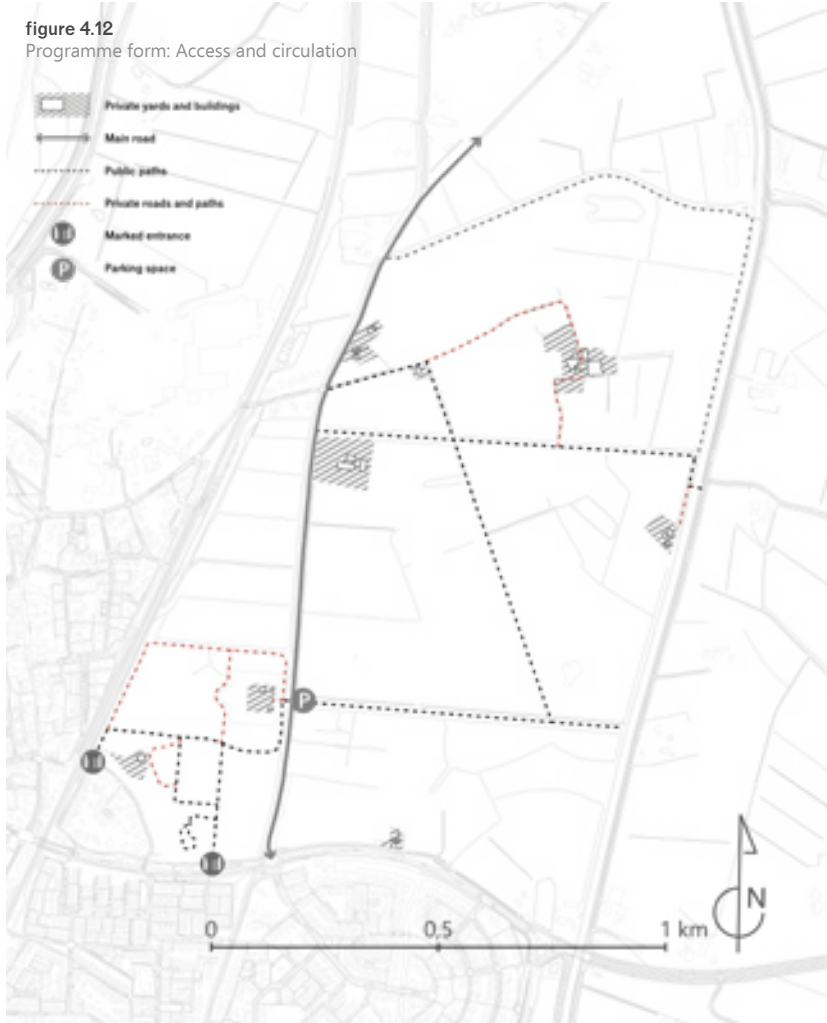


figure 4.12
Programme form: Access and circulation

Spatial form

Linear landscape experience

The strong lines of the axial framework are accentuated by densely planted double oak lanes on either side (see figure 4.13). This emphasises the structure in the third dimension. These straight axes also offer a linear experience of the landscape by the visitor. One example is the prominent vista on the church tower from the central axis, that articulates the proximity and relationship with the village (4.16). The experience of adjacent terrain depends on density of the vegetation under the trees. The central axis is partly planted with high evergreen rhododendrons, guiding the view forward (figure 4.13). The road 'Onder de Gelder' is planted with oaks without any undergrowth, which allows for a wider perception of the landscape (4.14).

figure 4.13
Section of the central axis

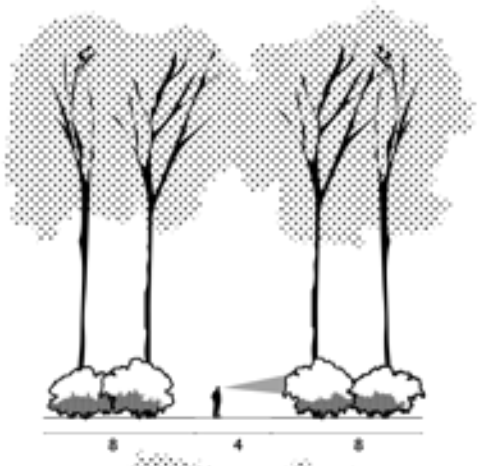
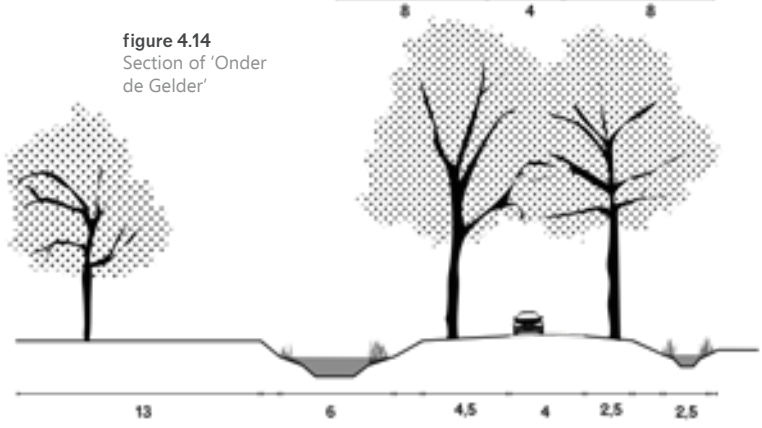


figure 4.14
Section of 'Onder de Gelder'



Vivid production landscape

The different forestry practices influence the experience of the estate. Within the estate, there are various kinds of forest making it a diverse experience when walking through the estate. The cadence of the trees is a recurring and omnipresent experience. Here, the rationality of the framework of axes is reflected in the rigidness of the tree plantations. Harvested plots of trees present a fascinating opening in the forest influencing the perception of light.

Inside-outside

The feeling of entering and 'being inside' the estate is cultivated by both explicit and implicit features. The explicit features are the gates placed at the three entrances of the park which physically mark the boundaries (figure 4.4). The implicit feature is the forest that encloses the space for the visitor (figure 4.15). When approaching the estate from the surroundings, the mass of trees stand out in the fairly empty small scale landscape. Moving through the trees and entering the void of the fields gives a more gradual entrance to the estate.

figure 4.16
The central axis with the framed vista on the church

figure 4.15
Panorama of the void inbetween the volumes of forest

Image form

Unity
The framework of axes and lanes physically unites the different areas and components of the estate. The position of the core on the central axis emphasises it as the focal point of De Gelder. There is a unity in planting since all of the axes in the estate are planted with the same species. Also the architecture of all built structures resembles unity. For example, all window shutters are decorated with the same pattern in the heraldic tinctures gules (red) and argent (white) (figure 4.17). This pattern is also used in the dovecote exterior (figure 4.7). The colours were adjusted to the family colours whenever the property changed ownership (Van der Horst, n.d.-a). Historically, it was used as a means to demarcate the territory.

Multifunctionality
The multifunctionality is manifested in multiple characteristics of the estate. Agricultural activities are combined with forestry practices, resulting in a diverse landscape. The cultivation of Rhododendrons illustrates a custom specialisation and smart double use of land (see figure 4.18). The natural capital at the estate does not only offers economic, but also aesthetic and nature values. Because of its scale, the estate can be considered a valuable asset for people and nature. Visitors can enjoy the green realm that also offers habitats to various flora and fauna.

figure 4.17
The coach house with the iconic pattern and colours on the doors

Peculiarity
The deliberate superimposition of the axial framework seems to be the most peculiar property of De Gelder. As discussed, the estate holds some fine well-preserved artifacts. Although these elements performed as functional components of the estate, their design and ornamentation resembles the importance of aesthetic quality. The ice cellar in the park and the ornamented dovecote are striking examples (figure 4.5 and 4.7). The pinetum in the park represents another interest for curation of green material (figure 4.3).

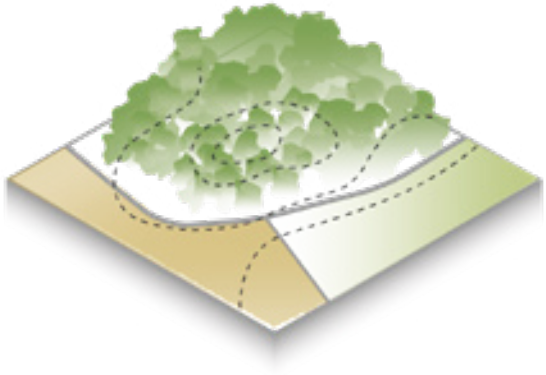
Structurality
The estate stands out in its surroundings because of the vertical forest masses that contrast with the small scale landscape on the river levee. From a distance the estate almost seems to foster the village. The development of the village was also influenced by the proximity of De Gelder. Urban developments have been physically limited to the railroad and the southern border of the estate. Nowadays, the estate functions as the backyard of Wijhe, as it is a close attraction for extensive recreation.

figure 4.18
Cultivation of Rhododendrons in between the trees

4.2 Case comparison

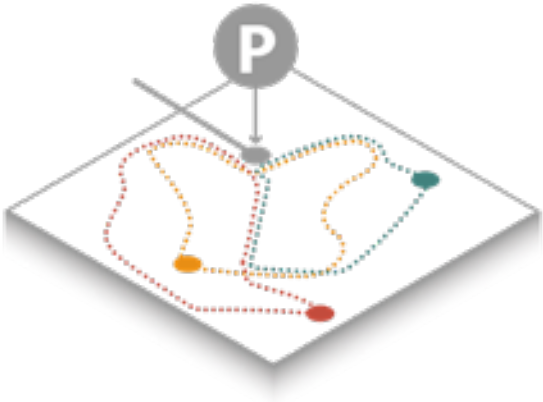
After analysing the three cases, the findings of each case were compared to extract the common spatial characteristics of the estate type in this region, which are illustrated and briefly explained in this section. The analytical framework of four compositional procedures has proven to be an effective and systemic tool in eliciting and organising substance across the three cases. However, since the synthetic process of designing does not adhere to these four procedures and many of the characteristics transcend this division, the framework was released in the articulation of these spatial characteristics. Below, the found spatial characteristics are ordered according to the physical scale.

E1. Three zones, one system
The estate can be roughly divided into three zones: the residential core with garden(s), the park and the productive territory. The borders and transitions between these different zones are neither rigid nor pronounced. However, the scale gradient in design and programme is distinct. The majority of the estate is designed to facilitate productive practices, like agriculture or forestry. The built and green cultural programme is concentrated in and around the park and the core of the estate. This distinct hierarchy should be designed when the estate type is confronted with the programme of a new estate.

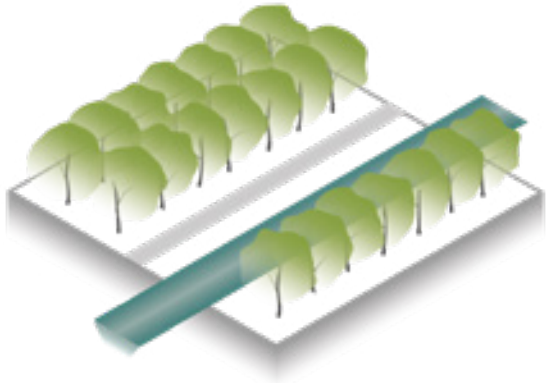


E2. Legible landscape morphology
The land use emphasises the morphology of the underlying landscape and makes it legable. Trees and forest are positioned on the higher sandy terrain, while the lower clay areas are used as pasture or for arable farming. The network of roads and pathways also follows the morphology of the landscape.

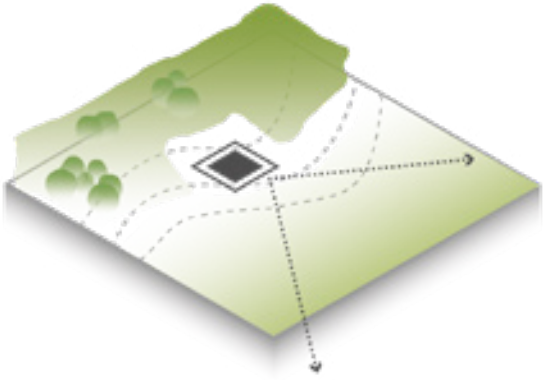
E3. Enclosed space
The large plots of forest enclose the open spaces within the estate. These green volumes frame the landscape and compose chambers in the landscape. It cultivates the experience of entering and 'being inside' the estate. Because the plots follow the irregular parcellation of the landscape type, the effect is a changing sense of depth and scale when walking through the estate.



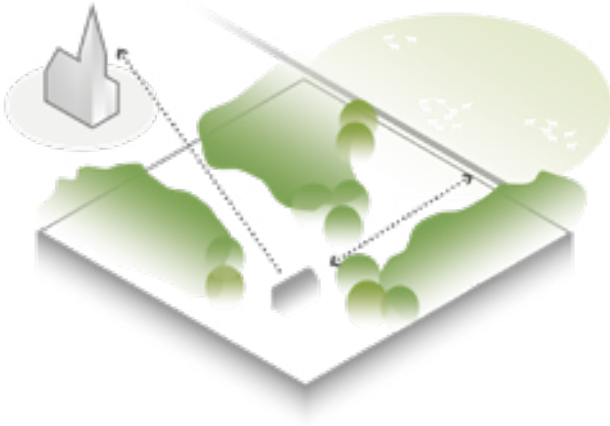
E4. Autonomous recreational area
The estate performs as an autonomous recreational unity within the region. The scale of an estate makes it suitable for hike that is customisable in length, where key features of the estate provide the visual and cognitive coherence. Near the core, there is a central place for parking cars from where a hike around the estate be started. Optionally, the routes are themed around certain features or historical layers of the estate that are explained with information signs.



E5. Emphasised landscape infrastructure
Old or new landscape infrastructure is emphasised within the boundaries of the estates. By planting trees along an important road or regional water course, these linear features are articulated in the third dimension. Besides, this enhances it as a green corridor for people and fauna. In a new estate, important historical regional infrastructure or newly introduced connections should be emphasised.



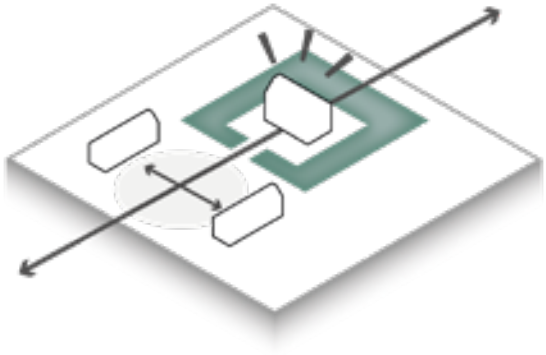
E6. Core and park on landscape gradient
The core and the park of the estate are positioned on a gradient in the landscape. This choice originated from the strategic defensibility of such a site. However, these gradients also offer the best views from the main residence, overlooking the lower fields and meadows. In a new estate, such a gradient also serves as a favourable location to design a diverse park that responds to the underlying variation in soil and hydrological conditions. The landscape gradient is also exaggerated by new artificial design interventions.



E7. Bidirectional vistas
Vistas are designed within the estate to cultivate a visual relationship with the surrounding landscape. They frame a view on an important landmark, like the church in the case of De Gelder. Vistas are also used to employ the surrounding agrarian landscape in a scenic route (see Windesheim, appendix B2). Thirdly, the vistas are designed to accentuate the important features within the estate itself. Employing vistas in the design of a new estate should highlight new focal features and presents a view towards the direct surroundings.

E8. Permeable park
The core (if publicly accessible) and park are more permeable than the larger productive territory of the estate. The network of pathways in park is oriented at offering a diverse experience of the designed landscape, while the accessibility in the larger part of estate is mostly restricted to the local roads and paths. This implicates the sense of scale when walking through the estate.

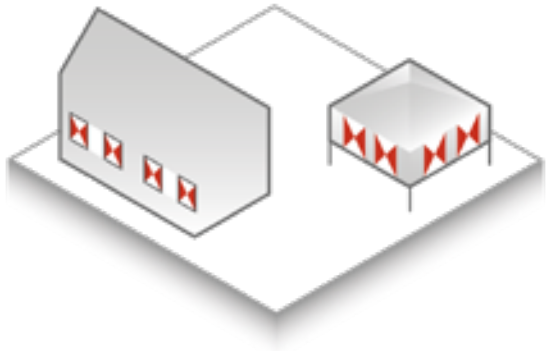
E9. Space for curation
A site in the core or park is used to acquire and maintain a collection for scientific or aesthetic purposes. The pinetum at the Gelder and the rose garden at Windesheim are botanical examples of this curational drift. At De Haere, there is an ongoing tradition of exhibiting both historical and modern artefacts in the garden. A new estate should have space within the robust structure of the garden or park for a dynamic programme that exhibits scientific or aesthetic novelty.



E10. Orthogonal cluster in the core
The layout of the core is a strong hierarchical feature of the estate type. A central axis runs through the centre of the core that extends into the park and estate territory. The core consists of multiple buildings where the main residence takes the central position. The outbuilding(s) are placed perpendicular in front of the main house and enclose a forecourt. This orthogonality is also reflected in the position of the gardens adjacent to the core. Either the entire cluster of buildings or the main residence is surrounded with a moat. Employing this orthogonal structure of volumes in a new estate creates an enclosed forecourt that serves as a central meeting space.

E11. Performative artefacts
The functional structures on the estate, like bridges, gates and furniture are uniquely designed objects. By devoting much attention to the appearance of these elements, they are now protected as cultural heritage and integral parts of the estate. Although some have lost their initial function, they remain important because of their cultural historical and aesthetic value. Designing performative artefacts in new estates monumentalises the confluence of the utilitarian and aesthetic values of estates.

E12. Marked entrances
Gates are located on the main entrances to the core and park. They are the physical indicator of entering the formerly private residence. Now they have been opened to public, the gates still remain as a legible landmark that cultivates the experience of entering the estate. The entrance gates of an estate share a similar ornamentation and materialisation. Gates at the entrance of a new estate should have a contemporary design and make use of local materials.



E13. Recognisable graphic feature
The residential and farm buildings at the estate carry the same recognisable pattern on their exterior. The design of the pattern is simple and the colours are bright, which makes it remarkable and memorable. The pattern also serves as a means to demarcate the spatial extent of the estate in the wider landscape context. As can be seen in the case of De Gelder, the pattern is also incorporated in other built structures. In the design of a new estate, this can be translated to a reappearing colours or materials in all built structures.

4.3 Conclusion

Studying and analysing the three local cases of the estate type of West Overijssel have provided many spatial characteristics. It is not an exhaustive list of characteristics, but forms an important foundation for an new estate. There where each location has its own features, the application of the characteristics differ in each estate making them unique and suitable in local context.
The spatial characteristics form an important framework when designing a sustainable energy estate and integrating the stated design considerations.

chapter 5

Landscape and site analysis

More specific site knowledge is needed in order to merge the design considerations and spatial characteristics of the estate type at the Noordmanshoek. This preceding analytical research motivates how the site and landscape context need to be studied and which features of the site need to be explicated.

The Noordmanshoek is located in the most western part of Overijssel, which is a part of the cultural and geographic region of Salland. This compelling and much-valued landscape is the result of many interactions between natural geological processes and consecutive cultural adaptation by its inhabitants. To design a new sustainable energy estate that is responsive to the surrounding regional landscape, a brief summary of the historical landscape development is presented first. Thereafter, the results from a more detailed site analysis of the Noordmanshoek and the immediate surroundings are discussed.

5.1 Regional landscape

The landscape of Salland is a diverse landscape that has its origin in the forces of ice, wind and water. The IJssel valley and its sequential fill originate from the geological events and processes in the Pleistocene and the Holocene (see figure 5.1). The geological analysis below is mainly informed by the work of Spek, Zeiler, and Raap (1996) and Haartsen and Storms (2009).

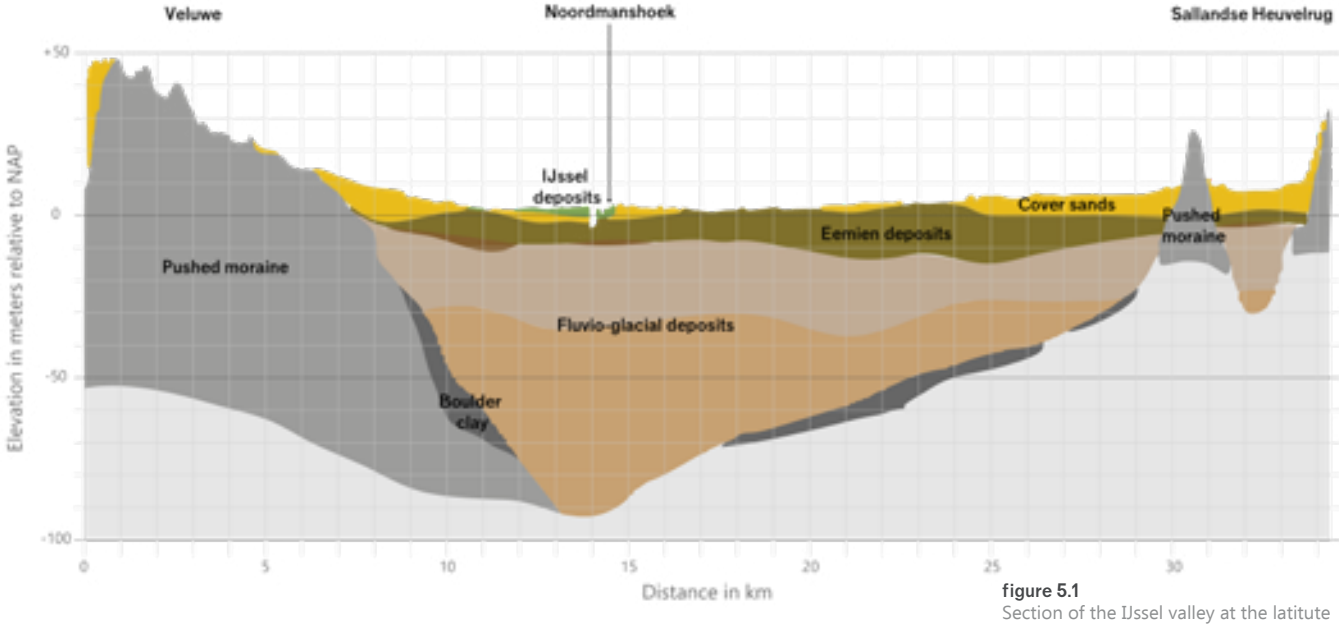


figure 5.1
Section of the IJssel valley at the latitute of the Noordmanshoek

figure 5.2
The glacier pushes up fluvial sediments, forming the pushed moraines and the glacial basin

figure 5.3
The glacial basin gradually fills up with fluvio-glacial deposits

figure 5.4
The river dunes and cover sand ridges are created by polar storms

The two most recent glaciations in the Pleistocene were most influential in shaping the distinct topography of Salland. During the Saalian glaciation (200.000-130.000 BP), a large ice cap from Scandinavia covered the northern part of the Netherlands. At what is now the valley of the river IJssel, one of the glaciers channeled deep into existing fluvial sediments and pushed these forwards and sidewards (figure 5.2). A deep glacial basin was formed, that was around 25 kilometers wide and up to 100 meters deep. These glacial forces created the high pushed moraines of the Veluwe in the west and the Sallandse Heuvelrug in the east.

As the global climate got warmer, the glacial basin was filled with the meltwater from the glacier and turned into a large lake. The water carried material from the moraines and deposited a thick layer of boulder clay at the bottom of this lake. After the glacier completely melted away and the lake disappeared, the basin was gradually filled up with fluvial sediments from the Rhine, a river that ran through the current IJssel valley with a system of fast-flowing braided river channels (figure 5.3). It deposited course sandy and gravel sediments. In the following warmer period of the Eemien (130.000-120.000 BP) the sea level rose and the Rhine turned into a meandering river that mostly deposited clay instead of sand.

During the Weichselian glaciation (120.000-10.000 BP), the glaciers did not reach the Netherlands but there was a dry and icy tundra climate with an almost permanently frozen soil. When the top soil did melt, the meltwater ran off westwards and created the characteristic east-west running pattern of ridges and valleys found in Sallland (figure 5.4). Because of the lack of vegetation, the wind could transport and deposit sand from dry riverbeds in a large part of the country. Salland was covered with a thick layer of these cover sands. During the Weichselian the IJssel became disconnected from the river Rhine and was fed by smaller streams. At that

time, the IJssel was merely a system of banks and gullies transporting meltwater in spring, but most of the time it fell dry. In the same manner as the cover sands, polar storms formed the river dunes directly east of the IJssel.

After the Weichselian period, the warmer Holocene epoch started which continues to this day (10.000 BP – present). The landscape became vegetated with forest and erosion decreased. Under the influence of seepage water, large peat bogs developed in the lower terrains of Salland which turned the IJssel into a small peat river fed by local streams (figure 5.5). The IJssel gradually changed from the fast-flowing braided pattern into a calmer, meandering river.

In the Roman era (around 600 AD) the peat brook was reconnected with the main stream of the river Rhine and the discharge of the IJssel increased. Due to the renewed water and sediment supply of the IJssel, the river landscape was created on top of the peat areas. At first, the river freely meandered through the valley creating rivers basins and levees. It regularly overflowed its banks and deposited clay sediments in the basin areas (figure 5.6). The river levees grew slowly in height and width due to sand deposition. The first settlements were on these levees and ridges, since the hinterland was still prone to periodic floods by the IJssel.

Around 1300 AD the river levees had closed together and river dikes were constructed. Natural runoff to the IJssel was no longer possible. The weteringen were dug in order to drain the hinterland although some areas remained marshy for centuries (figure 5.7). Settlement and agricultural practices were responsive to the landscape morphology where the food and energy systems made use of the wildly vegetated lower areas and the infertile higher areas.

figure 5.5
The area becomes vegetated because of the warmer climate and peat bogs develop in the lower areas

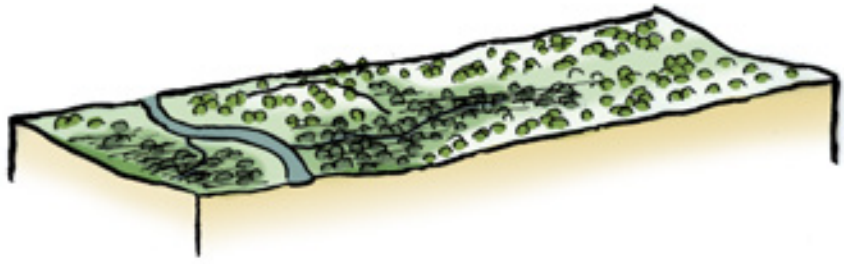


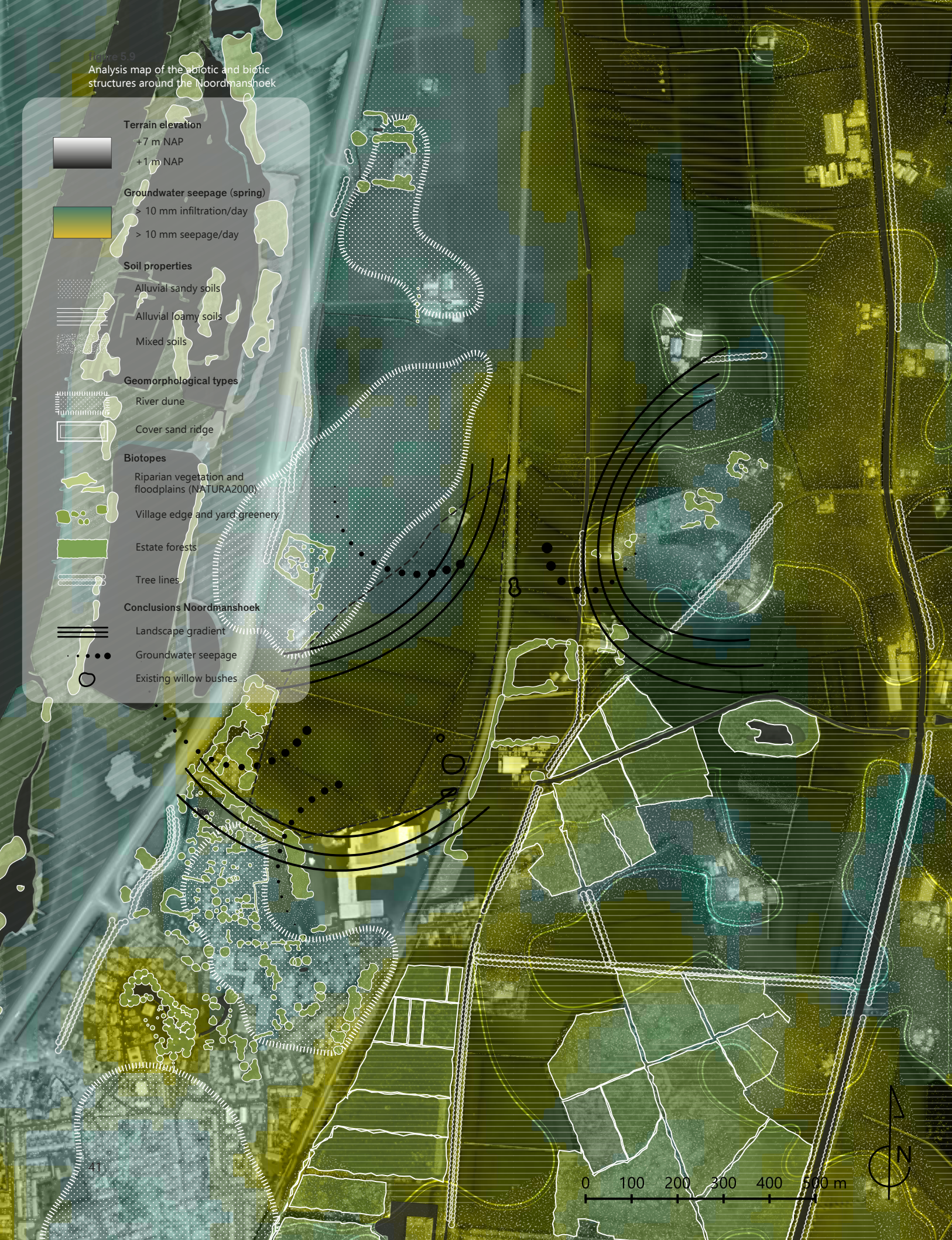
figure 5.6
The IJssel carries more sediment and creates the sandy river levees and the loamy river basins in between the existing elevations

figure 5.7
River dikes are constructed and the wetering are dug to drain the hinterland, whil some areas remain marshy

As can be seen on figure 5.8 the landscape context of the Noordmanshoek is located right on the transition between the river landscape and the landscape of cover sand ridges and valleys. In the following paragraphs four themes are studied in more detail on and around the site. First, the abiotic and biotic structures are discussed, which partly builds upon the geomorphological landscape development explained above. Secondly, the most important cultural historical elements and structures from the post-medieval era are illuminated and explained. Thirdly, the spatial opportunities and constraints of the site in the current situation are analysed. Lastly, the section on energy brings the challenge of the energy transition into the area and discusses the regional and local context.

figure 5.8
The Noordmanshoek is located on the transition between the river landscape and the cover sand landscape

figure 5.9
Analysis map of the abiotic and biotic structures around the Noordmanshoek



5.2 Abiotic and biotic landscape structures

The map in figure 5.9 shows the abiotic and biotic landscape structures of the Noordmanshoek. The site is located at the confluence of multiple landscape types as can be explained by the geomorphological processes described in the previous section. This landscape is unique compared to the other Dutch river landscapes because it is a rare product of the aeolian and fluvial dynamics coming to the surface. The ridges in the east and the distinctive elevated river dunes around the Noordmanshoek are the result of the Pleistocene sandy deposits (figure 5.10). The higher sandy natural river levee in the west and the lower loamy river basins directly east are a result of the alluvial deposits in the Holocene.

The geomorphological genesis of this landscape is reflected in the hydrological and soil conditions of the site. As can be seen in figure 5.9, water infiltrates at the heights of the river dunes and the cover sand ridges. This groundwater seeps up at the flanks and the lower terrains. The relative high amount of seepage water in spring at the Noordmanshoek originates from the surrounding river dunes, but also from the river and floodplains (figure 5.11 and 5.12).

There are three distinguishable biotopes around the Noordmanshoek (see figure 5.9). In the west, the floodplains of the IJssel (Buitenwaarden) are protected as a NATURA2000 area because they are of international importance for bird wildlife. This area consists of large open water bodies, riparian forests and extensively managed flowering grasslands. Another biotope is the lush village edge rich in various deciduous trees planted as solitaires and in avenues (figure 5.13). The third are the forests at the Gelder where especially the older mixed forests hold ecological value. Currently, the agricultural area to the north has few ecological assets except from some willows and trees around the farm buildings.

The landscape gradients in elevation, soil and groundwater levels at the site present valuable opportunities for diverse ecological development, but also the allocation of the (agri)cultural programme. The plot at the south eastern part of the Noordmanshoek is already an extensified natural grassland with some willow bushes.

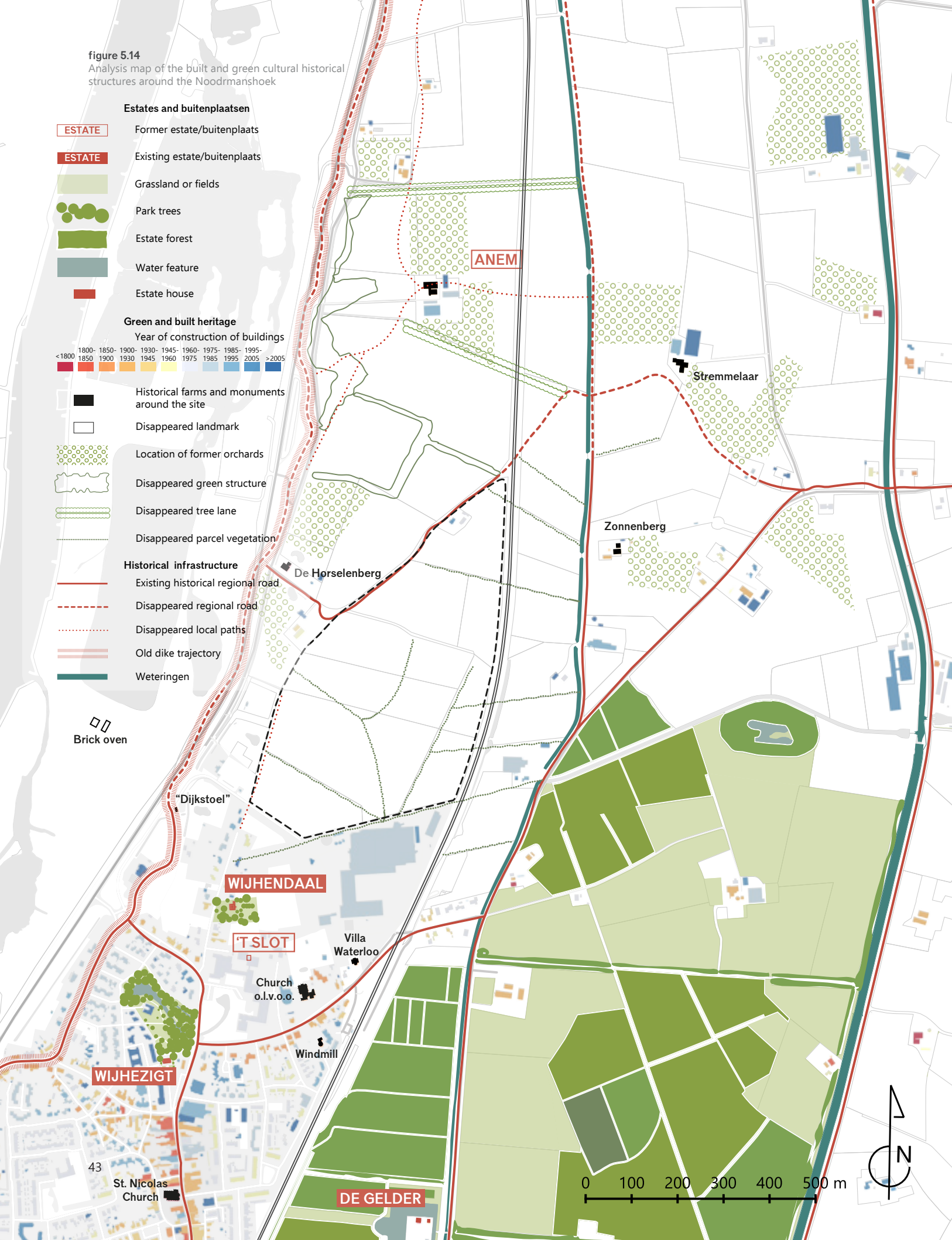
figure 5.10
The elevation of the river dune and lower hinterland is clearly visible at the site

figure 5.11
The floodplains during high discharge of the river

figure 5.12
Groundwater seepage at the Noordmanshoek

figure 5.13
The green lush northern village edge with the estate forests in the background

figure 5.14
Analysis map of the built and green cultural historical structures around the Noodrmanshoek



5.3 Cultural history

The connection between the natural morphology and the agricultural and energy system has gradually diminished in the previous century. Although the area has not been subject to large scale land consolidation projects, the upscaling and homogenisation of the agricultural landscape is also legible around the Noordmanshoek. Large dairy farming businesses dominate the landscape and arable farming for human consumption has almost completely disappeared. Characteristic agricultural practices and once abundant small scale landscape elements like the high-stem orchards (figure 5.15), willow plantations (twiegweerden) and the planted parcel borders have vanished from the area (see figure 5.14). This modernisation can also been seen in the infrastructural developments. The winding dike trajectory has been straightened, local roads have been cut off or removed, and the regional roads along the weteringen have been relocated (figure 5.14). Also, the construction of the railroad has cut through several parcellation patterns.

The establishment of estates in the landscape context of the Noordmanshoek is not a new phenomenon. The large adjacent estate De Gelder was discussed in chapter 4. Directly north of the Noordmanshoek was the former estate and havezate Anem. The parcels were individually sold and the house disappeared at the end of the 19th century. A farm with the same name reminds the location of the former havezate but from the park-like setting around the house as depicted in figure 5.15 has remained nothing. A few smaller "buitenplaatsen" were situated along the northern edge of the village, namely Wijhezigt, Wijhendaal and 't Slot (see figure 5.14 and 5.17).

The appearance of this northern village edge has changed substantially from the second half of the last century. New houses have been built along the Wijhendaalse weg, but also the industrial site of meat-processing factory Stegeman (formerly Meester) at the Stationsweg has expanded substantially (figure 5.18). The buitenplaatsen Wijhezigt and Wijhendaal have been absorbed by these village expansions and 't Slot was demolished to make place for a nursing home (Kunst, n.d.).

To conclude, the main opportunities resulting from this cultural historical analysis are both the reintroduction of the vernacular landscape elements and a revaluation of the green and built heritage around the site. The restoration of old landscape infrastructure can enhance the legibility of the landscape since this was more in line with the distinct topography of the site.

figure 5.15
The production of fruit in high-stem orchards was once fruitful business in the region

figure 5.16
Depiction of the former havezate Anem, an estate that was located directly north of the Noordmanshoek

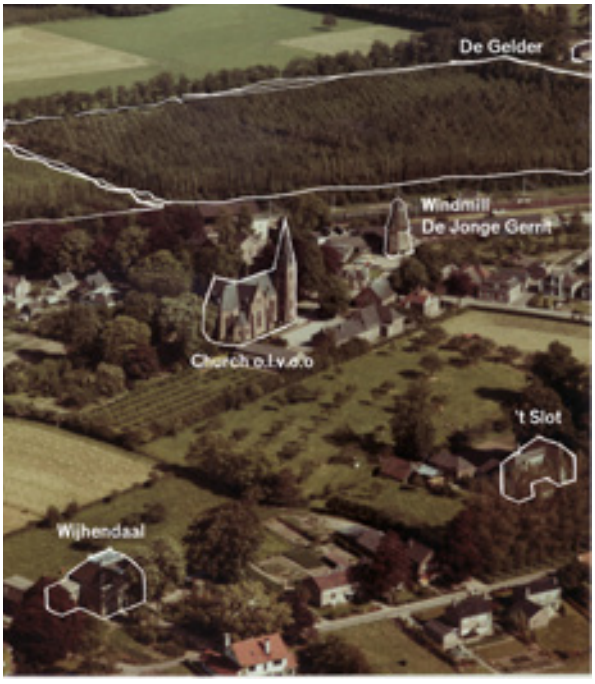


figure 5.17
Aerial photograph of the northern village edge (around ca. 1970), showing the different estates, buitenplaatsen and monuments

figure 5.18
The expansion of the Meester factory included the construction of two iconic chimneys which have been demolished

5.4 Energy

The development of the sustainable energy estate at the Noordmanshoek should be placed in the context of the Regional Energy Strategy West Overijssel (RES West-Overijssel, 2020). Based on the ambition and knowledge of the possibilities per municipality, the ambition is to generate 1,6 TWh of renewable energy per year in 2030. This offer contributes to the national goal of 35 TWh as formulated in the National Climate Agreement (see also figure 1.2). Olst-Wijhe is a one of the eleven municipalities in the RES West Overijssel and commits to generating 54 GWh of the total 1607 GWh (=1,6 TWh). This equivalates to only 3% of the regional target.

Within Olst-Wijhe there is a main focus on solar energy and not on large scale wind energy because of the constraints presented by infrastructure, residential areas, nature areas and a low flight zone (Gemeente Olst-Wijhe, 2019). The scale of the solar energy fields is informed by the landscape types in the area. For ecological considerations the floodplains and the forests in the south of the municipality are omitted from the generation of renewable energy. The river levee and the cover sand ridge landscapes are suitable for small scale generation and the river basin landscape is more suitable for large scale generation of solar energy. The Noordmanshoek is on the edge between the river levee and river basin landscape (figure 5.19).

Because the location of the Noordmanshoek is so close to the village Wijhe, it makes sense to consider the local electricity demand of the village. The annual domestic energy demand of Wijhe is about 131 TJ, not including transport. 19% of this energy demand is for electricity, while the remaining 81% is for heat. The electricity demand equivalates to 7061250 kWh (roughly 7 GWh) per year. A standard solar energy setup of 3000 300Wp panels per hectare delivers 792000 kWh per year. Hence, installing 8,9 ha of PV panels fulfills the annual domestic electricity demand of the entire village (figure 5.20).

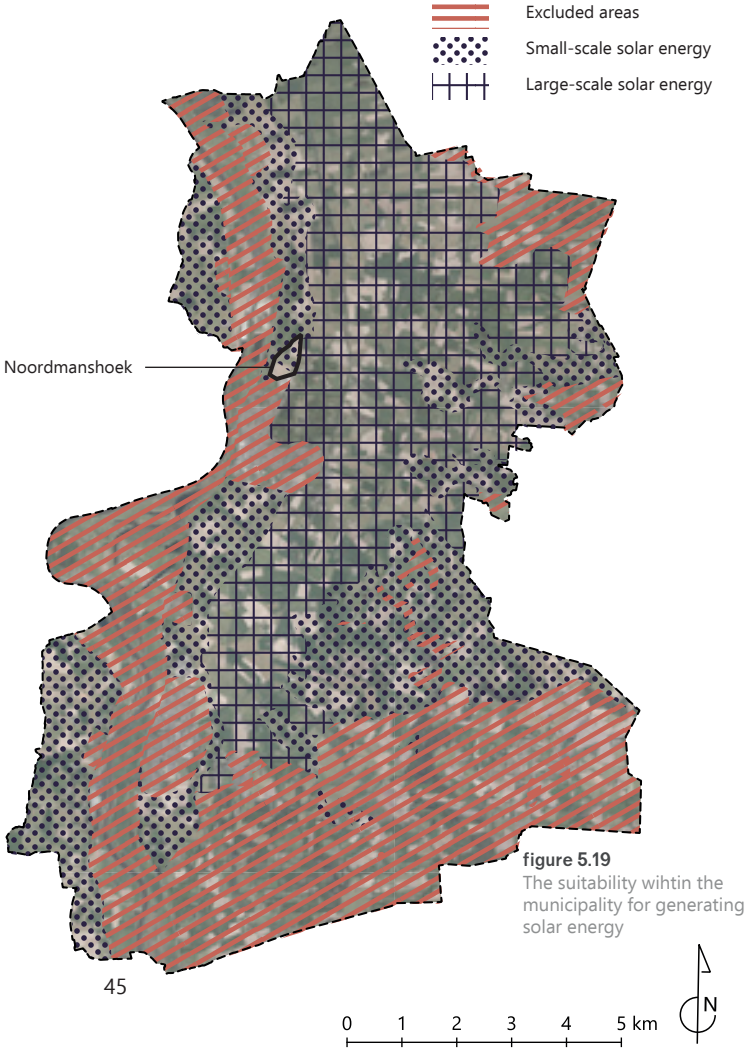


figure 5.19
The suitability wihtin the municipality for generating solar energy

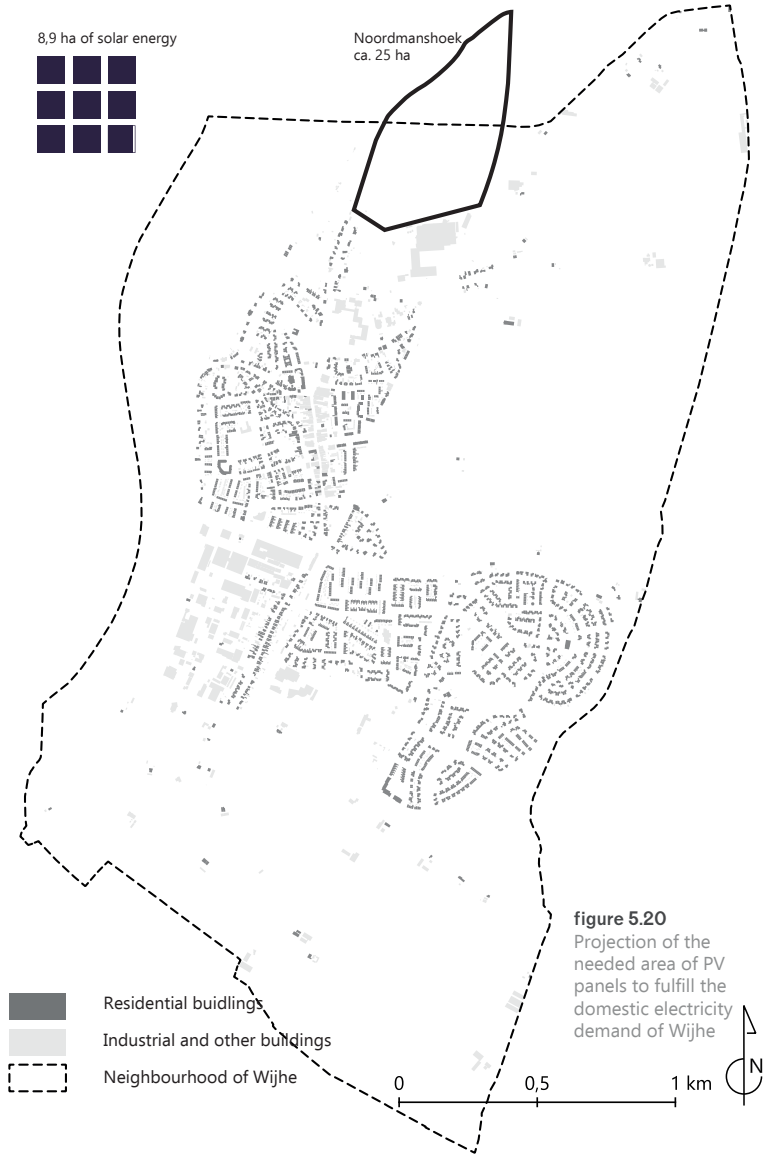


figure 5.20
Projection of the needed area of PV panels to fulfill the domestic electricity demand of Wijhe

5.5 Oppurtunities and constraints

Experience of the landscape

There are two important north south running connections from which the site is experienced by the landscape user, namely the dike and the railroad. Because of its elevation, the view from the dike road is different from the view on the lower adjacent road. The field of view is influenced by the vegetation on the eastern side of the dike, resulting in an alternating perspective of the site. The view from the train is more open and not obstructed by buildings or vegetation. Approaching the site from the north, definitely bears a lot of scenic qualities because it is enclosed by the green village edge and the estate forest. Also, the church towers of Wijhe loom above the tree tops and can be seen from far away (figure 5.21). Contrary to this attractive soft green village edge are the unattractive facades of the Stegeman factory and the large barns of the dairy farms (see figure 5.21 and 5.22).

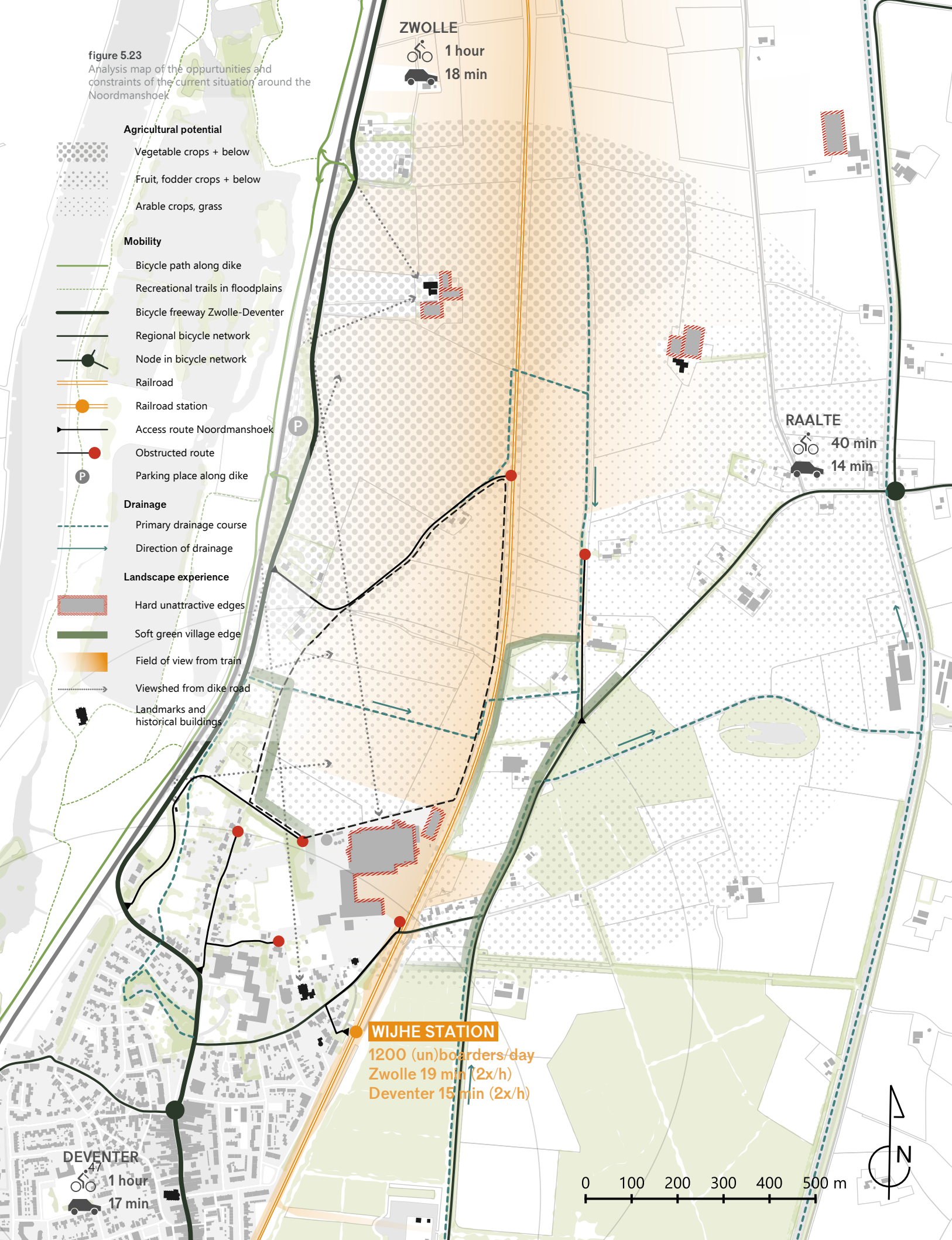
Agricultural potential

The diversity of the landscape in Salland is under pressure due to intensification and upscaling of agriculture. At the site, the current land use does not resonate with the favourable agricultural potential of the area (figure 5.23). The river dune is perfectly suited for cultivation of vegetables, the river levee for production of fruit, and the loamy basin for production of arable crops and grassland. Considering the proximity of the village, the site can play an important role in providing the inhabitants with fresh local produce and shorten the chain, like proposed in a recently executed pilot study (College van Rijksadviseurs & NOHNIK, 2020).

figure 5.21
The soft edge green edge of the village contrasts with the industrial white cladding of the Stegeman facade

figure 5.22
There are many attractive historical farms around the site, but the large barns compromise the small-scale landscape experience

figure 5.23
Analysis map of the oppurtunities and constraints of the current situation around the Noordmanshoek



Mobility and access

The dike is the most important regional connection for both cyclists and motorised traffic. The bicycle path along the IJssel is a recreational pathway that also gives access to the trails in the Buitenwaarden, while the road directly east of the dike (Het Anem, figure 5.24) is part of the planned bicycle freeway Zwolle-Deventer (Mondeel, 2018). The railroad forms the eastern border of the Noordmanshoek and many passengers pass the site by train. The proximity of the railroad station presents an opportunity to attract regional visitors to the new energy estate. Securing the connections to the bike freeway and the train station would embed the new energy estate in the regional mobility network (figure 5.23). However, many of the current access roads and paths run dead or are obstructed. For example, the shortest route from the station to the site ends at a fence of the Stegeman premises (figure 5.23 and 5.25).

Energy

The generation of renewable energy at the site should not compromise the existing landscape qualities and make a positive contribution to the current constraints. As discussed in section 5.4, the scale of the landscape is a leading principle for the introduction and adaptation of renewable energy infrastructure. However, the iconicity of an energy estate substantiates evocative deviation from the suggested regional policies. The landscape informs the appropriate land use combinations in regard to the abiotic and biotic conditions, but also to ensure a positive experience of the new landscape by people. This makes the generation of renewable energy at the site not only sustainable, but also memorable.

figure 5.24
A part of the bicycle freeway that runs along the site

figure 5.25
Many of the current access roads and paths towards the Noodrmandshoek run dead or are obstructed

chapter 6

Model study

After acquiring knowledge on design considerations, the spatial characteristics of the regional estate type and the site-specificities, the next step is to synthesise these different knowledge types into a design for the Noordmanshoek. Ultimately, the design process serves as a means to consolidate the design guidelines for a sustainable energy estate in the landscape context of West Overijssel. Before that, an intermediate model study was executed to explore the bandwidth of possibilities and to set the stage for the final design. This has resulted in two different models that are described and illustrated in this chapter.

Before diving into the results of this study, it is important to reiterate the purpose of the design in the light of the general research question of this thesis. This thesis revolves around designing sustainable energy estates in the context of West Overijssel. Therefore, the goal of this model exercise was not to come up with two definitive designs for an energy estate at the Noordmanshoek, but rather to research the flexibility of the concept, in which the site serves as the testing ground. In that regard, the model study was used to match, test and adjust the spatial characteristics of the estate type with the design considerations described earlier. The design iterations between these knowledge types were used to elicit specific design guidelines for the site as well as to deliver the ingredients for the final design of the energy estate.

figure 6.1
The designed synergy model for the energy estate at the Noordmanshoek

6.1 Synergy model

The experiment

Within the synergy model (fig 6.1), the morphology of renewable energy infrastructure is used as a source of inspiration for the estate type transformation [C4]. The energy infrastructure is distributed across the entire estate and there is a focus on showcasing different renewable energy technologies [C1] and exhibit the synergies with other land uses. There is explicit attention for agrivoltaic solutions that innovate the current agricultural practices in the region [C11, C18]. Embracing the new cultivation of the landscape for sustainable energy resonates in the design language of all the components in the energy estate [C4, C6].

An imaginary gradient can be placed over this model from south to north in regard to the synergies with renewable energy infrastructure. In the south there is a focus on efficient renewable energy generation and storage [C16, C22], in the middle part a focus on nature combinations [C14] and the northern part focuses on agricultural combinations [C2]. This gradient not only applies to the land use combinations, but also to the introduced landscape patterns and shapes. In the south, the new cultivation for energy is reflected in the rational south orientation [C4] while in the north the orientation is more responsive to the existing parcellation patterns [C26].

Core and park

In line with the local estate type, the core and park are positioned on a landscape gradient that exists in the south-western corner of the Noordmanshoek. This transition from river dune to river levee and subsequently to a lower area of this levee is used to design a park consisting of natural forest types [C7, C27]. The park consist of patches of forest separated by voids that create vistas from the core towards the historical landmarks Wijhendaal and the church tower.
The renewable energy that is generated at the estate is locally stored in a system that was adopted from MALTA Inc. (2018) [C18, C22]. The electrical energy is converted to thermal energy with a heat pump, creating a temperature difference. The heat is stored in molten salt and the cold is stored in another liquid. When needed, this thermal energy can be converted back to electrical energy through the reversed process. In this design, the storage tanks are positioned within the woodland and partly in the viewshed. This makes them peculiar alienating artefacts in the new park [C6]. A network of raised pathways makes this park and the battery tanks accessible for people [C6, C17]. The battery tank for cold storage is designed as a lookout point, which facilitates higher perspective of the energy estate [C3]. The core is located north of the park and consists of two building volumes that give space for a unique residential development [C13]. The garden west and north of the core features a more exotic program as a response to the natural forest in the park. Wind stalks (Atelier DNA, 2010) and exotic coniferous trees are clustered as clumps north of the core. They mark the height difference of the river dune and the entrance [C5]. The ditch is widened into a water feature that encloses the residential core [C29]. Directly west of this residential core, the experimental garden combines various configurations of PV arrays with the cultivation of exotic ornamental and consumption crops.

A new cultivation

Intensive solar energy infrastructure is concentrated in the south adjacent to the Stegeman factory [C16]. This dense field of east-west facing solar PV arrays provides efficient generation of renewable energy [C2] and its appearance responds to the scale and industrial character of the factory. This field is oriented exactly south (azimuth 180), imposing a new rational and provocative structure in the landscape [C4].
The north oriented solar PV arrays extend into a willow short rotation coppice, planted in the same scheme. This is a contemporary translation of the willow plantations that were historically cultivated for their branches in this region [C9]. The introduction of this new 'griend' is a source for biomass, but mostly holds educational, ecological and cultural historical values [C15]. The ditch that collects and drains much of the runoff water in the region is rerouted and meanders through this new. The arrays are harvested at different moments. This purifies the water from leached nutrients and pollutants [C11] and the ditch also protects the solar PV panels from theft [C21].

Agrivoltaic solutions

New synergies between solar energy infrastructure and agriculture are a focal theme in this model and result in different designed solutions. The centerpiece of the model is a circular field that

is based on the elliptical path of the sun [C4]. A dense configuration of solar energy infrastructure is placed on a moving structure that rotates along with the direction of the sun around a central pivot point [C23, C28]. Within this field, various arable crops are cultivated in concentric strips, creating a robust and resilient agricultural system [C11]. Because the solar field and the casted shadows gradually move over the crops throughout the day, the adverse effects on crop yield are mitigated [C19]. A dike is built around the northern structure that is higher in the west. During the day the structure rolls down this dike eastward around the central pivot point. The kinetic energy of this movement is stored and used to reposition the PV structure to the starting position during the night [C22]. Additionally, the irrigation and fertilisation systems can be integrated into this moving structure. The dike around the rotating solar field is planted with a double row of walnut trees to accentuate this new structure in the landscape [C4].

The area surrounding this circular field is designed as an extensive meadow where small livestock is farmed between configurations of low south facing solar PV arrays [C20]. These small fields are separated by rows of the native willow trees that reiterate the introduced rational south orientation [C9]. A memorable experience from the train is created by installing the solar PV arrays in increasing density towards the village [C2, C3]. This mimics the overall density gradient of the estate but this kinesthetic experience also symbolises the increasing need for renewable energy in the built environment.

In the northern part of the estate a synergetic strip cropping system is designed that is more responsive to the existing orientation of the parcels. This system draws both from agroforestry practices and experiments with vertical bifacial PV modules. At the northern boundary of the estate, the elevation of the river levee is emphasised by interchanging crop strips with rows of half-stem fruit trees [C9]. Further east, the crop rows are interchanged with arrays of bifacial PV, responsive to the lower part of the river levee.

6.2 Casco model

The experiment

In the casco model (figure 6.2), the design and allocation of the renewable energy infrastructure is more responsive to the existing landscape [C26] patterns and takes a less governing role in shaping the other components of the energy estate. As opposed to the synergy model, this model focuses on solar energy infrastructure and configurations that are more conventional. Land use combinations are less pronounced and innovative and instead focus on diverse ecological development [C10, C13, C14]. A gradient is applied to the estate where the density of the energy infrastructure increases towards the village edge [C2, C16]. Hence, the most intensive infrastructure is positioned closest to the consumer of the generated electricity at the estate.

Core and park

The core and park of the estate are located on the edge of the northern river dune. This landscape gradient running north west to south east is reserved for extensive solar energy infrastructure in combination with nature development [C27]. This gradient is also emphasised by designing the central axis of the estate along this gradient. One large building volume is placed within this central axis that gives opportunity for the development of multiple dwellings on the estate [C13]. Multiple vistas connect this focal point with the rest of the estate and the landmarks in the surroundings. The park is designed as an extensive area that features both loosely placed south facing solar PV arrays as well as larger solar tracker modules [C18]. The higher solar tracker modules are placed in clumps on the edge of the river dune in the west while the low PV arrays are placed loosely in the lower area in the east [C24]. This resonates the distinct height difference of the site. An experimental setup is designed at the southern border of the park to test the effect of different densities of solar energy infrastructure on the development of native flora species [C7, C18]. The bank of the existing ditch is altered in four different ways and the experimental setup is installed on top [C14]. In the park, pathways and trails lead the visitor along the different configurations solar energy, the farm and the main residence [C8, C17]. The extensive park performs as the transitional zone between the northern part and southern part of the estate.

Framed solar field

The southern part of the estate is mainly focused on the generation of renewable energy. A large field of south facing solar PV arrays is oriented according to the existing parcellation structure [26]. This south facing configuration still leaves room for light and water to reach the soil and let vegetation develop between the arrays [C7, C12]. The vista from the main residence towards the church is kept clear from PV arrays. A partly new ditch around this field protects the PV panels from theft and creates another biotope [C21, C29]. The borders of this field respond to the direct surroundings. The western border is designed as an orchard that creates a new permeable estate entrance from the village edge [C9, C25]. Various fruit species can be cultivated here, providing nutritional, botanical and educational value [C8]. The southern border is densely planted with native tree species to screen the façade from the Stegeman factory [C21]. This also emphasises the border of the estate and promotes the feeling of being inside. The eastern border is designed as a new griend (willow plantation) that compliments the existing willow bushes on this parcel [C9, C15, C29]. Cleared out vistas in this griend present a view on the energy infrastructure from the train [C3].

New agriculture

In the northern part, the elevation of river levee is accentuated with a large food forest. A food forest benefits from having edges because of the layered growth structure. Therefore, the forest is subdivided in smaller patches by vistas from the dike roads towards the buildings and vice versa. East of this forest are two arable fields where various crops can be cultivated. A helophyte filter along the eastern ditch captures excess leached nutrients from the arable fields [C29]. Together with the yield of the food forest, this northern part of the estate provides fruit, nuts and various other produce for the local inhabitants.

figure 6.2
The designed casco model for the energy esate at the Noordmanshoek

Spatial characteristic of the estate type	Translation into site specific design guidelines from experimental transformations	Derived from model	Applied considerations
E1. Three zones, one system	Renewable energy infrastructure is distributed over the entire estate to delineate the systemic extent and to accommodate different site-spefic synergies with agriculture and nature	S	1,2,3,6,8,11
	Arable farming and livestock farming are combined with renewable energy infrastructure to achieve a circular agricultural system	S/C	2, 11, 8, 13, 20
	Solar energy generation and innovative sustainable arable farming practices are integrated in synergetic systems at the northern agricultural interface	S	2,6,11,19,20,23,28
	Combinations of renewable energy with nature and recreation form a transitional area between the three zones.	S/C	8,14,17,25
E2. Legible landscape morphology	The gradually rising edges of energy estate the river dune in the north and river levee in the south are planted with robust green structures to delineate a boundary that is visible from inside and outside of the estate.	S/C	7,10, 13,14, 27
	Roads and pathways are designed along transitions in the new energy landscape	C/S	3, 17, 25, 26
	Adjust height of the renewable infrastructure and other landscape infrastructure to reflect the subtle height differences of the landscape	S/C	24,5
E3. Enclosed space	Preserve the lower area of the Noordmanshoek as a central plain dedicated to the generation of solar energy	C	16, 24, 26, 27
E4. Autonomous recreational area	A fine network of routes extends from the park towards the different subareas in the energy estate and highlights are designed along the routes	C/S	3, 8, 17, 25
E5. Emphasised landscape infrastructure	The patterns of solar energy infrastructure are extended into a contemporary design of native landscape elements like orchards and willow plantations	S	1, 4, 6, 8, 9, 15
	Solar energy infrastructure is placed in a visible increasing density towards the village edge	S/C	2, 3, 16
	Existing ditches around the concentrated solar energy infrastructure are used to create new ecotones that simultaneously serve as protective measures	S/C	3, 8, 10, 12, 14, 21, 26, 29
	Introduce contrasting energy informed landscape patterns close to the core and respond to the existing patterns and scale of the landscape further away from the core.	S	4, 16, 26
E6. Core and park on landscape gradient	The new core and park of the energy estate are positioned at the village edge where there is a transition in landscape types, underlying soil, as well as new gradient between renewable energy generation and consumption	S	14, 16, 27
	New residences are designed in the core to provide additional housing in the vicinity of Wijhe	S/C	11, 13
E7. Bidirectional vista's	Edges of energy infrastructure frame vistas towards and from the new core to surrounding (historical) landmarks and infrastructure	S/C	3, 4,7, 24, 25
	Use view from the train to exhibit synergetic solutions to the public	S	3,8, 18, 25
	Internal vistas link different parts of the energy estate with each other and create accessible corridors	C	3, 17
E8. Permeable park	Attractive and alternative small scale renewable energy land use combinations are concentrated in an accessible park	S/C	2, 14, 17
E9. Space for curation	Use the garden as a place for small scale experimentation and exhibition of novel renewable energy combinations.	S/C	18, 19
E10. Orthogonal cluster in core	An orthonogal layout of the core and the gardens resonates with the intensive solar energy infrastructure	S	3, 4, 6
	A moat creates an attractive protective barrier between solar pv infrastructure and visitors	S	12, 21
E11. Performative artefacts	Designed energy storage solutions are integrated in the green structure of the park	S	6, 18, 22
E12. Marked entrances	Design of entrances reflects a juxtaposition of native and exotic renewable energy technologies	S	3, 5, 6, 9, 17, 18, 25,
E13. Recognisable graphic feature	Different subareas have a connecting element in vegetation as well as in material and use of color.	C	6

figure 6.3
The model study has resutled int the identification of 25 design guidelines for a sustainable energy at the site of the Noordmanshoek

6.3 Evaluation and design guidelines

By means of different experimental transformations, this exercise has produced two alternative design models for a sustainable energy estate at the Noordmanshoek. However, the models themselves are not the conclusion that serve the general research question. It is neither the goal to choose one model over the other for the final landscape design. They are a means of evaluating the applicability of the identified spatial characteristics of the estate type in the design of a sustainable energy estate in this landscape context. In order to create a hybrid design that elaborates on the best of both models, the design guidelines that derive from the model study are summarised in figure 6.3. The general limitations of the site that have been found when creating the models are listed below to ensure they are addressed in the final design.

Obstructive factory edge
The large premises of the Stegeman meat-processing factory obstruct the creation of a meaningful dialogue between the new energy estate and the village of Wijhe. In the synergy model, the industrial character of this edge was extended into an intensive solar energy field. However, this results in an inaccessible transition between the village and the estate. In the casco model, the façade of the factory was screened with dense forest that creates a green wall between the factory and the estate. Both options are suboptimal, since neither employ this area as a functional transitional zone between the village and the estate.

Inadequate scale
The boundaries of the Noordmanshoek for the model study are somewhat arbitrary and also substantially smaller (about 4 times) than the geographic extent of the analysed estates in the region. However, these estates were established in a feudal system, where landownership was more hierarchal and involved large pieces of land. The result is that some of the spatial characteristics of the estate type are difficult to translate and convey at the scale of the Noordmanshoek. The establishment of new private contiguous estates of a similar extent is not feasible, but many rural transitions may also favour implementation at a larger scale than the Noordmanshoek. In order to research and test the possibilities for the estate as a catalyst for rural transition, it is beneficial to further expand the conceptual and physical boundaries of the new energy estate.
to further expand the conceptual and physical boundaries of the new energy estate.

chapter 7

Landscape design

In this chapter, the landscape design for the sustainable energy estate at the Noordmanshoek is described and illustrated. The knowledge that has been generated in previous chapter has been applied and accumulated into this final landscape design. However, the design is also an important means towards the consolidation of spatial design guidelines for a sustainable energy estate in West Overijssel which is needed to answer the general research question of this thesis. The design is reasoned from the conceptual fundaments towards the more detailed landscape interventions. At last, this chapter is concluded with the final design guidelines that result from this design research.

Anno 2050

The situational context of the final landscape design is a prospect for the year 2050. This far-sighted perspective allows for the inclusion of future developments in both technology and society. This requires the articulation of several assumptions. In line with the pilot study for Salland by College van Rijksadviseurs and NOHNIK (2020), the agricultural practices in the region are diversified and readjusted to the specificities and ecological capacity of the landscape. There is an increased societal concern for a landscape that not only produces, but also offers diversity and guards the cultural identity. Inhabitants of Wijhe are increasingly aware of their ecological footprint and reduce their consumption of meat in favour of more seasonal and local products. The aftermath of the COVID-19 pandemic has sparked an ongoing counterurbanisation trend that motivates new housing developments in the rural area of Salland.

7.1 Structural concepts

As introduced earlier in section 3.1, the ability to enhance and reconceive the structure of the landscape is one of the important qualities of an estate. The enclosed location and limited extent of the Noordmanshoek were found insufficient to establish the new energy estate as a meaningful structural element in the landscape. Therefore, three site-specific structural design interventions on the larger scale were formulated that provide guidance for designing the estate as an icon with regional significance.

figure 7.1
First structural concept: offset forest edge

Offset forest edge
Considering the strong visual properties of estate boundaries, an iconic and recognisable edge is realised along the northern perimeter of the new energy estate. This evokes a new entrance experience from the majority of north to south running roads, pathways and the railway. At the same time it is also a deliberate offset from the dense green wall of the historical estate De Gelder, which is currently the determining icon on the horizon when entering the village (figure 7.1). The southern boundary is more fluid and leaves enough margin at the interface to also secure the impressive sight of De Gelder.

figure 7.2
Second structural concept: redefining topography

Redefining topography
The undulating character of the site motivate a tailored and outstanding definition of a new topography. With the goal of creating an experienceable and robust landscape that reflects these unique properties, new distinct subareas are designed that are specified towards the site conditions, the direct landscape context and the historical layers (see figure 7.2). While these zones have their own character, they complement the overall structure of the energy estate through visual and functional connections. The higher terrains (river dune, ridges and river levee) become subject to an innovative mixing of renewable energy technologies with both agricultural and cultural functions. The central lower area (formerly inundated by the IJssel) becomes the power-generating valley of the village, where solar energy is combined with extensive agriculture and nature development.

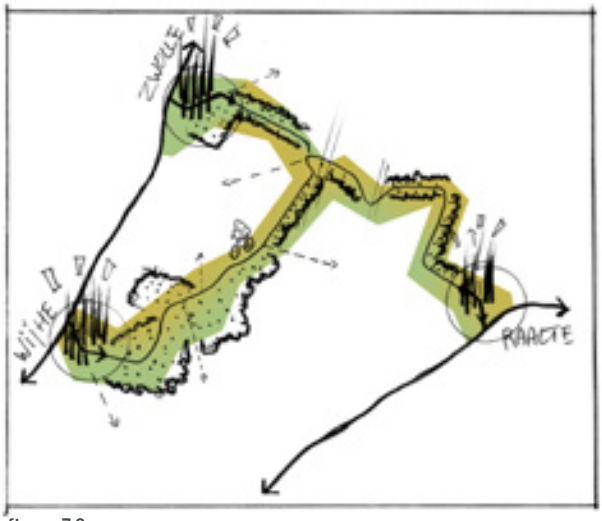


figure 7.3
Third structural concept: Iconic interface

Iconic interface
Within the estate, the gradients between different landscape types and systems are revived as an interface for people, flora and fauna (fig 7.3). From an ecological point of view, these gradients between the sandy river dune and loamy river basin offer great potential for nature development. Besides, the interface accommodates the missing link between the regional recreational network of the floodplains and dike in the west and De Gelder and agricultural hinterland in the east. The most important entrances along the regional cycling infrastructure are marked with high wind technologies that generate renewable energy, emulate a contemporary and thematic gate and also spark an inviting curiosity among passers-by.

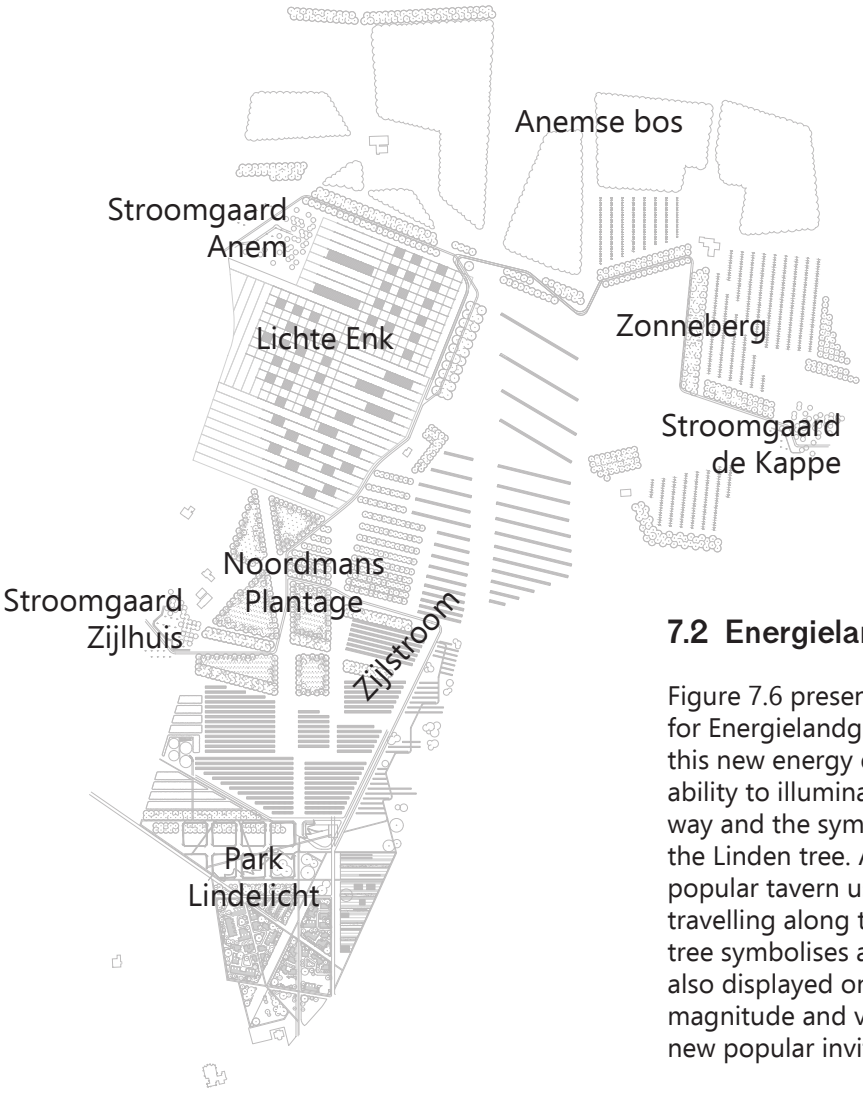


figure 7.4
Field guide for Lindelicht. The various new toponyms created in the design of the new sustainable energy estate

7.2 Energielandgoed Lindelicht

Figure 7.6 presents the final landscape design for Energielandgoed Lindelicht. The name for this new energy estate is a confluence from its ability to illuminate in both a practical and societal way and the symbolic relationship of Wijhe with the Linden tree. An hollow linden tree next to a popular tavern used to welcome the many guests travelling along the river dike (see fig. 7.5). This tree symbolises an important central icon and is also displayed on the coat of arms of Wijhe. By its magnitude and versatility, Lindelicht becomes a new popular inviting icon along the IJssel.

The extent of the energy estate is substantially larger than the projected models in the previous chapter. A more robust and meaningful implementation and advancement of design guidelines has led to the experimental expansion of the project area to the north and at the edge of the village. Another distinct intervention is the addition of the Stegeman factory premises to the estate. This factory is relocated towards the business park in the south of Wijhe to reconcile the northern edge of the village with agricultural landscape.

Lindelicht consist of several subareas with their own specific landscape interventions and characteristics and also a new toponym (fig. 7.4). Each of them will be explained in the remaining of this chapter, where the sequence and narrative emulates the entrance and movement from the north towards the core of the estate at the village edge.


Prins Willem werd toegezongen bij de reusachtige linde van Wijhe
34 kinderen in een holle boom

figure 7.5
The narrative is derived from a former iconic Linden tree along the river dike

figure 7.6
Landscape design for the sustainable energy estate Lindelicht
see appendix D for large map


Energielandgoed
Lindelicht
0 20 50 100 200 m
N

Legend landscape design

Anemse bos


Linden tree borders with pathway
Tilia platyphyllos


Forest plots
Partly grazed with pigs and chickens


Anem
New mixed farm

Stroomgaarden


Wind stalks
Wind energy harvesting technologies


Mixed fruit tree orchard
Mix of apple, pear, cherry and plum varieties


De Nerf
Main cycle and walking path

Zonneberg


Stremmelaar
Mixed livestock farm


Vertical bifacial PV arrays
Mixed with strips of fodder crops


Pasture
Rotation of grass-clover and rye grass

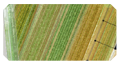

Fruit tree orchard
Mix of apple and pear varieties

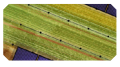

Walnut orchard
Juglans regia

Lichte Enk


Large-leaved linden trees
Tilia platyphyllos


Bridge
With extended lookout platform


Arable fields
Various crops cultivated in parallel strips

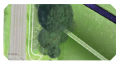

Masts with cables
Elevated bearing structure for canopies


Movable canopies
Light-weight thin-film solar PV surface

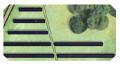

Accessible flower verge
Seeded with native flowering species

Zijlstroom


Solar PV arrays
On mixed pasture


Existing willows
Copse of willow trees


Solar fields
Inbetween wild flower-rich grassland

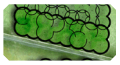

Zijlpad
Raised pathway inbetween low solar PV arrays


Willow trees
New groups of willow trees along ditch

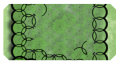

Ditch
Widened ditch with shallow profile

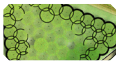

Flower rich grassland
Extensively grazed by sheep

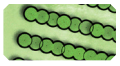
Noordmans Plantage


Linden tree borders with pathway
Tilia platyphyllos


Poplar production forest
Mixed with a native hard-wood tree species

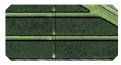

Larch production forest
Mixed with a native hard-wood tree species


Douglas fir forest
Mixed with a native hard-wood tree species

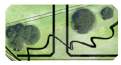

Douglas fir
Mixed with quercus robur

Park Lindelicht


Battery tanks with lookout platform
Molten salt energy storage plant


Twiegtuin
For waste water treatment and biomass

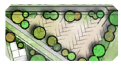

De Broedcel
For changing village programme

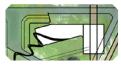

Existing willow and ash trees
With meandering PV ribbon


Forecourt
With a mix of park trees


Meester's tuin
Village garden with experimental PV setups


New dwellings in clusters
Framed by fruit and nut trees


Parking
For visitors


Huis lindelicht
Main residence with moat

Anemse bos
A new forest that stretches from the river dike in the west to the Schippershuizen road in the east demarcates the northern boundary of the estate. This new green edge forms a recognisable entrance and clear transition from the open landscape to the north. Planting the trees close to the dike and the railroad produces a memorable aesthetic mark because of the modulation in light when passing along. Within these woods, the location of the former havezate Anem is reconceived as a focal point, emphasised by vistas from the dike and the railroad (fig. 7.7). East west running alleys of large-leaved linden trees frame the forest as a part of the new estate Lindelicht. This way, the farm gets a new distinguished position without copying the historic conditions. Apart from the visual qualities of such a bold green edge, the forest also compensates for the emitted CO2 emissions of the agricultural business and the construction of the energy estate. A part of the forest is managed as an integral part of the livestock farms through the adoption of pigs and cattle that graze in and around the forest. This diversification of the livestock adds to the overall narrative of the estate and gives a special branding to the products that estate delivers.

Stroomgaarden
Three points along the perimeter of Lindelicht are designed as new outstanding features that mark the entrances into the estate. These 'stroomgaarden' are located along the river dike in the west and along the Kappeweg in the east. They offer an attractive and convenient access for cyclists and pedestrians from the regional recreational network. Figure 7.8 displays the detailed design for the northern entrance. The design builds upon the exiting friction between vernacular and alienating elements of the energy estate. At the three locations, the disappeared native high-stem fruit orchards are replanted in arrays that correspond to the orientation of the adjacent energy infrastructure. They are complemented with copses of high wind stalks (45 m) that guide people inwards and steer the view towards old and new landmarks. On one side of the road, wind stalks are 'planted' on an artificial river dune. The foundations are designed as a branch that connects the stalks but also provide infrastructure for people such as seating, an e-bike charging point and information signs. On the other side of the road, the stalks are planted as arrays mimicking the surrounding linden alleys. Together, they emphasises and dramatize the micro elevational differences at these locations.

figure 7.7
The new forest edge provides an iconic entrance and frames the site of the former havezate Anem

figure 7.8
Detailed design for the stroomgaard Anem entrance at the borderering the arable fields of Lichte Enk

figure 7.9
The location of the designed agrivoltaic solutions

Agrivoltaic systems

Innovative agrivoltaic solutions are integrated into the northern territory as to form an interface with the agricultural land, but also to diversify the economic model and build a relationship with the local and regional consumers. As a comprehensive resource for the village, Lindelicht does not only generate renewable energy but also suffices the local demand for fresh and diverse produce. Three synergetic agrivoltaic systems are designed within the territory of the energy estate (fig 7.9). These systems are partly responsive to the existing agricultural practices, but also react to the local site conditions its agricultural potential. Sections of the three systems and the area of application are shown in figures 7.10-7.12. Their specifications and how they function in their physical context are explained in more detail on the following pages.

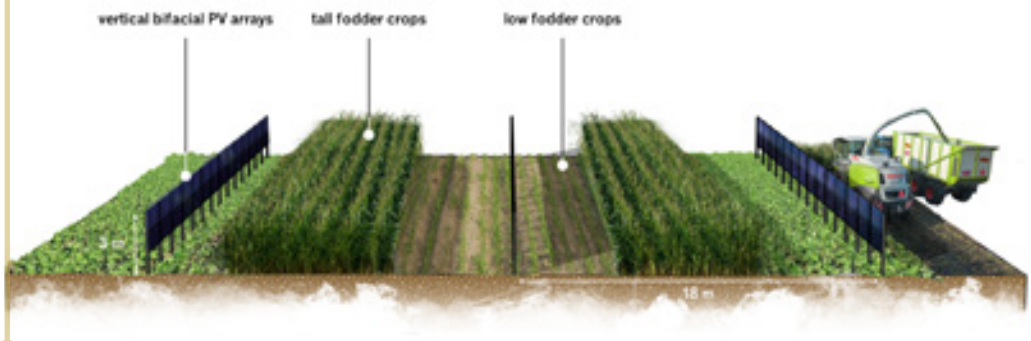


figure 7.10
The cultivation of fodder crops is interchanged with arrays of vertical bifacial. The spacing between the arrays allows for machinery to

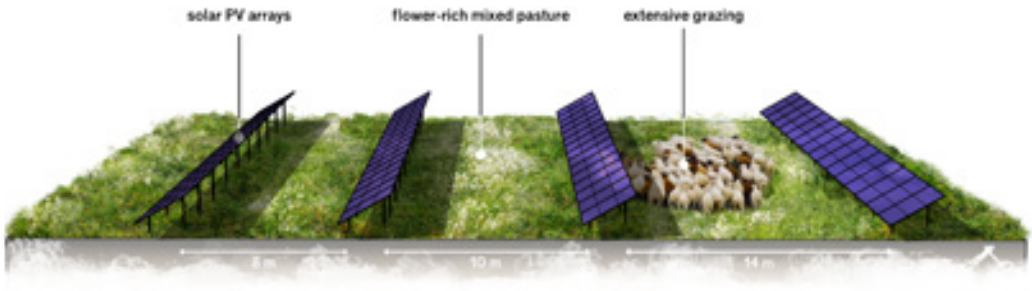


figure 7.11
Extensive grazing in between solar PV arrays

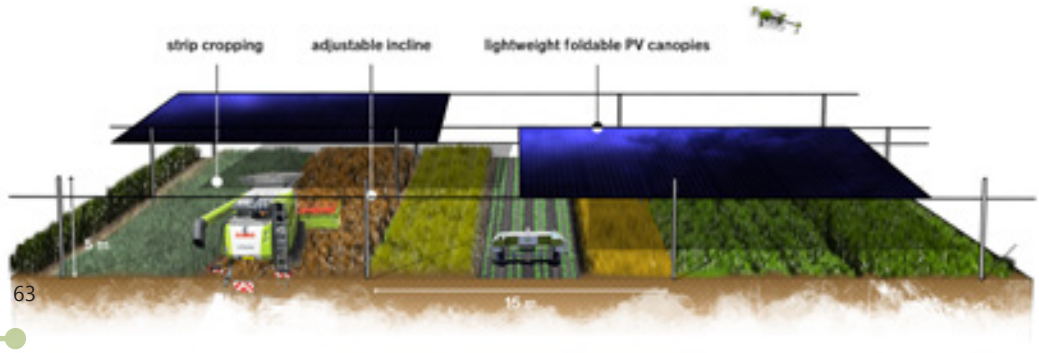


figure 7.12
Raised movable canopies allow for a second layer of land use that can react to the agricultural system below

figure 7.13
Aerial impression of De Zonneberg

De Zonneberg

East of the Zandwetering lies de Zonneberg, a former estate that gets renewed value as a part of the energy estate Lindelicht. The dairy farm Stremmelaar remains active in this area, but gets a more sustainable and pronounced relationship with the landscape of sandy ridges and loamy valleys. While the parcels for fodder crops were formerly dispersed around the area, they are now concentrated on the higher sandy ridges to the emphasize the topography (see figure 7.13). At these parcels, various fodder crops are cultivated in strips to create a resilient arable part of the livestock farm. The crop strips are interchanged with elevated structures mounted with vertical bifacial PV arrays that generate solar energy from both east and west facing photovoltaic cells. The edge of the parcels are planted with fruit and walnut tree orchards in the same orientation as the bifacial PV arrays, creating a compelling rhythmic accompaniment along the 'nerf'. The spacious planting and viewsheds still allow people to observe the energy infrastructure and give a visual iconity to the Stremmelaar farm (fig. 7.14), that gets a diversified income model from the delivering dairy products, fruits, nuts and also solar energy.

figure 7.14
New vistas are created with the help of renewable and green infrastructure

figure 7.15
Aerial impression of Lichte Enk

Lichte Enk

The top grade agricultural potential of the river dune is employed in the estate by regenerating it as the new arable 'enk' of Lindelicht, that provides sustainable produce for Wijhe and the region (fig. 7.15). A mix of crops are cultivated in parallel strips to establish a resilient and sustainable arable system (Faber, Cuperus, & Apeldoorn, 2020). This also creates a visual link with the arrayed solar energy infrastructure and a historical link to the way the common agricultural fields were parcellated in the past (Haartsen & Storms, 2009). A grid of masts with steel cables attached between them forms the base for a second production layer of the Lichte Enk. This solution is based on a proposal developed by Innobizzer ("Agrarische zonnesystemen," 2017), where the elevated structure bears adjustable and movable canopies covered with a thin-film CIGS photovoltaic surface, a very light-weight and efficient solar technology (Başol, 2017). Because of the flexibility of the system, the position of the canopies can be quickly adjusted to the operational dynamics of the arable farming underneath. Examples of different configurations are displayed in fig 7.16. The borders are planted with large-leaved linden trees that guide De Nerf (the main cycle and walking path). A new cycle bridge crosses the railway and Zandwetering in a singular structure that swerves around the Linden and offers a lookout platform for the Lichte Enk (fig. 7.17).

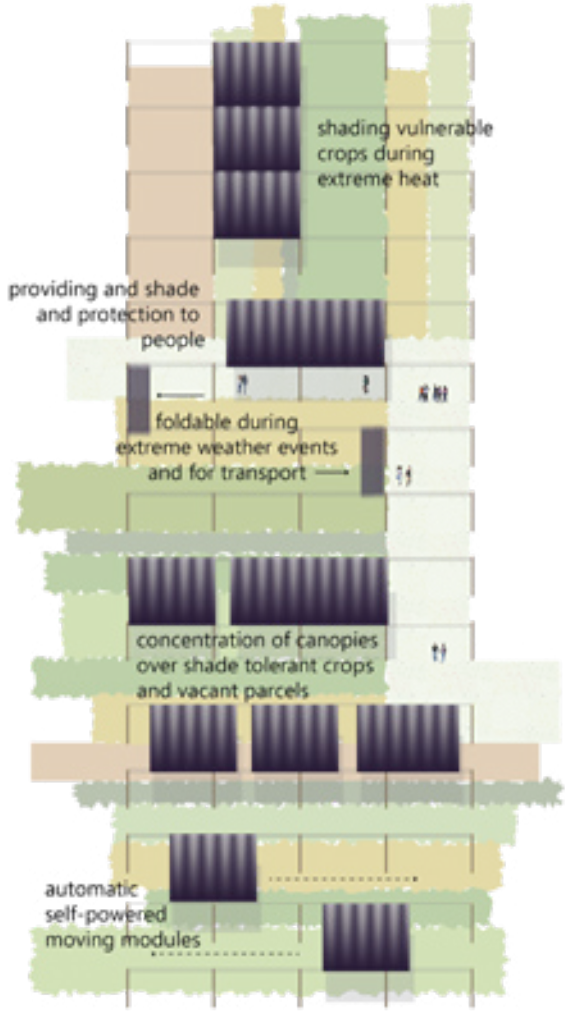


figure 7.16
Illustration of the different configurations of the canopies and the accessible flower strips inbetween

figure 7.17
The new cycle bridge over the railroad and Zandwetering also gives an impression of the Lichte enk

Zijlstroom and Noordmans plantage

This central space is dedicated to the efficient generation of solar energy in combination with extensive agriculture, forestry, recreation and ecological developments. The lower area of the Noordmanshoek is the result of inundations by the IJssel and it was later used to discharge water to the river via a sluice (zijl) in the dike (Spek et al., 1996). In Lindelicht, this central low area is retained as an relatively open and uniform space that connects the residential core and park at the village edge to the aforementioned agricultural subareas in the north. Solar PV arrays are placed in an increasing density and rationality towards the core. This rhythm starts up north in between the railway and the Zandwetering, where the orientation of the arrays matches the orientation of the ditches. The spacing between the arrays decreases southwards, which is experienceable from the train approaching the station of Wijhe.

Close to the village edge, the dense fields of exactly south-facing PV arrays impose a new rational structure on the landscape by deploying the space in between fields as vistas connect different parts of the estate. The tilt angle and height is limited so the sense of the landscape scale is preserved and the experience of the enclosing green edge is assured. This green décor is formed by a new forest on the edge of the river dune. Here, the trees are planted in the same lines as the PV arrays, resulting in dense forest patches in south and sparse tree lanes further north. The forest provides a local resource for building new houses in and around the estate.

The dense solar fields extend eastwards into a more spacious setup of lower PV arrays in combination with the further development of the existing nature area with willow bushes and wild grassland (fig. 7.20). By deploying an extensive solar PV setup around the already existing concentration of trees, ample light and water can reach the soil, facilitating ecological processes of emergence and succession. A raised pathway is integrated into the carrying structure of the PV arrays.

Westwards, the solar fields extend into a arrays of short rotation willow coppice. In the middle, tanks of the battery system rise above the willows. All of the renewable energy that cannot be discharged directly on the power grid is stored locally in a molten salt battery plant. The plant consists of four tanks, where one set is for the molten salt medium and one set for coolant medium (fig. 7.18). This plant is positioned on the location of a former elevation that was used to warn the village inhabitants for rising water levels or the operation of the discharge sluice. This place gets a new meaning in the Lindelicht estate by creating a lookout platform on top of one of coolant-holding tanks, providing an overview of Zijlstroom (fig. 7.19).

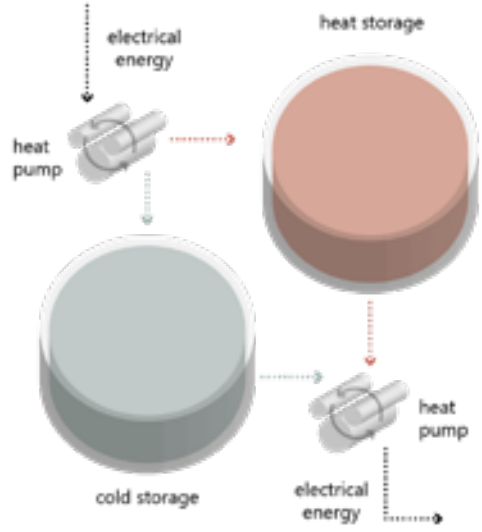
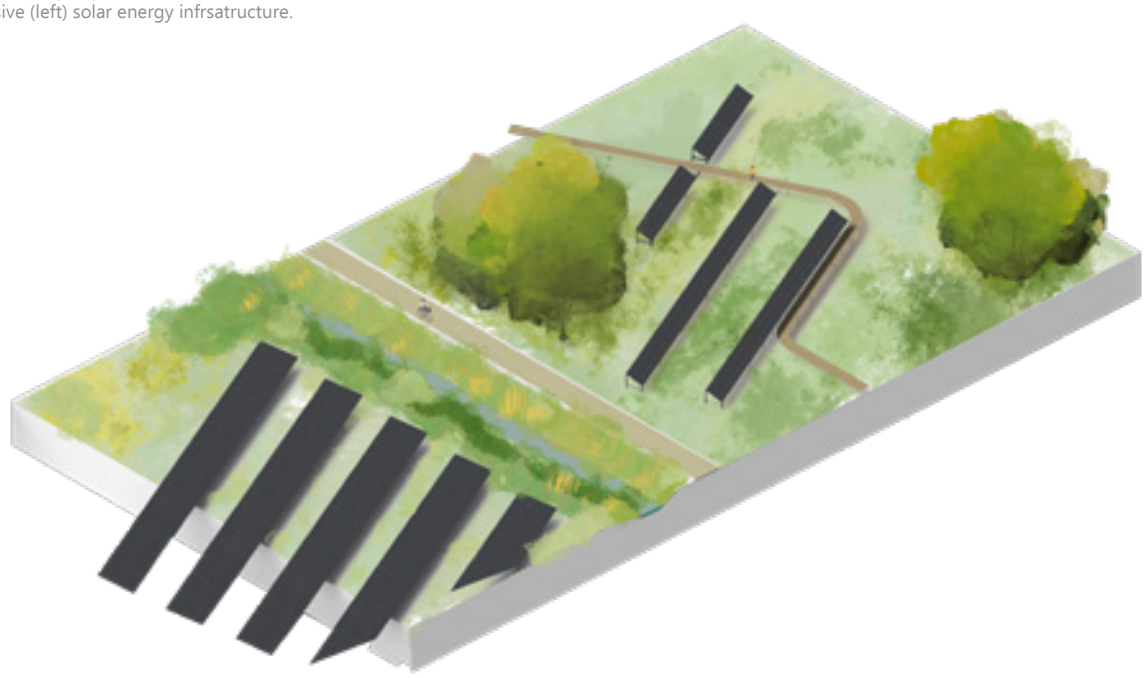


figure 7.18
Illustration of the energy sttorage system that stores heat in molten salt

figure 7.19
Representation of the energy storage plant, where one of the two coolant tanks doubles in function as a viewing platform. The willow plantation serves a double function for biomass and as a water purification plant for the new housing built on the estate.

figure 7.20
The zijlpad (right) is a raised pathway that is integrated in the carrying structure of the PV arrays. De nerf (middle) is the main path that connects the different parts of the estaste which offers perspective of both extensive and intensive (left) solar energy infrsatructure.



Park Lindelicht

The core and park of Lindelicht become the new face of the village edge. It is a new addition to the existing and former buitenplaatsen that have been established on this northern fringe of Wijhe. The formerly obstructive premises of the Stegeman factory are redeveloped into a largely public park and gardens, complementing the soft green edge, and creating a permeable entrance to the estate from the village and the nearby train station (fig. 7.21). Vistas towards and between historical and new landmarks embed the park in the direct context and form the new layout for the park. The central axis runs from the main house towards the church tower and extends northwards into Zijlland. The plots in between this layout of vista offer space for sustainable housing developments and one parking space for visitors of the estate. Three clusters accommodating 74 new dwellings in total, offer a unique living option on the estate park. The edges of these clusters are planted with a variety of fruit-bearing trees and other edible species. This emphasises the vistas but also creates a productive soft edge between public and private space. The existing large trees are integrated into the design of the new neighbourhood.

Two new innovate gardens connect the western and southern entrance of the park to Huis Lindelicht. The orthogonality in the design of the gardens is a reflection and abstraction of the rational aesthetics of the solar energy infrastructure. In between the railroad and the new dwellings lies the strokentuin, that is both a productive as well as an experimental garden. It is used by the new neigboorhood for growing crops at parcels that are bordered with strips of edible shrubs and small trees. Various experimental agrivoltaic pilot setups are integrated into the strips of this garden.

The cellentuin consists of raised 'cells' which create framed spaces in between fields of wild native vegetation. These cells facilitate a dynamic changing program serving the village inhabitants. For example, they provide everyday meeting spaces, but can also host exhibitions for the IJsselbiennale. A network of raised pathways connects the different cells with each other and a ribbon of thin-film organic PV connects swerves around the existing and new trees, creating a new three dimensional shape to the meandering streams that used to run at this edge of the village towards the floodplains.

figure 7.21
Detailed design of the core gardens park of Lindelicht
see appendix D for a larger version


N
0 10 20 50 100 m

figure 7.22
Diagram of the traffic circulation at the park that is limited for motorised traffic and offers a dense network of pahtways

A dense network of different pathways has been designed through the park and gardens to offer the inhabitants of Wijhe wih a new recreational asset. Motorised traffic is limited and largely separated from slow traffic, as can be seen in fig 7.22. De Nerf is the main cycling and walking pathway at the estate that connects the different subareas to each other. At the main entrance of the estate, it connects to the Stationsweg, also providing a convenient approach route from the public transport network.

Legend

- vistas
- housing clusters
- car road visitors
- access roads (shared space)
- cycle/walking path
- primary walking paths
- secondary walking paths
- walking path with limited access
- railroad Zwolle-Deventer
- local road

Ornamentation and materialisation

In order to establish unity between different built elements on Lindelicht, an ornamental detail is derived from two distinct site-specific features. The first is the presence of the large-leaved linden tree (Tilia Platyphyllos). Apart from the consequent use of this tree in the design, the peculiar shape of the leaf is abstracted into a pattern that is incorporated in the infrastructure at the estate, like the railing of the bridge and viewing platform on the battery tank, as ornamental feature of De Nerf and in the design of a bench (fig. 7.24). Secondly, the tradition of weaving the willow branches is visualised in the façade of the main residence. This also emphasis the interwovenness of the both renewable and other landscape infrastructure at the energy estate. The ornaments shown below are made from biocomposite materials that can be locally harvested at the estate.

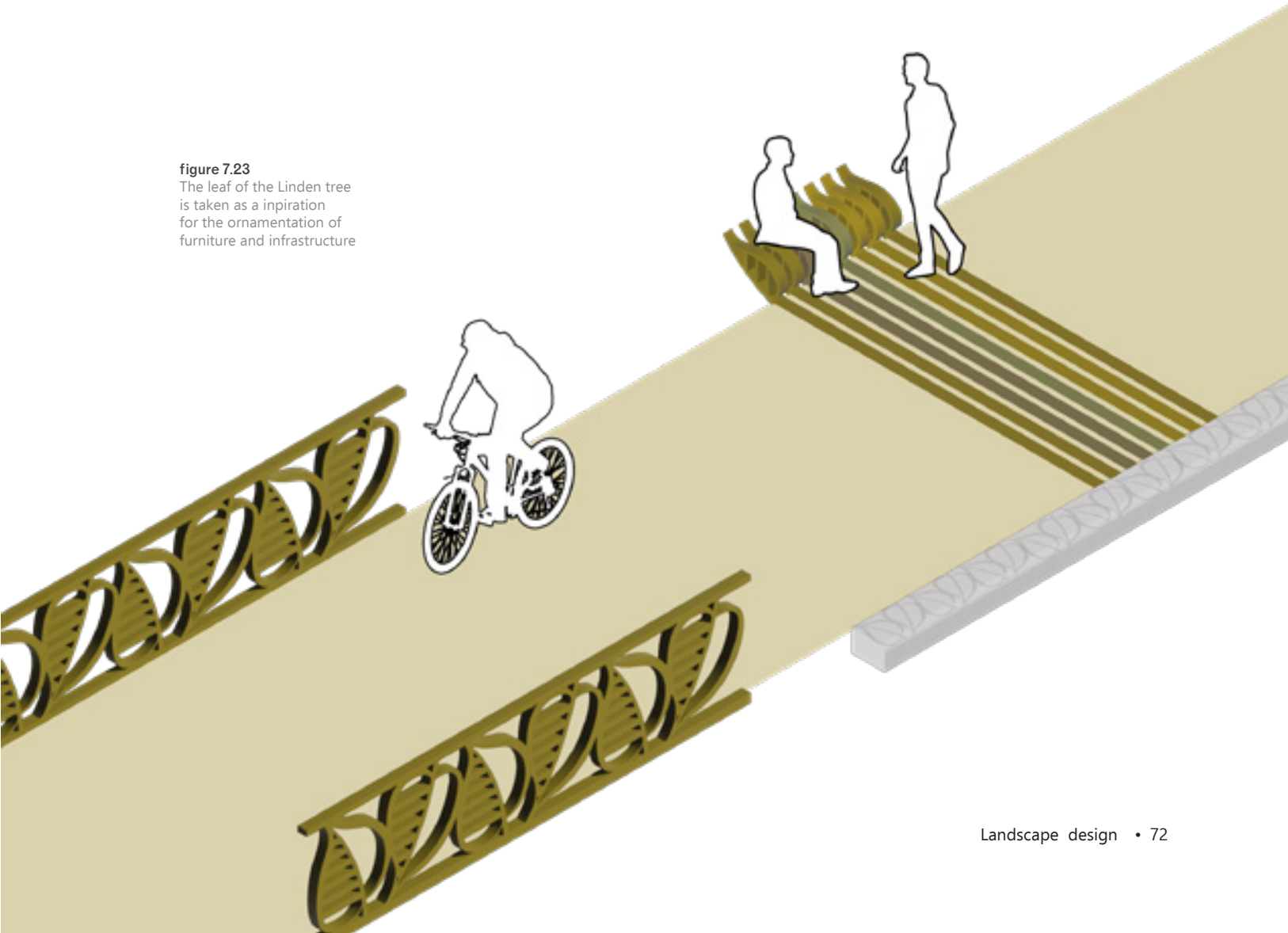


figure 7.23
The leaf of the Linden tree is taken as a inpiration for the ornamentation of furniture and infrastructure

7.3 Evaluation

Estate performance

The concluding part of this chapter is divided into three parts. Firstly, the performance of the estate is evaluated by reflecting on the output in energy and other services. Secondly, additional strategic consideration are given for the realisation and phasing of the design. Finally, the design is evaluated according to the four core qualities in order to consolidate the final design guidelines.

Energy yield
Although not giving a comprehensive image of the estate performance, the actual quantitative energy yield of the design must be addressed. All of the different installed PV technologies generate a combined annual energy yield of 9,2 GWh (see appendix C for calculations). The total of 42 windstalks placed at the entrances generate another 0,7 GWh per year. This gives a combined total of 9,9 GWh, which is more than enough to suffice the domestic electricity demand of Wijhe (7 Gwh, see section 5.4), and even some of the increasing demand for electricity for transport. Besides, the molten salt battery plant has a capacity of 10 MW, which allows for the short-term storage of energy, realigning supply and demand. The thermal energy stored in this system can be converted back to electrical energy when needed, but part of it can also be used for heating the new houses in park Lindelicht. Note that biomass is not included in the calculations since it would only serve a marginal addition to the energy output of the energy estate. Instead, the biomass from the willow plantation is processed into bio composite materials that are used to build other components of the energy estate.

Performance in time
The extent of the project estate Lindelicht requires a consideration of the realisation and strategic considerations in time. The Noordmanshoek will be the first development of the estate where the realisation of the Noordmans plantage is combined with the cultivation of crops for biobased building materials. The new agricultural practices will be gradually phased into the areas of Lichte Enk and Zonneberg, together with the planting of the forest, linden, fruit and nut trees. This gives both time and resources for the relocation and redevelopment of the Stegeman factory premises. After that the energy technologies at Lichte Enk, Zonneberg and at the Stroomgaarden can be installed using the locally grown resources.

Design guidelines

The process of creating this final design has allowed for a further application and evaluation of the design guidelines that were developed in the previous chapter. The iterations, adjustments, integrations and evaluations have resulted in the following spatial guidelines for designing sustainable energy estates in the context of West Overijssel. By linking them to the four qualities of estates, the ambition is to further consolidate the future position of sustainable energy estate within in the overarching estate tradition.

Structurality
The structural quality of the final landscape design is to be found in both the creation of a regional icon, but also the way it reads and activates the undulating texture of the landscape as a base for local interventions. By defining a new sequestration forest edge in the north and creating marked entrances with high wind energy technologies, it becomes a new visual landmark on the horizon of the river landscape. Furthermore, the underlying and surrounding landscape conditions have motivated the design of different configurations of renewable energy infrastructure in response to the potential agricultural, natural and cultural benefits.

Design guidelines for structurality

- Boundaries and entrances are marked with outstanding (renewable energy) features of significant scale.
- Spatial structures, characteristics and combinations of renewable energy infrastructure are responsive to micro-elevational differences at the site and the particularities of the surrounding landscape
- A new core is designed as an emphasised focal point and its park provides an attractive entrance and small-scale transitional zone towards the larger scale renewable energy infrastructure.

Unity
Although the subareas have unique characteristics, unity is achieved by addressing both the visual and functional integration of renewable energy infrastructure with the other landscape systems. On a larger scale, the green and recreational interconnecting framework on the landscape gradients create large central

spaces for generating renewable energy. A network of viewsheds and vistas is created by using the edges of the solar fields and other supporting infrastructure. On the smaller scale, uniformity is assured by planting schemes, materialisation and ornamentation.

Design guidelines for structurality

- A green structure with embedded networks for recreation and transport of energy connects different areas of the estate and their energy infrastructure with each other
- A central open area extends from the core with vistas in between solar energy infrastructure
- The rationality of energy infrastructure resonates in other strong lines within the energy estate

Multifunctionality
The variety of ways that renewable energy infrastructure has been integrated with other landscape functions illustrate the multifunctional qualities of the landscape design. Solar energy has been integrated into synergetic agrovoltaic systems at the northern agricultural fringe. The village edge is dedicated to providing inhabitants with a new transitional zone towards the estate and agricultural context.

Design guidelines for multifunctionality

- Multiple agrivoltaic solutions are designed to facilitate a circular system between the agricultural businesses at the estate and to provide a sustainable an local food producing landscape
- Different permeable structures of renewable energy infrastructure allow for attractive and special recreation possibilities
- Design the edge of renewable energy systems as new connective biotopes, making use of the existing ecological potential and gradients

Peculiarity
The peculiar qualities that make the design stand out are integrated in the many scale levels on which the energy estate performs. New toponyms for subareas and energy systems are coined. Innovative technologies are placed in both large setups and tangible small configurations. Also, the way that the rationality of the design is conflicted with the vernacular landscape elements provides an attractive contrast.

Design guidelines for peculiarity

- New toponyms and peculiar design details are created to link renewable energy infrastructure and site-specific characteristics
- Juxtapose native elements with renewable energy technologies to create a visible contrast between the old and new features of the landscape
- Design alternative technologies in the park to evoke curiosity and provide educational value

chapter 8

Discussion and conclusion

In this final chapter of the report, the results of this research are discussed and the most important reflections and conclusions are presented. In the discussion, the way the research outcomes were generated are critically reflected upon and any shortcomings and limitations of the study are pointed out. The chapter is concluded with a reiteration and reflection of the most important findings and their significance for the discipline of landscape architecture as well as the wider societal contribution.

8.1 Discussion

SRQ1: What design considerations from sustainable energy landscapes are relevant for the design of a sustainable energy estate in the context of West Overijssel?

The four sustainable qualities identified in section 3.1 have informed the selection and identification of relevant design considerations. This induction was established by the accumulation and generalisation of claims about Dutch estates in literature. For this very first inquiry, the choice was made to analyse literature that describes estates in the general and not dive into specificities about single estates. The consequence is that these four qualities were found to be too general to compose an effective evaluative framework for studying the literature. It is therefore arguable whether these four qualities fully grasp the performance of estates in their specific context. Nevertheless, the formulated qualities are timeless which makes them suitable for application and translation in a contemporary context. It may also be argued that that these qualities are applicable for every designed landscape and not only specifically for estates. Whether the inclusion of these qualities also leads to the design of sustainable estates depends on how they take shape in response to the program, the site and other context-specific factors. Hence, further research on designing sustainable energy estates would benefit from an advancement of the evaluative framework according to the landscape context. This makes the assembly and assimilation of knowledge more concise and articulated.

The subsequent second part of the literature study led to the formulation of relevant design considerations for a sustainable energy estate in the landscape context of West Overijssel. This selection covers many different themes and aspects of designing sustainable energy landscapes. In the research, the saturation point for a sufficient yet not overwhelming amount of design considerations remained arbitrary. However, within the scope and objective of this thesis, the list of design considerations was not a conclusive product since it mostly served as complementary input for designing. A conjunction of the spatially informed research on estate design and the more literature informed research for design in an iterative research module might

make for a more specified set of solutions and design principles.

SRQ2: What are the spatial characteristics of the estate type of West Overijssel that can be employed in the design of a sustainable energy estate?

The first point of discussion here is the nature and application of the analytical framework that was applied to acquire the spatial characteristics. This method has originated from the realm of architectural theory, but has been applied several times to analyse landscape architectonic compositions(Nijhuis & Bobbink, 2012; Steenbergen et al., 2008; Steenbergen & Reh, 2005). Especially the recent reflection and modification by Van der Velde (2018) has advanced the method as an effective analytical framework in the complex practice of landscape architecture. On the one hand, the adoption of this method has promoted analysis beyond the layout of the estate and favoured the study of experiential and cognitive features. On the other hand, the four compositional procedures hardly offer any boundaries or guidelines for the condensation of the right knowledge. Therefore, the research outcomes were largely influenced by the personal interpretation and application of the method. Also, access to detailed information on the design of the three historical estates was limited, which made the data collection and analysis more dependent on observations by the researcher.

The second point of discussion is whether the three selected estates in the comparative case study combinedly give a representable expression of selected the estate type. The purposive selection of De Gelder, De Haere and Windesheim as the embedded cases was motivated by their common type (havezate), a comparable geographic extent and because they share similar topographic conditions with the Noordmanshoek. This limited selection allowed for a more detailed and comprehensive analysis of each embedded case. Further research could validate and complement the identified essential characteristics by studying the other havezaten in the region. Nevertheless, studying more havezaten would ultimately lead to an adverse generalisation of the estate type, for this process would eliminate specific qualities. As observed in the comparative case study, some of the most recognisable and distinguishable features of these estates are strongly tied to the uniqueness of the site and embedded in peculiar details.

DQ: How can a design for a sustainable energy estate at the Noordmanshoek look like by means of experimental transformation of the estate type of West Overijssel?

The spatial context of the Noordmanshoek has been a testing ground for experimental design research on sustainable energy estates in the landscape context of West Overijssel. The designs are a result of many iterations on multiple scale levels between the different types of generated (site-specific) knowledge. Although the application and transformation of this knowledge has been communicated as well as possible, the creation of these models remains subject to the chaotic and non-linear process of designing. Some of the design choices are experimental prospects fed by the creative insights of the researcher, which are often hard to entangle and verbalise completely. Overall, the development of the novel energy estate concept benefits from these divergent leaps, because it helps to delineate the scope of the concept. Still, the integration and reflection on the generated knowledge adheres to the converging rigour of traditional research.

A second related point of discussion is the comparison and evaluation of the two models that were made. Even after the research for design, the conceptual boundaries of the sustainable energy estate are not clear-cut, which makes a rigid evaluation procedure difficult, if not impossible. While several attempts were made to weigh the models against each other, it was concluded that they differ too much to be comparable at the same level. This can be explained by the multiple purposes that the model study serves at the same time. It provides design guidelines, presents potential site-specific interventions, and also evaluates the generated body of knowledge. Besides, the aggregation of landscape interventions into a model or design for a sustainable energy estate should always be motivated by a strong overarching notion that is able to establish recognisable unity on multiple scales.

In the design research for a sustainable energy estate at the Noordmanshoek, delineating the scale and boundaries has been a particular challenge in both the landscape analysis and the design process. While the two models were developed in respect to the real life boundaries of the Noordmanshoek, the borders were stretched substantially in the final landscape design to research the interaction with the larger landscape context. The release of political and juridical limitations of land ownership and other restrictions allowed for a more inciting exploration of both the conceptual and physical boundaries of sustainable energy estates in the landscape context of West Overijssel. From both the preceding projects on energy estates and this design research in Wijhe, it is evident that a sustainable energy estate exceeds the size and nature of many current practice developments of renewable energy infrastructure. Just like historical estates, the identification and definition of the site and boundaries should be informed by the extent of existing and newly introduced landscape systems in order to conceive a sustainable functional unity. Still, the boundaries as projected in the final design are highly suggestive and motivate further research in a variety of landscape types and new forms of cooperation and land stewardship.

Reflecting on the design guidelines as the focal means and outcome of this design research, their applicability must be considered. Although generalized to the essential meaning, the design guidelines are largely informed by the specificities of the site, for example the village edge and the close relationship to the river landscape of the IJssel. Besides, the guidelines are the result of an integration of the consequential design choices that were found to be effective for this particular site. Other iterations of the generated knowledge may produce totally different designs and may therefore also bring new guidelines to the table that were left untouched. This motivates the future application and development of the design guidelines at other sites and also a disambiguation for the many different specific landscape types of the region.

8.2 Conclusion

The conclusion of this thesis report is divided in three parts. First, concluding insights about the specific research questions and the design question are discussed. Thereafter, the overarching conclusions in regard to the general research question and the achievement of the research objective are addressed. Finally, some final important remarks and recommendations for further research are brought forward.

The research for design produced 29 design considerations for a sustainable energy estate in the landscape context of West Overijssel. Almost all of them were used in the design of the offered to be valuable in the design process of the models and the final design. Their multitude and diversity provide a lot of versality, but also illustrate that designing a sustainable energy estate involves the activation and integration of knowledge from technical, ecological, social and agricultural domains. They serve as a practical starting point but must be complemented and integrated with place-specific spatial characteristics and local narratives to make them valuable in the design process.

Research on design resulted in 13 essential spatial characteristics of the estate type of West Overijssel, based on a comparative case study between three historical estates in the region. The specific features of each embedded case were condensed into the shared essential characteristics that are most prominent in the estate type. These characteristics range from the larger-scale to more detailed aspects, which exemplifies the estate as a medium for design that lies in between the garden and the meso-scale landscape. All the defined characteristics possess a sufficient amount of flexibility that makes them adjustable for the contemporary program and design that is required in a sustainable energy estate.

In the experimental model study, all of the characteristics were translated in a contemporary way by confronting them with the new program and considerations of designing a sustainable energy estate at the site. The diversity of the models illustrate the malleability of the estate type characteristics, but they do require creative translations and combinations to make them

suitable for the goal. This exploration resulted again in 25 site-specific design guidelines. These were applied in the process of making the final landscape design, which allowed for the identification and consolidation of the final design guidelines.

The process described above has ultimately served to answer the general research question: what design guidelines can be developed for a sustainable energy estate in the context of west Overijssel, based on the estate type of this region? First of all, by means of this thesis, it is shown that it is indeed possible to employ the estate as a means for designing sustainable energy landscapes. By research-through-designing, several design guidelines have been generated for designing a sustainable local solution within the national and global energy transition, building upon the integrative nature of estates. The question that transcends the practical nature of design considerations and spatial characteristics and design guidelines is why and how the research contributes of the wider societal and academic discourse of sustainable energy landscape design. This question is also expressed in the duality of the project title, where 'empowering' can be interpreted in two different ways.

The articulation of empowering as a qualitative adjective produces insights into the societal implications of the design research by a reflection of its performance. The sustainable energy estate has the ability to empower as a regenerative area, securing the various needs of people, flora and fauna, where both functional and spatial integration produce an attractive landscape. It also emphasises the accommodation of renewable energy infrastructure in the landscape as more than only a technological advancement, but as an integral part of the many ongoing and forthcoming challenges in the Dutch landscape. In this respect it takes a long term position as opposed to the many current short-term renewable energy developments. Although the renewable energy targets will not be achieved by only establishing energy estates, its diverse output that transcends KWh should be considered a valuable asset. Thereby, it has the ability to inspire and revisit the relationship between the consumer and generation of renewable energy.

Empowering can also be interpreted in the progressive present tense. This addresses the research as a means to advance the concept of the energy estate both in a practical and theoretical sense. Of course, the practical significance is embedded in the development of design guidelines for sustainable energy estates in the context of West Overijssel. However, the methods and way of revaluing historical designed landscapes for the sake of designing contemporary challenges may also proof to be valuable for other relevant themes like rural and climate-adaptive transitions. Therefore, it is important to keep developing the estate as a performative medium with the ability to achieve both strategic goals and beautiful places.

Recommendations

In the coming years the Noordmanshoek in Wijhe will be developed as a new energy estate. Although this research project has somewhat deviated from this real-life case, there are still some valuable lessons that are also applicable to the development. It is especially important to take a long-term perspective in redeveloping this edge of the village for not only renewable energy but also providing a mix of agricultural, ecological and cultural amenities. While the current plans are limited to the boundaries of the Noordmanshoek, potential future expansion of the energy estate must be taken into account during the design and development.

For further research and development on topic of energy estates, I would suggest a further elaboration of the concept through design and evaluation in other landscape contexts. This should be preceded by a thorough analysis of the local estate type and the landscape characteristics. In order to realise the energy estate as a feasible case, new forms of cooperations between municipalities, provinces, farmers and local initiatives should be researched.

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Appendix A

Table of references for the design considerations

Design considerations	**Scientific sources**	**Other energy estate designs** AE= Airport Eelde ZZ= Zwolle Zuid WM= Wells Meer	**Other sources**
C1. Combine different energy technologies	(Hernandez et al., 2019)	AE, ZZ, WM	(ROM3D, 2015) (NP RES, 2019)
C2. Include intensive and extensive energy infrastructure	(Klaassen et al., 2018) (Van der Zee et al., 2019)	AE, ZZ, WM	(Holland Solar, 2019) (Provincie Overijssel, 2020) (NP RES, 2019)
C3. Visibility of energy infrastructure	(Stremke & Schöbel, 2019)	AE, WM	(Provincie Overijssel, 2020)
C4. Adopt rational energy patterns	(Scognamiglio, 2016)	ZZ, WM	(Rijksdienst voor Cultureel Erfgoed, 2018)
C5. Emphasise landscape features with wind technologies	(Stremke & Schöbel, 2019)	WM	(H+N+S Landschapsarchitecten, 2019)
C6. Design all energy infrastructure components	(Stremke & Schöbel, 2019) (Apostol et al., 2016)	AE, WM, ZZ	(Provincie Overijssel, 2020) (H+N+S Landschapsarchitecten, 2019)
C7. Expand pollinator habitat	(Gasparatos et al., 2017) (Klaassen et al., 2018) (Van der Zee et al., 2019) (Hernandez et al., 2019)	AE, WM	(Holland Solar, 2019)
C8. Provide educational value	(Başol, 2017) (Zuidema & De Boer, 2017)	WM	(Provincie Overijssel, 2020)
C9. Revive cultural historical landscape elements	(Stremke & Schöbel, 2019)	AE, WM	(NP RES, 2019) (Rijksdienst voor Cultureel Erfgoed, 2018) (H+N+S Landschapsarchitecten, 2019)
C10. Consider wider ecological network	(Klaassen et al., 2018) (Van der Zee et al., 2019)	ZZ, WM	(Gemeente Arnhem, 2016) (Natuur- en Milieufederaties & Natuur & Milieu, 2019) (Cesar et al., 2018)
C11. Address broader rural challenges	(Hernandez et al., 2019)	AE, ZZ	(H+N+S Landschapsarchitecten, 2019) (Provincie Overijssel, 2020)
C12. Prevent soil dehydration	(Van der Zee et al., 2019) (Klaassen et al., 2018)	WM	(Holland Solar, 2019) (Natuur- en Milieufederaties & Natuur & Milieu, 2019) (Cesar et al., 2018)
C13. Secure Long term benefits	(De Boer et al., 2018)	AE, WM	(Holland Solar, 2019) (H+N+S Landschapsarchitecten, 2019) (RES West-Overijssel, 2020)

C14. Create diverse and attractive biotopes	(Van der Zee et al., 2019) (Klaassen et al., 2018)	AE, WM, ZZ	(Provincie Overijssel, 2020) (Natuur- en Milieufederaties & Natuur & Milieu, 2019)
C15. Make biomass multifunctional	(Gasparatos et al., 2017)	AE, WM	(Rijksdienst voor Cultureel Erfgoed, 2018)
C16. Cluster intensive energy infrastructure	(Stremke & Schöbel, 2019) (Van der Zee et al., 2019)	AE, WM	(NP RES, 2019) (ROM3D, 2015)
C17. Design accessible energy infrastructure	(Stremke & Schöbel, 2019)	WM, ZZ	
C18. Accommodate innovative technologies	(Scognamiglio, 2016)	AE, WM, ZZ	(Gerretsen & Rijpers, 2017)
C19. Use alternative solar PV technologies	(Amaducci, Yin, & Colauzzi, 2018) (Hernandez et al., 2019)	WM	(Cesar et al., 2018)
C20. Farm small livestock under PV arrays	(Van der Zee et al., 2019) (Gasparatos et al., 2017)	WM	(ROM3D, 2015) (Holland Solar, 2019)
C21. Protect with natural landscape elements	(Stremke & Schöbel, 2019)	ZZ, WM	
C22. Integrate energy storage solutions	(Hernandez et al., 2019)	WM, ZZ	(NP RES, 2019) (Gerretsen & Rijpers, 2017)
C23. Make solar PV infrastructure mobile	(Van der Zee et al., 2019) (Amaducci et al., 2018)	-	
C24. Decline angle of PV arrays	(Scognamiglio, 2016)	WM	(Provincie Overijssel, 2020)
C25. Connect to regional mobility network		AE,WM,ZZ	(Natuur- en Milieufederaties & Natuur & Milieu, 2019)
C26. Preserve landscape patterns	(Stremke & Schöbel, 2019) (Scognamiglio, 2016)	WM	(Rijksdienst voor Cultureel Erfgoed, 2018)
C27. Landscape informed nature goals	(Gasparatos et al., 2017) (Klaassen et al., 2018)	AE, WM	
C28. Spread energy yield over day		WM	(ROM3D, 2015)
C29. Enhance existing ecological potential	(Klaassen et al., 2018)	WM	(Natuur- en Milieufederaties & Natuur & Milieu, 2019) (H+N+S Landschapsarchitecten, 2019)

Appendix B

Case studies of De Haere and Windesheim

B1. De Haere

Introduction

Along the river dike, just south of the village of Olst, the estate De Heare is located along the river dike. This estate complex is a real treasure in this landscape. The history of De Haere goes back to at least 1329. At that time it was not yet a havezate, but a farmstead. Nobleman and knight Hendrik van Oldeneel gave order to build the havezate in 1559. Over the years the building has changed considerably and also the park and wider estate terrain has undergone many transformations.

Nowadays, De Haere covers an area of 130 ha in total and consists of a main house with park and annex buildings. In addition, the estate is characterised by a number of farms, mixed forest, meadows and arable land. Remarkable is that 150 years ago a fake ruin is built by former occupant of De Haere, the Frenchman Pierre Gustav Voûte. Lastly, parts of the 'IJssellinie', the defensive line along the river IJssel, can be seen on the estate. In the period 1950 to 1968 the line had to ensure that a possible advance of the Russian Army was delayed by flooding the area along the river. This defense was ultimately not necessary. Currently, the estate is owned by the Stitching IJssellandschap.

Basic form

The basic form the estate can be illuminated by looking closely at the at the natural morphology of the landscape, but also at the man-made landscape infrastructure. A large river dune complex stretches out over almost the entire estate in a southwest-northeast direction. The resulting elevation and hydrological differences have been decisive in the overall layout of the estate. The historical local infrastructure was also important in directing the spatial extent of the estate. Especially the dike in the west and in the east the smaller Bockhorsterstraat and Hengforderweg were important regional connections. The extent of the estate territory as investigated by (Albers & Haartsen, 2011) differs from the boundaries that were drawn up during the establishment of the NSW in 1928. However, in this analysis the dike is considered the most western boundary and the railroad the most eastern boundary.

Core and park

The core and the landscape park are focal features of the estate and really stand out from the surrounding landscape because of vistas from the dike. Also in this case, the geomorphology of the landscape has informed their position in the estate. The core is located on the edge of the river dune, where groundwater levels were available to dig a moat around the manor house. The many transformations of the park throughout its existence are still readable in the its current-day appearance. The core is positioned roughly in the centre between the dike road and the Bockhorsterstraat. It comprises the moated manor house and the L-shaped ensemble of coach house, hunting lodge and horse stable. Both are centred around a forecourt. Directly east from this forecourt is a park-like garden that extends to the Bockhorsterstraat. Instead of a clear division, there is a gradual transition between the core and the park.

The park extends both to the east and west from the core along the central axis, but the most prominent element is the large meadow and adjacent old woodland that is located directly west of the core. The layout of the park has been changed and adapted over the course of history. From the structure of tree lanes that used to frame the manor in the centre is only one lane left. In several phases, the park got its current shape as the English landscape style garden through the extension and adjustment of the water feature, the creation of new wider vistas and the addition of the eastern park-like garden (Ottens et al., 2019). However, these interventions were always responsive to the existing conditions, which makes the different phases of the garden and park design still visible.

Programme form

Agriculture and forestry

The agricultural programme at De Haere is a diverse composition of pastures, fields and mixed forest plots. Their joined effect on the experience of the landscape is the reflection of the irregular underlying parcellation patterns of the landscape. Most of the parcels are bordered with woodland that make the forests large interconnected areas. The enclosed space in these spaces form the stage for grazing livestock and arable farming.

Built structures

The manor house and the adjacent ensemble of buildings are the main features and also the oldest built structures of the estate. The manor currently houses a restaurant and the office of IJssellandschap. Both older and newer farm buildings around the estate are embedded in the overall green structure of De Haere. The exotic looking former land steward dwelling and sober gate pillars mark the western entrance of the estate at the dike. De Haere also contains built structures of ornamental and military purposes. The garden features some ornamental built structures of which the castle tower ruin folly is a key feature of the English landscape garden. Another more recent addition is the giant solar dial. Another significant is the collection of bunkers, defense artillery, and the sluice system in the dike as a defense system of the IJssellinie (Landgoederen in Overijssel, n.d.-b). The bunkers are hidden in the forest of the park, and provide another distinct historical layer to the estate.

Access and recreation

Almost the entire estate is publicly accessible. The Heaereweg is the main road that connects the core and the park of the estate with the dike in the west and the Bockhorsterstraat in the east. At the western entrance this road is not accessible for motorised traffic and a parking space is facilitated at the dike road. At the eastern end the entrance road leads to a larger parking place, just north of the core. Starting at these parking spaces an extensive network of walking routes is available to the visitor. These routes make the core, the garden and the park a very permeable landscape. The network also extends into the larger forest plots on the estate. The suggested walking routes are themed according to the different historical layers of the estate.

Spatial form

Coulisse landscape

In the major part of the estate, the landscape is experienced from small local roads and paths. The plots of forest on the estate provide a small-scale and diverse experience of the landscape. These vertical masses emphasise the historical irregular parcellation pattern and form ‘chambers’ that frame pastures and fields. This makes the landscape experience very diverse with sudden views of fields, green walls of trees and paths next to forest edges. Many of the farms and residential buildings on the estate are positioned at the edge of these chambers.

Vistas

Vista’s from both the dike road give the manor house a distinct position in the surrounding landscape. The vista from the dike is wide an allows for a view into the estate lands. The vista from the east is a framed view supported by lines of trees. A vista from the main house to the farmhouse Graskamp was built in the beginning of the 20th century, connecting the different buildings of the estate (Ottens et al., 2019).

Image form

Unity

The spatial layout of the estate with the large masses of forest that form an enclosed background for the manor house in the centre clearly convey a sense of unity to the landscape observer. Also the wide vista from the dike into the central void makes it stand out as a legible untity. In this layout, the central axis plays an important role as a linear element, connecting the park, the core and garden with each other. The extension and integration of designed landscape features into the productive territory, like the water feature, provide attractive and accessible connections.

Multifunctionality

Besides the multifunctional land uses for agriculture, forestry and arable farming, De Haere serves many recreational options. Extensive recreation is facilitated via an extensive network of pathways with the core and garden as important nodes. Here, both the house and gardens serve as exhibition spaces, securing also an important socio-cultural role. The large meadow in front of

the manor does not only function as pasture, but also in the framing the scenery from the house. Here, the line between different functions the ornamental and functional performance of the landscape disappears. As the history of De Haere shows, multifunctionality is not a static quality and changes over time. However, the remains of the different layers compose an interesting narrative. This creates different themes spaces within the estate, like the garden and the bunkers.

Peculiarity
The different layers of the park and their remaining characteristics make the estate a living palimpsest. It also displays the continuous adaptation of the estate to display or convey certain ideas about nature-culture relationships. This is an ongoing tradition at the estate and results in temporal (exhibitions) but also permanent artefacts (sun dial and folly) in the garden.

Structurality
In scale and mass, De Haere performs as a structural icon along the IJssel. The large open spaces that are framed by the forest plots make the morphology legible and readable for people. Also in the design of the park features, the existing landscape conditions are used as a base. In the Haeare this resulted in the wiel (relict from dike breach) being extended into a water feature of the park. By offering a lot of recreational abilities, De Haere also becomes an important structural node in the regional recreational network.

B2. Windesheim

Introduction
Windesheim is located next to the village Windesheim, south of Zwolle and north of Wijhe. The history of the estate dates back to the 12th century, where the historic house was first mentioned as "Hof Winsem". The medieval havezate was demolished around 1745, and five years later a stately home was built on its foundations. Afterwards, the house was bought by Joachim Baron van Plettenberg, who gave the Dutch landscape architect Jacob Otten Husly in 1789 the order to design the park and gardens based on the English landscape style. Thereby several design principles including the principle of sharp contrasts, such as light versus dark were used. This design has been well preserved for centuries and still defines the structure of the park. Later, Leonard Springer designed the formal gardens of the estate in a French formal style. In 1944, during World War II, the manor house was destroyed by firebombs, leaving only ruin on a moated island accompanied by the two remaining outbuildings. The estate is currently managed by 'Stichting Landgoed Windesheim', that focuses on the continuation of the estate as a sustainable entity.

Basic form

The territory of the estate is positioned on the transition between the higher river levee dune complexes of the Ijssel in the west and the lower Molenpolder in the east. The vast area of Windesheim consist of a large agglomeration of agricultural land surrounding the village of Windesheim, interchanged with afforested areas and plots, waterbodies and nature connections. The south-north running infrastructure of the railroad and regional road intersects the estate. Perpendicular to these regional connections is the Windesheimerweg, that connects the core to the village. The analysis focuses mainly on the core, gardens, park and the direct surrounding agricultural areas as identified for the NSW act, in order to address their spatial relationships.

Core and park
The core and park of Windesheim are positioned on the elevations of a river dune, just like the adjacent village. The residential core contains the ruins of the destroyed main house that is

surrounded by a moat and the two remaining outbuildings surrounding a forecourt. This orthogonal layout of the buildings is extended into the outline of the formal gardens on either site of the house, designed by Springer around 1914. The geometry of the gardens provide a sharp contrast to organically shaped landscape park. A central axis extends from the centre of the moated island into this richly afforestated park, north of core. Its current appearance is a result of adaptations by the hand of multiple owners and landscape designers in history (Van Tilborg, 2011). The largest influence to this park has been the design of architect J.O. Husly at the end of the 18th century. The house used to be surrounded on all sides by a straight structure of avenues, but Husly deliberately introduced organic shapes into the design. His design was characterised by organic forms, various avenue structures, a fine network of meandering paths, artificial hills and peculiar water features. The increasing popularity of the English landscape style at this time is clearly reflected in his design. The north-western extension to the park was designed by G. A. Blum in the beginning of the 19th century, that extends the pathways along the edges of a new part of the forest park (Ottens et al., 2019).

Programme form

Agriculture and forestry
The agricultural programme on the estate is mainly shaped by arable and dairy farming practices. However, these are interchanged with plots of varying plots for nature development, forming a mosaic of different land uses and appearances. The distribution and design of the different land uses is very responsive to the underlying landscape conditions, where the polder in the east features rectangular stretches of forest and the plots on the river levee and river dune follow an irregular pattern. Various tree species are cultivated at the estate for the production of local timber. Previously the production consisted mainly of poplars, today this has been transformed into mixed hardwood plots. In recent years the agricultural sector has developed considerably, which brings new challenges to the estate. In addition to regular agriculture, experiments are also being conducted with "organic farming" and circular agriculture (Landgoed Windesheim, n.d.).

Access, recreation and nature developments
The diverse landscape types of Windesheim offer a lot of recreational opportunities. Besides the park that can be considered a recreational entity on its own, the estate features many pathways connecting the river landscape with the agricultural hinterland of the polder. Because of its position and extent, the part of the lands of Windesheim are also use to develop a regional nature and recreational corridor eastwards to Heino. The large lakes ('tichelgaten') south of the core result from clay excavations in the previous century for the production of bricks by 'steenoven Oldeneel'.

Spatial form

Park as experiential interface
The park with its large forest stands out in this fairly open part of the IJssel landscape that the estate Windesheim is embedded within. Thereby it is perceivable as a big remarkable spatial gesture from the surrounding infrastructure like the railroad, the regional provincial road to Zwolle, and the local and recreational roads adjacent to the river. When within the park, the surrounding landscape is deployed as the part of scenery from the routes, creating a special dialogue between the different productive areas and the recreational, ornamental park.

Water as guiding element
Next to forest and nature, water is typical for the spatial forms of the estate. Blum complemented Husly's design and expanded especially at the northern end of the park. He gave water a more prominent place in the design by dugging ponds that merged with existing drainage. In this way the connection between old and new was sought. By introducing differences in height, the bank ridges were further expressed. This can be seen in the northwest corner of the estate. Throughout the park there are surprising views to the house and the agricultural surroundings.

Image form

Unity
Central axis connects the core, the gardens, the park and central fields south of the core. The collection of organic forms, water elements and paths unites the different areas of the estate and give the estate a romantic English appearance. A

unity in the design has also been created through proper use of materials, colours and planting. The windows of the houses each contain white with red shutters and throughout the estate small garden features share the same ornamental language.

Multifunctionality
Agricultural activities are combined with forestry practices, resulting in a diverse landscape. The park is a layered entity in the estate that bears great cultural-historical, natural-historical, ecological and recreational values. The diverse mix of nature, agriculture, forest and other built artefacts benefits the attractivity of the estate and attracts inhabitants of Windesheim and Zwolle.

Peculiarity
The park is a very peculiar element within the estate, because of its size but also the very profound layered designed spaces and features. Besides, the contrast between the formally designed gardens and the organic shapes makes for an interesting combination that visually. The many exotic trees in and around the park show how the estate functions as a living horticultural museum. Experimental agricultural practices at the estate show an interest in broader rural challenges.

Structurality
In de design of the park the connection to existing regional landscape infrastructure sought by connecting new ponds to the existing drainage system. This provides the estate its own iconic character, in line with the characteristics of the area. The estate stands out in its surroundings because of the vertical forest masses with meandering paths through it. Furthermore, the estate has a strong spatial relationship the village of Windesheim by deploying vistas from the park towards the historical landmarks.

Appendix C

Calculations

Reference numbers solar PV			
Regular setup:	360	Wp monocrystalline PVpanels 1*2 m	
	0,5	panels / m2	
Efficiency of panel in NL	0,9	KWh/Wp	[1]
Vertical bifacial setup	360	Wp bifacial solar PV panels 1*2 m	
efficiency	1,15	in respect to regular setup	[2]
Thin film CIGS			
efficiency	0,82	in respect to regular panels	[3,4]

Reference number wind technologies			
Windstalks			
	1203	windstalks with annual capacity of	[3, 5]
	20000	MWh	
	16,63	MWh / windstalk/year	

Calculations energy output Lindelicht

Subarea							Yield/ year (Kwh)	Yield/year (Gwh)
	PV technology	Total surfa	no. of panels	Wp / panel	Wp/m2	Installed Wp		
Zijlstroom	South-facing PV arrays	36274	18137	360	180	6529320	5876388	5,88
Zonneberg	Vertical bifacial arrays	5988	2994	360	180	1239516	1115564	1,12
Lichte Enk	Thin-film CIGS	16132	n.a.	n.a.	147,6	2381083	2142975	2,14
Gardens	PV experimental	763	381,5	200	*	76300	68670	0,07
	subtotal yield							9,20
	Wind technologies		Total wind stall	KWh / windstalk				
Stroomgaard	Wind stalks		42	16625			698254	0,70
	subtotal yield							0,70
Total energy yield								9,90

* assumed average number for more efficient and less efficient technologies

Used sources

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Appendix D

Designs

Energielandgoed Lindelicht

0 20 50 100 200 m

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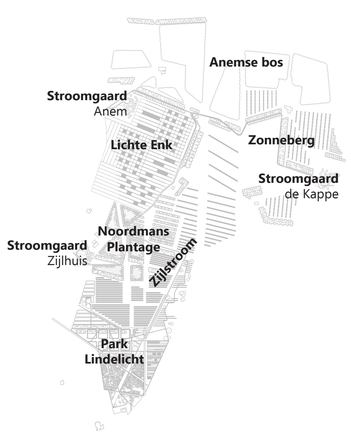
Toponyms



Legend

Anemse bos

- **Linden tree borders with pathway** — Tilia platyphyllos
- **Forest plots** — Partly grazed with pigs and chickens
- **Anem** — New mixed farm

Stroomgaarden

- **Wind stalks** — Wind energy harvesting technologies
- **Mixed fruit tree orchard** — Mix of apple, pear, cherry and plum varieties
- **De Nerf** — Main cycle and walking path

Zonneberg

- **Stremmelaar** — Mixed livestock farm
- **Vertical bifacial PV arrays** — Mixed with strips of fodder crops
- **Pasture** — Rotation of grass-clover and rye grass
- **Fruit tree orchard** — Mix of apple and pear varieties
- **Walnut orchard** — Juglans regia

Lichte Enk

- **Large-leaved linden trees** — Tilia platyphyllos
- **Bridge** — With extended lookout platform
- **Arable fields** — Various crops cultivated in parallel strips
- **Masts with cables** — Elevated bearing structure for canopies
- **Movable canopies** — Light-weight thin-film solar PV surface
- **Accessible flower verge** — Seeded with native flowering species

Zijlstroom

- **Solar PV arrays** — On mixed pasture
- **Existing willows** — Copse of willow trees
- **Solar fields** — Inbetween wild flower-rich grassland
- **Zijlpad** — Raised pathway inbetween low solar PV arrays
- **Willow trees** — New groups of willow trees along ditch
- **Ditch** — Widened ditch with shallow profile
- **Flower rich grassland** — Extensively grazed by sheep

Noordmans Plantage

- **Linden tree borders with pathway** — Tilia platyphyllos
- **Poplar production forest** — Mixed with a native hard-wood tree species
- **Larch production forest** — Mixed with a native hard-wood tree species
- **Douglas fir forest** — Mixed with a native hard-wood tree species
- **Douglas fir** — Mixed with quercus robur

Park Lindelicht

- **Battery tanks with lookout platform** — Molten salt energy storage plant
- **Twiegtuin** — For waste water treatment and biomass
- **De Broedcel** — For changing village programme
- **Existing willow and ash trees** — With meandering PV ribbon
- **Forecourt** — With a mix of park trees
- **Meester's tuin** — Village garden with experimental PV setups
- **New dwellings in clusters** — Framed by fruit and nut trees
- **Parking** — For visitors
- **Huis lindelicht** — Main residence with moat

Legend park design

Built structures

Huis Lindelicht: Three integrated dwellings

New dwellings: Mixed housing types, partly built with local building materials

Entrance pavillion: Biocomposite structure, covered with thin-film PV for shading

Gardens

Meester´s tuin: Small scale strip cropping with experimental PV configurations

Lichte lint: Meandering ribbons of organic solar PV

Exhibition cells: biobased concrete retaining wall facilitating seating and walking path

Twiegtuin: Willow plantation for biomass and treatment of local waster water

Infrastructure

Access road visitors (car): Towards and from the regional dike road

Access road inhabitants: Semi-private access road for inhabitants

De Nerf: Main walking and cycling path (shared space) and access road inhabitants

Raised pathway: Connecting the different cells and public part of moated island

Moat decking: To provide seating at the waterfront

Semi-paved walking path: Connecting the village edge to the park and estat

Parking space: For visitors of the estate and of the neighbourhood

Renewable energy

Solar PV arrays: South-facing, 4 panels wide, max. 1,7 m high

Solar PV arrays: South-facing, 2 panels wide, integrated pathway

Vegetation and water

Large-leaved Linden trees
Tilia platyphyllos

Existing trees: Various species

Park trees: see right

Food trees and shrubs: see right

Moat: Shallow nature-friendly banks

Wild grassland: Managed by extensive grazing

New park trees:

- Sweet chestnut
  Castanea sativa
- Red beech
  Fagus Sylvatica purpurea
- Lebanese cedar
  Cedrus libani
- Acacia
  Robinia pseudoacasia
- Sugar maple
  Acer saccharum
- Pin oak
  Quercus palustris
- Common Linden
  Tilia x Europaea

Food trees:

- Walnut
- Medlar
- Apple
- Pear
- Cherry
- Plum
- Mulberry
- Hawthorn and shadbush
- Dogwood and hazel

N

0 10 20 50 100 m