The bright side of solar energy

how solar energy can be used as a tool to improve spatial quality

Coos van Ginkel
Wageningen university

SOLAR ENERGY

SPATIAL QUALITY

The bright side of solar energy
how solar energy can be used as a tool
to improve landscapes

a thesis submitted in partial fulfillment of
the requirements for the degree of

Master of Science in Landscape Architecture Wageningen University

Coos van Ginkel

December 2019

Dr. ir. I. (Ingrid) Duchhart (examinator)

Dipl. Ing. S. (Sven) Stremke (supervisor)

Ir. D. (Dirk) Oudes (second supervisor)

Ir. S. (Steven) Slabbers (external supervisor)
BoschSlabbers Landschapsarchitecten / Provincie Noord-Holland

Acknowledgement

What started out as a personal question, turned into the interesting research journey of my master thesis.
I want to thank both my tutors Sven Stremke and Dirk Oudes from Wageningen University.
I much enjoyed working on this research, which wouldn't have been the same without their critical questions and enjoyable tutoring.
Also, I want to thank my co-students, I enjoyed the group discussions and learned much from debatting the challenges we faced.
I specifically want to thank my co-students David de Boer and Lianne Klein Lankhorst for their very helpful feedback on my research and design.

I owe thanks to Steven Slabbers, provincial advisor on spatial quality at the Province of North-Holland. His input on my thesis helped me to improve the design and develop the story behind it

I also want to thank my wife, Elisabeth, for supporting me from the first thoughts about the topic of my master thesis until handing in the last products. Her help in helping me to critically reflecting upon this research and improving it has been invaluable.

As this thesis also marks the end of my studies, I want to thank my parents for supporting and encouraging me throughout the whole time of my studies.

Throughout my studies I got to know someone particularly well. He was in fact the most faithful companion throughout this master thesis. Finishing my studies I want to give thanks to God.

Coos van Ginkel
Delft, November 2019

Abstract

Abstract
In the coming years a transition will take place towards a renewable energy based energy system. In the Netherlands a large part of this renewable energy needs to be produced within the landscape. In the coming years, the impact of renewable energy on the landscape worldwide will be enormous, in a dense country like the Netherlands this impact will be even larger than elsewhere. Landscape experts urge that the energy transition should not harm the existing landscape but rather be used to improve spatial quality by making it a part of integral regional design.
Recently many solar parks have been built, however, knowledge about how to use them to improve spatial quality is still scares. This research contributes to closing this knowledge gap. In this thesis three existing solar energy parks are being analysed, as well as the Northwest Haarlemmermeer, which is the design location. The outcome of this is translated into the design of three models, which form the foundation for an integral design for a solar energy landscape.
Six categories of functions for multifunctional solar energy landscapes are identified: biodiversity, water retention, airport, recreation, PV-energy and landscape infrastructure. They are translated into both general and site-specific design guidelines on three different scale levels.
Based upon this three ways of organizing these functions are considered and analysed: parallel, stacked and mixed. Organising the functions next to each other (parallel) is considered to have the largest positive impact upon spatial quality on this scale.
Together, the design guidelines, model study and integral design give a clear picture of how a multifunctional solar landscape can function as a tool to achieve other spatial goals and so improve spatial quality.

Keywords
Solar landscape, solar park,
solar energy, spatial quality, landscape quality, multifunctionality, energy transition, research through design, parallel, stacked, mixed

The bright side of solar energy
how solar energy can be used as a tool to improve landscapes

Coos van Ginkel
email: coos_vanginkel@live.nl
Phone: +316 41710587

Chair group landscape architecture
Phone: + 31 317 484058
email: office.lar@wur.nl

Postal address
Postbus 47
6700 AA Wageningen
The Netherlands

Visiting address
Gaia (building nummer 101)
Droevendaalsesteeg 3
6708 PB Wageningen
The Netherlands

Table of contents

1. Introduction..9

1.1 Motivation
1.2 Introduction
1.3 Problem statement
1.4 Theoretical framework
1.5 Research location
1.6 Objective
1.7 Research questions
1.8 Method

2. Research..19

2.1 How other solar energy parks contribute to spatial quality
2.2 Current spatial quality of the Northwest Haarlemmermeer
2.3 Current spatial challenges of the Northwest Haarlemmermeer
2.4 Conclusion

3. Design...63

3.1 Introduction
3.2 Model study
3.3 Criteria & evaluation
3.4 Integral design for a multifunctional solar energy landscape
3.5 Conclusion and discussion

4. Conclussion...99

4.1 Conclusion
4.2 Discussion

5. Bibliography..102

6. Appendix...104

1 INTRODUCTION

1.1 Motivation

During an internship at a landscape architecture office I got to take part in a regional design workshop for the Dutch province of North Holland. In one of the workshops the discussion went on and on about the implementation of renewable energy in the landscape. Some dominant stakeholders said, that renewable energy would ruin the beauty of the landscape. They insisted to pursue this opinion and the meeting was almost concluded, when suddenly someone else spoke up. A 60-year-old lady from a small municipality stood up, and vigorously told us that we must take on our responsibility. She argued that our actions will determine the future of our children and grandchildren. Instead of debating the beauty of the existing landscape, we should start to take care of our planet.

Once more I realized that we can not remain silent in the discussion about renewable energy. On the contrary, we have to engage in the debate about the impact of renewable energy in the landscape. How can we protect the existing landscapes and invest in their beauty, but at the same time take our responsibility and add renewable energy sources within these landscapes?

Therefore I ask myself whether there is a way to combine the necessity of renewable energy and the existing landscape without compromising on the beauty of nature? If we are going to transform our landscapes in the Netherlands drastically and partially irreversible by adding renewable energy in the coming decades, would it not be possible to use this to improve our landscapes at the same time?

As a topic for my master thesis I want to accept this challenge, because I believe that there are answers that will help us to not only implement the needed renewable energy sources, but also to use this to improve our landscapes.

1.2 Introduction

In the coming years, the impact of renewable energy on the landscape worldwide will be enormous, in a dense country like the Netherlands this impact will be even larger than elsewhere and is therefore the focus of this research.
Most of the renewable energy needs to be produced within the landscape, in so-called windfarms or solar parks. However, they have an enormous impact upon the landscape and therefore often the development of these project cause great resistance among local residents.
Landscape experts urge that the energy transition should not harm the existing landscape but rather be used to improve spatial quality by making it a part of integral regional design (Stremke, 2019, College van Rijksadviseurs, 2018). Since the Paris agreement worldwide and the climate deal specifically in the netherland the energy transition is gaining momentum.
In the last years, much research already has been done about the landscape impact of wind energy (Schöne, 2007, Schröder et al. 2008, Feddes, 2010) as these were the main sources of renewable energy. However, to have a stable energy provision a mix between solar and wind energy is needed (College van Rijksadviseurs, 2018), to obtain this recently many solar parks are being built, although knowledge about the landscape impact is still scares, therefore the focus of this thesis is on solar parks.

Although many solar energy parks are being build examples of integral regional design cannot be found yet. Therefore, this thesis wants to contribute to this knowledge gap by analysing existing multifunctional solar energy parks, making a model study to evaluate the different ways of organising the multiple functions of such a park and finally by giving an example of how solar energy can be used as a tool to improve spatial quality, by making an integral design for a multifunctional solar landscape with a capacity of 3 Petajoule.

1.3 Problem statement

The Dutch government aims at a CO_2 reduction of 49% in 2030 compared to 1990 (Rutte-III, 2017). However, still much must be done to achieve this goal (Planbureau voor de Leefomgeving, 2019). A large part of the reduction of CO_2 emission must be achieved by the transition towards renewable energy. Although this is a world-wide problem, the challenges are extra-large in a dense country like the Netherlands.
This energy transition is going to impact the landscape enormously. Dutch Prime minister Mark Rutte compares the energy transition even to the reconstruction of the Netherlands after World War II (Rutte, 2018).

In the professional discourse it has widely been recognized that there is a problem with the current practice of just fitting in renewable energy sources, only focussing on making the energy transition as cheap and efficient as possible. A shift in thinking must take place towards using the energy transition to make better landscapes (Hocks et al. 2018, Stremke, 2019). To maximise the outcome of this energy transition, a large positive impact on spatial quality should be generated (College van Rijksadviseurs, 2018). This can be done by addressing this problem together with other challenges like climate resilience, biodiversity and quality of living environment (Sinke, 2019). To change the landscape in such a way that the landscape improved by the energy transition.

1.4 Theoretical framework

1.4.1 Renewable energy, solar energy & PV

Renewable energy is defined as a form of energy, capable of being constantly regenerated by natural processes at reasonable rates (Spellman, 2016, Twidel & Weir, 2015). In the Netherlands, sun and wind are considered the main sources of renewable energy and a balance between these two sources is strived for (Sijmons et al., 2017, College van Rijksadviseurs, 2018).
There are three common types of solar energy: PV panels, concentrated solar power (CSP) plants and solar thermal collectors (Roth, 2018). In the Netherlands the use of PV panels is by far the most common and efficient form of solar energy production.
When PV panels are placed within the landscape many different names are being used, however three names seem to become dominant: solar gardens, solar parks and solar landscapes. Because no suiting definition exists yet, for the context of this thesis these concepts are understood as follows: a solar garden is the smallest form of and area with PV panels. The name 'garden' is somewhat misleading, as these gardens exist out of multiple hectares. A solar energy gardens contains several patches of PV panels, spread across the area. Different functions are combined with the production of solar energy. Commonly these solar gardens can be found close to residential areas and people can participate either financially other practically. Solar parks are larger and at this moment more common in the Netherlands. Again here the word park should be understood correctly, these are larger areas with PV panels, where the production of solar energy is the dominant functions. They are usually located further away from residential areas, are mostly not accessible for public and have a more industrial character.
One scale larger, one can speak of an energy landscape. A solar energy landscape is made up of several solar energy parks together with the needed large-scale landscape infrastructural functions, both related and unrelated to the production of solar energy.

As a unit for the electricity production of this areas with solar energy commonly Petajoule (PJ) is used. 1 Pj is the production of a solar energy park of 300-500 hectares or the electricity consumption of 90.000 households, as can be seen in the figure. For the Netherlands about 200 Pj renewable electricity needs to be produced by means of solar energy. It is estimated that 105 Pj can be produced on roofs and combined with infrastructure. However still a large part must be produced 'within the landscape' in solar gardens, park and landscapes (College van Rijksadviseurs, 2018).

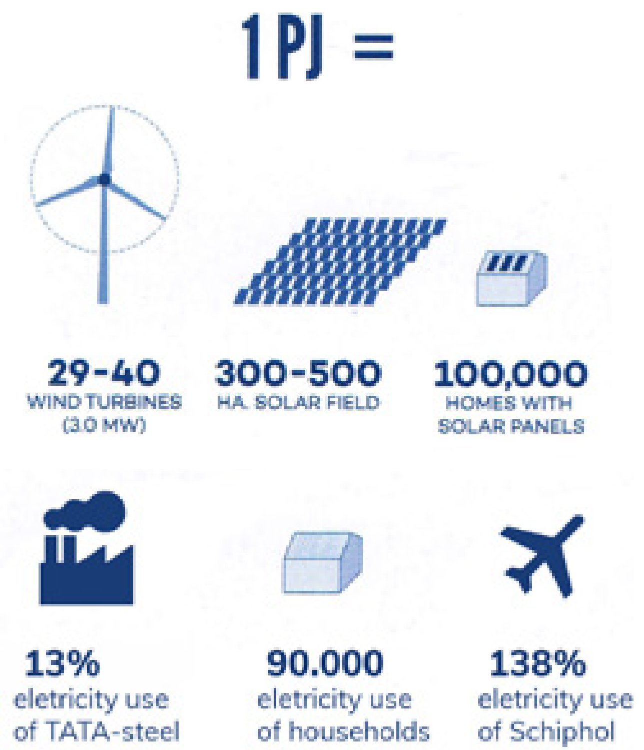


Figure 1: Production & consumption of 1PJ (Adjusted from: Posad Spatial Strategies / Generation.Energy, see appendix 6.1)

1.4.2 Spatial quality

To describe the quality of a landscape, one can speak about spatial quality or landscape quality. Landscape quality is about visual or aesthetic value. However, it has been recognized that this term should be widened to also include local storylines, experiences and local values (Jerpasen and Larsen 2017, as cited in Roth 2018). Spatial quality, is a more comprehensive term (Janssen-Jansen et al., 2009), it is an indication of value that the user of a location at a certain time ascribes to that place. What this entails is different from place to place and from person to person (Dauvallier, 2009).
Applied to energy landscapes, spatial quality is defined as the care for liveable cities and landscapes in which complex climate- and energy challenges are combined with other functions and challenges in the living environment (Hocks et al. 2019). Spatial quality has both objective and subjective aspects. Some of the criteria which help to understand and work with spatial quality will be outlined.

Criteria
Function, experience, future
The basic criteria for spatial quality are: functional value, experience value and future value (Hooijmeijer et al., 2001). Functional value is about the functional suitability, the effectiveness and accessibility. Experience value is about the identity, form, visual appearance or experience of beauty by users of the location. The future value is about the ability of the landscape to cope with changing circumstances, this includes adaptability, flexibility and sustainability (Hooijmeijer et al., 2001, VROM, 2011). To have a successful project these three must be in balance (Stremke, 2019).

Economic, social, ecological, cultural
Using space asks for a balance between economic, social, ecological and cultural interests. When social and cultural interests are taken together, these criteria resemble the people-planet-profit concept of sustainable development (Janssen-Jansen et al., 2009).

Bringing these first two sets of criteria together in a table helps to operationalise spatial quality (Hooimeijer et al., 2001). The table visualizes the wide spectrum of spatial quality and shows that spatial quality has objective and subjective indicators (Spaans and Trip, 2010).

Location
What is considered quality is also strongly site specific (Hooijmeijer, 2001). One must look at the landscape identity, the relationship between users and the landscape (Janssen-Jansen et al., 2009). Spatial quality must be defined for each case individually, defining both the strengths and opportunities of the location (VROM, 2011).

	Economic	Social	Ecological	Cultural
Functional value	Allocation-efficiency Accessibility External effects Multi-purpose	Acces Division Participation Choice	Safety Nuissance Pollution Fragmentation	Freedom of choice Diversity Encounter
Experience value	Image Attractiveness	Inequality Solidarity Security	Space Peace Beauty Health	Individuality Beauty Contrast
Future value	Stability/flexibility Agglomeration	Inclusiveness Cultures of poverty	Stocks Ecosystems	Heritage Integration Renewal

Table 1: criteria for spatial quality (source: Hooimeijer et al., 2001)

1.4.3 Multifunctionality

The concept of spatial quality lays at the heart of landscape architecture. However, to be able to design for spatial quality, the concept needs to be operationalized for this purpose. A helpful definition, related to the topic of renewable energy is formulated in the recent book ‘Space in the climate deal’: ‘we mean with spatial quality: the care for liveable cities and landscapes in which complex climate- & energy challenges are combined with other functions and challenges in the living environment’ (Hocks et al. 2018, p.6). In order to reconcile renewable energy systems and landscape quality, integrated approaches are needed (Roth et al., 2018), in which the challenge of the energy transition is seen in relation to other spatial challenges. A double goal, or win-win situation should be aspired, by connecting forms and functions that support and strengthen each other (Hooijmeijer et al., 2001). However, the way in which these different functions are connected differs.

Different forms of multifunctional use

In current practice three different categories have been defined of how solar energy can be combined with other functions.

Parallel function

Solar energy parks designed in a parallel way will have a monofunctional field of PV panels, with next to it other functions. One can think of a bush row around the park or some recreational facilities next to the park. Often, these extra functions are used as a transition to make the solar energy park fit into the landscape.

Stacked function

When designed in a stacked way the PV panels are on top of other functions. There can be a positive, neutral or negative relation between the two functions. An example of a positive relation is a solar energy park on top of a water basin, decreasing evaporation of the water, while the water cools the PV panels. Negative would be on top of agriculture, as less panels can be placed and most crops will grow less.

Mixed function

When the solar park exists out of many smaller patches of PV panels, with other functions in-between, it is defined as a mixed function park. In such a case usually the amount of PV panels per hectare is relatively low. An example would be a neighbourhood park where 30% of the ground space is used for PV panels, and the rest of the space for recreation.

Figure 2: Parallel function (own work)

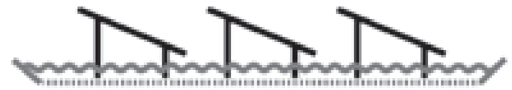


Figure 3: Parallel function (own work)

Figure 4: Parallel function (own work)

1.5 Research location

1.5.1 Criteria

On of the aims of this thesis is to make a design for an integral design for a multifunctional solar landscape. In order to find the optimal location for such a solar landscape different criteria are being used.

1. The distance between the producer of energy and the consumer of energy should be as little as possible (Sinke, 2019; College van Rijksadviseurs, 2018, Sijmons et al., 2017).

2. The closer the solar energy park is to an electricity station, the easier and cheap it is to connect it to the grid (Sinke, 2019; Sijmons et al., 2017).

3. Rather having a few large solar energy landscapes at suiting locations than many small ones everywhere (Sinke, 2019; College van Rijksadviseurs, 2018). Large quantities ask for significant space and a hosting landscape with the right size and scale.

4. Landscapes with a current low spatial quality should be used, to really be able to use solar energy as a tool to improve the landscape.

5. Also solar landscapes should be located where future developments are expected or desirable. After 25 years, solar energy areas are expected to be taken away or renewed for another 25 years, afterwards new functions will be located there. As much is invested within the solar energy area, it is commonly accepted that it is most likely that these areas will get an 'urban' functions, instead of being brought back to their original function. Therefore any potential future development of the location should be considered before the solar panels are being located.

1.5.2 The location

In this research the focus lays on the Netherlands. One of the regions where these 5 criteria come together, is the Northwest Haarlemmermeer. Less than 200 years ago, the than largest lake of the Netherlands was pumped dry and a large-scale agricultural area was created. However, being located within the metropolitan region of Amsterdam, the area is rapidly urbanizing, putting enormous pressure on the spatial quality of the area.
The fragile structures of the polder (Bijhouwer, 1971) can't cope with the enormous pressure of economic development of the metropole. The polder is rapidly being filled with houses, room for the airport and highways, while at the same time trying to provide room for recreation, water retention and circular agriculture. In chapter 2.2 and 2.3 a thorough analysis of the current situation of this region will be made.


Figure 5: Indication on map Netherland (adjusted from: bing maps)


Figure 6: Indication in metropolitan region Amsterdam (adjusted from: bing maps)


Figure 7: Northwest Haarlemmermeer (adjusted from: bing maps)

1.6 Objective

Solar energy is often seen as a threat for spatial quality. This thesis challenges this conception by making an integral design for an integral design for a multifunctional solar landscape. This will contribute to the spatial quality of the location, by connecting to other spatial challenges.
The solar landscapes will be able to produce approximatly 3 Pj. As 100 Pj of solar energy needs to be produced within the dutch landscape (College van Rijksadviseurs, 2018) 33 of such parks will together produce sufficient solar energy for the Netherlands.

1.6.1 Objective

To find out how an integral design for a multifunctional solar landscape can function as a tool to achieve other spatial goals and so improve spatial quality

by

analysing both other solar energy parks and the design location, analysing the best way to spatially organise multifunctional solar energy landscape and making an integral design for a multifunctional solar landscape in the Haarlemmermeer.

1.7 Research Questions

1.7.1 General Research Question

How can solar energy landscapes be used as a tool to improve spatial quality?

1.7.2 Specific Research Questions

1. How do other solar energy parks contribute to spatial quality?

2. What is the current spatial quality of the Northwest Haarlemmermeer and how can it be strengthened?

3. What are current spatial challenges of the Northwest Haarlemmermeer and what are potential solutions?

1.7.3 General Design Question

How can an integral design for a multifunctional solar landscape have a large positive impact on the spatial quality of the Northwest Haarlemmermeer?

1.7.4 Specific Design Questions

1. Which way of spatially organising different functions, in a solar energy landscape, with the production of PV-solar energy has the largest positive impact on spatial quality?

2. How can an integral design for a multifunctional solar energy landscape, with a capacity of 3Pj, in the Northwest Haarlemmermeer look like?

1.8 Method

This research exists out of three parts. The first specific research question is a case study of other solar energy parks and can be understood as research on design. The specific research questions 2-3 are research for design, informing the design. Design guidelines will be formulated out of the outcomes of the 3 specific research questions, which will help to answer the design question. The design question can be considered research through designing (Lenzholzer et al. 2013).
A design guideline can be understood as a guideline that gives guidance for design action, giving a specific direction by excluding many others. It is an abstraction that works beyond a specific case to a more generalisable set of situations (Van den Brink et al., 2016)

1.8.1 Analysing how other solar energy parks contribute to spatial quality

A reference study among different multifunctional solar energy parks in the Netherlands, will be conducted. This will be done by looking how other functions and spatial challenges have been addressed and what landscape infrastructures therefor have been altered. Three parks will be analysed by undertaking a document study as well as a field visit and where possible interviews. The parks will be selected from a list, using criteria. The outcome of the research for each park will be a detailed description, a list with specifications, maps and a list of design guidelines that can be derived from the analysed parks.

Input:

Document study

Visit of site

Relevant stakeholder interview

Output:

Description of park

Analysis maps

Design guidelines

1.8.2 Examining the current spatial quality of the Northwest Haarlemmermeer

Changing a landscape, starts first of all with understanding the existing landscape.
Gathering this information will be done by direct observation during field visits, combined with secondary sources such as policy documents and (historical) maps, to come to a clear analysis of the current spatial quality and characteristics of the location.

The outcome of this research will be different theme maps, a landscape description, including the characteristics and a definition of the current spatial quality, which will help to formulate design guidelines.

Input:

Direct oberservation

Policy documents & newspaper articles

(Historical) map study

Output:

Theme maps

Landscape description

Design guidelines

1.8.3 Examining the current spatial challenges of the Northwest Haarlemmermeer

Like the analysis of the spatial qualities, the analysis of spatial challenges will be done by direct observation, combined with secondary sources such as policy documents and newspaper articles

The outcome of these questions will be a problem tree, from which the main problems will be identified. The main problems will than be further described and where relevant potential solutions related to multifunctional solar energy parks will be mentioned. In addition, maps will be made that give evidence where these problems are located. Design guidelines will be concluded from this.

Input:

Direct oberservation

Policy documents & newspaper articles

Output:

Problem tree

Description of problems

Problem maps

Design guidelines

1.8.4 Examining the optimal spatially organising of different functions in a solar energy landscape

To answer this question the design guidelines, derived from the specific research question, are translated into 3 spatial models. These three models are based on three categories of multifunctional use, as discussed in the theoretical framework. All three models are located within the same boundaries and have approximately the same amount of PV panels. They incorporate as much as possible suitable design guidelines. These 3 models make it possible to compare their differences and see which one contributes most to the spatial quality of the location. The eventual integral design of solar energy landscape will have a capacity of 3 Pj, however the purpose of this model study is simply to analyse the best way of spatially organising the different function within a solar energy landscape, for this purpose a solar energy landscape of 1 Pj is more suiting.

To create good insight into the value of the three different models, they will be tested according to criteria based upon literature about spatial quality. The three basic criteria for spatial quality are: functional value, experience value and future value (Hooijmeijer et al., 2001). Based upon these basic criteria more specific criteria will be formulated, which will help to evaluate the models. Secondly landscape architecture experts will judge the models based upon the same basic criteria.

1.8.5 How can a multifunctional solar energy landscape in the Northwest Haarlemmermeer look like

The evaluation of the three different models is the starting point for an integral design for a multifunctional solar energy landscape. The model that was rated the highest will be used as a basis for this design, however aspects of the other models can be used to improve the design. By addressing other spatial challenges of the Northwest Haarlemmermeer this design aims to optimally contribute to the spatial quality of this area. It also tests suitability of the design guidelines for this location as well as for the scale of solar energy landscape.
The final design will be worked out in maps, cross-sections, visualisation, planting designs and other supporting products. The products will be worked out on 4 levels: XL, L, M and S. The XL scale shows the Northwest Haarlemmermeer and its direct surroundings (approximately 20 x 20 km). The L scale focusses on the area where most PV panels and other functions are located (approximately 6 x 4 km). The M scale zooms in to one or more relevant knots (approximately 300 x 200 m). The S scale shows one or more relevant details such as street furniture.

Figure 8: Three different models : parallel, stacked and mixed (source: own work)

2 RESEARCH

2.1 How other solar energy parks contribute to spatial quality

2.1.1 Introduction
A reference study has been conducted among multifunctional solar energy parks in the Netherlands. The focus of this reference study is on multifunctional solar energy parks and the way in which landscape infrastructure is being adjusted in and around it.
Landscape infrastructure is defined as the natural or constructed physical structure or betastructure of the landscape delivering material or immaterial benefits and services as well as the recycling of energy and materials (Belanger, 2013 as cited in Picchi et al. 2019), such as roads, fences, trees etc.
The goal of the reference study is to extract the design guidelines that are used to create these multifunctional solar energy park. Secondly it creates more insight into the differences and similarities between parallel, stacked and mixed solar energy parks. Altogether it will answer the question: 'how do other solar energy parks contribute to spatial quality?'

2.1.2 Case selection
Out of a variety of different parks, the three most relevant were chosen for this reference study, based on the following criteria:

Multifunctionality
As described in chapter 1.4.3 the spatial arrangement of multiple function within a solar energy parks can be categorised as parallel, stacked and mixed. Three parks will be analysed that each display one of these three categories.

Additional functions
Secondly the different functions within the multifunctional park are listed. Some of these functions might hold extra relevance, because of the specific situation of the Northwest Haarlemmermeer.

Landscape infrastructure
Lastly the extent to which landscape infrastructure has been adjusted is listed.

Evaluation
An overview of all parks can be seen in the table. The solar parks Sinnegreide in Achtkarspelen, Groningen Airport Eelde and Laarberg where selected as most relevant cases. In the following subchapters they will be introduced and analysed.

Multifunctionality	Location	Additional functions	Landscape infrastructure
Parallel	Andijk	Biodiversity	3-meter-wide edge of bushes around the solar field. Fence
Parallel	**Achtkarspelen**	**Recreation + biodiversity**	Public orchard of 50 trees, flower meadow, edge of bushes, trees and reed. Fence
Stacked	Heeten	Livestock	Fence
Stacked	Ubbena	Biodiversity	Flower meadow between and underneath panels. Fence
Stacked	Boekelermeer	-	Fence
Stacked	**Eelde**	**Airport**	-
Stacked	Assen	Parking	-
Stacked	Cocksdorp	Water retention	-
Stacked	Lingewaard	Water retention	-
Mixed	**Laarberg**	Biodiversity + water retention + livestock	**Ponds, wadi's, bush rows, fruit trees. Fence**
Mixed	Hengelo	Biodiversity + recreation + water retention	Trees, wadi's, flower meadows. Fence

Table 2: Selection from multifunctional solar energy parks (source: own work)

2.1.3 Park Sinnegreide Achtkarspelen

Introduction

Solar energy park Sinnegreide lays at the North side of the rural village Buitenpost, and is part of the municipality Achtkarspelen. Around the park lies a 6-10-meter-wide green edge. One part exists out of bushes and trees and another part of lowered ground, where reed is planted. At the street side there is an orchard where visitors can sit and find out more about the park. In the orchard and in a field within the fenced off solar panel field area a flower mix has been sown. The park combines biodiversity and recreation with the production of solar energy in a parallel way.

An overview of all the facts of the park can be found in the table

History

In 2016, the municipality of Achtkarspelen set out a tender to transform the agricultural land into a solar energy park. The tender was won by the company Solarfields, who today is the owner of the park and leases the ground from the municipality. The solar park forms a loose edge around a business park, leaving enough for the business park to grow in the future.

General information	
Country	Netherlands
Address	Newtonstraat 30, Achtkarspelen
Coördinates	53.260417, 6.153222
Website	https://www.solarfields.nl/zonnepark/sinnegreide-achtkarspelen/
Year of opening	2018
Year of first kWh	2018
Year of initiation	2016
Proces duration	2 years
Size (hectares)	12
Nearest build up area	Industrial building, 25 meters from park
Stakeholders	
Design firm	Laos Landschapsarchitectuur
Engineering firm	Solarfields
Developer	Solarfields
Initiator	Municipality Achterkarspelen
Involved community	Buitenpost
Local government	Municipality Achterkarspelen
Mid-level government	Province Friesland
National government	Dutch government (Subsidy)
Solar system features	
Nominal power (MW)	11.7
Number of modules	30 436
Power per panel (kWp)	0.38
Density of power (MW/ha)	0.975
Module height from the ground	1.5 and 3 meters
Tilt angle	13.5
Surface area modules (ha)	7
Pore space (ha)	5
Color PV	Standard blue
Distance between rows	1.8
Concurrence	Panels of 1.5 and 3 meters high
Orientation	South

Table 3: Factsheet Sinnegreide (source: own work)

Spatial characteristics of PV system
All PV panels are orientated south and are standing in rows. The PV panels are orientated with a low angle and therefore only have narrow space between the single rows of PV panels. The old parcel edges are kept open as service roads between the patches of PV panels. The patches follow the original shape of the former fields.

The PV system exists out of two parts of different height, the high part exists out of the three northern patches with a height of 3 meters, the lower part, which is closer to the orchard and the street, has a height of about 1,5 meters. The distance between the panels is consistent. The park consist of four patches in total, around these patches there is a fence. The transformers are places far from the road, although they can be seen, they are not likely to be noticed.
Within the fenced of part of the park a field is sown in as a wildflower meadow.
A bush and reed edges are located outside the fence, as well as an orchard. Along the orchard runs the main path towards the gate of the fenced of part.

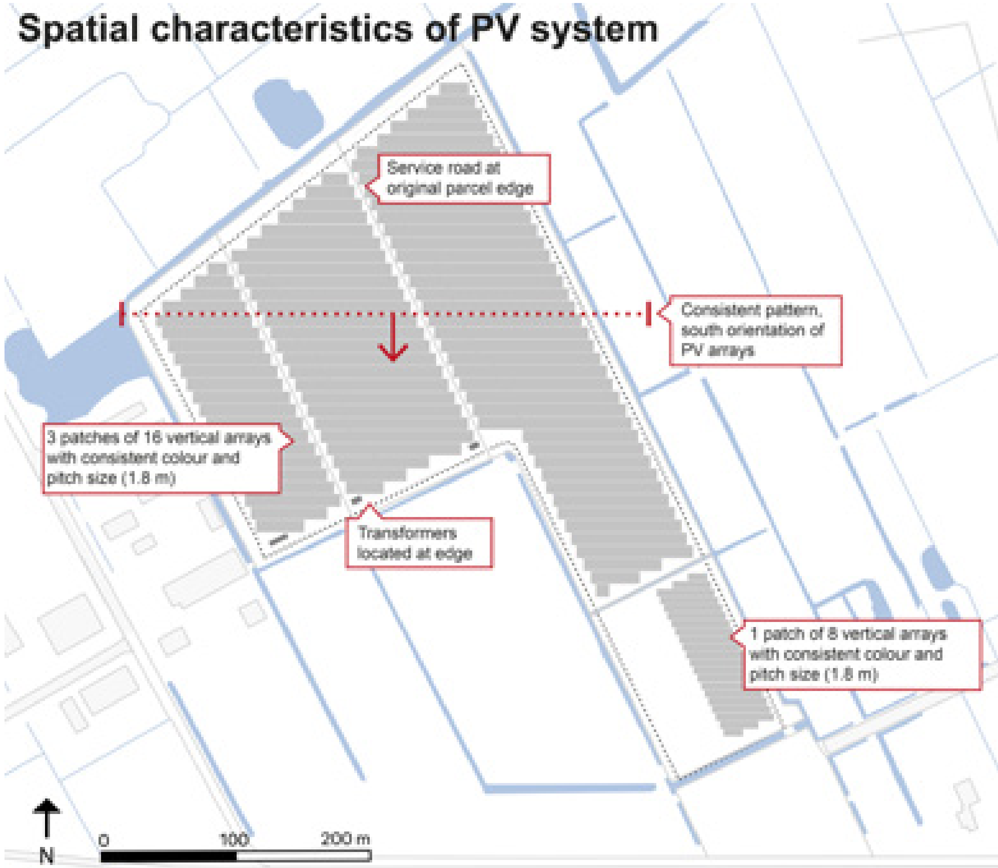


Figure 9: Spatial characteristics of PV system map (source: own work)


Figure 10: Two different height of panels (source: own picture)


Figure 11: Fence and different patches of PV (source: own picture)

Parcel size vs patch size

As a basis for the solar energy park several existing fields were used, of which the shape was not adjusted. The north-south orientated ditches between the parcels seem to have vanished. All other ditches were kept and some even widened. Each patch of PV was located on one parcel. The service roads run between the parcels. The parcel used for the orchard already used to be a somewhat different used piece of land.

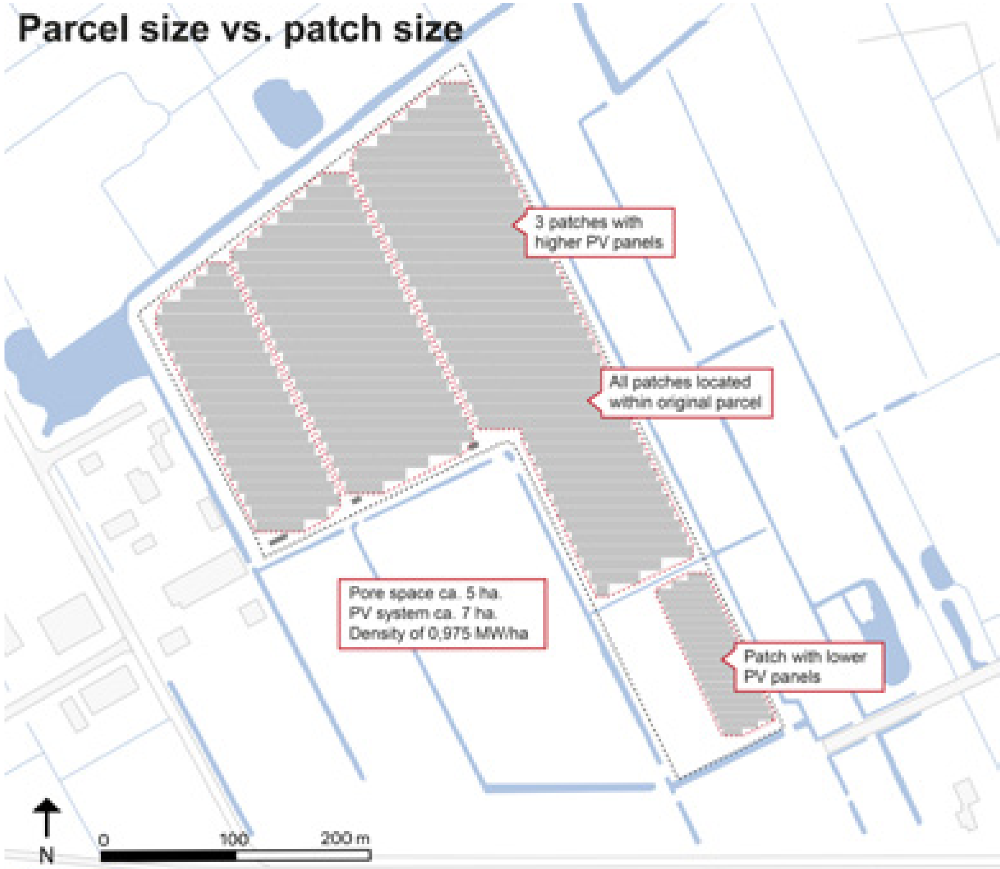


Figure 12: Parcel size vs. patch size (source: own work)


Figure 13: View from the east (source: own picture)


Figure 14: Orchard and view from south (source: own picture)

Visibility & screening
The solar park is located at the edge of the village Buitenpost. One local road passes it, connecting the business park with the regional road close by. Next to the local road there is a bike path. The park and its PV panels are well visible from the road and bike path. However, theroad is not often used as the main entrance of the businesspark is at the otherside.

Furthermore a few houses are located nearby. However, the park is located rather far from the residential areas of the village.

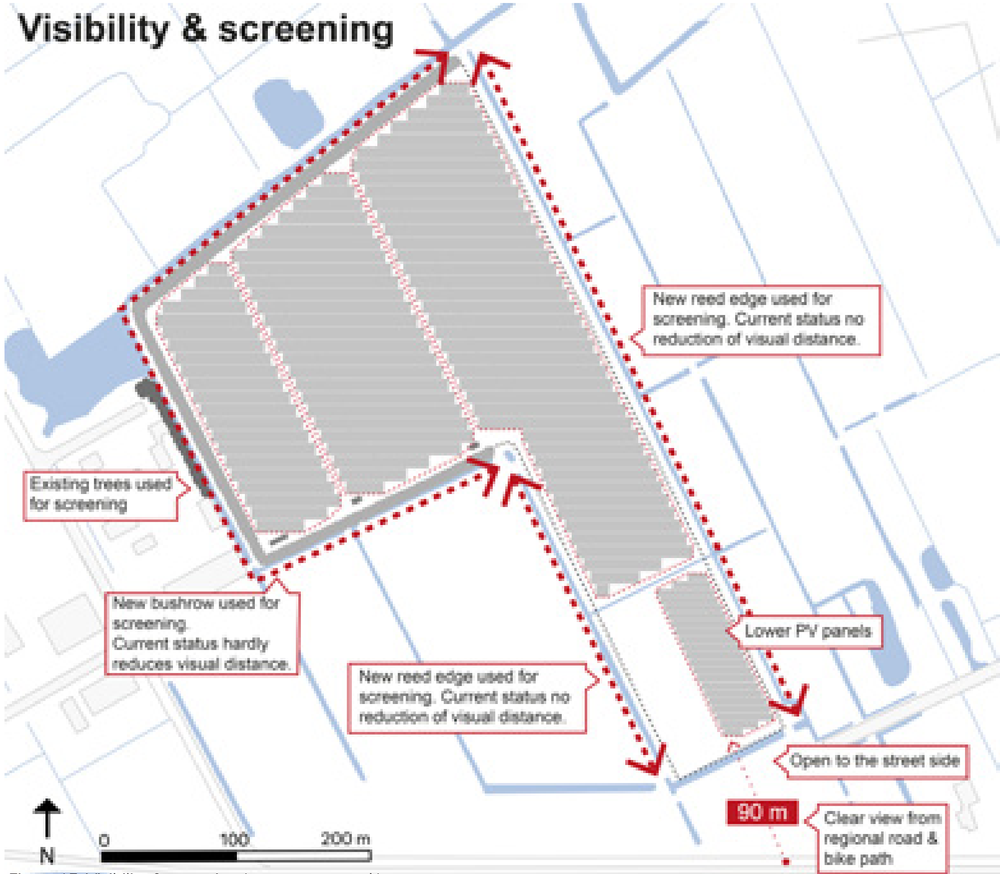


Figure 15: Visibility & screening (source: own work)


Figure 16: Low PV panels (source: own picture)


Figure 17: High and low PV panels (source: own picture)

Transition landscape
The solar energy park has three types of edges. At the north and partially the western and southern side it is surrounded by a 5-meter-wide bush and tree edge. This edge is not full grown yet, so the park is visible from these sides.
At the east side and partially the western side the park is surrounded by a reed edge. This has recently been planted and still allows the view to the panels. Also, in the future the PV panels will remain visible above the reed edge. At the south side where the orchard is located the PV-panels are well visible.

The solar park is located on the transition zone from a dryer landscape north from the park to a more wet landscape south east of the park. At the north side of the park there are bush and tree rows at the edge of parcels, south-east from the park edges are formed by gutters and the view is open. The design of the park edges seems to respond to this by having tree and bush rows at the north side and at the south-east side a more open reed edge.

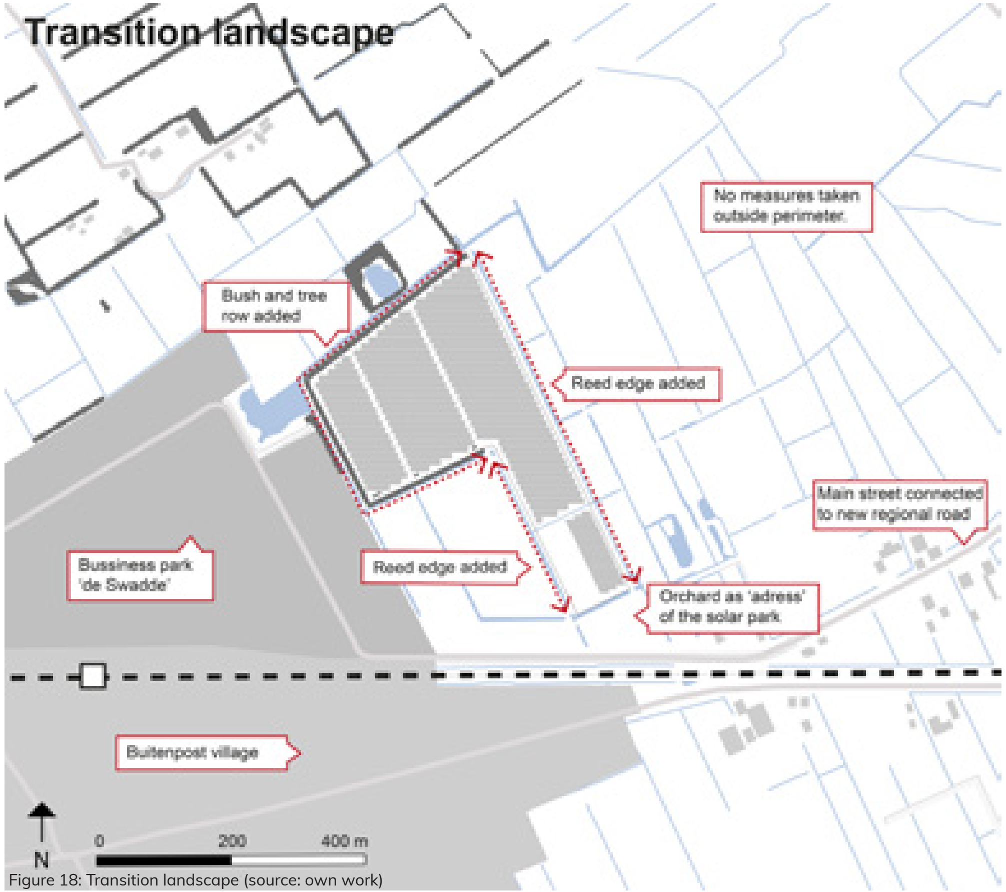


Figure 18: Transition landscape (source: own work)


Figure 19: Bush and tree edge (source: own picture)

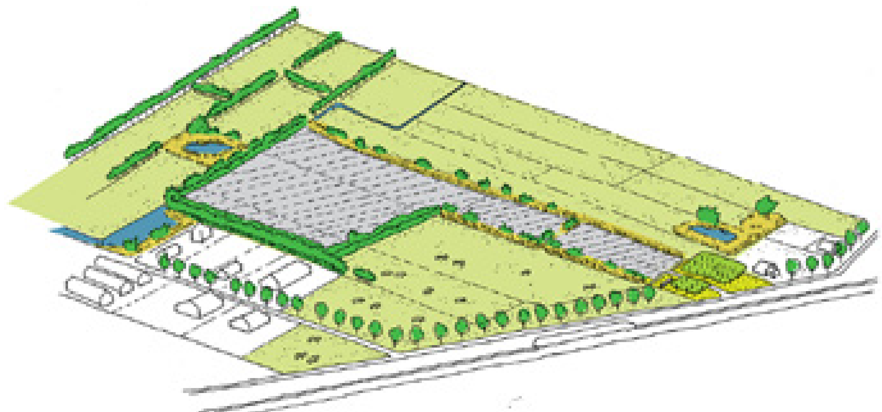


Figure 20: PV park and connection to landscape (source: Laos Landschapsarchitectuur)

Multifunctionality

The space around the solar energy park is used for 2 main functions: recreation and biodiversity.

To enhance biodiversity the ditches around the park have been widened and a green edge has been created. At the north and east side this is a 5-meter-wide bush row with a mix of bush and tree species, at the other sides, the ground has been lowered, and reed has been planted. Within the fenced off area of the park a flower meadow has been created, next to the solar panels.

Also, between the fenced off area and the road, a 'wild park' has been created. Here, fruit trees are planted in a flower meadow. There are plans to let sheep graze in the solar park. Passer-by can park their bikes at the orchard and rest on the picknick bench or pick fruits. The park is not located along a regional bike route or near a residential area.

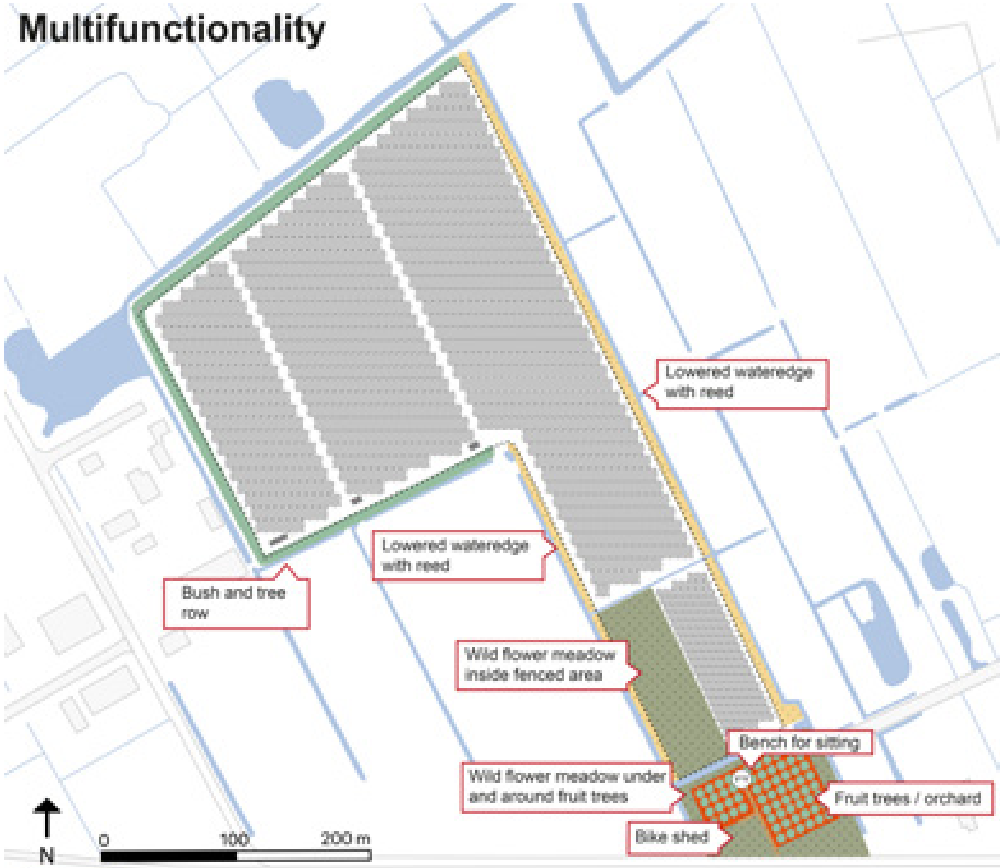


Figure 21: Multifunctionality (source: own work)

Figure 22: Orchard (source: own picture)

Figure 23: Picknick bench and wildflower meadow (source: own picture)

Conclusion

The edges of the park exist out of bush and tree rows and reed edges. These edges correspond with the surrounding landscape of dry grounds with bush and tree rows in the north and more transparant edges in the form of reed at the south-east side of the solar energy park.

The solar energy park therefore integrates well into the existing landscape and with this decreases the visual impact of the PV panels within the landscape, while at the same time increasing biodiversity in the edges.

Although the tree and bush row will in the coming years be very effective in screening the PV park, the reed edge will remain to low and therefor allow sight on the PV panels. Although this type of edge is suiting the open landscape character of the more wet landscape it is in, it is not very suited for screening.

The patches of PV panels are located within the original parcels, with lower PV panels closer to the landscape users, this reduces the visual impact.

Although different recreational ammenities are being provided, such as an orchard an a picknick bench, due to the absence of a regional biking route or nearby residential area is is to be questioned if these facilities will be used.

2.1.4 Groningen Airport Eelde

Introduction

Within the boundaries of the regional airport Groningen Eelde, a solar park has been built. The solar park entails both, a field of solar panels within the triangle of the three landings strips of Groningen Eelde Airport as well as a solar roof, connecting the terminal with the platform. The airport is a rather small regional airport, with about 240.000 passengers per year. The solar energy park producing 21.9 MW is one of the larger one of the Netherlands.

History

In 2014 the province of Drenthe and the municipality Tynaarlo together hosted a design competition for an iconic solar park at Groningen Eelde Airport in cooperation Groenleven and Groningen Eelde Airport. The competition was won by buro Harro, who proposed to transform the airport into an 'energy estate', refering to the local history of estates.

According to Groenleven, the developer of the current solar park, this is a more pragmatic translation of the initial vision of the energy estate.

General information	
Country	Netherlands
Address	Machlaan 14 Eelde
Coördinates	53.125667, 6.586250
Website	https://www.groenleven.nl/zonnepark-groningen-airport-eelde
Year of opening	2019
Year of first kWh	2019
Year of initiation	2016
Process duration	2 years
Size (hectares)	20
Nearest build up area	Airport buildings, 140 meters
Stakeholders	
Design firm	Unknown
Engineering firm	Groenleven
Developer	Groenleven
Initiator	Province Drenthe
Involved community	Groningen Airport Eelde
Local government	Municipality Tynraarlo
Mid-level government	Province Drenthe
National government	Dutch government (Subsidy)
Solar system features	
Nominal power (MW)	21.9
Number of modules	63000
Power per panel (kWp)	0.35
Density of power (MW/ha)	1.095
Module height from the ground	Unknown
Tilt angle	Unknown
Surface area modules (ha)	20
Pore space (ha)	181.5
Color PV	Standard blue
Distance between rows	Unknown
Concurrence	-
Orientation	South

Table 4: Factsheet Eelde (source: own work)

Spatial characteristics
Unfortunately, no maps or air photos of the solar energy park are available for use by research yet. Therefor an estimation was made based on renderings.
The shape of the parcel is determined by the existing shape of the airport and it's airstrips. The PV system is located between the airstrips, leaving room between the PV panels and the airstrips.
The PV system is divided into two areas between the landing strips.
Al solar panels are orientated in rows with a south direction. The service roads between the patches are made on a regular distance from each other. The transformers seem to be located along these service roads.
Due to the fact that whole area of the airport already was sufficiently fenced-off, no adjustments had to be made to this.

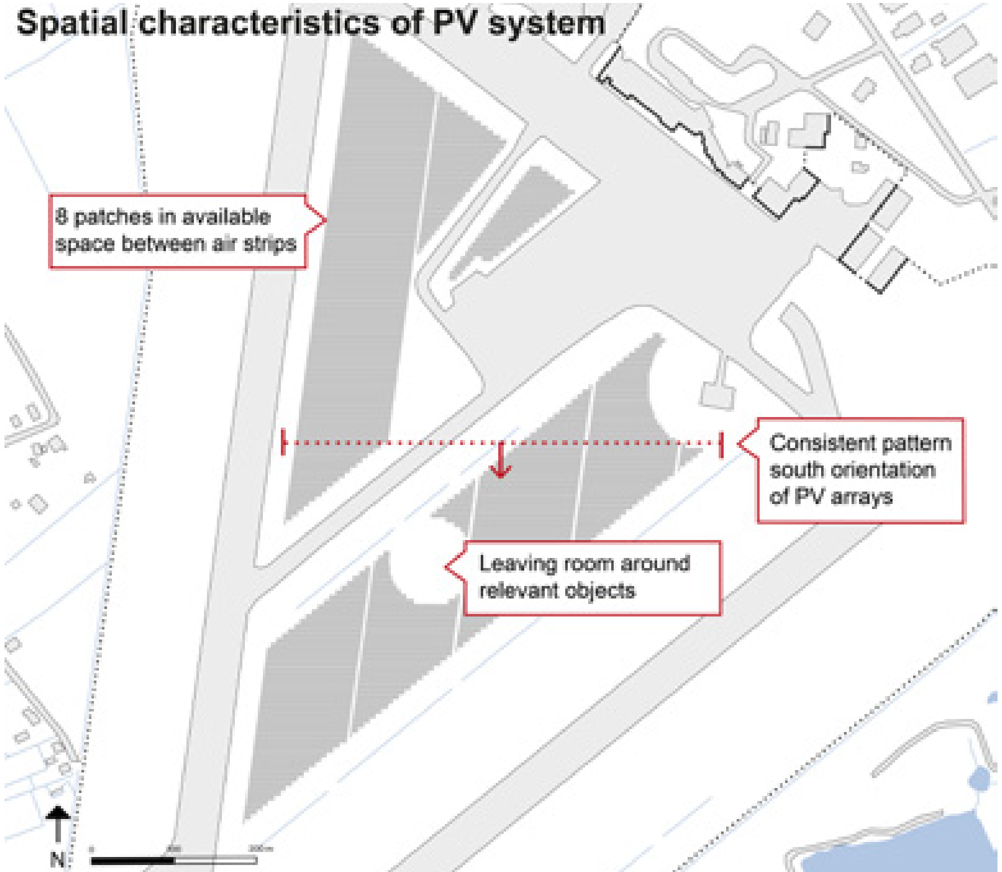


Figure 24: Spatial characteristics of PV system (source: own work)


Figure 25: Rendering of solar energy park (source: groenleven.nl)

Parcel size vs. patch size

The solar energy park exists out of 8 patches of PV panels. Around some structures or objects a zone has been kept open, as well as around the air strips.

The service roads between the patches run parallel to the second north-south orientated landing strip.

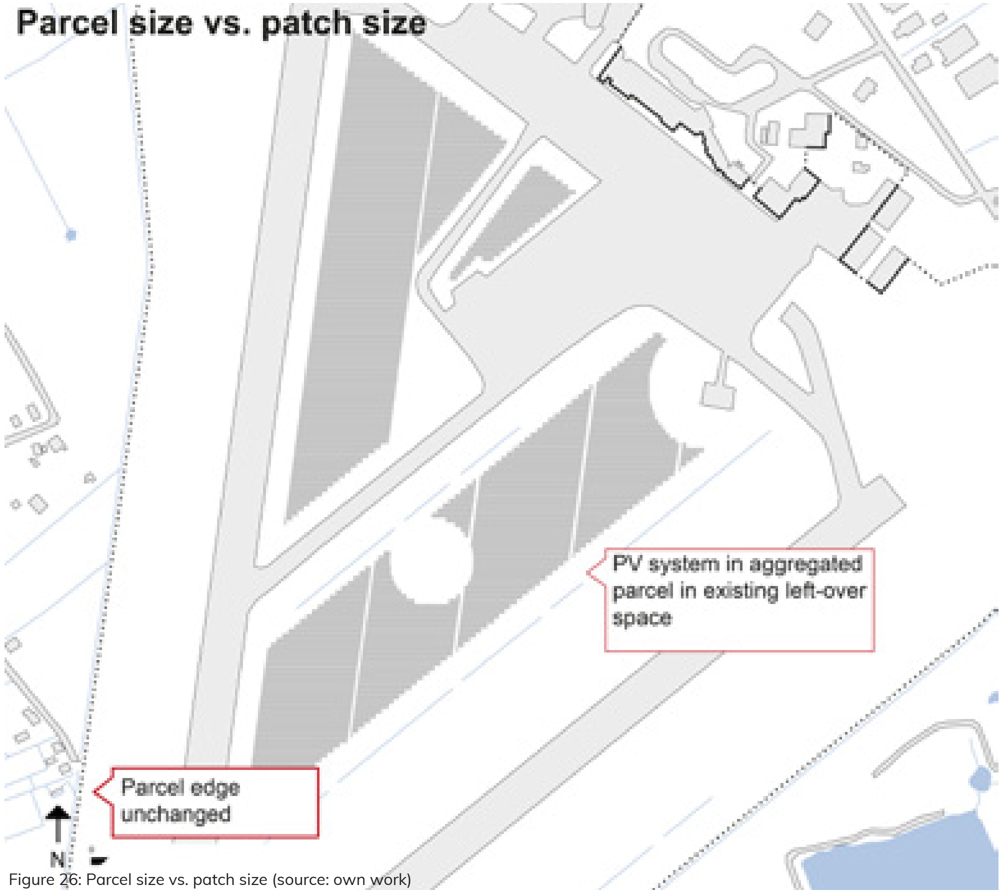


Figure 26: Parcel size vs. patch size (source: own work)


Figure 27: Patch of PV panels (source: Groningen Airport Eelde)


Figure 28: PV panels next to air strip (source: groninger internet courant)

Visibility & screening

As a person not making use of the airport the closest one can get to the PV panels is by visiting the panorama terrace of the airport, on a distance of 140 meters of the PV panels. Different regional, local and unpaved roads run along the airport, however because the PV panels are in the middle of the airport grounds, the distance to any landscape users remains large and they are hardly visible.

However making use of the airport the PV panels are well visible from the air or when getting in or out of the airplane.

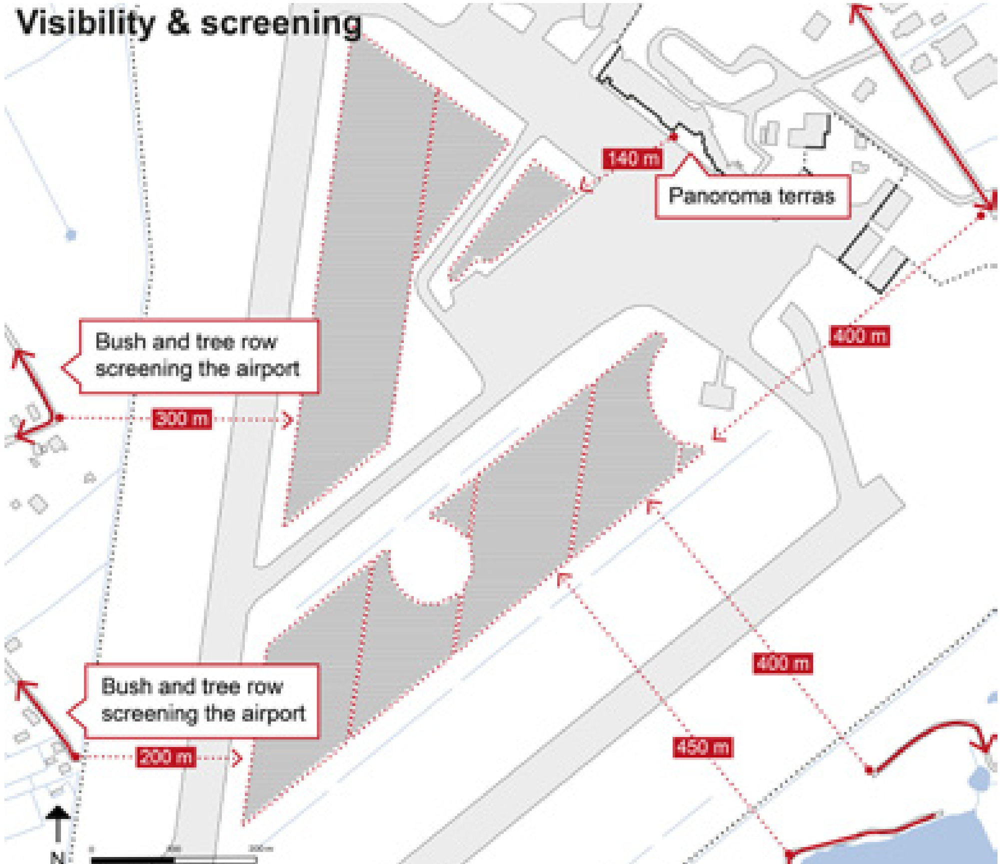


Figure 29: Visibility & screening (source: own work)


Figure 30: View from panorama terrace (source: own picture)

Transition landscape

Hardly anything of the PV panels can be seen from outside the airport. At most edges the airport is surrounded by trees and bushes. At the north-east side, where the airport is more open, the PV panels can be seen from the panorama terras, from a local road and from afar from the regional road.

The solar energy park fits into the functional and technical appearance of the airport. However, both the airport and the solar energy park look rather alien within the larger half-open surrounding landscape. Cut-off streets and landscape structures and introducing completely different shapes, directions and scale to the surrounding area.

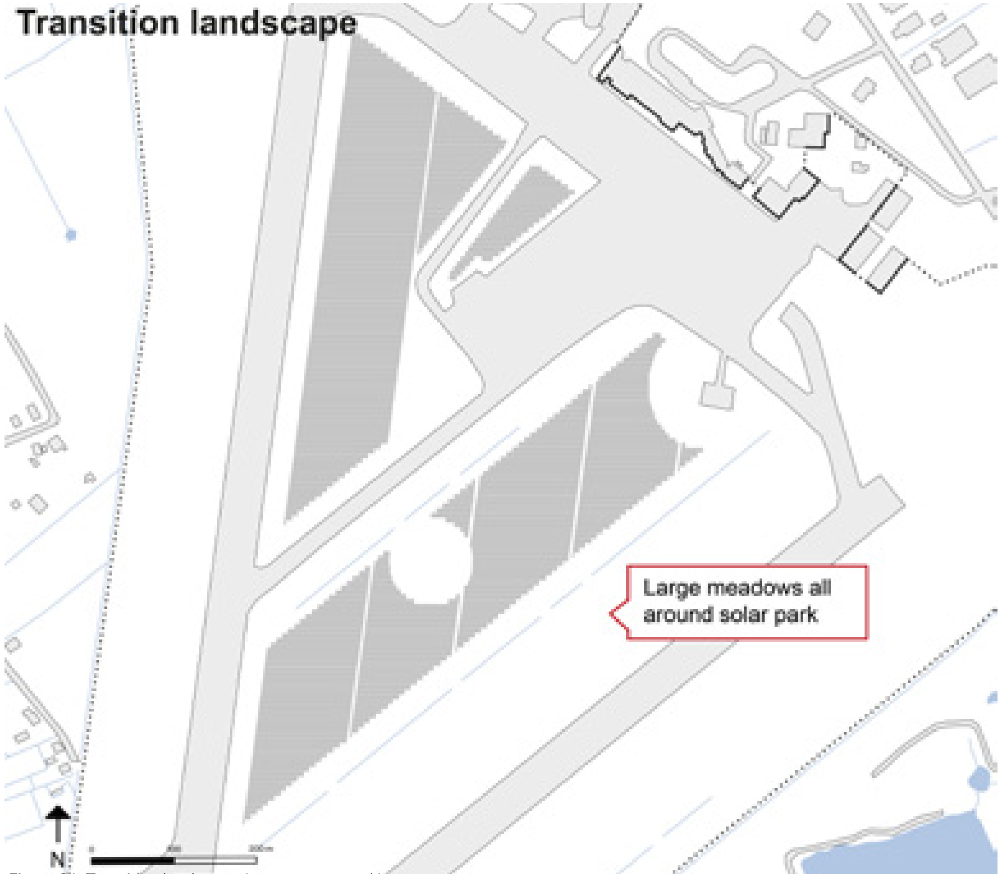


Figure 31: Transition landscape (source: own work)

Figure 32: Airstrips and PV panels (source: groninger internet courant)

Multifunctionality

Implementing solar energy within the strict safety regulations of an airport brought extra challenges to the development of this solar energy park. The construction workers were only allowed to cross the landing strips twice a day. In the design certain heights and distance needed to be worked with. Furthermore, due to the history of the location, intensive archaeological research needed to be done before the work could start. Advantages on the other hand were that the airport is already fenced of and the space where the PV panels were instaled on, was previously unused 'left-over' space. The modern PV panels cause no problems with reflection and are therefor not blinding the pilots when landing.

Besides the large patches of PV panels, a roofed passage connecting the planes with the terminal has been built, which also was covered with PV panels.

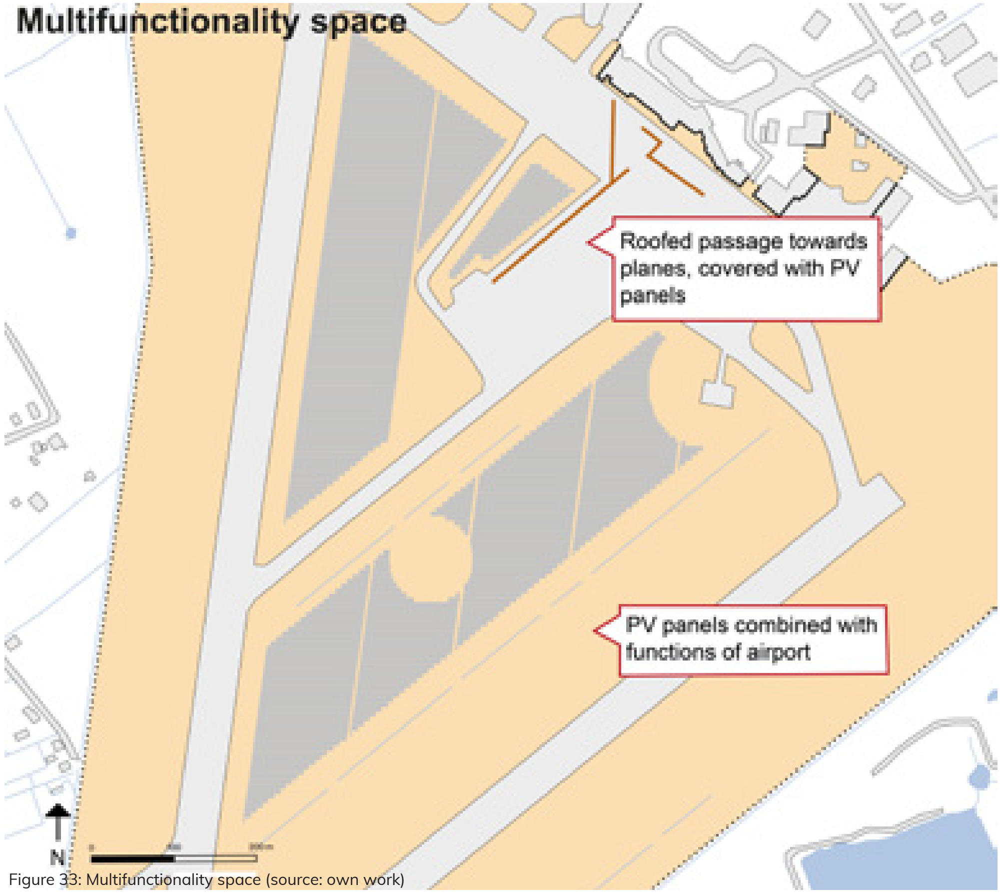


Figure 33: Multifunctionality space (source: own work)


Figure 34: Roofed passageway (source: groenleven)


Figure 35: Construction of PV panels (source: RTV Drenthe)

Conclusion

At Groningen Eelde Airport the function of airport and production of solar energy seem to go hand in hand. At the airport a large area of left-over space is available, which is already fenced of and with minimal visual impact on its surroundings.

The PV panels are hardly visible from outside the airport. However people using the aiport experience the PV panels from the sky as well as the ground. For them the function of a solar energy park fits in the pragmatic or functional lay-out of the airport.

Besides the main patches of PV panels, also a roofed passage was built, which also is covered with PV panels. However, this is the only added function of this solar energy park.

2.1.5 Solar park Laarberg

Introduction

At the Northwest corner of the new regional business park Laarberg, the solar energy park Laarberg is located. The PV panels were installed on top of a water retention area and in an area specifically designed to enhance biodiversity. Besides this, the solar energy park provides some recreational opportunities.

History

When developing the regional business park Laarberg measures needed to be taken for water retention and nature compensation. During the design of an area for water retention and nature compensationthe idea came up to combine this with a solar energy park. First the water retention area was created, later the solar park was added to it.

General information	
Country	Netherlands
Address	Ruiterpad 14a Groenlo
Coördinates	52.064361, 6.609806
Website	https://www.greenspread.nl/referenties/projectplan-solarpark-laarberg
Year of opening	2018
Year of first kWh	2018
Year of initiation	2014
Proces duration	4 year
Size (hectares)	7
Nearest build up area	Farm, 25 meters
Stakeholders	
Design firm	Unknown
Engineering firm	Unknown
Developer	Greenspread
Initiator	Gebiedsontwikkeling Laarberg
Involved community	-
Local government	Municipality Groenlo
Mid-level government	Province Gelderland
National government	Dutch government (Subsidy)
Solar system features	
Nominal power (MW)	2.23
Number of modules	6664
Power per panel (kWp)	0.33
Density of power (MW/ha)	0.319
Module height from the ground	1.2
Tilt angle	20
Surface area modules (ha)	1.4
Pore space (ha)	5.6
Color PV	Standard blue
Distance between rows	10
Concurrence	-
Orientation	South

Table 5: Factsheet Laarberg (source: own work)

Spatial characteristics of PV system

The PV park is placed within the original pattern of the landscape. The location of the PV panels is independent of the landscape patterns. All PV panels are elevated to be protected from high water. The distance between the rows is consistent. All panels are orientated south. The transformers and inverters are located close to the road, at the gate. The size of the area with PV-panels was determined by the electricity connection that was available.

The solar energy park is surrounded by a fence. An the park is not open for public. However, an open day is organised every year. Furthermore at the south side 20 meters has been kept open between the street and the fence, for recreational purposes.

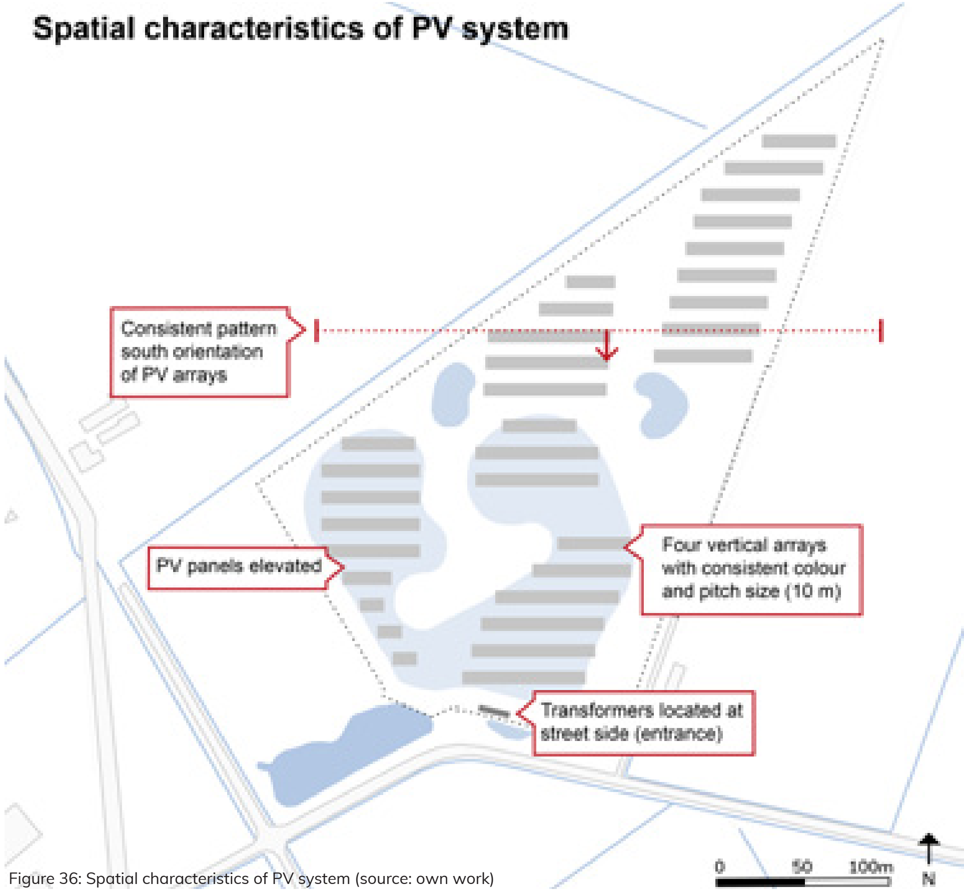


Figure 36: Spatial characteristics of PV system (source: own work)

Figure 37: PV park (source: own picture)

Figure 38: Park and water inlet (source: own picture)

Parcel size vs patch size
The shape of this parcel has not been adjusted for the function of solar energy park.
The solar energy park exists out of 6 clusters of PV panels. They are irregularly shaped and spread across the park. All the patches exist of the same height of PV panels with the same space in-between.

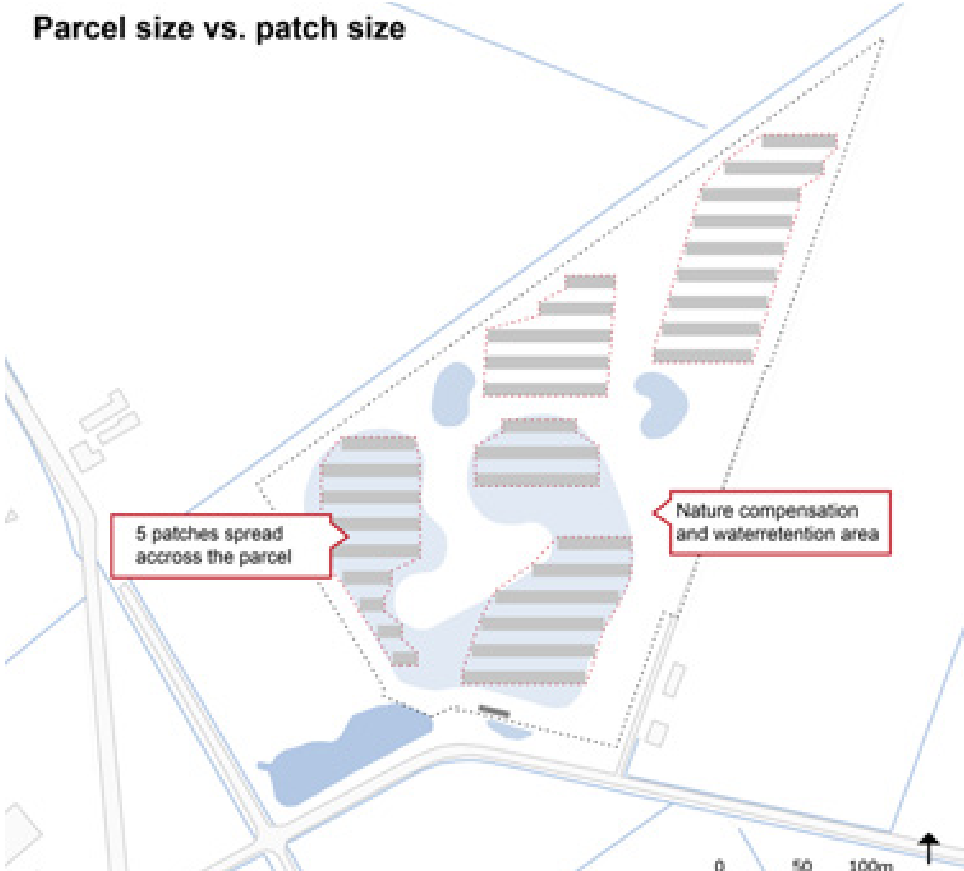


Figure 39: Parcel size vs. patch size (source: own work)


Figure 40: Patches of PV panels elevated (source: own picture)


Figure 41: PV panels irregular patches (source: own picture)

Visibility & screening

Currently the solar energy park is hardly visible from afar, and this will only become less as the business park at the south and east side will grow. Between the main road along the park and the solar park itself there is a 20 meters meadow. At two other sides the existing bush and tree row has been enlarged. At the west side a large meadow is located between the solar park and a walking path.

Currently the main landscape users are a fewlocal residents and tourist using the regional bike path that runs along the park. A third group are people driving by on the main road north-west of the park, however from here the park is not visible.

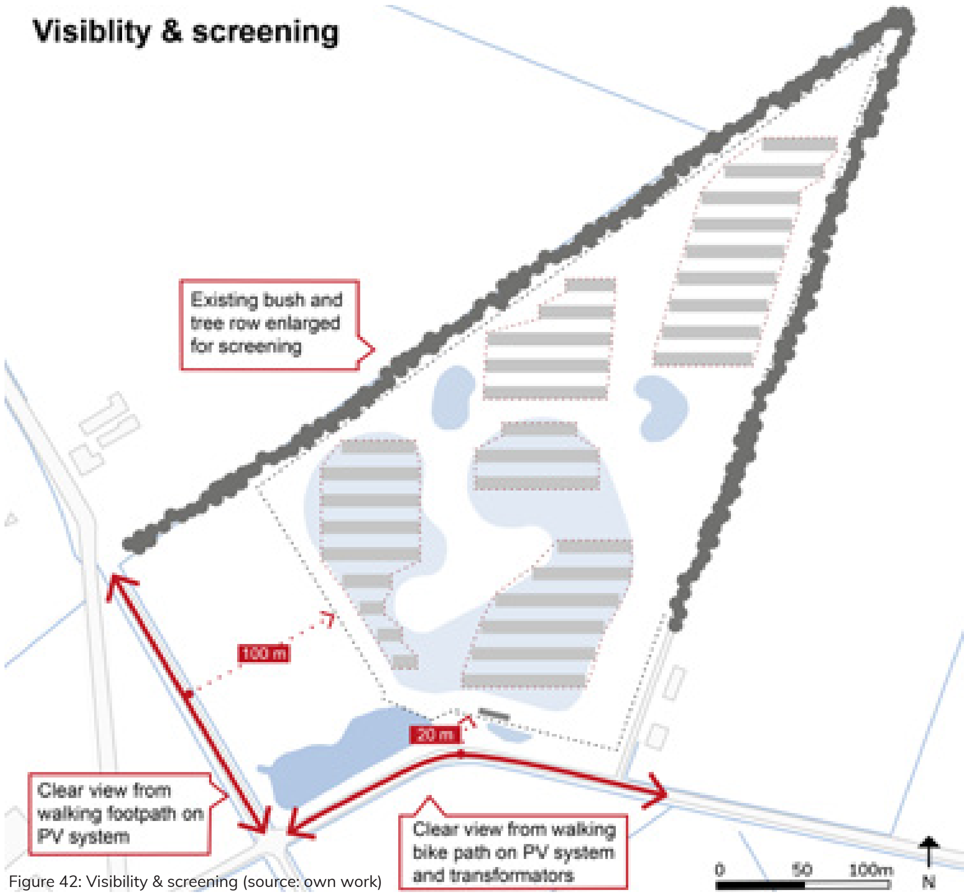


Figure 42: Visibility & screening (source: own work)


Figure 43: Wildgrass meadow (source: own picture)


Figure 44: Field between walking path and PV park (source: own picture)

Transition landscape

The solar energy park is located within the typical chamber landscape of the east of the Netherlands. These chambers are formed by bush and tree rows. At the northern and eastern edge such a bush and tree row were already existing and was enlarged when the park was created. At the west side a large field is located between the park and the next tree and bush row. Only from the south side the PV panels are well visible.
Here a distance has been kept in the form of fields between the solar park and the bike path.

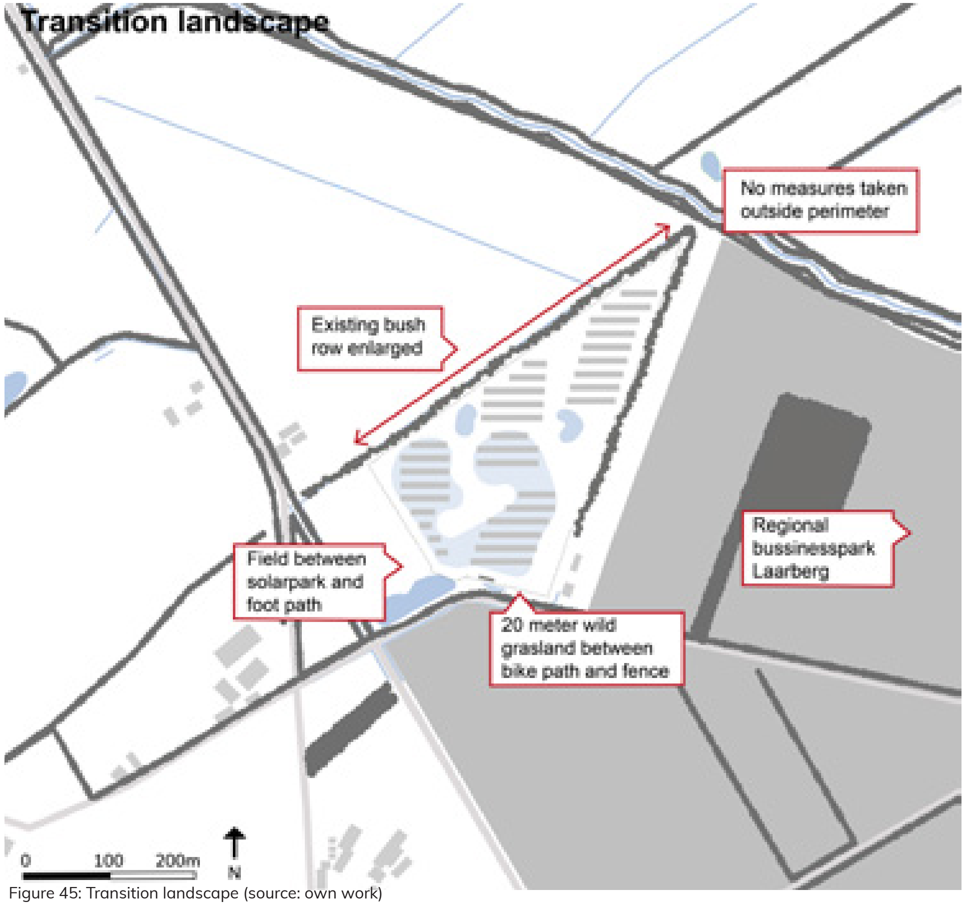


Figure 45: Transition landscape (source: own work)


Figure 46: Wildflower meadow (source: own picture)


Figure 47: Bush and tree rows (source: own picture)

Multifunctionality

The solar energy park combines the production of renewable energy with water retention and infiltration, biodiversity and recreation.

The water retention area should help to mitigate the extra water run-off of the business park. Here rainwater can be stored, before infiltrating or flowing further into the water system.

The solar park functions as a mitigation area for loss of foraging area for sparrows and little owls. Existing trees are as much as possible kept and fruit trees are added, to create an optimal habitat for the little owl. Furthermore, three ponds were created, the bush row has been enlarged and fruit trees have been added to the solar park. Also, sheep are grazing in the solar park where a wildflower and herb mix has been sown.

The park is located along a regional biking route. Between the fence of the park and this bike path 20 meters has been kept open. In this area a picknick table with an e-bike charging station is placed.

Figure 48: Multifunctionality (source: own work)


Figure 49: Elevated PV panels (source: own picture)


Figure 50: Elevated PV panels, bush and tree rows and pond (source: own picture)

Conclusion

The park is located within one of the chambers of the existing landscape and a meadow has been kept open between the park and the sides that are visible. This makes this solar energy park fitting within the landscape. Furthermore the park is a rather low density of PV panels and therefore leaves more room for other functions and appears to more attractive.

The basis for the solar energy park was an existing water retention and nature compensation area. The function of solar energy park was easily be stacked on these original functions.
Inspiring is the combination of a water infiltration area underneath the PV panels.
Also, biodiversity has been enhanced by for example adding fruit trees.

The patches of PV panels are located a bit further back in the park. However, the transformers and inverters are located at the entrance and 'frontside' of the park. Sitting on the picknick bench unfortunatly the view towards the solar energy park is dominated by the inverters and transformers.

Over all this solar energy park is a good example of a mixed function park. The density of PV panels is relatively low, and different functions can be found around, between and underneath the PV panels.

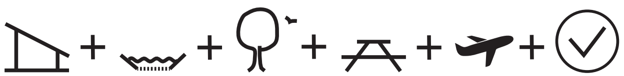
2.1.6 Conclusion

Introduction

In this chapter three different multifunctional solar energy parks were analysed to answer the question: How do other solar energy parks contribute to spatial quality? The answer is given in the different description and maps of the parks. However, to make the findings more generalisable, also design guidelines were formulated.

Functions

Within the three cases that have been studied the production of solar energy is being combined with water retention, biodiversity, recreation and an airport.



Water retention has two aspects: water storage and water infiltration. When designing for water storage or infiltration the whole water system needs to be considered: where does the water come from and where does it go to? For water storage the ground level needs to be lowered and the solar panels need to be elevated.

Biodiversity is a goal often combined with the production of solar energy. At solar park Laarberg specific species were aimed for. This helps to focus on a specific type of biodiversity. Different measures can be taken to enhanced biodiversity. Many solar parks incorporate a bush row around the solar park in the design. The value of this can be enhanced when local tree and bush species are used and mixed. Furthermore, a feature that is seen in several solar parks is the use of both fruit trees and wildflower meadows to support bees and other insects.

Recreational aspects are also taken into consideration both in solar park Laarberg as well as in Sinnegreide. Features that can be seen are fruit trees, picknick benches, places to park bikes and charging possibilities for E-bikes. Also, it becomes clear that recreational routes and networks need to be taken into consideration.

The combination with an airport has been analysed at solar park Eelde. Here it can be clearly seen that it is well possible to combine these functions. The panels in this case need to be non-reflective and a 30-meter distance from the airstrips must be kept.

Lastly, in order to achieve spatial quality it is not sufficient to add functions, also attention needs to be payed to the general landscape structures and identity of this landscape. This was done at solar park Laarberg and Sinnegreide by using suiting local edges of the park.

An overview of all the design guidelines can be found in the following tables. They are subdivided into three scale levels: patch, solar landscape and surrounding landscape.

Patch level

Category	What	Purpose	Where
Biodiversity	Wet nature	Habitat and foraging for amphibians. Wet vegetation.	Underneath and between PV panels
	Wildflower meadows / wild grasslands	Habitat and foraging insects for insects.	Underneath and between PV panels
	Elevate PV panels & cables	Water retention	Underneath PV panels
Water retention	Non-reflective PV panels	Not blinding airplanes	Near airstrip
Airport	Artificial hills	Reduce ground noise	Underneath PV panels
PV- energy	Lower PV panels	Decreasing visual impact solar energy park	Close to landscape user
	Higher PV panels	Producing more solar energy	Further from landscape user

Table 6: Design guidelines patch level (source: own work)

Solar landscape level

Category	What	Purpose	Where
Biodiversity	Ponds	Habitat and foraging for water animals, amphibians, insects and rare vegetation	Between patches
	Half wet reed land	Habitat and foraging amphibians. Some screening	Edge
	Fruit trees	Foraging for insects	Between patches or edge
	Wildflower meadows / wild grasslands	Habitat and foraging insects for insects.	Under or between patches or edge
	Bush and tree rows	Habitat, foraging and corridor for birds and small mammals. Screening	Edge.. Located so they do not shade PV panels
Water retention	Permeable water retention	Water retention and infiltration	Under and between patches
	Combine with wet-nature	Habitat and foraging for amphibians. Wet vegetation.	Under and between patches
Airport	Bush area	Habitat for fox, natural predator of geese	Between patches or edge
	No open wett nature	Potential habitat for geese	Between patches or edge
	Trees and bushes	Filter the air (species like vibernum & eleagnus)	Between patches or edge
Recreation	Information	Provide information about the park	Entrance of park
	Bikecharging, watertap and sitting	Provide facilities for visiters	Between patches or entrance
	Fruit trees	Oppertunity to pick fruits	Between patches or entrance
Landscape structures	Transition zones around patches	Increasing visual distrance to landscape user	Edge

Table 7: Design guidelines park level (source: own work)

Surrounding landscape level

Category	What	Purpose	Where
Water retention	Inflow and overflow on xisting waternetwork	Effective and robust watersystem	-
	Local landscape structures	Such as bush rows, reed edges, fruit trees etc. Enhance identity of landscape	Transition zones
Landscape structures	Landscape with pragmatic or industrial character	Suiting the appearance of PV - energy	-

Table 8: Design guidelines landscape level (source: own work)

2.2 Current spatial quality of the Northwest Haarlemmermeer

2.2.1 Introduction

The Haarlemmermeer can be considered as one of the youngest parts of the Netherlands. This chapter gives an overview of the history of this former lake., which will help to understand its landscape structures as well as its spatial quality.

2.2.2 History

Less than 200 years ago the Haarlemmermeer was still the largest lake of the Netherlands. It was known as the 'waterwolf', because it ´ate´ the peat land around it and in this way became larger and larger.
In 1837, it was decided by Royal Decree to reclaim the lake. A ring canal was dug around the lake and steam water pumps were built (de Cruquius, de Lynden and de Leeghwater) next to it. In 1849 they started to pump dry the land. Finally in 1852 the lake fell dry.

Within the reclamation side a water system was dug with two main canals, going towards the pumping stations and crossing in Hoofddorp, which originally was called Kruisdorp (crossing village). Further south along the main canal the village Nieuw-Vennep was founded. All the canals and waterways were dug in a grid, laying the basis for the shape of the polder. Afterwards roads were laid out along the main canals, with trees on one side. The lay-out of the Haarlemmermeer, as the reclamation side was called, was sober and focused on agricultural production.

To protect the city of Amsterdam a defense work was built in a wide circle around the city: the Stelling van Amsterdam. Within the Haarlemmermeer the Geniedijk as well as fortresses were constructed together between 1888 and 1903. Outside this defense line there was an inundation area, which could be flooded in case of an enemy attack (Provincie Noord-Holland, 2018)

After having being almost only an agricultural area for 100 year, this stars to change after world war II. The villages and cities started to expand, and Schiphol was growing. Between 1945 and 2018 the city of Hoofddorp grew from 5.000 to 73.000 inhabitants (Provincie Noord-Holland, 2018).
Schiphol moved from the edge of the reclamation side to the west, in order to have more room. Later two airstrips were added: the Kaagbaan in 1968 and the Polderbaan in 2003.

Until 2012 the Northwest Haarlemmermeer was part of a national buffer zone and building was strongly restricted. After 2012 this the province took over this protection, however many new buildings and roads were added to the area the last two decades

2.2.4 Landscape structures

From the history of the area most landscape structures can be understood. To understand a reclamation three scales must be considered picture, frame and room. In which the picture is the lay-out of the reclamationside itself, the frame is the edge of the reclamationside, typically a ringcanal and dyke, and the room is the connection with its surroundings. In order to achieve spatial quality all three should function well (S. Slabbers, personal communication, 25 August 2019).

Picture

The basic historical lay-out of the Haarlemmermeer is a grid structure consisting of blocks of 2 x 3 km used for agriculture. The lines of this grid were formed by roads and smaller and larger canals. The main axes of this grid were the 2 main canals of the area, crossing in Hoofddorp and ending at a pumping station.
This grid has been criticised to exist out of too large fields and too narrow linear structures to function well and be attractive (Bijhouwer, 1971).On top if this original structure many new landscape structures have been added. The three dominant ones are: the north-south orientated airstrips of Schiphol, the flow-dominated forms of highways and the expansion of cities and villages.

Figure 51: Map 1840 (source: topotijdreis.nl)

Figure 53: Map 1875 (source: topotijdreis.nl)


Figure 55: Map 1950 (source: topotijdreis.nl)

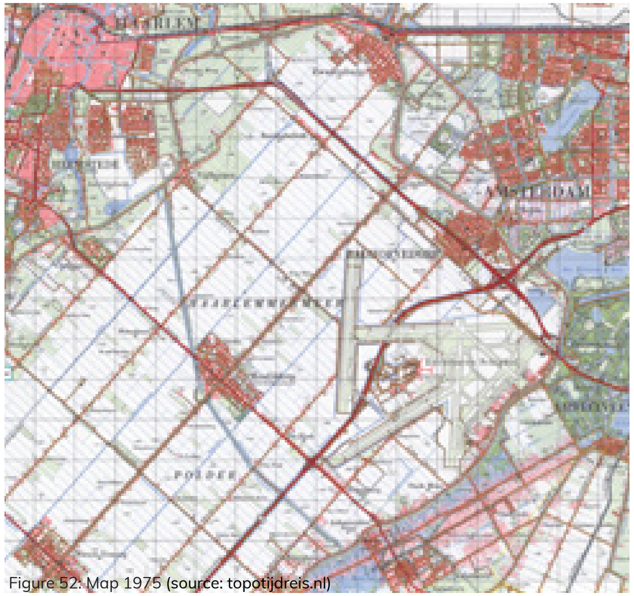


Figure 52: Map 1975 (source: topotijdreis.nl)

Figure 54: Map 2000 (source: topotijdreis.nl)

Figure 56: Map 2018 (source: topotijdreis.nl)

Frame
The frame of the Haarlemmermeer is the ring canal and ring dyke. This clear edge is well visible on satellite pictures, however walking or driving through the polder one will not notice that this dyke and canal is actually a linear structure surrounding the whole Haarlemmermeer and therefore connecting many locations.

Room
The identity and character of the Haarlemmermeer is not only defined by what happens within the boundaries of the reclamation side. Also the connection with its surroundings is important.
Visiting the Northwest Haarlemmermeer, one will notice this at once. At the horizon the high rises of Haarlem and Amsterdam, are well visible. Less visible are the nearness of important nature and recreation areas such as the Mooie Neel, the dunes behind Haarlem and the Amsterdamse bos.

2.2.5 Conclusion
The Northwest Haarlemmermeer is an area in transition. The former agricultural land is rapidly urbanising and different new functions find a place within the Haarlemmermeer.

2.2.4 General spatial quality
As was explained in chapter 1.4.2 spatial quality exists out of functional value, experience value and future value. These 3 values can be put into a table together with economic, social, ecological and cultural (Hooimeijer et al., 2001). This table helps to gather the broad range of aspects spatial quality is concerned with, even as some of these seem to go beyond the work of a landscape architect. In the table this scheme has been filled in for the Northwest Haarlemmermeer, providing an overview of the wide range its spatial quality consists of.

	Economic	Social	Ecological	Cultural
Functional value	-Airport -Large parcels -Logistic functions -Jobs -Diverse economy -Infrastructure	-Division old and new residents	-Large plots -Water ways -Tree lanes	-Reclamation side
Experience value	-International -Schiphol -Space -Green -Spacious living -Affordable housing	-Young well-off families -Self-reliance	-Agriculture	-Space -Optimism -Defense line Amsterdam
Future value	-Space	-Strong neighbour-hoods	-Agriculture and nature	-Heritage

Table 9: Spatial quality of Haarlemmermeer (based on Hooimeijer et al., 2001)


Figure 57: Picture - Cruquis pumping station (source: own picture)


Figure 59: Picture - Grid and fields (source: own picture)


Figure 61: Picture - Main canal and pumping station Lynden (source: own picture)


Figure 58: Picture - highway crossing the grid (source: own picture)


Figure 60: Frame - ring dyke and ring canal (source: own picture)


Figure 62: Room - view on Haarlem (source: own picture)

Figure 63: Landscape structures (source: own work)

The original landscape can be understood as a grid structure with large agricultural fields. However expanding cities, airport and highways have added new patterns to the landscape. In order to enhance the spatial quality of the area 3 scale levels need to be considered: the room, the frame and the picture.
Three conclusion that can be drawn from this chapter are:

- Enhance picture by strengthening the grid. Both the patches and lines.

- Enhance the frame, by making it readable and useable.

- Enhance the room, better connections with qualities around the area.

To be able to design a solar energy landscape for the Northwest Haarlemmermeer specific design guidelines were formulated. These design guidelines were divided within the categories: biodiversity, recreation and landscape structure. These design guidelines are based upon the analysis of the reclamationside in terms of picture, frame and room.

Surrounding landscape level

Category	What	Purpose	Where
Biodiversity	Connection with surrounding nature areas	Increase robustness nature networks. Increase biodiversity	-
	Tree lanes	Corridor for birds and small mammals	At lines of grid
Recreation	Bike routes connecting recreational destinations	Attractive bike network for recreation	-
Landscape structures	Park exists out of one or more polder blocks	Enhance readibility of landscape	-
	Patches within original landscape pattern / fields	Enhance readibility of landscape	-
	Improve functioning and appearance of lines	Enhance readibility of landscape	Lines
	Ring dyke visible & accessible	Enhance readibility of landscape	Ring dyke

Table 10: Design guidelines (source: own work)

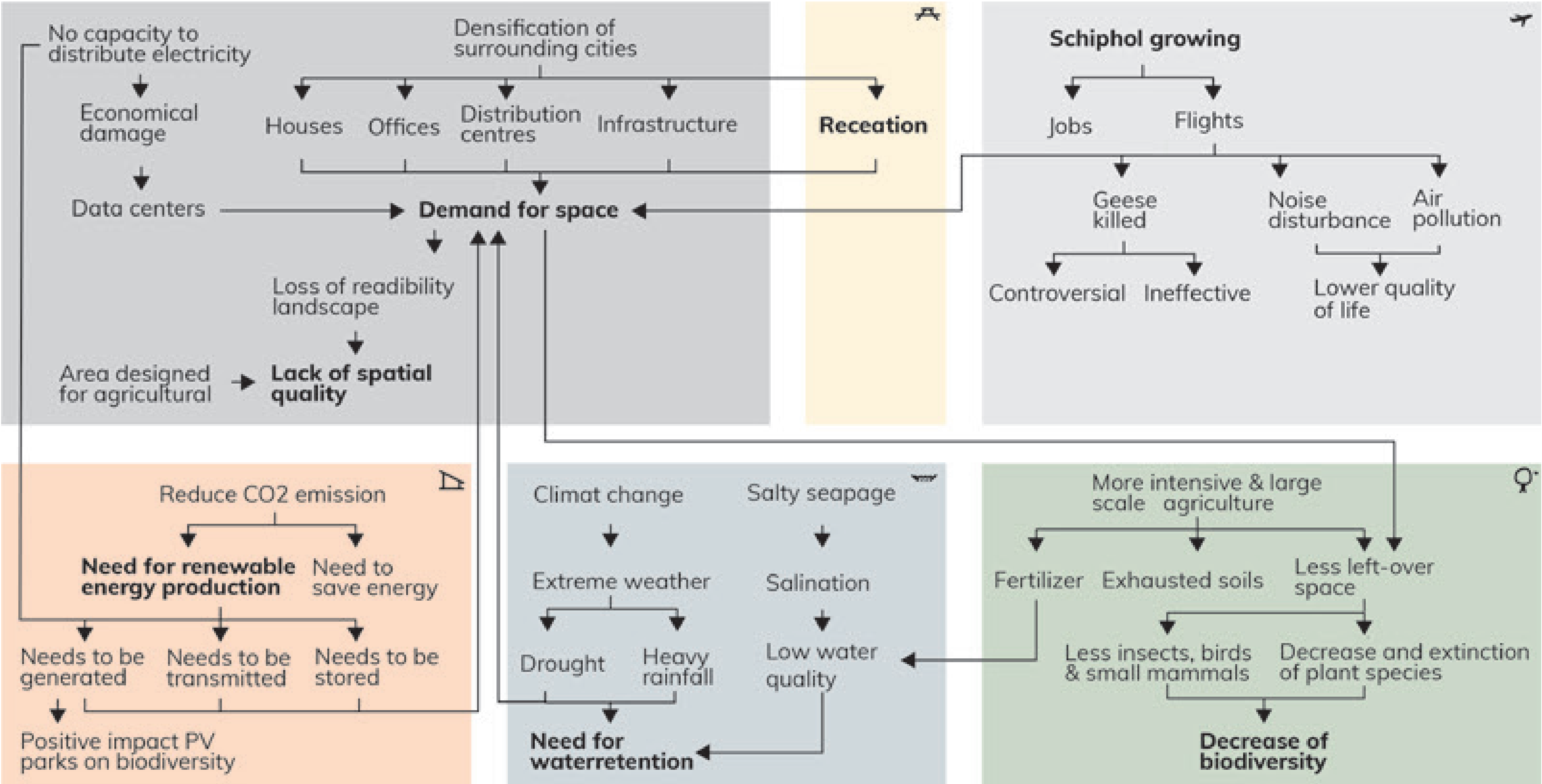


Figure 64: Problem tree (source: own work)

2.3 Current spatial challenges of the Northwest Haarlemmermeer

2.3.1 Introduction
The Haarlemmermeer is a dynamic region within the metropole of Amsterdam. This former agricultural area is rapidly transforming into one of the main ports of Europe, but this is only one of the many spatial challenges this region is facing. In order to create a clear overview of the spatial challenges, their causes, effects and relations, a problem tree is used. Besides that, the spatial challenges are described. Potential measures for these challenges related to solar landscapes are briefly discussed. In this way the problems are translated into design guidelines.

2.3.2 Lack of spatial quality
Already in 1971 J.T.P. Bijhouwer commented on the Haarlemmermeer that the area was poorly designed. He stated that enormous agricultural plots were connected by narrow streets with single lines of popular trees. The structures of the polder were fragile (Bijhouwer, 1971). Ever since, these problems has never been adequately addressed. The current Provincial Advisor on Spatial Quality, states that the Haarlemmermeer drastically lacks spatial quality. This is due to the existing fragile structures of the polder and it is becoming worse due to the enormous demand on space in this area (S. Slabbers, personal communication, 25 August 2019). Although these two experts mainly focus on the experience value, this also entails the functional value and to a larger extent the future value.
In 2030, 1 million extra homes need to be built in the Netherlands, and a significant part of this will be done within the metropolitan region of Amsterdam. This means that the metropole will become denser. However, other metropolitan functions such as offices, distribution centres, data centres, highways, Schiphol Airport, golf courts and holiday resorts increasingly need space. This most likely results in a decrease of the spatial quality. However, when addressed adequately these needs can also be used to turn the now rather lifeless Northwest Haarlemmermeer into when of the most qualitative regions of the metropole.

2.3.3 Recreation
When the cities are becoming denser, the residents of these cities need to have good opportunities to enjoy the green areas around the cities. Between the expanding cities of Haarlem, Hoofddorp and Amsterdam, from its location the Northwest Haarlemmermeer potentially could be such a location. However, currently the recreational value is very low. It has both poor recreational connections as destinations.
To make the increase the recreational potential of this location both these connections and destinations need to be improved. Routes to and through the area needs to be improved or created for cycling, walking, canoeing and mountainbiking. Also destinations such as restaurant, viewing platform and pavilions could be created.

2.3.4 Schiphol growing
Everywhere you in the Northwest Haarlemmermeer one sees and hears the airplanes. Schiphol is one of the largest airports of Europe and provides many jobs for this region. The airport was once located far from the city; however, the airplanes became larger, the airport got bigger and the city grew nearer. This is causing many challenges such as noise disturbance and air pollution, decreasing the quality of life in this region. Although many possibilities are being discussed to reduce these problems, no big changes are to be expected soon.
Some promising potential measures to cope with these challenges are: hills that can help to reduce the ground noise. This already has been implemented in park Buitenschot. A second measure that can be taken is to plant more trees and bushes.
Another significant spatial challenge for the airport are geese, flying around the airport, they often create dangerous situations for pilots and airplanes, while at the other side many animals get injured or killed by airplanes. In order to prevent this, currently over 1000 geese are

being killed every year by hunters. However, this is becoming increasingly controversial. At the same moment it is becoming clear that the effectiveness is limited. To cope with this challenge the regional government and animal rights organisation suggest to make the area around Schiphol less attractive for geese, by changing the function of the agricultural fields around the airport. Furthermore bush areas could be created, serving as a habitat for foxes, the natural predator of geese. Lastly no open wet nature areas should be created, as this would attract geese.

2.3.5 Need for renewable energy production
In order for the metropolitan region of Amsterdam to become energy neutral a lot of renewable energy needs to be produced. This energy needs to be generated, transmitted and stored.

2.3.6 Need for water retention
The whole Haarlemmermeer faces two main challenges regarding water: salinization, lack of surface water / water retention (Van Paridon & De Groot, 2012). To deal with the salination, caused by seepage, the Haarlemmermeer is constantly being flushed through with sweet water. More water storage is needed to keep up the water quality. Also due to an increasingly 'extreme' climate, more water retention is needed in order to prevent droughts.

2.3.7 Decrease of biodiversity
Already for the last decennia a decrease of biodiversity in rural areas has been going on because of intensifying agriculture. However, in the last years, the Northwest Haarlemmermeer has been segregated in many parts due to new highways and airstrips. This caused both a loss of habitats as well as connections for animals.
Especially in regions which currently have a low nature value and intensive agriculture has exhausted the soil, a positive impact can be expected from ecological designed and maintained solar energy parks. This could add living environment for birds and increase soil quality (Klaassen et al., 2018 p. 3)
This emphasizes the potential a solar energy park can have for the biodiversity of the exhausted intensive agriculture lands of the Northwest Haarlemmermeer.

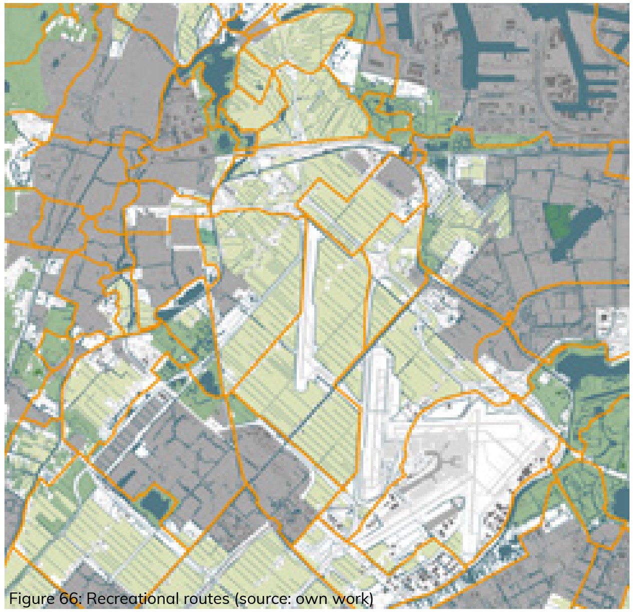


Figure 66: Recreational routes (source: own work)

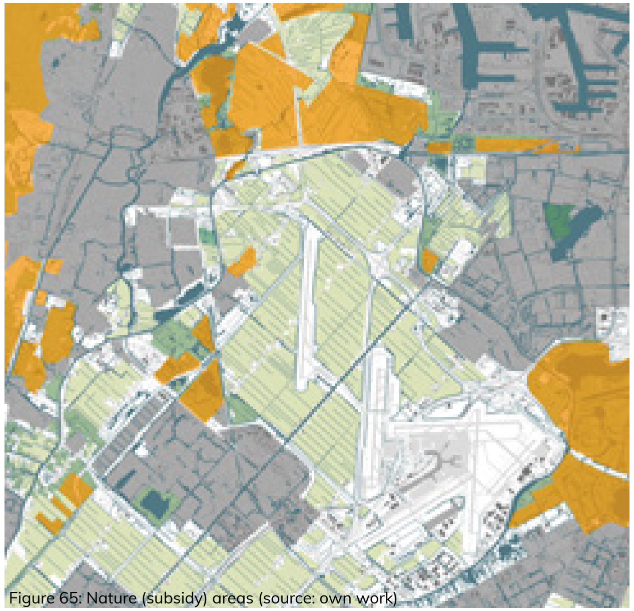


Figure 65: Nature (subsidy) areas (source: own work)

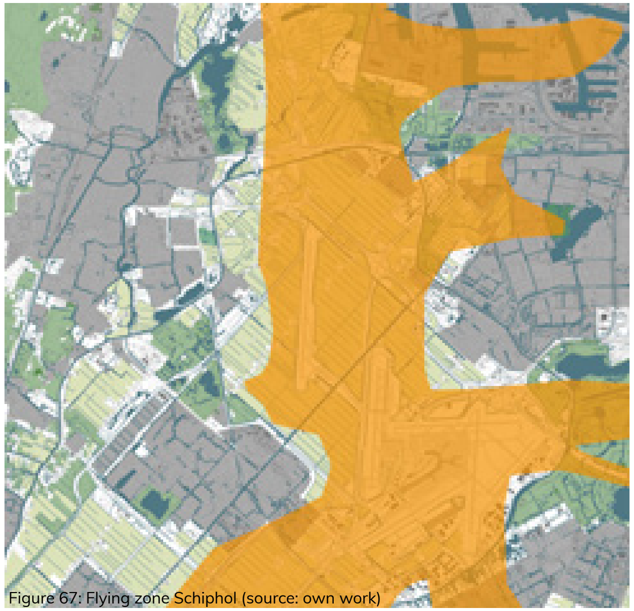


Figure 67: Flying zone Schiphol (source: own work)


Figure 68: Lack of spatial quality (source: own picture)


Figure 70: Poor recreational connections (source: own picture)


Figure 72: Polderbaan Schiphol (source: own picture)


Figure 69: Renewable energy sources (source: own picture)


Figure 71: Main canal, need for water retention (source: own picture)


Figure 73: Decrease of biodiversity (source: own picture)

2.3.5 Conclusion

The dynamic region of the Haarlemmermeer is facing many challenges, due to urbanisation, climate change and an enormous need for space for a variety of functions. The main challenges that should be regarded in the spatial design of the Haarlemmermeer are:

- General spatial quality
- Recreational routes and destinations
- Quality of life for residents
- Geese
- Implement renewable energy
- Water retention
- Opportunities for biodiversity

To answer these challenges also potential solutions have been mentioned. In the table more elaborated design guidelines are formulated to answer the spatial challenges of the Northwest Haarlemmermeer.

Solar landscape level

Category	What	Purpose	Where
Airport	Bush area	Habitat for fox, natural predator of geese	Between patches or edge
	No open wett nature	Would attract geese	Between patches or edge
	Trees and bushes	Filter the air (species like vibernum & eleagnus)	Between patches or edge
Recreation	Restaurant	Provide needed facilities and attract people	Entrance of park
	Viewing platform	Attracting people, viewing, landmark	Between patches or edge
	Information	Provide information about the park	Entrance of park
	Bikecharging, watertap and sitting	Provide facilities for visiters	Between patches or entrance
	Fruit trees	Oppertunity to pick fruits	Between patches or entrance
	Mountain bike routes	Oppertunity to use elevation in the park	Between patches or edge
	Canoe routes	Oppertunity to use water in the park	Between patches or edge

Table 11: Design guidelines (source: own work)

2.4 Conclusion

The question: How can solar energy landscapes be used as a tool to improve spatial quality? was answered by answering three subquestions. The first subquestion helped to gain a better understanding about multifunctional solar energy parks, the second and third question helped to understand the Northwest Haarlemmermeer and its spatial challenges.

In order for solar energy landscapes to improve spatial quality they need to be multifunctional. Six categories of relevant functions for a potential multifunctional solar energy landscape in the Haarlemmermeer were found: biodiversity, water retention, airport, recreation, PV-energy, and landscape structures.
Multifunctionality takes place on three different scale levels: patch, solar landscape and surrounding landscape. The patch consists of a few PV panels and its immediate surroundings. The solar landscape is the area of PV panels and its edges. The surrounding landscape is the solar landscape and its surroundings. To improve the spatial quality, measures on all three of these scale levels must be taken. The three scale levels can be seen in the figures.

In the following tables design guidelines can be found for all categories and scale levels. The design guidelines together form the input for answering the design question.

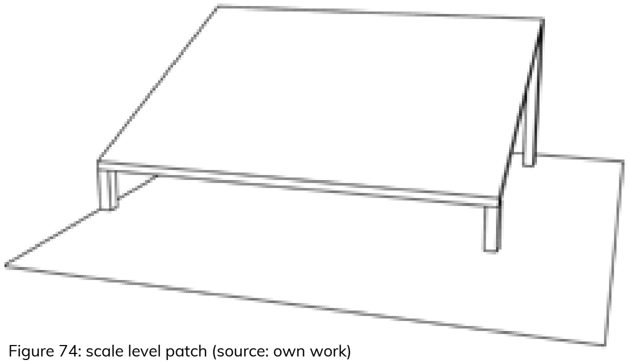


Figure 74: scale level patch (source: own work)

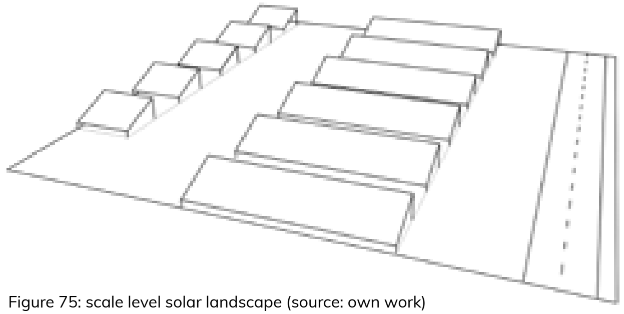


Figure 75: scale level solar landscape (source: own work)

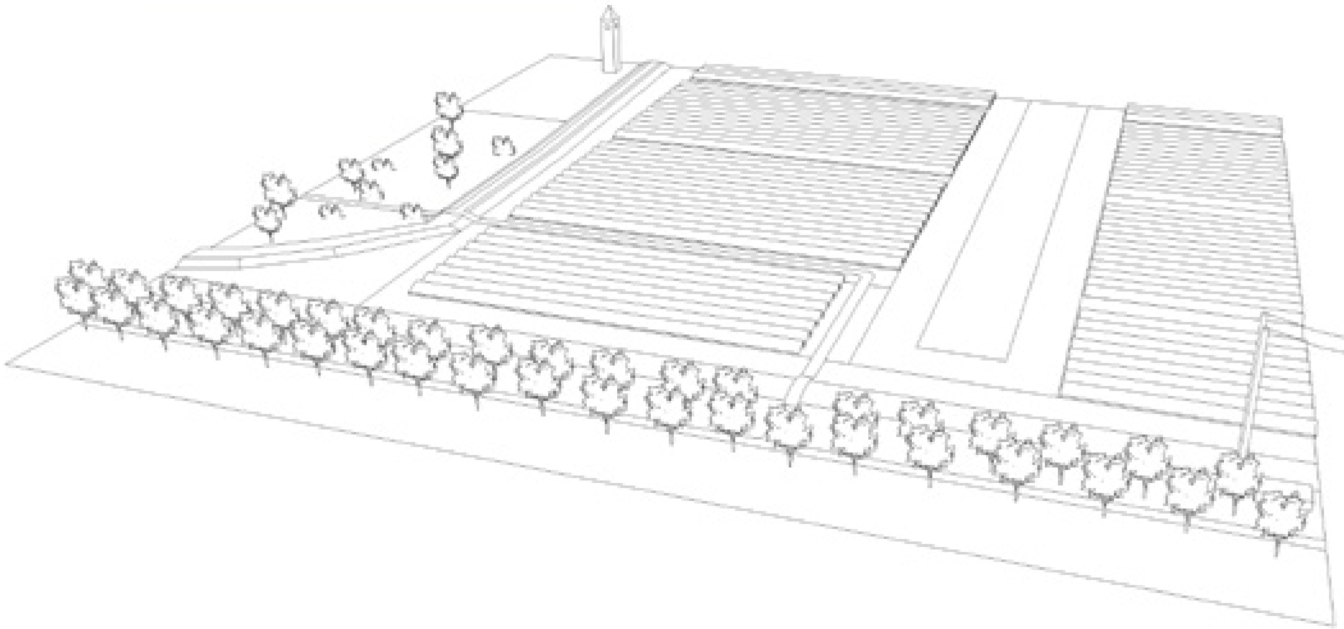


Figure 76: scale level surrounding landscape (source: own work)

Patch

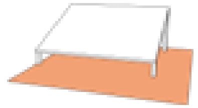
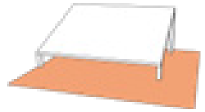
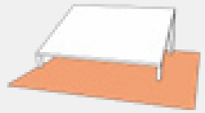
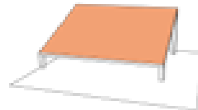
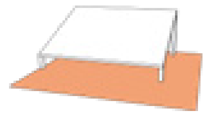
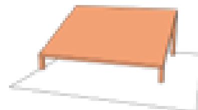
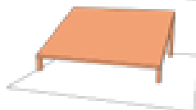
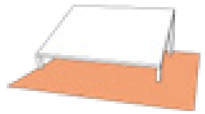
Category	What	Purpose	Where	Location
Biodiversity	Wet nature	Habitat and foraging for amphibians. Wet vegetation.	Underneath and between PV panels	
	Wildflower meadows / wild grasslands	Habitat and foraging insects for insects.	Underneath and between PV panels	
Water retention	Elevate PV panels & cables	Water retention	Underneath PV panels	
Airport	Non-reflective PV panels	Not blinding airplanes	Near airstrip	
	Artificial hills	Reduce ground noise	Underneath PV panels	
Recreation				
PV- energy	Lower PV panels	Decreasing visual impact solar energy park	Close to landscape user	
	Higher PV panels	Producing more solar energy	Further from landscape user	
	Transformers and inverters hidden	Attractive appearance of park	Underneath and between PV panels	
Landscape structures				

Table 12: Design guidelines patch (source: own work)

Solar landscape

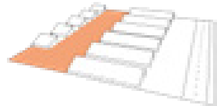
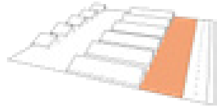
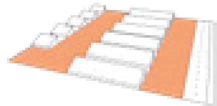
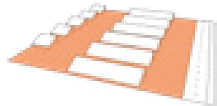
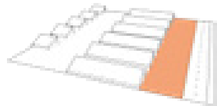
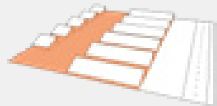
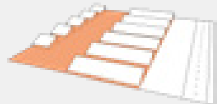
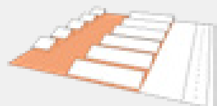
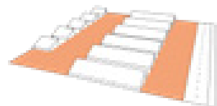
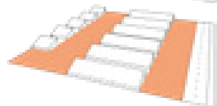
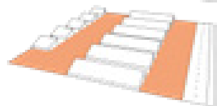
Category	What	Purpose	Where	Location
Biodiversity	Ponds	Habitat and foraging for water animals, amphibians, insects and rare vegetation	Between patches	
	Half wet reed land	Habitat and foraging amphibians. Screening	Edge	
	Fruit trees	Foraging for insects	Between patches or edge	
	Wildflower meadows / wild grasslands area	Habitat and foraging insects for insects.	Under or between patches or edge	
	Bush and tree rows	Habitat, foraging and corridor for birds and small mammals. Screening	Edge. Located so they do not shade PV panels	
Water retention	Permeable water retention	Water retention and infiltration	Under and between patches	
	Non-permeable water retention	Water buffer	Under and between patches	
	Combine with wet nature	Habitat and foraging for amphibians. Wet vegetation.	Under and between patches	
Airport	Bush area	Habitat for fox, natural predator of geese	Between patches or edge	
	No open wet nature	Would attract geese	Between patches or edge	
	Trees and bushes	Filter the air (species like vibernum & eleagnus)	Between patches or edge	

Table 13: Design guidelines solar landscape (source: own work)

Solar landscape

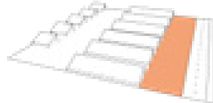
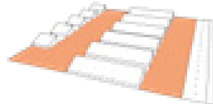
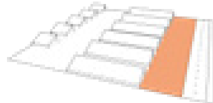
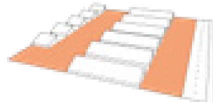
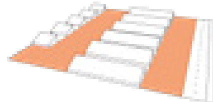
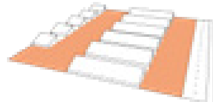
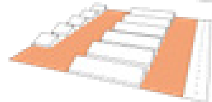
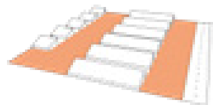
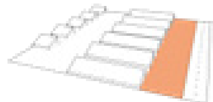
Category	What	Purpose	Where	Location
Recreation	Restaurant	Provide needed facilities and attract people	Entrance of park	
	Viewing platform	Attracting people, viewing, landmark	Between patches or edge	
	Information	Provide information about the park	Entrance of park	
	Bikecharging, watertap and sitting	Provide facilities for visiters	Between patches or entrance	
	Fruit trees	Oppertunity to pick fruits	Between patches or entrance	
	Mountain bike routes	Oppertunity to use elevation in the park	Between patches or edge	
	Canoe routes	Oppertunity to use water in the park	Between patches or edge	
	Pavilion	Attracting people, viewing, landmark	Between patches or edge	
PV- energy				
Landscape structures	Transition zones around patches	Increasing visual distrance to landscape user	Edge	

Table 14: Design guidelines solar landscape (source: own work)

Surrounding landscape

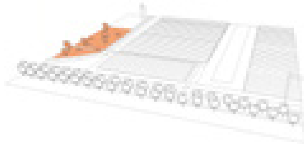
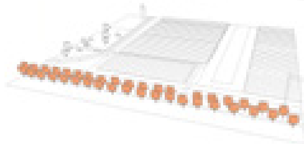
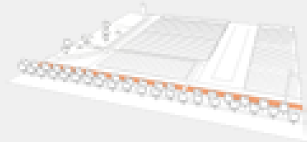
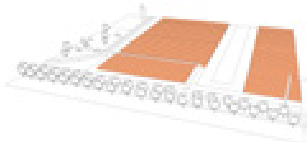
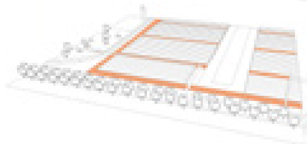
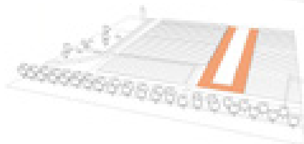
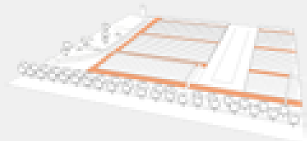
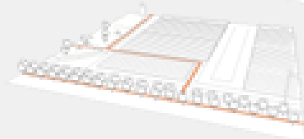
Category	What	Purpose	Where	Location
Biodiversity	Connection with surrounding nature areas	Increase robustness nature networks. Increase biodiversity	-	
	Tree lanes	Nature corridor for birds and small mammals	Lines of grid	
Water retention	Inflow and overflow on existing waternetwork	Effective and robust watersystem	-	
Airport	Agricultural fields out of production	Not attracting geese	Near airstrip	
	Iconic solar landscape	Recognisable landscape from the air	-	
	30 meters around airstrips kept open	Safety zone	-	
Recreation	PV park accessible	Using park for recreation	-	
	Bike routes connecting recreational destinations	Attractive bike network for recreation	-	

Table 15: Design guidelines surrounding landscape (source: own work)

Surrounding landscape

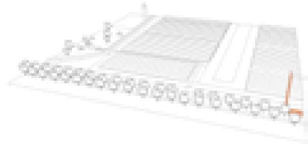
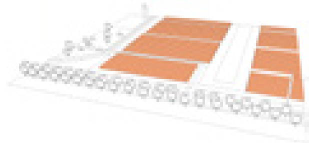
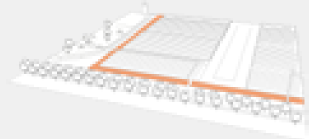
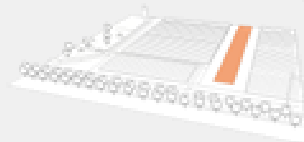
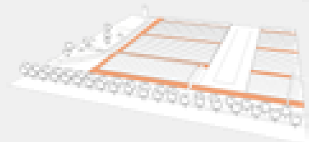
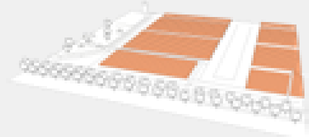
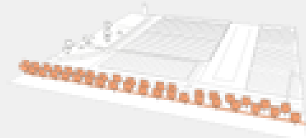
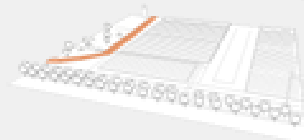
Category	What	Purpose	Where	Location
PV- energy	Located close to electricity station	Connecting easily to existing network	-	
	Panels logical orientated within landscape pattern	Readibility landscape	-	
Landscape structures	Local landscape structures	Enhancing identity of landscape Such as bush rows, reed edges, fruit trees etc.	Transition zones	
	Landscape with pragmatic or industrial character	Suiting the appearance of PV - energy	-	
	Park exists out of one or more polder blocks	Enhancing readibility of landscape	-	
	Patches within original landscape pattern / fields	Enhancing readibility of landscape	-	
	Improve functioning and appearance of lines	Enhancing readibility of landscape	Lines of grid	
	Ring dyke visible & accessible	Enhancing readibility of landscape	Ring dyke	

Table 16: Design guidelines surrounding landscape (source: own work)


3
DESIGN

3.1 Introduction

Several functions that can be combined with the production of PV-solar energy, have been distinguished in the research on and for design process. Depending thereon, design guidelines have been formulated. This is the starting point of the research through designing process, which answers the question: how can an integral design for a multifunctional solar landscape have a large positive impact on the spatial quality of the Northwest Haarlemmermeer?

Based upon these design guidelines, three models for solar energy landscapes will be designed. Each model represents one of the three categories of multifunctional use of space: parallel, stacked and mixed. All three models are located within the same boundaries and have approximately the same amount of PV panels. They incorporate as much as possible suitable design guidelines.
The models will be tested by criteria and experts on functional, experience and future value. The models that is rated best will be the starting point for one integral design for a multifunctional solar landscape, which aims to improve the spatial quality of the Northwest Haarlemmermeer by addressing the different spatial challenges of this area.

The figure displays the systematic approach of the research through designing process and shows how the different parts build upon each other.

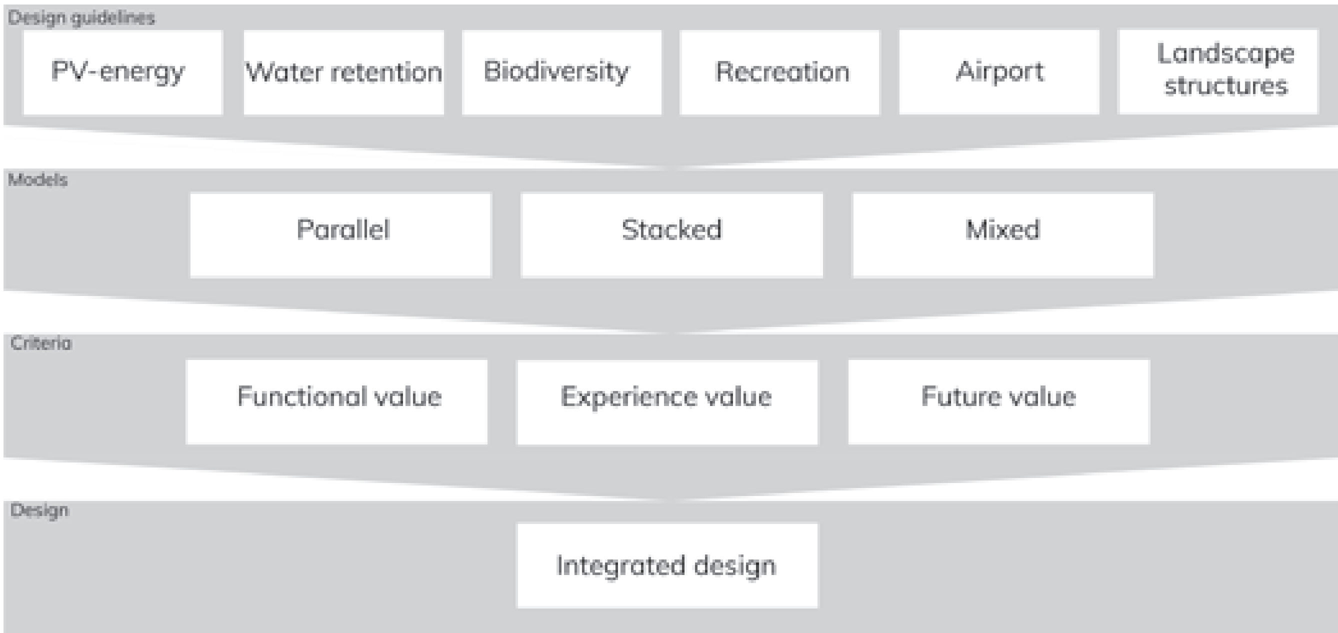


Figure 77: Research through designing process (source: own work)

3.2 Model study

3.2.1 Introduction

The goal of the model study is to answer the specific desgin question: which way of spatially organising different functions, in a solar energy landscape, with the production of PV-solar energy has the largest positive impact on spatial quality?

The three models are located within the same area of the Haarlemmermeer. This area is one of the blocks of the grid, with a size of 2 by 3 kilometres. The chosen block is positioned at the end of a powerline and borders on the village Vijfhuizen in the south. The challenges of a hardly accessible and unattractive area for recreation, lack of biodiversity and water retention, the noise and air pollution, as well as geese of Schiphol and the fragmented landscape structurescan all be found in this location.

Therefor this location holds all the potential to design a solar energy landscape that functions as a tool to improve the spatial quality.

The map on this page shows the location of the model area, within the larger context of the Northwest Haarlemmermeer. On the next page the area for the model study can be seen in more detail. On the left side of this map the applied guidelines in defining the location can be found.

Figure 78: indication of solar energy landscape and power line (source: own work)

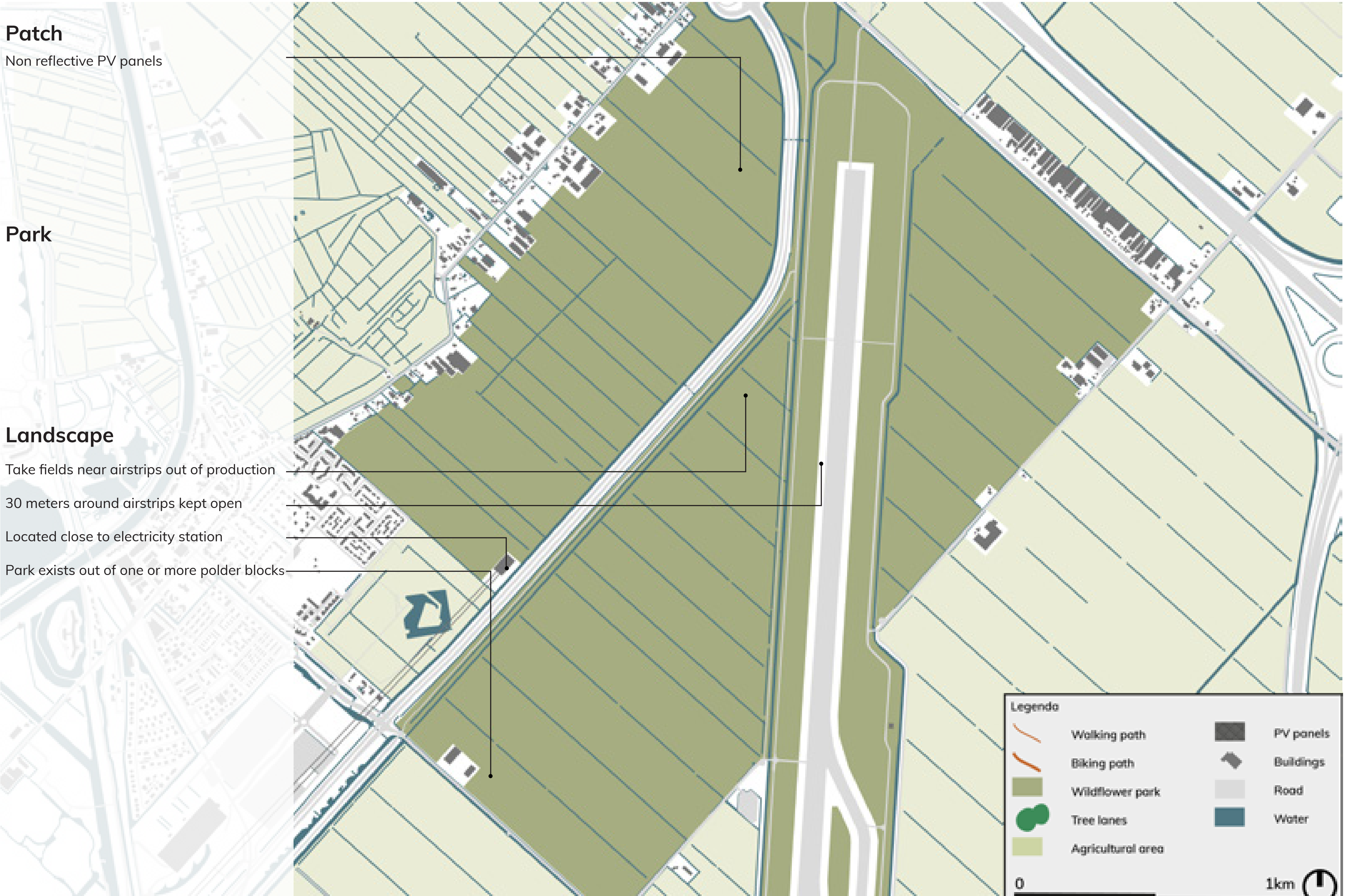


Figure 78: location of models and applied design principles (source: own work)

3.2.2 Parallel model

In the parallel model, the function of PV energy is located next to the other functions. In this model the grid of the Haarlemmermeer is emphasized by wide tree lanes with different species in the east-west orientated lanes than in the ones orientated north-south, creating a system of ‘streets and alleys’.
However most of the other functions are located between and along the large patches of PV panels in the form of linear park.

PV panels
The PV panels are orientated south with a minimal distance between the PV panels. The height of the panels is 3.5 meters above ground level and one row is 7.5 meters wide. The space between the panels is 3 meters. The design of the patches of PV panels is focused on the production of solar energy, all other functions are located around these patches.

Water retention
A 10-meter-wide canal is dug around the patches with PV panels, to store water. Due to the fact that an open wet nature / water retention area attract geese it is not possible to create a wet retention area next to the PV panels.

Biodiversity
In this model, habitats are created on the water edges, in the water, in flower meadows, in bush rows and within the tree lanes. A wide waterway is dug around the PV panels, with gentle slopes, to create opportunities for nature. Wildflower strips are created along the waterway’s. The whole park is bordered of with a wildflower strip and a bush row. This creates the optimal habitat for birds, bees and insects.

As mentioned before the grid of the polder is being emphasized with double tree lanes. These exist out of a variety of species and provide habitat for different kinds of birds, bats and insects.

Recreation
A wide range of recreational possibilities is created, for local residents, people working in the area, but also tourists. Within the park there are possbilities to sit, pick fruits or fill up a water bottle. The whole polder becomes a more attractive place to recreate, due to the attractive lanes where one can bike through. Within the linear parks between and around the patches of PV the broad waterways invite for canoe tour or a stroll through the wild flower meadows surrounding it.
Near the airstrips also a viewing platform is created, both as a landmark within the solar energy landscape, as well as a place for airplane spotters to go to.

Airport
Emphasizing the grid of the polder makes the Haarlemmermeer a recognisable landscape. Especially everybody who is flying to and from Schiphol will see straight away that this is a special landscape they have landed in.

Landscape structure
In-between the tree lanes the solar energy landscape is experienced as a rather open landscape. Here, in-between the PV panels only small trees and bushes are to be found. This emphasizes the grid of the polder, existing out of lines and open fields. The waterways surrounding the patches of PV remain within the rigidness of this grid.

Patch

Wildflower meadow between panels

Park

Ponds between patches

Wildflower meadow area

Fruit trees for picking and insects

Bush areas habitat for fox

Trees and bushes filtering air

Widened waterways

Information about the park at entrance

Canoe routes inside park

Restaurant at entrance of park

Bike charging, watertap & sitting

Viewing platform within park

Transition zones around PV patches

Landscape

Tree lanes emphasize lines of grid and are nature corridor

Iconic solar landscape from air

Bike routes linking recreational destination

Patches within orginal landscape pattern

Local landscape structures for transition

Improving functioning and appearance of lines

Ring dyke visible and accessible

Figure 79: parallel model and applied design guidelines (source: own work)

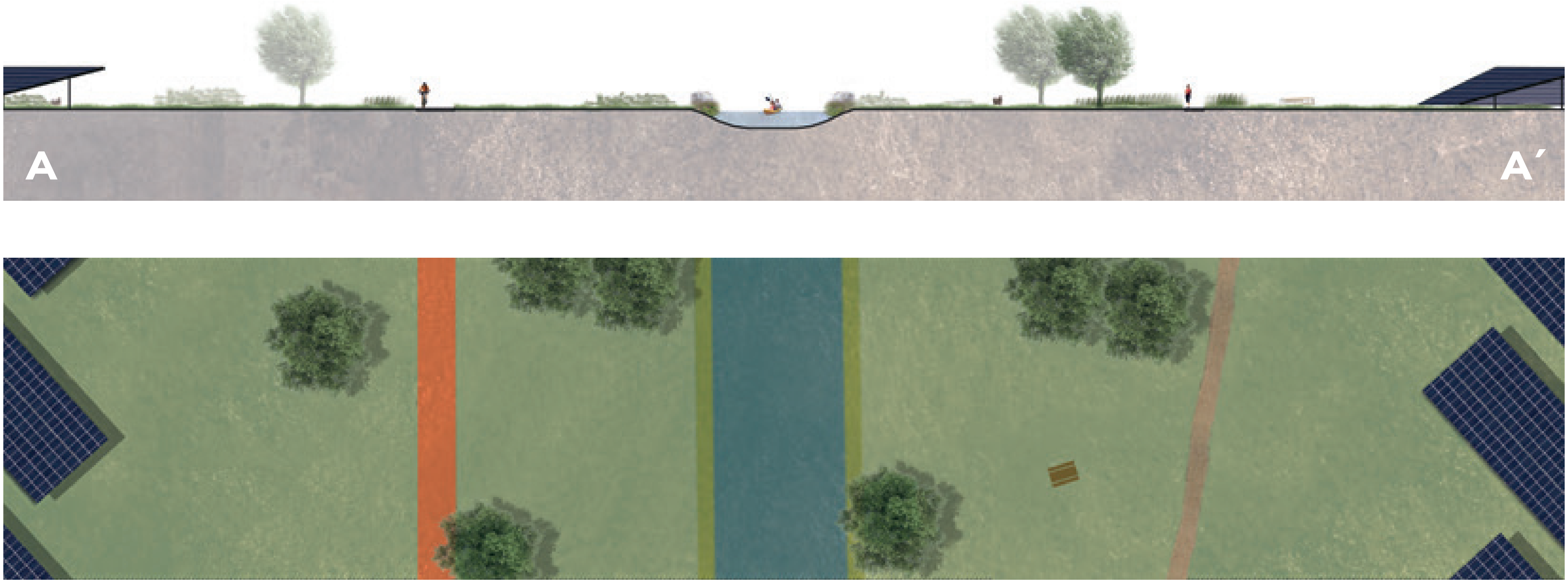


Figure 80: section parallel model (source: own work)

3.2.3 Stacked model

In the stacked model, the PV panels are located on top of other functions. In the area around the airstrips this function is artificial hills which help to reduce the ground noise of airplanes. For the areas where this is not relevant, the PV panels are located on top of a water retention and wet nature area. Due to the precondition that each model has the same amount of PV panels and the location remains the same, a choice was made to leave a part of the area 'unchanged' as a wide transition zone between the PV panels and the residential area.

PV energy

In the area where the PV panels are located on top of the hills to absorbe the ground noise, the panels are orientated south. This is the best orientation for the noise absorbtion. The height of the hills is 4 meters and they are 15 meters wide in total. The space between the panels is 7.5 meters, as this is the north side of each hill. As can be seen in the section.

At the water retention area, the PV panels are well visible and therefore orientated within the landscape pattern. In order to prevent the wet nature area from becoming a habitat for geese, the distances between the PV panels are kept minimal. Here the PV panels are elevated 1 meter from the ground level and are in total 4 meters high. One row is 7.5 meters wide and the distance between the panels is 3 meters.

Water retention

A large water retention area is located underneath the PV panels. Here the ground level needs to be lowered half a meter in order to store roughly 500m^3 water. The PV panels and cabels above the water retention area are 1 meter elevated.

Biodiversity

Three types of habitats are created. First the water retention area with reed edges around it creates an interesting habitat for different animals, as well as many types of vegetation. As said before, the PV panels are attached to the south side of the hills, the north side therefore, can be used to sow wildflower mix, which creates habitat for birds, bees and insects. Lastly, a few walking and biking paths cross the park with wildflower strips around them, which are also habitat for bees and insects.

Recreation

All the three models are reconnecting old lines of the grid which have been cut-off by roads or airstrips in the past by introducing bridges and tunnels. This creates many new recreational routes. Besides that this model also provides walking and biking paths. Including a mountain bike path through the hilly part of this solar energy landscape. Also a pavilion, in the form of a large noise absorbing hill, is located near the airstrip. From here the airplanes can be observed. The pavilion is shown in the section.

Airport

The hills reduce the ground noise, which is the most disturbing noise the airplanes make in this area. Already some of these hills hadve been implemented previously, however combining them with the production of solar energy makes it possible to upscale this intervention.

Furthermore the water retention area is covered with PV panels, which makes this area unattractive for geese.

Landscape structure

On top of the water retention area the PV panels are orientated within the landscape pattern. Also, the reed edge created around it fits into the identity of this open area field. Lastly the wide transition space between the PV panels and the houses decreases the impact for local residents.

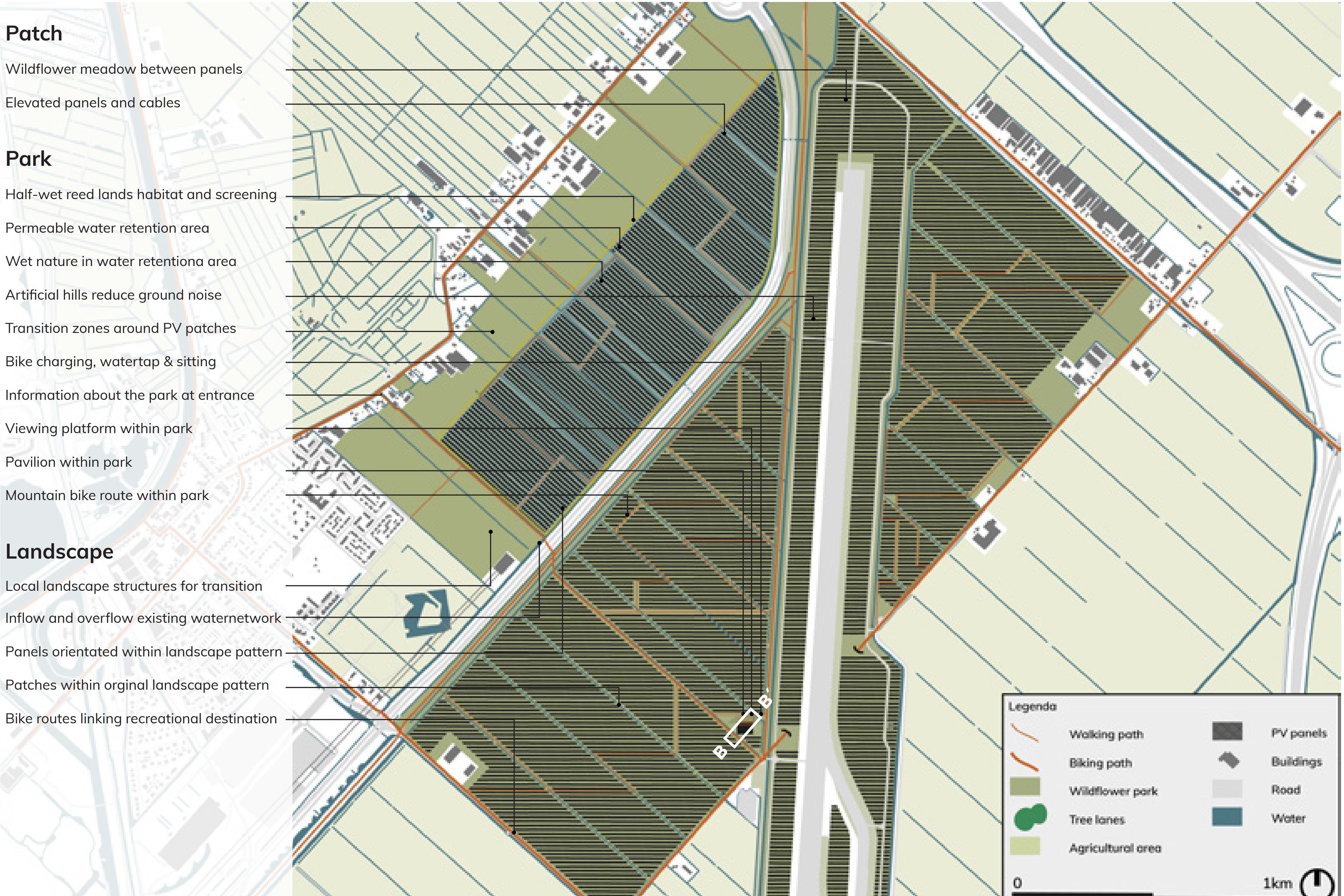


Figure 81: stacked model and applied design guidelines (source: own work)

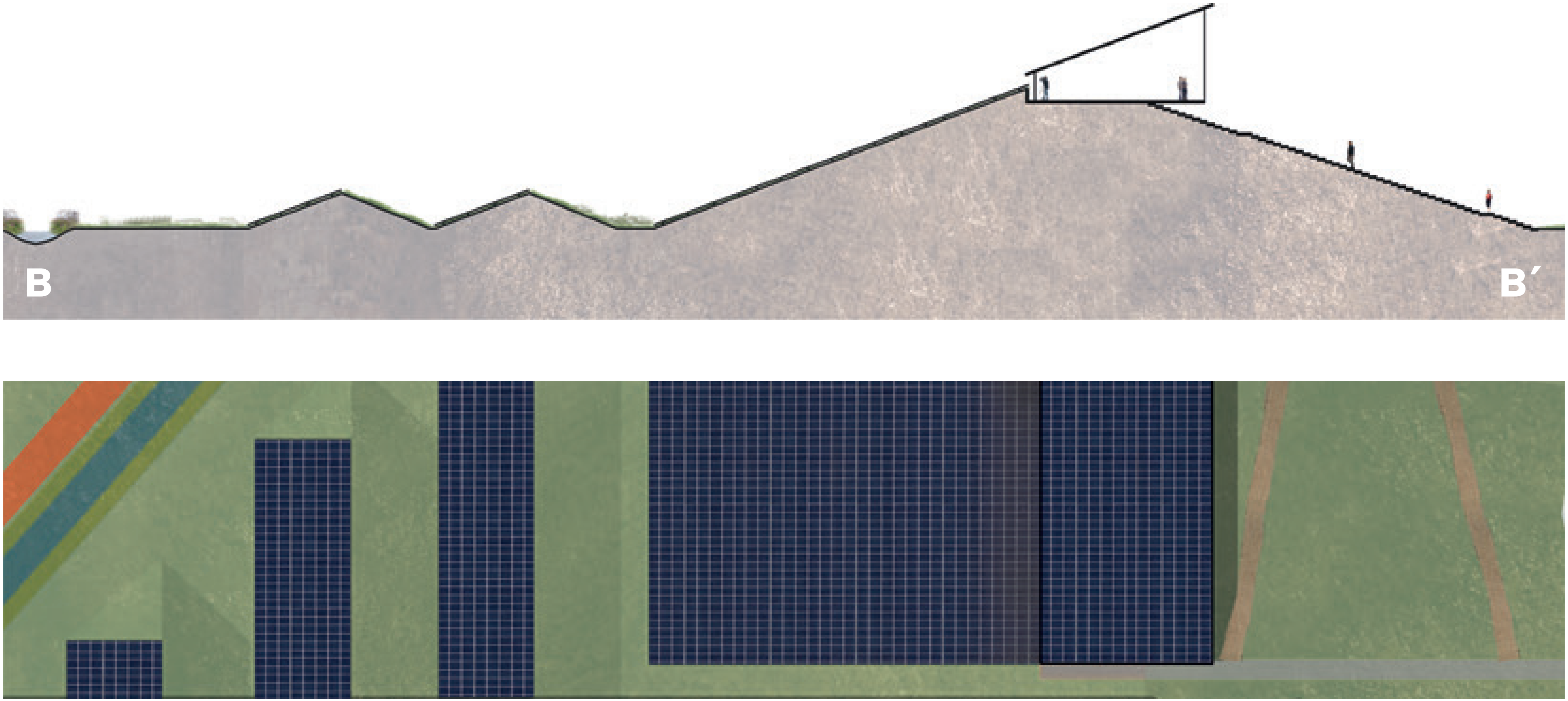


Figure 82: section stacked model (source: own work)

3.2.4 Mixed model

In the mixed model the patches of PV panels are smaller and are mixed with other functions. A design for a mixed model can be made in different ways. In order to stay close to the identity of this rational landscape a new grid was introduced. Within this grid several strips were kept open, functioning as hallways. These hallways are surrounded by bush and tree edges, creating rooms around the hallways. In these rooms the PV panels are located.
Within this lay-out a strip around the airstrips is again used for ground noise reduction in the form hills with PV panels on top. Furthermore, there are two water retention area underneath the PV panels and on ground patches of PV panels.

PV energy

Clusters of PV panels are spread through the park. The panels on top of the hills are orientated south. All the other patches of PV panels are orientated within the landscape pattern.
The space between the rows of PV panels is 7.5 meters in the patches on top of the hills, as well as some small patches west in the park. However most patches have a 3 meters between the rows. All PV panels are between 3.5 and 4 meters high and 7.5 meters wide.

Water retention

Two water retention areas are created within the PV park. Here the ground needs to be lowered half a meter. These water retention areas can store about 500 m^3 of water in total. The PV panels and cabels above the water retention area are 1 meter elevated.
Also the waterways around the PV park are widened.

Biodiversity

Around, between and even underneath the PV panels there is a lot of opportunity for nature. Different habitats that can be found are: bush- & tree rows, wildflower meadows and wet nature. The many bush- and tree rows create habitat for all sorts of birds and insects. as well as for small mammals such as foxes. The wildflower meadows provide habitat for bees and other insects, while the wet nature is habitat to several rare plants.

Recreation

The solar energy landscape offers numerous walking and bike routes. One can stay on the main lanes or explore the different rooms with PV panels. Also, all needed facilities are located within the area. One can find a restaurant, bike charging points and a bike rental. Furthermore there are oppertunities for sitting, watertaps and fruit trees to be picked from within the area.

Airport

The many tree and bush areas both provide habitat for foxes, the natural predator of geese, and also filter the air. Furthermore, the hills surrounding the airstrips reduce the ground noise, caused by airplanes starting and landing.

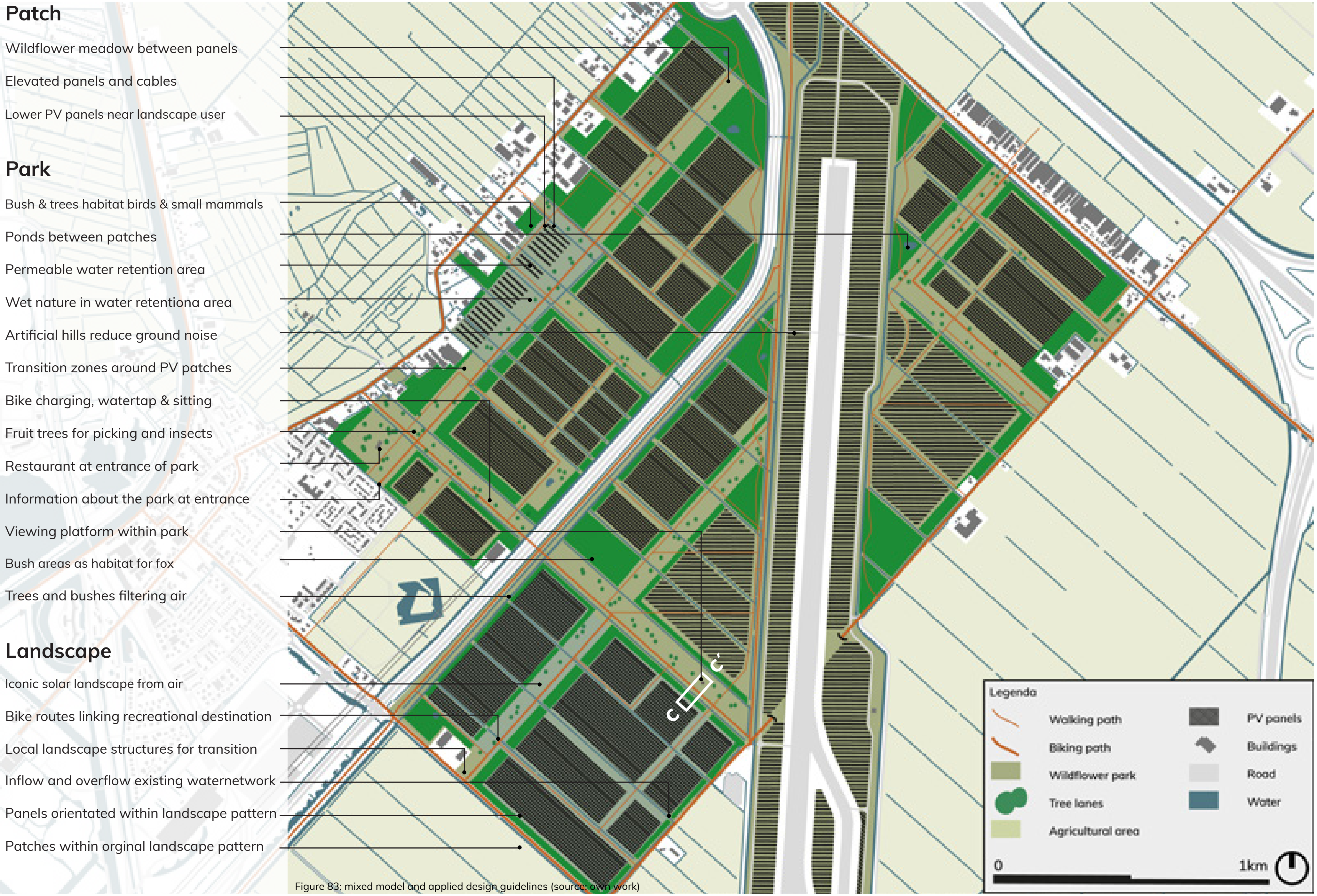


Figure 83: mixed model and applied design guidelines (source: own work)

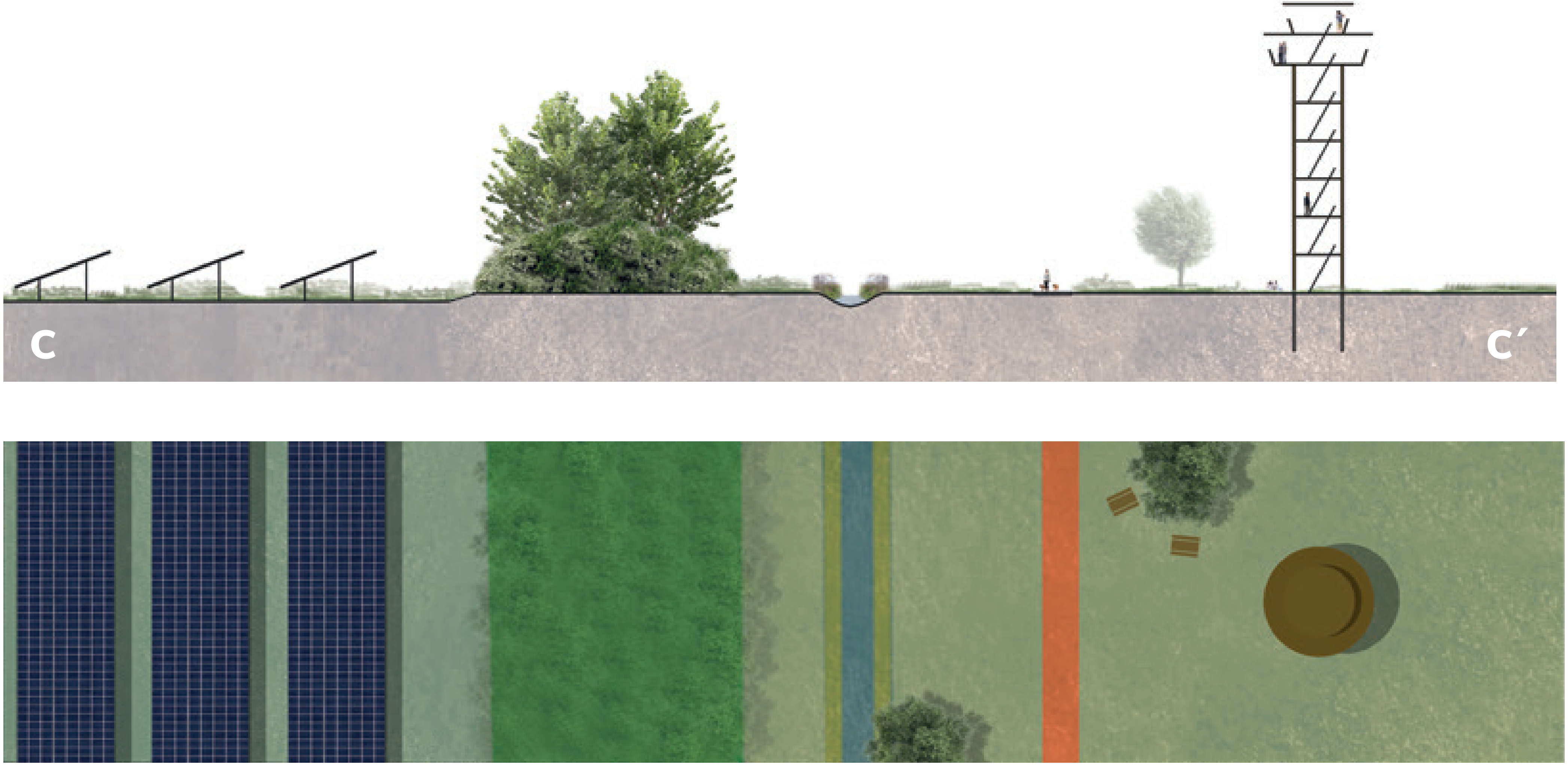


Figure 84: section mixed model (source: own work)

3.3 Criteria & evaluation

3.3.1 Introduction

The evaluation of the models will be done in two ways, to verify the outcome. First the models will be tested by criteria on functional, experience and future value. And secondly landscape architecture experts will judge them by the same three categories.

3.3.2 Comparison

All three models are located within the same area and have approximatly the same amount of PV panels. However the lay-out is very different, due to the different ways of organising the different functions. When a first comparison is being made it is clear that their is a significant difference in which design guidelines have been applied. This derives directly from the suitability of each of the organising principles to combine functions. The stacked model for example doesn't allow for bush and tree rows, as it is not realistic to stack these functions, where the parallel model doesn't allow for a water retention area, as this can not be created next to the PV panels. This has a direct effect on the spatial quality of the models. However a more indept evaluation of the models will be made by means of criteria and expert judgement.

3.3.2 Criteria

The three overarching criteria for the evaluation of spatial quality are functional, experience and future value. These three topics will functions as groups, within these groups specific criteria to evaluate the spatial quality of a solar energy landscape will be defined. The criteria for functional value derive from theory on ecosystem services and more specifically the CICES framework. The criteria for experience value are based upon literature on landscape aesthetics as well as literature on the aesthetical experience of solar energy parks. Lastly the criteria for future value are mainly based directly upon the literature on spatial quality.

Functional value

- human food production[1]
- livestock[1]
- solar power[1]
- regulating water flows[1]
- pollination[1]
-providing habitats for wild plants and animals[1]
- space sport and recreation[1]
- anti-goose measurements
- fragmentation[4]
- reduce noise airplanes

Experience value

- nature to destress[1]
- recognisability[2]
- complexity[3,4]
- openness[3,4]
- liveliness[3,4]
- degree of protection[3,4]
- minimal visual distance from carroad[3]
- minimal visual distance from bike/foodpath[3]
- Reduce noise airplanes

Future value

- flexibility[2]
- extensibility
- effective to maintain[2]

The models will be judged according to these criteria. For each specific criteria a model scores between -2 and 2, in which -2 is a negative impact on spatial quality and +2 is a postive impact on spatial quality. For the functional value this could work as follows:

-2 Available space schrinks between 50-100%
-1 Available space schrinks between 10-50%
0 Available space remains between -10-10%
1 Available space increases between 10-50%
2 Available space increases between 50-100%

Per group the average score is calculated. The average per groups is added up, showing which model scores best.

The criteria are based upon the following sources:

1. Tribot et al. 2018
2. Hooijmeijer et al. 2001
3. Del Carmen et al. 2009
4. Scognamiglio 2016

	Parallel	Stacked	Mixed
Functional value			
Human food production	- 2	- 2	- 2
Livestock	-1	-1	- 1
Solar power	2	2	2
Regulation of water flows	0	1	1
Pollination	0	0	0
Providing habitats for wild plants and animals	1	1	1
Space sport and recreation	1	0	1
Anti-goose measurements	0	1	1
Fragmentation	1	1	1
Experience value			
Nature to destress	1	0	1
Recognisability	2	0	1
Complexity	1	0	2
Openness	-2	-1	-2
Liveliness	1	-1	2
Degree of protection	2	1	2
Minimal visual distance from carroad	2	- 2	1
Minimal visual distance from bike/foodpath	- 1	- 2	- 2
Less noise of airplanes	0	2	1
Future value			
Flexibility	2	- 1	1
Extensibility	2	1	- 1
Effective to maintain	1	2	- 2
Total	0.22	0.33	**0.44**
Average functional	**0.67**	- 0.33	**0.67**
Average experience	**1.67**	0.67	- 0.67
Average future			
	2.56	**0.67**	**0.44**
Total			

Table 16: evaluation of models by criteria (source: own source)

Interpretation of evaluation

Firstly the scores per group will be discussed, before discussing the final judgement. In the rubric on functional value the mixed model scores best, this is because it incorperates more functions than the two other models.

In the category experience value the mixed model and the parallel model score the same result, however, for different reasons. The mixed model shows a higher complexity and liveliness, whereas the parallel model has more distance from landscape users.

Under the topic future value the parallel model scores highest. This is because for this model no soil needs to be moved or removed, as well as the linear parks form a green blue grid, in which the function of solar energy can easily change in something else.

All in all, the parallel model scores the highest. The score of the criteria will be compared to the scores of the experts in the follwing chapter.

3.3.3 Experts

Spatial quality has both objective and subjective parts.Therefore the evaluation of the models by criteria from literature alone is not sufficient. Experts need to judge the models as well, to see if what the criteria consider spatial quality is also considered spatial quality by experts.
Six graduation students of landscape architecture at Wageningen University, were invited to a meeting, where the models as well as the concept of spatial quality and the three basic criteria were explained. The following definitions for the criteria were given:
Functional value: usable, effective,
easy to create and maintain, accessible & consistent. Experience value: Identity, recognisable, diverse, meaningful. Future value: flexible, extensible, sustainable. (Hooijmeijer et al. 2001). Based on this the experts evaluated the models. The evaluation worked as follows: for each basic criteria they could score one model with 3 points (best), one with 2 points and one with 1 point (lowest). The outcome can be seen in the table.

	Parallel	Stacked	Mixed
Functional	15	15	7
Experience	11	10	15
Future	14	9	12
Total	40	34	34

Table 17: evaluation of models by experts (source: own work)

Although the different values are not far apart from each other, the parallel model also in this evaluation scores the highest.

3.3.4 Validity

To be able to compare the outcomes of both evaluations of the models, the outcomes are compared in the following table. The outcomes of the criteria are in black, the ones of the experts in orange.
To be able to compare the two evaluations, the outcomes are given in percentages. To not have to work with negative numbers all outcomes of the criteria are added by 1. The overview can be seen at the end of this column.
Comparing the two sets of outcomes the following things can be seen: at functional value the parallel and the stacked model score the best according to experts, however the outcome by the criteria is the opposite. This can be explained by the fact that the definition of functional value given to the expert is quite different from the ecosystem services used for the criteria.
At experience value the outcomes are more comparable, according to the criteria the parallel and the mixed model score the highest, according to the experts only the mixed model scores highest.
The experts mentioned that the future value was very difficult to define, as this concept remains difficult to grasp. However, in both tests the parallel model scores highest.

3.3.5 Evaluation

By testing the models in two different ways a good evaluation could be made. Looking at the total score the parallel model seems to be the best way of organising the different function within a solar energy landscape to achieve a large positive impact on spatial quality. However, the criteria make clear that this model can be improved when it considers certain aspects of the other models.
Therefore, the parallel model will be used as a basis for the integrated design for a multifunctional solar energy landscape, in which also parts of the other models will be used.

	Parallel		Stacked		Mixed	
Funct.	10%	14%	10%	14%	11%	7%
Exp.	13%	10%	5%	9%	13%	14%
Fut.	22%	13%	13%	8%	3%	11%
Total	45%	37%	28%	31%	27%	32%

Table 18: comparison evaluation, criteria black, experts in orange (source: own work)

Figure 85: Expert meeting (source: own picture)

3.4 Integral design for a multifunctional solar energy landscape

3.4.1 Introduction

It can be concluded from the model study that a parallel way of organising multiple functions within a solar energy landscape has the largest positive impact upon spatial quality.However by adding some of the aspects of the stacked or mixed model the positive impact on spatial quality can even be increased. These two findings, together with the design guidelines, form the starting point for answering the question: ´How can an integral design for a multifunctional solar energy landscape, with a capacity of 3Pj, in the Northwest Haarlemmermeer look like?´

The goal of this design question is to test the design guidelines as well as the outcomes of the first design question by making a design for a large solar energy landscape. The area of the solar energy landscape consist of 1500 hectares, where the production of solar energy is combined with water retention, nature, the airport, recreation and overarching landscape structures.

In the following the design will be described on three scales: the regional design of the whole Northwest Haarlemmermeer, the solar energy landscape design of the area where the PV panels are located and a detailed design of a part of this solar energy landscape.

3.4.2 Regional design

Introduction

The Northwest Haarlemmermeer is an agricultural area within the metropolitan region of Amsterdam. West from this part of the Haarlemmermeer the city of Haarlem is located. Haarlem has a recreation area called: 'the Mooie Nel' at the east side of the city and a large coastal nature area at the westside of the city. On the other side of the Haarlemmermeer is the city of Amsterdam. An important recreation and nature area for this city is the Amsterdam bos.
The clear outline of the Haarlemmermeer with its continuous ring canal is well recognisable from the satellite picture. However, from within the area the dyke and its canal are often a 'backside' and are not so recognisable or attractive.
Within the Haarlemmermeer the city of Hoofddorp is located. This city lays at the crossing of the two main canals of the reclamation area. These canals are straight lines between the historical pumping stations and form the basis of the grid in which the Haarlemmermeer originally has been laid out.

The model study was conducted within one of the blocks of this grid, the one connected to the village of Vijfhuizen. The solar energy landscape itself will consists of three of these blocks. In this way a solar energy park of 1500 hectares and potentially producing 3 Petajoule can be created.
The large scale of the solar energy landscape makes it possible to test to which extend the design guidelines, mainly derived from solar energy parks, can be applied to solar energy landscapes and what other things are maybe needed to design on this scale.

Design

The concept of a parallel designed solar energy landscape is that multiple functions are located next to each other. This can be done on the scale levels of the patch, park and landscape, as can be learned from the conclusion of the general research question. The regional design is mainly informed by the measures on a landscape level.

The solar energy landscape exists out of 3 blocks of the grid. This area is located around the two main airstrips of Schiphol and changes the function of the current agricultural fields. From north to south it is crossed by the main canal of the Haarlemmermeer, ending at the northside at the historical pumping station of Lynden. This main canal, with its wide tree lanes, will become one of the two main recreational axes of the park, connecting

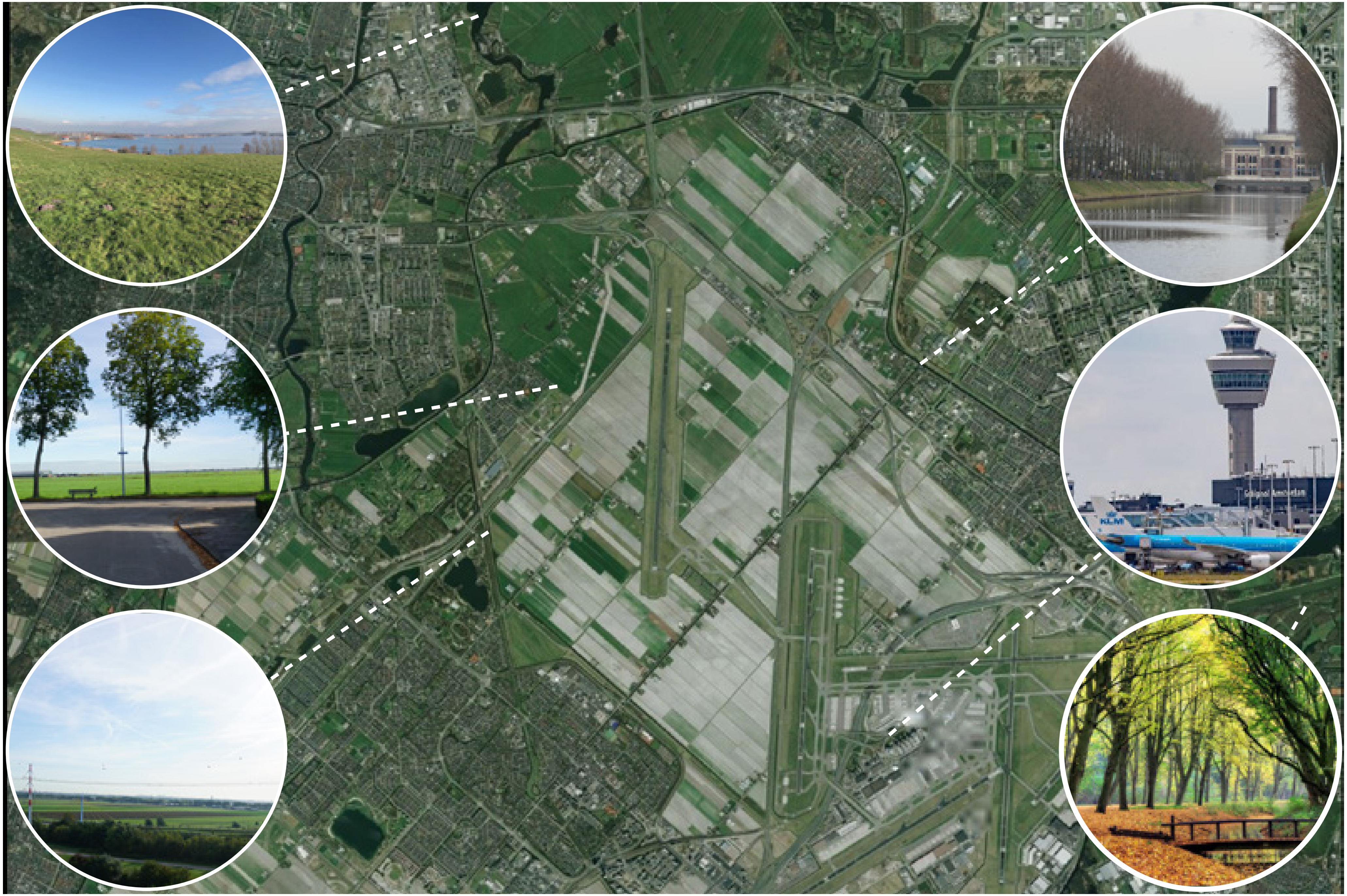


Figure 86: Design location Northwest Haarlemmermeer (sources: bing maps, Harry Arp, nu.nl, rtv Amstelveen, own pictures)

Hoofddorp with Amsterdam. The second important axis is the one at the north side of the main part of the solar energy landscape. This line connects both the city of Amsterdam and Haarlem as well as the nature areas of the Amsterdamse bos and Mooie Nel and with that even the coastal nature area behind Haarlem. The design intends both axes to function as main nature corridors and the main recreational connections. Therefore a strip of 100-200 meters on both sides of the axes is used as a nature area. This area exists out of wildflower meadows, shrubbery, bushes, fruit trees and ponds, providing habitat for insects, birds and small mammals.

Both, the lines of the grid of the Haarlemmermeer as well as the continuous line of the ring canal are used as a basis for the regional design. These lines function both as an attractive recreational connection as well as a nature corridor. Where possible the streets are transfomed into bike streets, giving priority to cyclist. Where this is not possible a 4-meter-wide bike path is created apart from the main road, leaving a 5-meter-wide buffer zone in-between.
The grid is emphasized by a double tree lane, and can be seen from eye-level perspective as well as looking out of an airplane. The north-south orientated and the east-west orientated tree lanes will get different trees. Using the different trees for the different directions will increase the recognisability and make it easier to orientate.
As the main canal is the backbone of the lay-out of the Haarlemmermeer, it will be emphasized with 3 rows of trees on each side of the water. The first 6 meters of the edge of the agricultural plots adjacent to the lines of the grid will be sown in as wildflower meadows, to increase the potential of these lines as nature corridors.

Design guidelines

Biodiversity
Nature corridors are being created in order to increase both the local and the regional biodiversity. The different tree lanes along the lines of the grid exists of different tree species.
The following design guidelines were used:

- Connecting with surrounding nature areas
- Tree lanes

Airport
The solar energy landscape is surrounding the two main airstrips. In this way the agricultural fields that attract geese are taken out of production. Also, the tree lanes added to the whole Haarlemmermeer will help to filter the air and create a recognisable landscape from the air and on the ground.
The following design guidelines were used:

- Agricultural fields out of production
- Trees and bushes
- Iconic solar landscape
- 30 meters around airstrips kept open

Recreation
Attractive bike routes are created throughout the whole Haarlemmermeer, connecting many (recreational) destinations. The PV landscape will be a new destination for recreation.
The following design guidelines were used:

- PV park accessible
- Bike routes connecting recreational destinations

PV - energy
At the village of Vijfhuizen there is an endpoint of a powerline and an electricity station.
The following design guideline was used:

- Located close to electricity station

Landscape structures
The large-scale agricultural area together with the airstrips of Schiphol gives this area a very pragmatic and almost industrial character. .Tree lanes both emphasize the lines of the grid as well as the ring dyke surrounding the Haarlemmermeer.
The following design guidelines were used:

- Local landscape structures
- Landscape with pragmatic or industrial character
- Park exists out of one or more polder blocks
- Improve functioning and appearance of lines
- Ring dyke visible & accessible

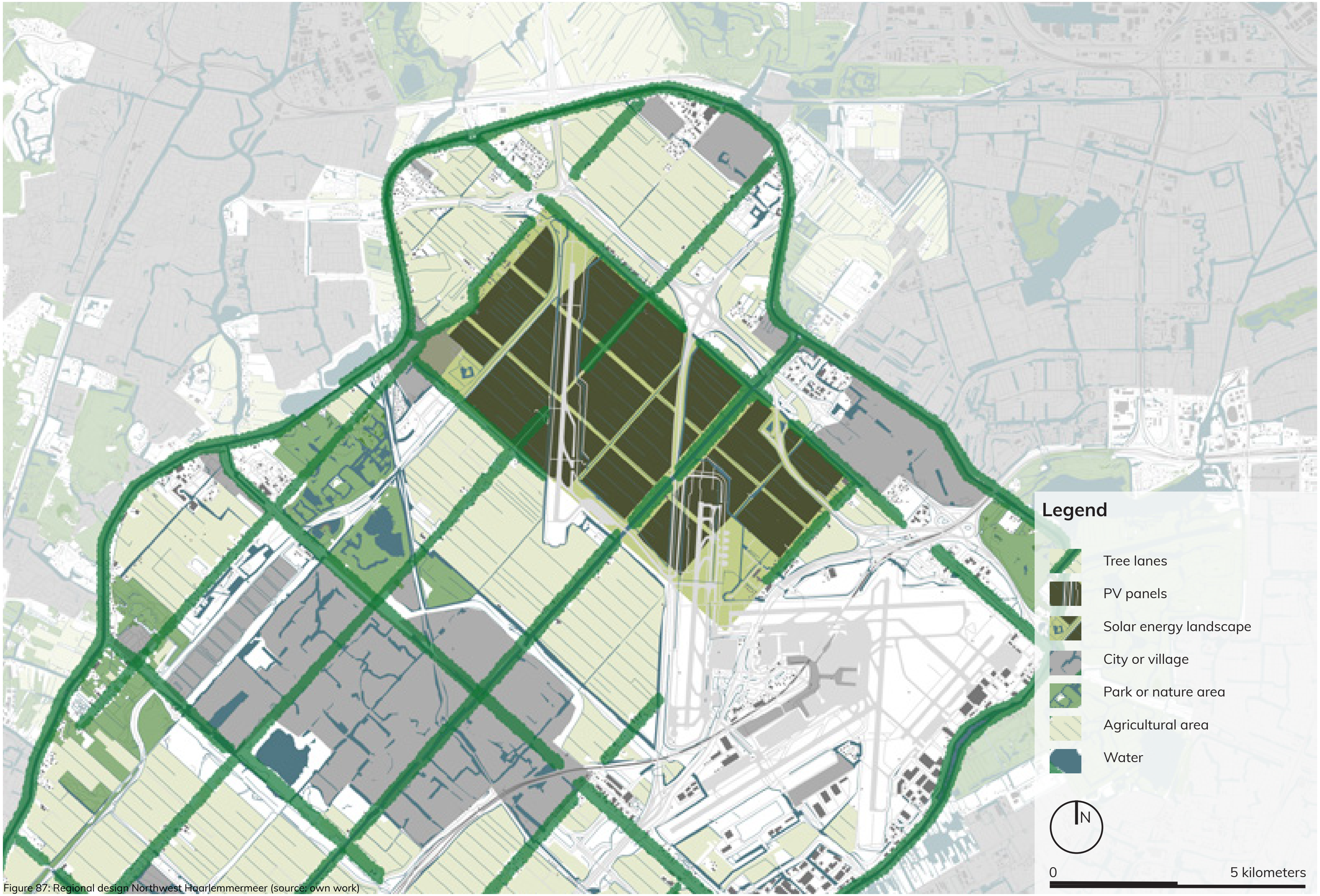


Figure 87: Regional design Northwest Haarlemmermeer (source: own work)

3.4.3 Solar energy landscape

Introduction

The actual solar energy landscape is the location where most functions are located. This area exists out of 3 blocks, with the main canal of the Haarlemmermeer being located between the two eastern blocks. North-west of this area the village of Badhoeverdorp is located and on the opposite corner the village of Vijfhuizen can be found. Furthermore, the two airstrips Polderbaan and Kaagbaan are within this area, as well as the two highways A5 and A9.

Design

The solar energy landscape can be divided into three area with different characters: the park, the hills and the water retention area. The 'park' areas are located close to the villages of Vijfhuizen and Badhoeverdorp, where more room for other functions than the production of solar energy is used. Parts of these 'parks' are used as a smaller water retention area. Surrounding the airstrips the PV-panels are located on top of small hills, which absorb the ground noise of airplanes.
In the northern part of the area the production the PV panels are located on top of a large water retention area.
Between the large areas of PV panels, a linear park is located of 60 meters wide. A 4-meter-wide bike path is running through this park and connecting the different parts.

Park

Close to the villages is more room for recreation within the solar energy landscape. Each patch of PV panels is approximately 180 x 180 meters. Walking- and biking paths are located between the patches. Because the PV-panels are located on top of a water retention area, the paths are a little bit elevated, creating small dykes between the fields of PV panels. Most of the patches of PV panels have a height of 1.45 meters from the small dykes and can be looked over. The patches of PV panels within the park further away from the village are 2.8 meters from the small dykes.
Some areas within the park have been left open as areas for picnick, sports and play.
Transition zones are created out of reed (Typha angustifolia), bushes or wildflower meadows are located at the sides.

Hills

Around the airstrips the PV panels are located on top of hills. These hills are 3-meter-high and 15.7 meters wide in total. The park strips within this area of the park exist of wildflower meadows, with fruit trees on the north-south axes. The fruit trees are both for picking the fruits as well as for insects. The wildflower meadow also provides habitat for many insects and is located both within the park strips as well as on the backsides of the hills. The soil needed for these hills comes from the excavated water retention areas.

Water retention

The water retention area is excavated and the PV panels are elevated. The PV panels here are 3.5 meters high. The linear park within this area of the landscape exist of reed (Typha angustifolia) and willows on the north-south axes. The wood from the willow trees can be used as biomass. Typha angustifolia can be used among others as: animal food, environmentally friendly pesticide and insulation material (Cazander, 2018).
The canals that lies within the blocks is being widened for the purpose of the water retention area.

The landscape can be experienced in many ways, either by biking between the trees on the lanes and between the PV panels within the linear parks or walking in the areas close to the villages. Also, a mountain biking route is being designed through the diverse scenes of the park. This route takes the biker through the water retention areas, wildflower meadows, and bushes and over and between the hills.
The roads of the tree lanes are being slightly elevated, creating a view over the PV panels. At the north side of the park there is a nature corridor. Here there are some bushes and wildflower meadows, as well as room for organic agriculture.

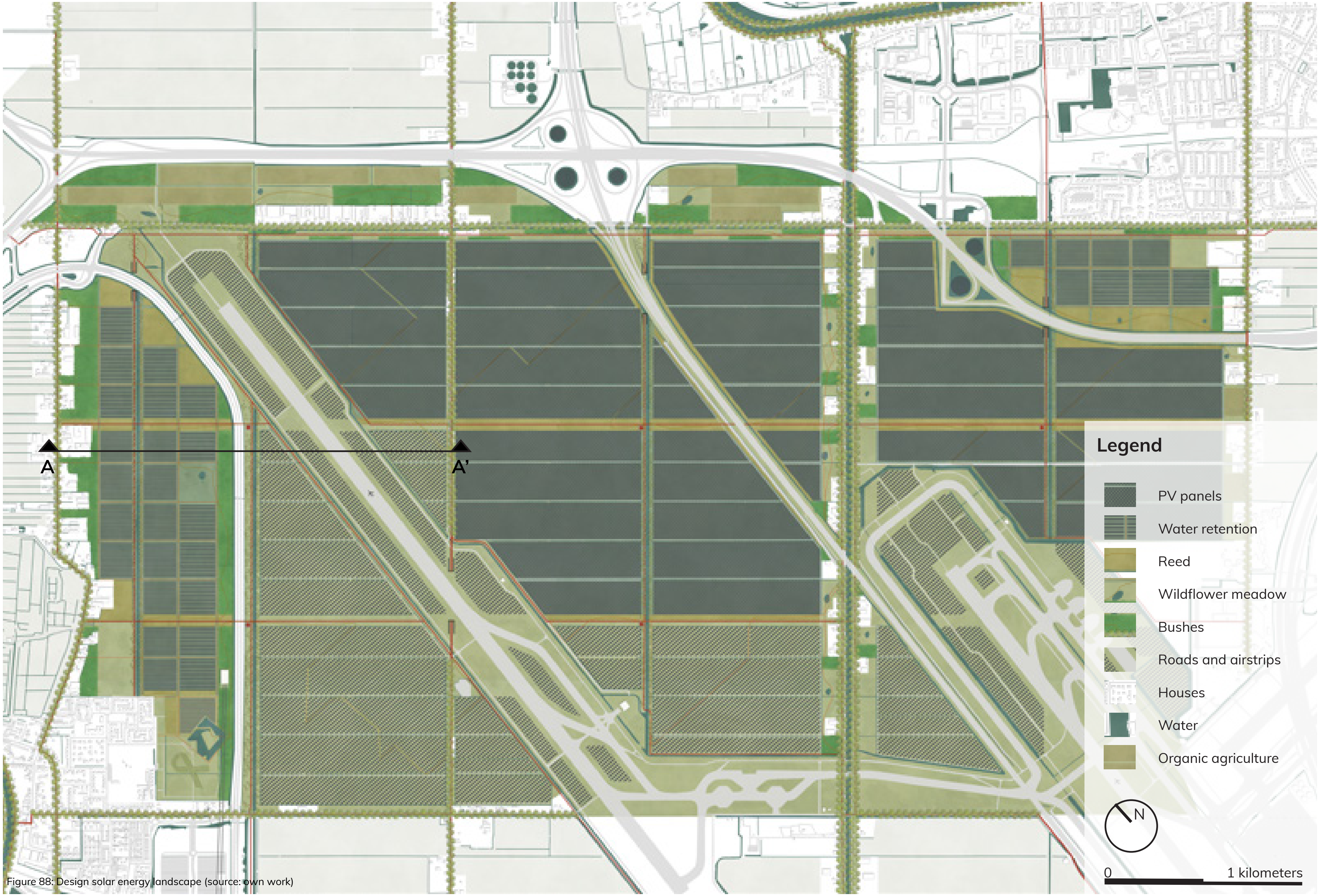


Figure 88: Design solar energy landscape (source: own work)

Figure 89: Sections (source: own work)

Towers
To make the solar energy landscape recognisable both from inside as well as from the outside, five viewing towers are located within the solar landscape.
The 25-meter-high towers are at the crossings of the bike lanes between the PV panels. Although they stand in the middle of the solar energy landscape, they can be seen from outside and attract people to explore this landscape.
Together these five towers tell the story of the Haarlemmermeer. They represent a light house, referring to the time before the reclamation, a grain silo, referring to the agricultural time of the area, a defence tower, referring to the defence line of Amsterdam, present within the area, a control tower, referring to the airport and lastly a renewable energy tower.

All of the towers have the same height and are made of red metal, being recognisable landmarks of this solar energy landscape.

Design guidelines

Biodiversity
To increase biodiversity different zones are created. A wet nature area is located underneath part of the PV panels, together with reed lands. Also large wildflower meadows with bushes, ponds and fruit trees are located within the linear parks as well as alongside the tree lanes. The following design guidelines were used:

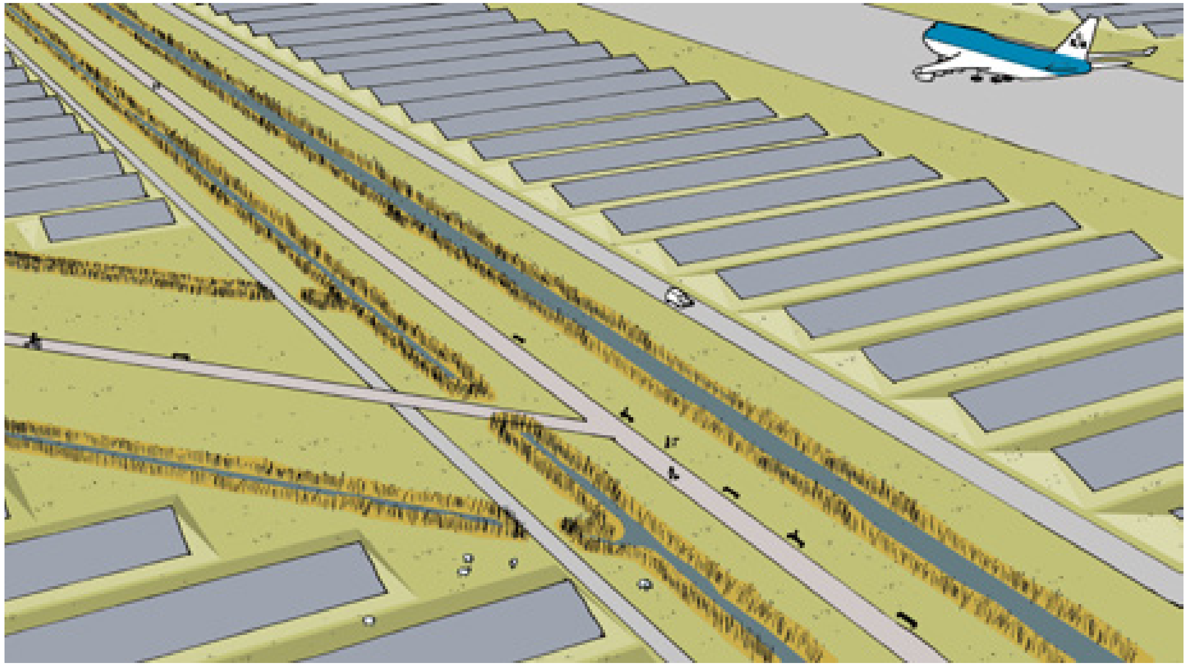


Figure 90: Axonometric impression of park at Vijfhuizen (source: own work)

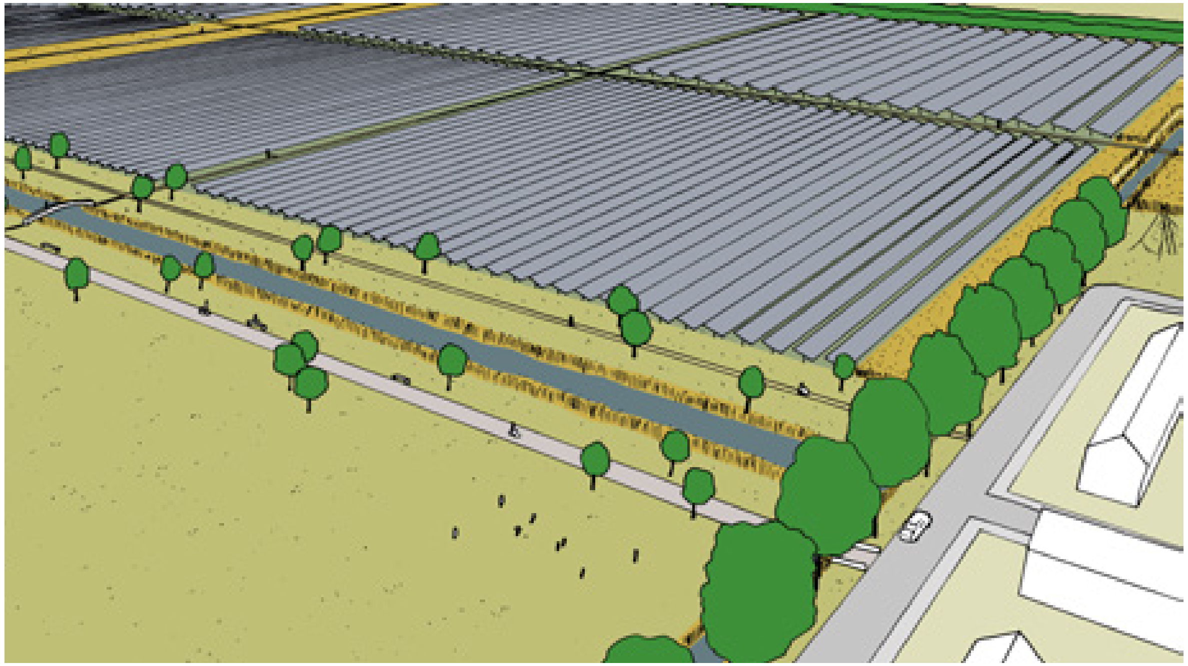


Figure 91: Axonometric impression of hills and airstrip (source: own work)

- Ponds
- Half wet reed land
- Fruit trees
- Wildflower meadows / wild grasslands area
- Bush and tree rows

Water retention
A large water retention area was created underneath the PV panels, combined with wet-nature. The following design guidelines were used:

- Permeable water retention
- Combine with wet-nature

Airport
Several larger and smaller bush areas have been created along the tree lanes. Also the wet nature areas are covered. The following design guidelines were used:

- Bush area
- No open wet nature
- Trees and bushes

Recreation
The solar energy landscape provides much room for recreation. Alongside the path benches with the opportunity for bike charging, water taps and information can be found. Also viewing platforms create opportunities to enjoy the landscape.
Besides that it is possible to experience the landscape also by mountain bike and canoe. The following design guidelines were used:

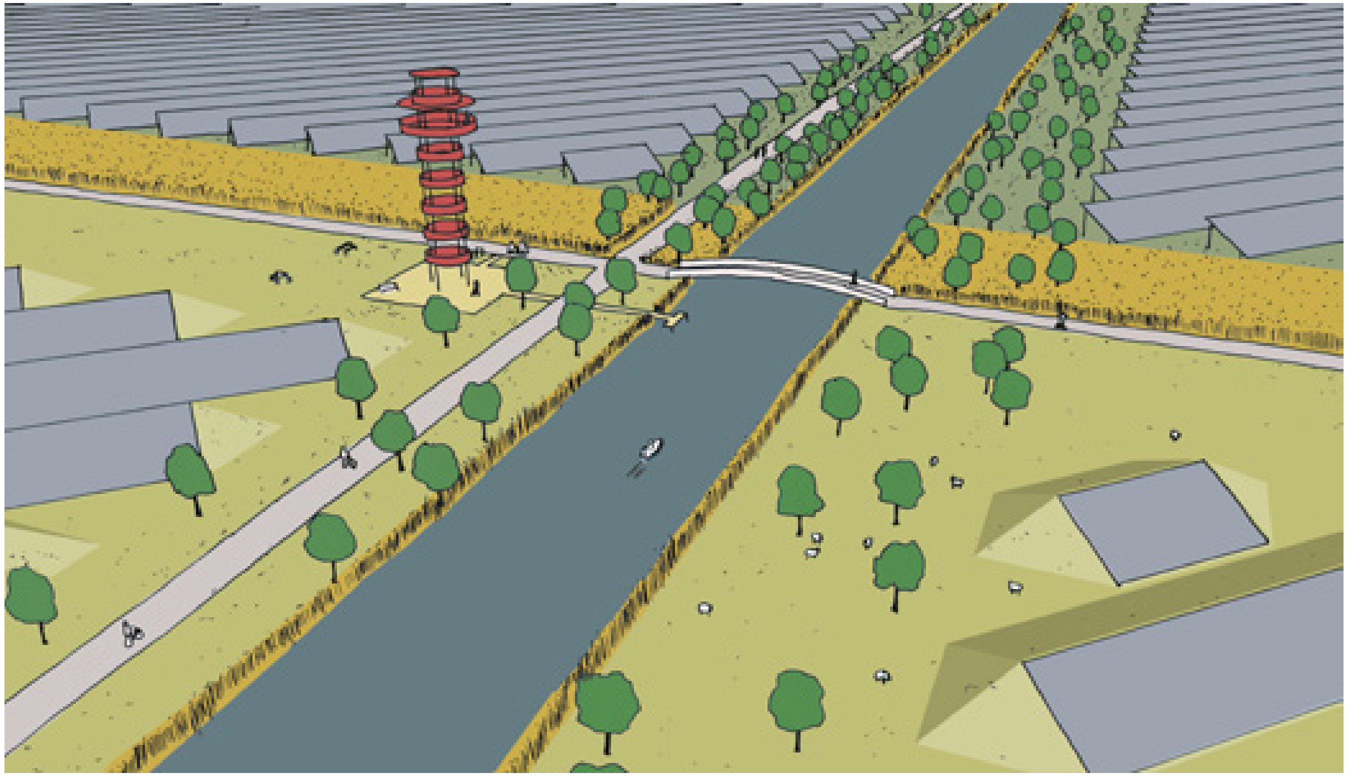


Figure 92: Axonometric impression of hills and water retention (source: own work)

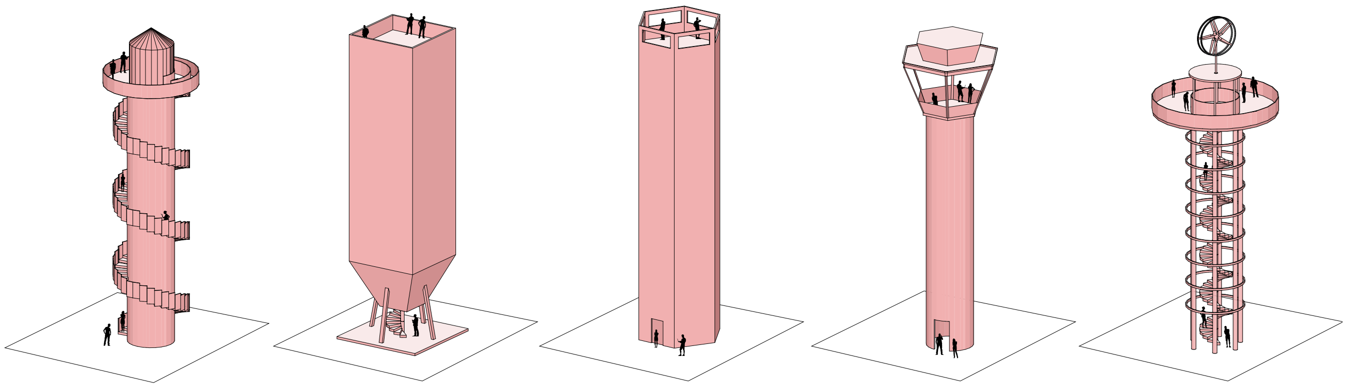


Figure 93: Viewing towers: light house, grain silo, defence tower, control tower, renewable energy tower (source: own work)

- Viewing platform
- Information
- Bike charging, water tap and sitting
- Fruit trees
- Mountain bike routes
- Canoe routes

PV-energy
Different heights of PV panels are used. Closer to the villages the PV panels are kept lower, where as in the rest of the landscape higher PV panels are used. The following design guidelines were used:

- Lower PV panels
- Higher PV panels

Landscape structures
Around the patches of PV, transition zones are created with wildflower meadows, reed or bushes. The transition zones between the villages and the PV panels is larger than that between individual houses. Similarly, the transition zones around important tree lanes are wider than transition zones around less important lanes. The following design guideline was used:

- Transition zones around patches

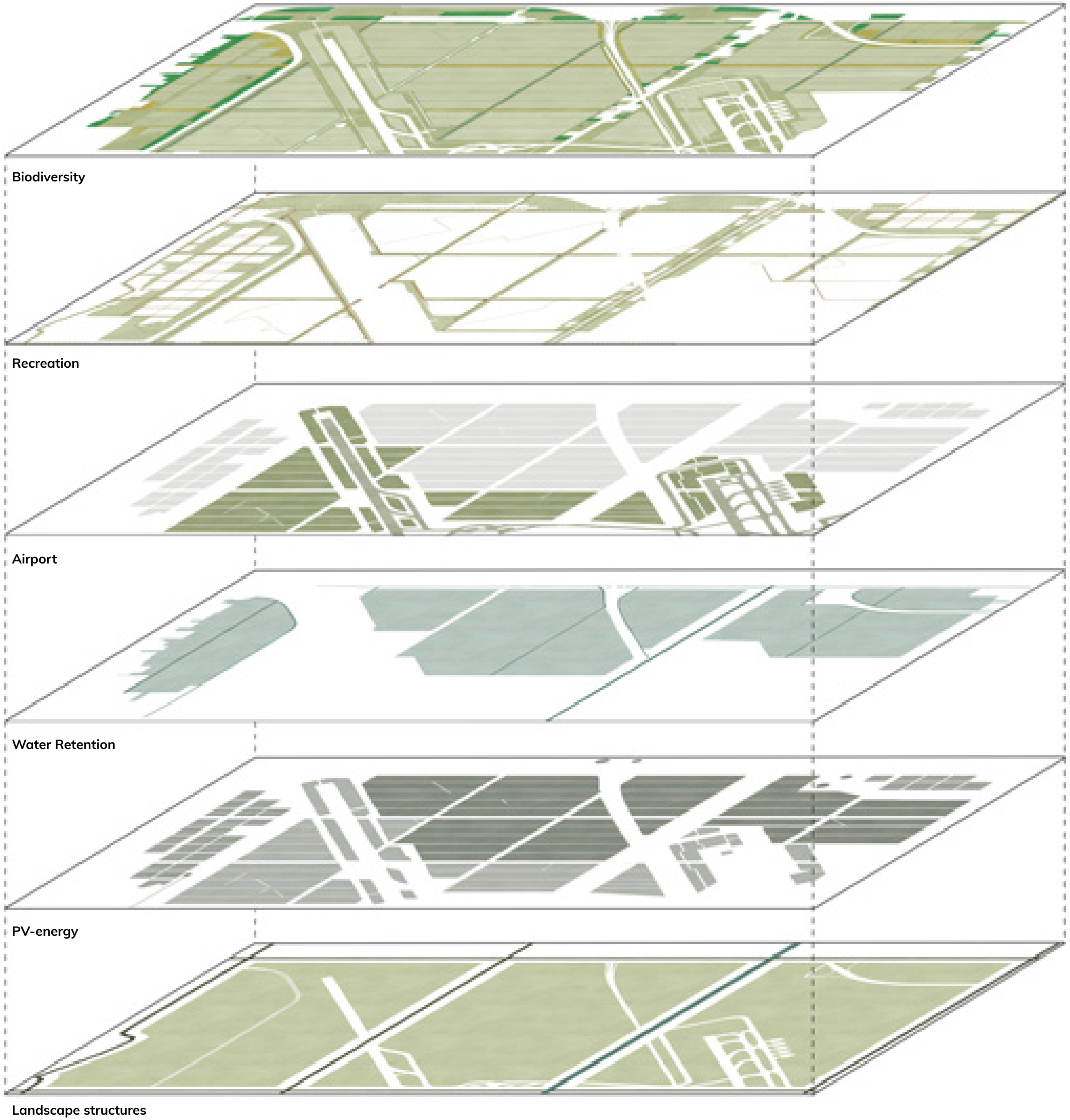


Figure 94: Layers of design (source: own work)

3.4.4 Detailed design

As the main canal is the backbone for the lay-out of the Haarlemmermeer it becomes one of the main recreational axes. The place where the biking path crosses it forms an interesting location for the detailed design.

The patches of PV panels are located 130 meters away from the road. The northern patch of PV panels is on top of a water retention area, whereas the southern patch is on top of hills. Along the patch a service road is located. Between the two patches there is the linear park leading towards one of the viewing towers. The path is 4 meters wide and provides opportunities for many sorts of sport. Biking from the viewing tower towards the bridge over the canal one passes a restaurant on its left hand and a bike street along the canal. On the other side of the canal a busier street is located with a separate bike path.

The restaurant is located within the transition zone between the street and the PV panels. Within the transition zone there are wildflower meadows, ponds, bushes and shrubbery and a both a walking path and a mountain bike route.

The restaurant and the solar energy landscape can also be accessed by boat or canoe. A landing stage is connected with stairs to the street. This makes it also possible to experience this area by boat.

Design guidelines

Biodiversity

A lot of room for nature is created within the transition zone between the road and the PV panels, however also between and underneath the PV panels measures have been taken. The following design guidelines were used:

- Ponds
- Bushes
- Wet nature
- Wildflower meadows / wild grasslands
- Fruit trees
- Reed

Water retention

The northern patch of PV panels is on top of a water retention area. The following design guidelines were used:

- Elevate PV panels & cables
- Combine with wet-nature

Recreation

On the crossing between two recreational bike paths several functions come together. The following design guidelines were used:

- Restaurant
- Canoe
- Fruit trees
- Mountainbike route

Airport

The southern patch of PV panels is on top of hills, to reduce the ground noise of airplanes. The following design guidelines were used:

- Artificial hills

Figure 95: Section detailed design C-C’(source: own work)

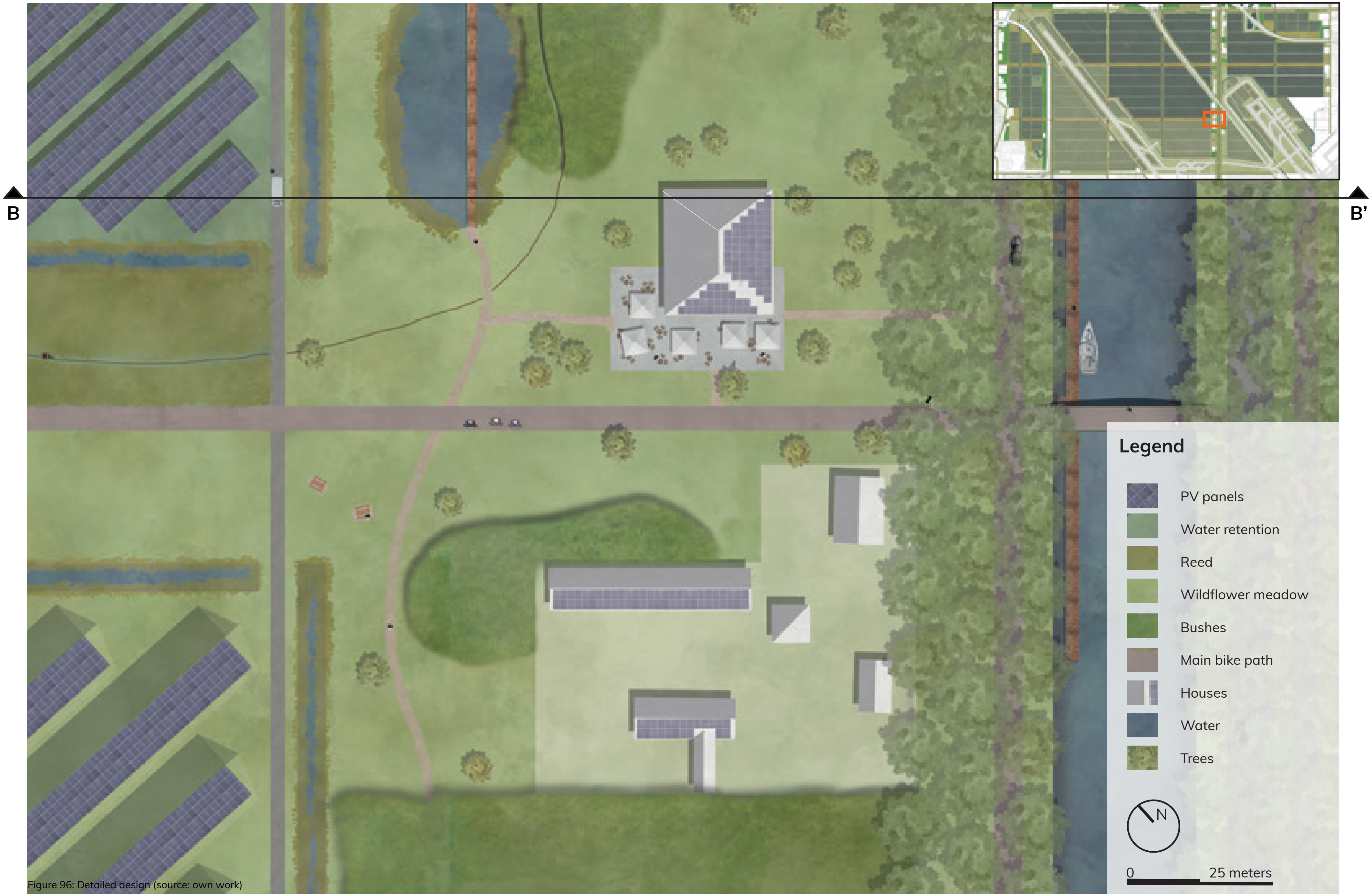


Figure 96: Detailed design (source: own work)

3.4.5 Planting design

A planting design was made for the whole solar energy landscape. The goal of the different vegetation is to create an attractive and recognisable landscape, to provide habitat especially for birds and insects and to filter the air.

Lanes

Throughout the whole Haarlemmermeer existing tree lanes are being renewed and enlarged. The north-south orientated tree lanes will consist of of Populus Canadensis, the east-west orientated tree lanes of Tilia Tomentosa.
On each side of the ring canal a double line of Ulmus Columella will be planted. These last two species are especially known to have a large potential to filter air (Hiemstra & van der Sluis, 2009)

- Populus Canadensis on north-south orientated tree lanes
- Tilia Tomentosa on east-west orientated tree lane
- Ulmus Columella around the ring canal

Water retention area

A large part of the solar energy landscape is being used as a water retention area. This lower wet area can hold a lot of nature value. The following plant are proposed:

Tree:
- Salix Alba

Reed:
- Typha angustifolia (reed)

Wildflower meadow:
- Achillea Ptarmica
- Angelica Sylvestris
- Barbarea Stricta
- Epipactis Palustris
- Scrophukllaria Umbrosa
- Alopecurus Pralensis
- Melica Uniflora
- Deschampsia

Hills area

Within the other part of the solar energy landscape the production of solar energy is combined with the reduction of ground noise. Within this dryer part there is room for different fruit trees and wildflower meadows.

Tree:
- Malus Domestica
- Prunus Domestica
- Prunus Avium
- Pyrus Communis

Wildflower meadow:
- Alopecurus Pralensis
- Melica Uniflora
- Deschampsia
- Allium Schoenoprasum
- Agrostemma Githago
- Anchusa Officinalis
- Centaurium Erythrea

Transition zones

Around the large patches of PV panels there are transition zones. In this optimal habitat for birds and insects there are fruit trees, bushes and shrubbery, and wildflower meadows.

Tree:
- Malus Domestica
- Prunus Domestica
- Prunus Avium
- Pyrus Communis

Wildflower meadow:
- Alopecurus Pralensis
- Melica Uniflora
- Deschampsia
- Allium Schoenoprasum
- Agrostemma Githago
- Anchusa Officinalis
- Centaurium Erythrea

Bushes and shrubbery:
- Crateagys Monogyna
- Prunus Spinoza
- Amalanchier Lamarckii
- Corylus Avellana
- Rosa Rubiginosa
- Viburnum Opulus
- Euonymus Europaeus

Figure 97: Planting design (source: own work)

Main canal

Figure 98: Visual main canal (source: own work)

Park


Figure 99: Visual park (source: own work)

Hills and viewing towers

Figure 100: Visual hills and viewing tower (source: own work)

3.4.7 Future perspective

The main research question of this thesis is: 'How can solar energy landscapes be used as a tool to improve spatial quality?'. Spatial quality is among others about the future potential of a landscape. One of the aims of the designed solar energy landscape is to improve the landscape structure, beyond the timespan of the solar energy landscape itself. It is assumed that in the coming decades solar energy parks will become unnecessary, as PV panels become more efficient and can be integrated within all sorts of surfaces. For this design it can be assumed that this solar energy landscape will gradually be taken out of production around the year 2050. By this time the metropolitan region of Amsterdam will be more urbanized, and the Airport of Schiphol will be moved outside of the metropole. The former solar energy park will be turned into a new city, with a full grown green blue structure and iconic renovated viewing towers remembering of the past when this area used to be a solar energy landscape.

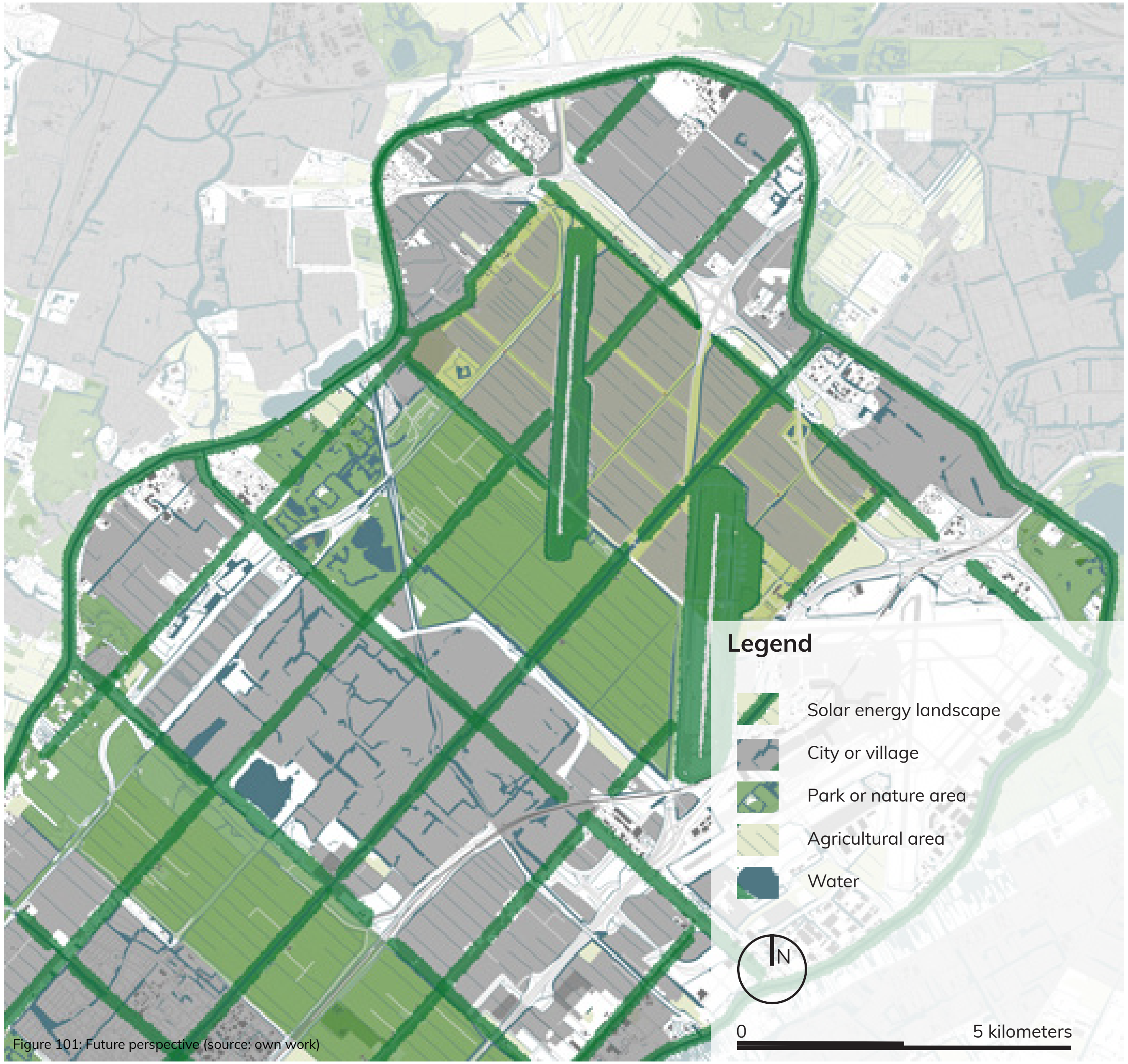


Figure 101: Future perspective (source: own work)

3.5 Conclusion and discussion

3.5.1 Introduction

The goal of this chapter is to answer the design question: 'How can an integral design for a multifunctional solar landscape have a large positive impact on the spatial quality of the Northwest Haarlemmermeer?'. Starting point to answering this question is the conclusion of the previous chapter, the design guidelines derived from analysing solar energy parks as well as the design location.
A model study was conducted to answer the question: 'how can a multifunctional solar energy landscape be best spatially organised.'
The resulting conclusions, together with the design guidelines were the starting point for answering the second design question: How can an integral design for a multifunctional solar energy landscape, with a capacity of 3Pj, in the Northwest Haarlemmermeer look like? The goal of this is to test both the design guidelines as well as the outcome of the model study on a large scale.

3.5.2 Spatially organising different functions

Conclusion

The first step to answering the general design question was a model study. Three different spatial models translated the design guidelines into a solar energy landscape of 500 hectare and producing 1 Petajoule. The three models were evaluated both by criteria as well as experts. Overall, it is concluded that the parallel model has the largest positive impact upon spatial quality, both according to the criteria as well as experts. However, it was also found that the mixed model scored higher on the experience level and the stacked model also scored well on functional value. This shows that none of the three modelsis able to bring about the full potential to increase spatial quality. It could therefore be concluded that a combination of the three models will have the largest positive impact upon spatial quality. In the final design the parallel model was leading, however the other models were also made use of.

Discussion

To be able to make a good comparison between the three different models, the location and amount of PV panels were fixed. Also, the three ways of organising were slightly exaggerated, to be able to make a clear comparison. However, the ways of organizing functions automatically made it impossible to apply the same design guidelines for each model. The stacked model has for example a large water retention area, whereas this was not possible for the parallel model, as the water retention area needed to be covered. Designing the three different models was a constant balance between staying close to the organizing principle and designing three realistic and equal alternatives.
A second challenge was evaluating the three different models. Verifying the outcome of the criteria and that of the experts with each other made it possible to check the outcome. Especially on the aspect of functional value the outcomes of both evaluations were very different. This can be explained due to the difference between the definition given to the experts (usable, effective,
easy to create and maintain, accessible & consistent), and the translation of the same concept into ecosystem services within the criteria. Obviously, the different interpretation of the concepts cause different outcomes. The criteria that were used could be improved by going back to the definition of each concept.

3.5.3 Integral design

Conclusion

The parallel model was used as a starting point for the integral design of a multifunctional solar energy landscape, with a capacity of 3Pj, in the Northwest Haarlemmermeer. However, to increase to positive impact on spatial quality this was combined with aspects of the mixed and stacked model. The whole solar energy park got a basic lay-out based upon the parallel model. By doing so large areas of

PV panels could be created, while at the same time attractive routes with wide transition zones around them could be created.
However, also aspects of the other two models were used. The solar energy landscape consists of three zones: ‘parks’, hills and a water retention area. The ‘parks’, incorporate many aspects of the mixed model, such as smaller and lower patches of PV panels and walking paths between them. This was found to be suiting close to residential areas. The hills and the water retention area clearly a combination of both the parallel and stacked way of organising the different functions. Three conclusions can be drawn from applying parts of the three models within the integral design:

1. A parallel way of organizing a solar energy landscape is an effective way of creating both large patches of PV panels as well as routes with wide transition zones, for recreation as well as nature.

2. A mixed way of organizing the different functions is more suiting near residential areas.

3. The stacked and parallel way of organizing do not exclude each other, but instead can be combined to create a more interesting and effective multifunctional solar energy landscape.

The design guidelines were used both for the models as well as for the integral design. These guidelines were derived from analysing existing multifunctional solar energy parks as well as the design location and covered 6 categories. Many aspects of the design guidelines were incorporated in the final design, such as ponds, elevated PV panels, fruit trees and benches. The general design guidelines, derived from the analysis of soalr energy parks, offered the main programm for the solar energy landscape. However, to make the design place specific the design guidelines derived from the second and third specific research question were needed.
Furthermore, to make a design for a diverse and relevant solar energy landscape many more design decisions were taken, such as: bike paths through the solar energy landscape, wider and narrower transition zones depending upon importance of road / residential area, different trees on different axes, viewing towers telling the history of the location, large reed areas. The aim of these design decisions was to make to landscape accessible, to create diversity and to add a narrative to the solar energy landscape.
Also, the three previously mentioned conclusions about organizing the different functions can be considered as design decisions. Conclusions that can be drawn with regards to the design principles:

1. Both general design guidelines for solar energy landscapes as well as guidelines for the specific landscape are needed

2. More design guidelines are needed to create an accessible and diverse landscape as well as to add a narrative to the design.

Discussion
Parts of the solar energy landscape are organized in a mixed way. However, the patches of PV panels are still about 180 x180 meters, with walking paths between them. This could also be considered a more detailed parallel way of organizing. In this case it was defined as mixed, because more room for other functions was created and the patches of PV panels were smaller. From this it becomes cleaer that it is difficult to exactly define when a soalr energy park or landscape is parallel and when it is mixed.

Within the design guidelines just six categories of functions were used, although more functions might be used such as infrastructure, biomass production or agriculture. These functions were not analysed within the existing solar energy parks and considered of less importance to the design area, however for other locations the types of functions must be reconsidered.

4 Conclusion

4.1 Conclusion

The goal of this thesis is to find out how an integral design for a multifunctional solar landscape can function as a tool to achieve other spatial goals and so improve spatial quality. This was done by analysing both other solar energy parks and the design location, analysing the best way to spatially organise multifunctional solar energy landscape and making an integral design for a multifunctional solar landscape in the Haarlemmermeer.

Six categories of functions for multifunctionality were analysed: biodiversity, water retention, airport, recreation, PV-energy and landscape structures. For these categories exact design guidelines were formulated, based upon the analyses of solar energy parks as well as the Northwest Haarlemmermeer. The design guidelines were organised on three different scale levels: patch, solar landscape and surrounding landscape.

Secondly it was tested how the multiple functions within a solar energy landscape could best be organized. This was done by a model study with three different models: a parallel, a stacked and a mixed one. Organizing the different functions parallel to each other was found to have the largest positive impact upon spatial quality. Secondly it was learned that also aspects of the other ways of organizing could be used. This was further tested within an integral design.

From the integral design it was learned that the parallel way of organizing the different functions indeed was a good basis, however this didn't exclude also stacking functions. Secondly a more mixed way of organizing was found to be more suiting close to residential areas.

The integral design also tested the previously formulated design guidelines. Both the general and the site-specific design guidelines were found to be helpful in designing a solar energy landscape. However, to design an accessible and diverse landscape as well as to add a narrative to the design many more design decisions needed to be added. To suite these purposes more design guidelines would be needed.

Together, the design guidelines, model study and integral design give a clear picture of how a multifunctional solar landscape can function as a tool to achieve other spatial goals and so improve spatial quality.

4.2 Discussion

An important starting point for the design and therefore for the findings of this thesis were the design guidelines. Although they were proven to be useful, they were no complete. In order to create more general design guidelines more solar energy parks and landscapes would need to be analysed. This would provide more insight into the existing six categories of functions, and new categories will come up. Also, a more extensive research into the challenges of the Haarlemmermeer and its potential solutions will lead to more accurate design guidelines.

To create more insight in the best way of organising a solar energy landscape the model study should be repeated in one or more different landscapes. In this it would be relevant to see if the outcomes change if the landscape becomes more urban or more rural. Also, it is expected that the size of the solar park or landscape will influence the choice for the parallel or mixed model.
Additionally, the evaluation of the models would need to be improved. Clearer definitions of spatial quality and the three categories of spatial quality are needed. By this experts could make a better judgement and the specific criteria can be improved,
Furthermore, the representation of the models can be improved by making them more realistic and adding eye-level perspective. It would also be relevant to have the models tested by local residents, this was not possible for this research due the fact that changing the current agricultural land in an enormous solar energy landscape would have been a controversial for the residents.

To create more insight in how a solar energy landscape can be used to improve the spatial quality similar solar energy landscapes need to be designed for other landscapes types. These other locations should also apply to criteria for finding a location mentioned in chapter 1.5.
These other design would make it possible to find out if the same 6 categories of functions apply there, or if other functions needed. Also it could be tested if the parallel way of organizing functions also is applicable somewhere else.

Lastly research should be conducted if for each province of the Netherlands three suiting location for solar energy landscapes can be found. Together these multifunctional solar energy landscapes could produce the needed 100 Petajoule. All these solar energy landscape improve the spatial quality, and more fragile landscapes will not have to host small solar energy parks.
This design provides the first part of this puzzel, of how the energy transition can be used not only to produce energy in a sustainable way, but also as a tool to improve the landscape.

5. Bibliography

Bijhouwer, J. T. P. (1971). Het Nederlandse landschap. Kosmos.

Cazander, R. (2018, October 7). Lisdodde is een gewas met potentie. Retrieved from: https://www.ad.nl/groene-hart/lisdodde-is-een-gewas-met-potentie~aecdca63/

CBS (2018, December 12). Regional kerncijfers Nederland. Retrieved from: https://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=70072ned&D1=81-88,139-154,237-245&D2=39,82&D3=21-23&VW=T

College van Rijksadviseurs (2018). Panorama Nederland, College van Rijksadviseurs Den Haag

Dauvallier, P. (2009). Werkbank ruimtelijke kwaliteit, praktische hulp bij structuuvisies en gebiedsprocessen. Ruimtelijke Ordening, 26, 22-30.

Del Carmen Torres-Sibille, A., Cloquell-Ballester, V. A., Cloquell-Ballester, V. A., & Ramírez, M. Á. A. (2009). Aesthetic impact assessment of solar power plants: An objective and a subjective approach. Renewable and Sustainable Energy Reviews, 13(5), 986-999.

Feddes, Y. (2010). Een choreografie voor 1000 windmolens. College van Rijksadviseurs Den Haag

Hiemstra, J. A., & \van der Sluis B. J. (2009). *Bomen voor schone lucht.* Plant Publicity Holland/De Groene stad

Hocks, B., Tolk, L., Wijnakker, R., Sijmons, D., Kupers, P., Spaandonk, T., Streng, G., van den Dobbelsteen, A., Vermeulen, M., Willemse, B., Kuijers, T. Stremke, S., Oudes, D. (2019). Ruimte in het klimaatakkoord.

Hooimeijer, P., Kroon, H., & Luttik, J. (2001). Kwaliteit in meervoud. Conceptualisering en operationalisering van ruimtelijke kwaliteit voor meervoudig ruimtegebruik. Gouda, Habiforum.

Janssen-Jansen, L., Klijn, E. H., & Opdam, P. (2009). Ruimtelijke kwaliteit in gebiedsontwikkeling. Gouda, Netherlands: Habiforum.

Klaassen, R. H., Schaub, T., Ottens, H. J., Schotman, A. G. M., Snethlage, J., & Mol, G. (2018). Literatuurstudie en formulering richtlijnen voor een ecologische inrichting van zonneparken in de provincies Groningen en Noord-Holland: Eindrapportage. University of Groningen.

Lenzholzer, S., Duchhart, I., & Koh, J. (2013). 'Research through designing'in landscape architecture. Landscape and Urban Planning, 113, 120-127.

Milieucentraal (2019, March 28). gemiddeld energieverbruik. Retrieved from: https://www.milieucentraal.nl/energie-besparen/snel-besparen/grip-op-je-energierekening/gemiddeld-energieverbruik/

Oudes, D., & Stremke, S. (2018). Spatial transition analysis: Spatially explicit and evidence-based targets for sustainable energy transition at the local and regional scale. Landscape and Urban Planning, 169, 1-11.

Picchi, P., van Lierop, M., Geneletti, D., & Stremke, S. (2019). Advancing the relationship between renewable energy and ecosystem services for landscape planning and design: A literature review. Ecosystem services, 35, 241-259.

Planbureau voor de Leefomgeving (2019). Kortetermijnraming voor emissies en energie in 2020

Provincie Noord-Holland (2018). Prachtlandschap Noord-Holland! Leidraad landschap en cultuurhistorie

Roth, M., Eiter, S., Röhner, S., Kruse, A., Schmitz, S., Frantál, B., ... & Karan, I. (2018). Renewable Energy and Landscape Quality. Pan, 126, 2-2.

Rutte, M. (2018 September,18.). Radio Interview. Retrieved from https://www.nporadio1.nl/prinsjesdag-2015/onderwerpen/472134-rutte-de-energietransitie-is-qua-grootte-vergelijkbaar-met-de-wederopbouw

Rutte-III, R. (2017). Vertrouwen in de toekomst.

Schiphol (2019, March 28). Reduceren van energieverbruik. Retrieved from: https://www.schiphol.nl/nl/schiphol-group/pagina/reduceren-van-energieverbruik/

Schöne, M. B. (2007). Windturbines in het landschap: Nieuw plaatsingsbeleid op basis van landschapsbeleving gewenst door de jongste generatie windturbines (No. 1501). Alterra.

Schröder, R. R. G., Schöne, L., Slabbers, S., Loohuis, R. O., Nagtegaal, L., Heersche, J., & Bulens, J. D. (2008). Schetsboek windturbines & ruimtelijke kwaliteit; landschappelijk onderzoek naar vides en concentratiegebieden. Alterra/Bosch Slabbers/Bureau Schöne.

Scognamiglio, A. (2016). 'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision. Renewable and Sustainable Energy Reviews, 55, 629-661.

Sinke, W. (2019). 'Het is tijd voor pv 2.0, we bewegen steeds verder weg van one-size-fi ts-all-oplossingen', Solar Magazine, may, 14-16

Spaans, M., & Trip, J. J. (2010). Ruimtelijke kwaliteit en rijksbemoeienis. Rooilijn, 43(6), 406-11.

Sijmons, D., Frijters, E., Wijnakker, R., Hugtenburg, J., Stremke, S., Hocks, B., Gerretsen, P. (2017). Energie & ruimte: Een nationaal perspectief. Vereniging Deltametropool. (2017).

Spellman, F. R. (2016). The science of renewable energy. CRC Press.

Steunpunt erfgoed NH (2018, November). De zonnehuid van de vuilstort – Alkmaar. Retrieved from https://www.steunpunterfgoednh.nl/de-zonnehuid-van-de-vuilstort-alkmaar/

Steunpunt erfgoed NH (2018, December). Kameleontisch dubbelgebruik: een zonneweide op. Retrieved from https://www.steunpunterfgoednh.nl/kameleontisch-dubbelgebruik-texel/

Stremke, S. (2019). Het gaat om trots, niet om geld, Binnenlands bestuur, week 8, 37-39

Stremke, S., & Schöbel, S. (2019). Research through design for energy transition: two case studies in Germany and The Netherlands. Smart and Sustainable Built Environment, 8(1), 16-33.

Tribot, A. S., Deter, J., & Mouquet, N. (2018). Integrating the aesthetic value of landscapes and biological diversity. Proceedings of the Royal Society B: Biological Sciences, 285(1886), 20180971.

Van den Brink, A., Bruns, D., Tobi, H., & Bell, S. (2016). Research in landscape architecture: methods and methodology. Routledge.

Van Paridon & De Groot. (2012). Water in de structuurvisie Haarlemmermeer 2030. Vpxdg Amsterdam

VROM-raad. (2011). Ruimtelijke kwaliteit : Verkenning (Advies / vrom-raad, 079). Den Haag: VROM-raad.

6. Appendix

6.1 Energy consumption

1 PJ = more than 90.000 households (144% of households Haarlemmermeer, 19% of households Amsterdam) (Electricity only, the total energy use is higher, because of heating via gas) (Milieucentraal, 2019) (CBS, 2018)

1 PJ = 138% of the whole current electricity use of Schiphol (200 million kWh) (Schiphol, 2018):

1 PJ = 13% of the electricity use of TATA-steel (TATA-steel, 2014) (which is less than 8% of total energy use)

Figure 102: Consumption of 1PJ (source: own work)

6.2 Choice of solar energy parks

6.2.1 Parallel function

Andijk

In this park a combination has been made between energy production goals and nature goals. Around the park a bush row is planted, which will become about 3 meters high, which can be considered a landscape element.
This green edge will make the panels disappear from the eye, but also increases biodiversity, attracting bees and other insects.

Almost the entire space is covered with PV-panels organised in an east-west setup. The green edge around it, which increases biodiversity and makes the park more fitting into its environment can be best considered as a parallel function, taking up relatively little of the total ground level of the park.

Achtkarspelen

In this park a combination has been made of energy production, biodiversity and recreation. The vision of Laos landscape architects, who made the design for this solar energy park, was to give the park 'an address.' This is done in the form of a 50 tree large orchard at the street side, where people can relax and charge there bike or phone. The solar panels are located behind the orchard.
This park can be considered a parallel function park. Around the solar panels, a green edge is created and an orchard for biodiversity and

6.2.2 Stacked functions

Heeten

In Heeten the solar energy park is owned by a cooperation from the villages itself. All profit should flow back into the community. A green edge around the park was planned and left space for, however it has not been planted so far. The park itself is grazed by sheep.
As the green edge is never planted the multifunctionality is limited to the sheep grazing underneath and between the PV-panels. This is to be considered as stacked functions, where there is no relation, neither positive nor negative relation between the two functions.

Ubbena

In the village of Ubbena a relatively small solar energy park was created, which calls itself the first eco-solar energy park of the Netherlands, because the production of solar energy is combined with biodiversity. The park is located on top of an old landfill, which can be considered left-over space. To achieve the goal of biodiversity the rows with panels stand further apart than is common and in-between a special mix of seeds is sown to attract bees and other insects.
The park is located on a former landfill, this could be considered a stacked function. The combination of biodiversity and solar energy can be considered either parallel or stacked. As the space between the rows is not much more than usual, one can hardly speak of a trade-of at the side of in the efficiency of the set-up of solar panels. The main function of the park is to have an efficient solar energy park, and in the left-over space underneath and in-between a special seed mix is sown. Therefore, this park can be considered a stacked function park.

Boekelermeer

Near the city of Alkmaar, a solar energy park is built upon an old landfill. This solar park has specially been designed in such a way that the panels follow the shape of the landfill. The landfill can be considered left-over space.
This solar energy park on top of a former landfill can be considered be a stacked function solar energy park.

Eelde

At Groningen Eelde Airport a solar energy park is being built in the space between the runways. This space between the runways can be considered as a left-over space. Establishing the solar panels here was rather easy, as the airport was already fenced of and the area has a 'pragmatic focus'
The solar energy park can be considered a stacked function, as the space between the runways needs to remain open.

Assen

In this case a solar energy park has been combined with a large motor-cycle parking lot at the TT circuit in Assen. It is a nice example of stacked functions, where the solar panels also provide shade and keeps the motorcycles dry. Also, the very big parking lot is not used most of the time.

Cocksdorp
On the island of Texel, a relatively small solar energy field is located on top of a water basin. The panels can't be seen from afar, as they are hidden behind a small slope. The panels form a closed surface on the water. Also, the panels prevent evaporation of the water while the water at the same time cools the panels, which increases its energyproduction capacity. Panels on water is to be considered a stacked function, in this case the two functions also profit from each other.
Lingewaard
One of the largest floating solar energy parks can be found in Lingewaard. This park is completely initiated and owned by local entrepreneurs who wanted to find a solution against the evaporation from the water basin, used for the surrounding glass houses.
This park combines two functions on top of each other. Both functions profit from this. This is to be considered a stacked function.

6.2.3 Mixed functions

Laarberg
In Laarberg the production of electricity via PV-panels is combined with biodiversity and water retention. The park is used for water storage, therefor the construction for the PV-panels is extra high. Besides that, the edge with trees and bushes is even enlarged, fruit trees are added and sheep grazing underneath and between the PV-panels. By doing so a potential location for birds and bats is created. The park is designed in a way that different functions all have importance. There is clearly a trade-off in the number of solar panels that was installed, to have room for other function. Therefore, this park can be considered as a mixed function park.

Hengelo
Solar energy park 'de Kwekerij' is located in Hengelo. Here, the production of solar energy is combined with nature development and recreation purposes. The park is daily opened for visitors.
A clear trade-off at the efficiency side of solar energy can be seen in this park, to have more room for recreation and nature, therefor this park is a good example of a mixed functions park.

6.3 Rubric model evaluation

	-2	-1	0	1	2
Functional value					
human food production[1]	Square meters shrink between 50% – 100%	Square meters shrink between 10% – 50%	Square meters remain between 10% loss or gain	Square meters available 10% – 50% extra	Square meters available 50% – 100% extra
Livestock[1]	Idem	Idem	Idem	Idem	Idem
solar power[1]	Idem	Idem	Idem	Idem	Idem
Regulating water flows[1]	Idem	Idem	Idem	Idem	Idem
Pollination[1]	Idem	Idem	Idem	Idem	Idem
providing habitats for useful wild plants and animals[1]	Idem	Idem	Idem	Idem	Idem
space sport and recreation[1]	Idem	Idem	Idem	Idem	Idem
Anti-goose measurements	Idem	Idem	Idem	Idem	Idem
Fragmentation[4]	Landscape becomes a lot more fragmented	Landscape becomes a little more fragmented	Landscape fragmentation doesn't change much	Landscape becomes a little less fragmented	Landscape becomes a lot less fragmented
Total:					
Average:					
Experience value					
nature to destress[1]	Square meters shrink between 50% – 100%	Square meters shrink between 10% – 50%	Square meters remain between 10% loss or gain	Square meters available 10% – 50% extra	Square meters available 50% – 100% extra
Recognisability[2]	Landscape becomes a lot less recognisable	Landscape becomes a little less recognisable	Landscape recognisability doesn't change much	Landscape becomes a little more recognisable	Landscape becomes a lot more recognisable
Complexity[3,4]	Landscape becomes a lot less complex	Landscape becomes a little less complex	Landscape complexity doesn't change much	Landscape becomes a little more complex	Landscape becomes a lot more complex
Openness[3,4]	Landscape becomes a lot less open	Landscape becomes a little less open	Landscape openness doesn't change much	Landscape becomes a little more open	Landscape becomes a lot more open
Liveliness[3,4]	Landscape becomes a lot less lively	Landscape becomes a little less lively	Landscape liveliness doesn't change much	Landscape becomes a little livelier	Landscape becomes a lot livelier
Degree of protection[3,4]	Landscape feels a lot less protected	Landscape feels a little less protected	Landscape degree of protection doesn't change much	Landscape feels a little more protected	Landscape feels a lot more protected
Minimal visual distance from carroad[3]	0 – 10 meters	10 – 50 meters	50 – 200 meters	200 – 400 meters	More than 400 meters
Minimal visual distance from bike/foodpath[3]	0 – 10 meters	10 – 50 meters	50 – 200 meters	200 – 400 meters	More than 400 meters
Less noise airplanes	A lot more noise from airplanes	More noise from airplanes	No impact on airplane noise	Less noise from airplanes	A lot less noise from airplanes
Total:					
Average:					
Future value					
Effective to maintain	Becomes a lot more	Becomes a little more	Remains more or less the same	Becomes a little less	Becomes a lot less
Flexibility	Changing and adding functions is very difficult	Changing and adding functions is difficult	Changing and adding functions is between difficult and easy	Changing and adding functions is easy	Changing and adding functions is very easy
Extensibility	Very difficult to extent park	Difficult to extent park	Between difficult and easy to change park	Easy to extent park	Very easy to extent park
Total:					
Average:					
Total					
Average functional					
Average experience					
Average future					
total					

Master thesis
landscape architecture

The bright side of solar energy
how solar energy can be used
as a tool to improve landscapes

Coos van Ginkel
Wageningen university