Developing Solar Energy Landscapes

How an Area-based Approach Can Help in Developing Them Sustainably

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Title:
Developing Solar Energy Landscapes: How an Area-based Approach Can Help in Developing them Sustainably

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Abstract

The transition to renewable energy impacts existing landscapes. The results of these transformations are called 'energy landscapes'. Specifically, this research focuses on solar energy landscapes (SELs). Currently, the energy systems and the location are often still seen as two separate entities. Researchers argue that the development of energy landscapes should be sensitive to local contexts. An area-based approach in the development of SELs can connect the energy systems to the landscape and the local context. Thus, this research studies how area-based planning can play a role in the development of an energy landscape, so that they are developed sustainably. Sustainable energy landscapes are landscapes that sustain qualities and values of cultural landscapes and sustain activities in the future. Different SELs in the Netherlands are investigated through a case study approach. They are researched through interviews and document analysis. From the data it became clear that using an area-based approach can have an impact on the functions, design, acceptance, and the process of development of an SEL. The research has found ways in which SELs can be developed taking into account local contexts. Regarding sustainability, mostly the socio-economic and environmental dimensions of sustainability can be impacted by taking an area-based approach. Working area-based can play an important role in working integrally instead of sectorally, which is required if we are to strive for long-term sustainable renewable energy provision. From the results can be concluded that working integrally is often still a challenge in creating an integrated SEL. The typology on the area-based approach, and its relationship to the sustainability of SELs presented in this paper gives direction to and provides ingredients for decision-making on sustainable energy landscapes. Further research is needed on how integrality can be further achieved in developing SELs, and policy support is needed to facilitate developing multifunctional SELs that are embedded in the local context.

Foreword

With this research, I have completed the master thesis of the master Cultural Geography at the University of Groningen, Campus Fryslân. In the master´s programme, I broadened my knowledge on dealing with cultural considerations and at the same time climate adaptation challenges in planning. This research combines all the subjects that I was most interested in: combining climate adaptation with other assignments, trade-offs, landscape experience, public participation and planning processes.

With the completion of this master's thesis, five years of studying have come to an end. I look forward to putting into practice what I have learned over the years further.

I would like to take this opportunity to thank a few people. First, the idea for this topic was provided to me through my internship at Weusthuis en Partners, where I had the opportunity to still be a part of the team while conducting the research. I want to thank my colleagues, who have given me the opportunity to take such an interesting research subject, and who have supported me along the way.

I also want to thank the civil servants from the Municipality of Súdwest-Fryslân, whom have helped me concretize my research. I learned a lot from this, and it was nice to be close to practice in doing my research.

Also, I would like to thank my supervisor, Ronan McDermott, for supervising my thesis. Thank you for making time for me and guiding me throughout the process in a very supportive way.

Furthermore, I would like to thank all participants and everyone who contributed to my research, and thus, my graduation.

Lastly, I want to thank my dear family and friends who have been of great support during my studies and the completion of my thesis.

I hope you will enjoy reading my thesis. And let me hope you learn something from it in the process!

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Groningen

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1. Introduction

The transition towards renewable energy sources is unavoidable to reduce global greenhouse gas emissions (Picchi, 2022). As can be witnessed across the globe, this transition to renewable energy changes existing landscapes (Picchi, 2022). The results of such transformations are called 'energy landscapes'. Over the centuries, energy landscapes have assumed many forms. Compared to fossil energy systems, renewable energy systems have lower energy densities than fossil ones, and thus require more space per final unit of power provided (Pasqualetti and Stremke, 2018). While more and more renewable energy initiatives are arising, this leads to discussion about the use of the scarce space (Van der Zee et al., 2019). Next to this, energy landscapes are associated with trade-offs among supported ecosystem services, and local communities often oppose their installation because of the expected landscape change (Bianchi and Ginelli, 2018; Oudes, Picchi and Stremke, 2021; Picchi et al., 2022). De Boer and Zuidema (2015) confirm that also in the energy transition in the Netherlands, there is a lack of sensitivity to local, regional and societal interests (de Boer & Zuidema, 2015). The energy transition mainly revolves around economic feasibility, technological efficiency and democratic legitimacy, and the energy systems and the location are often still seen as two separate entities (Oudes, Picchi and Stremke, 2021).

Instead, researchers argue that the development of energy landscapes should be sensitive to local contexts, and thus area-based (De Boer and Zuidema, 2015; Stremke, 2015). Area-based planning is about balancing local potentials and needs, stakeholder interests, local and regional circumstances, and solving local issues by integrating local and regional economic, ecological, and social policies (De Boer and Zuidema, 2015; Boonstra and Frouws, 2005). Herein lies the relevance to research how area-based planning can practically play a role in developing energy landscapes, as it can connect the energy systems to the landscape and the local context. Thus, this research studies how area-based planning can play a role in the development of an energy landscape, so that they are developed sustainably. Developing energy landscapes sustainably is necessary to maintain or improve landscape qualities at the local scale (Stremke, 2015). Stremke (2015) speaks of sustainable energy landscapes when they are developed to sustain qualities and values of landscapes for the future.

There are many types of energy landscapes (Pasqualetti and Stremke, 2018). Specifically, this research will focus on solar energy landscapes (SELs). Different SELs in the Netherlands are investigated as case studies in this research. They will be explored through qualitative data collection in order to answer the research questions. The research questions that will be answered through this research can be found in Figure 1.

How can an area-based approach play a role in developing solar energy landscapes sustainably?

1. How can solar energy landscapes be defined?
2. In what way can different functions be combined in a solar energy landscape?
3. What does the process of developing a solar energy landscape look like?
4. How can an area-based approach play a role in developing solar energy landscapes?
5. How can solar energy landscapes be developed sustainably?

Figure 1 - Research questions for this research

The academic relevance of this research lies in the fact that renewable energy production often comes with local trade-offs. Howard et al. (2013) mention that in the planning of renewable energy production, the knowledge on how to minimise local negative impacts, such as degraded ecosystem services, and maximise energy benefits, is often incomplete. This is in line with Stremke (2015) who states that it remains critical to maintain, or even improve, landscape qualities at the local scale in developing energy landscapes, and mentions that there is frequently a clash between local rights to landscape and renewable energy production. There remains strong opposition from local communities and citizens towards the implementation of large-scale renewable-energy projects (Flacke and de Boer, 2017). Oudes, Picchi and Stremke (2021) state that the basic issue here is that the energy systems and the locality are seen as separate entities. This research will investigate in what way the SEL can be integrated within the locality. Furthermore, it will be an addition to the body of research that tries to understand how the physical and socioeconomic landscape characteristics can influence the development and success of sustainable energy initiatives, which is part of the ongoing research agenda (de Boer & Zuidema, 2015).

2. Theoretical framework

The energy transition to renewable energies often elicits resistance at the local level (Howard et al., 2013). However, it is sometimes also argued that the energy transition offers an opportunity to develop the cultural landscapes of the 21st century. The landscapes can express new responsibilities (also regarding sustainability), and with that, regain ownership and local pride (Oudes, Picchi and Stremke, 2021). This theory is very much about how the production of renewable energy is integrated within existing landscapes and local contexts. The concepts of SELs as well as area-based approaches play a role in this. The following paragraphs introduce these main concepts, accompanied with the theories that this research builds on.

2.1 Energy Landscapes

Ambiguity arises around what is exactly meant by the concept of energy landscapes since, since it has many different definitions (Stremke, 2015). In a broad sense, the concept refers to the transformation of landscapes due to a demand for energy, illustrating the change in energy demands over the years. All types of energy landscapes originate from activities directly related to energy developments (Pasqualetti and Stremke, 2018). Both the demand for energy, and the supply of it influence the physical environment and, thus, are a concern in spatial planning and landscape design (Stremke et al., 2012). Traditional and centralised energy systems are mainly regulated by national and/or state/provincial governments. In contrast, renewable energy production is more a part of the local and the region. Thus, it requires strong engagement from local communities (Flacke and de Boer, 2017).

2.1.1 Solar Energy Landscapes

Pasqualetti and Stremke (2018) have made a distinction between the different types of energy landscapes, and they make a distinction between renewable energy landscapes and 'conventional' energy landscapes. SELs are categorised as renewable energy landscapes and are the focus of this research. Pasqualetti and Stremke (2018) define them as the result of transformations to the landscape due to our demand for energy, in which there is made use of solar energy for electricity generation or heat provision. Compared to other energy landscapes, renewable energy systems usually require more land per final unit of power provided

(Pasqualetti and Stremke, 2018). This leads to discussion about the use of the scarce space (Van der Zee et al., 2019).

Meeting our energy needs with sustainable energy sources is a major challenge, which is why more and more solar parks are being built. Many solar parks are aimed at achieving the highest possible production, which means as many panels per hectare as possible (van der Zee et al., 2019). In literature there is an increasing focus on the multifunctionality of solar parks, and recent publications highlight the need to take into account societal considerations in the creation of SELs (de Vries et al., 2023). This mostly became important in the light of (local) resistance against planned solar power plants (Flacke and de Boer, 2017; Oudes, van den Brink and Stremke, 2022). However, Van der Zee et al. (2019) argue that in reality there is still little attention for the combination of solar parks with other functions.

2.1.2 Sustainability in energy landscapes

Sustainable development is defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). With regard to sustainability in landscapes, Antrop (2006) argues that there are two perspectives on this. The first perspective emphasises landscape as an integrator for qualities and values that are there, that need to be sustained (Stremke, 2015). It focuses on the preservation of inherent landscape qualities and values, which can be natural resources, cultural heritage objects, and immaterial values like a sense of place (Antrop, 2006). The second perspective focuses on sustaining partial activities in the landscape (Stremke, 2015). It relates to the question of what type of landscape is to sustain, and explores the possibilities that new developments offer, so that new narratives can possibly be added (Antrop, 2006). Stremke (2015) links this definition to landscapes focused specifically on energy. For this, he combines the two perspectives by Antrop (2006) into one and defines sustainable energy landscapes as energy landscapes that sustain qualities and values of cultural landscapes and sustain activities in the future.

In defining sustainable energy landscapes, it is important to note that sustainable energy, by definition, is produced from a renewable energy source, but that renewable energy is not necessarily sustainable (Stremke, 2015). Renewable energy production is sometimes associated with negative impacts on the economic, environmental, political, and sociocultural systems of the communities adjacent to them (Abebe et al., 2023). This is also related to the fact that SELs are nowadays not only located in remote and low population density areas but are also developed in urban and rural landscapes where people live and do their daily activities (Oudes, van den Brink and Stremke, 2022). It is said that a decentralisation of the energy system can result in clashes between local rights to landscape and the global progress towards a low carbon economy (Stremke, 2015). Oftentimes, the development of energy landscapes encounters strong opposition from local communities and individual citizens, a concept that is often referred to as NIMBY (Flacke and de Boer, 2017). Furthermore, there is growing recognition that renewable energy systems can have substantial negative impacts on a range of ecosystem services in the locality where they are situated, such as food production, or soil quality (Howard et al., 2013; Stremke, 2015; Van Aken, Binani and Cesar, 2021). SELs require land previously occupied by other uses and therefore increase land use pressure, which also raises a discussion about the use of the scarce space (Oudes and Stremke, 2021; Van der Zee et al., 2019). In the end, a landscape is an integrative concept in which ecological, social and

aesthetic aspects of energy-related interventions need to be approached together (De Waal and Stremke, 2014).

According to Antrop (2006), sustainability is a very general concept that is not easily implemented in practical work. To make this link to practise possible, the theory relating to the concept of a 'sustainable energy landscape' by Stremke (2015) deserves more attention when looking at developing SEL in the landscape in a sustainable way. This theory provides a conceptual framework that enables shaping landscapes that do not merely accommodate renewable energy technologies but that can be considered sustainable. Stremke (2015) defines 'sustainable energy landscapes' as: "*A physical environment that can evolve on the basis of locally available renewable energy sources without compromising landscape quality, biodiversity, food production, and other life-supporting ecosystem services.*" (Stremke, 2015, p.5). In order to research how SELs can be integrated into a local context, the various aspects of an SEL should be considered, as can be done with this framework.

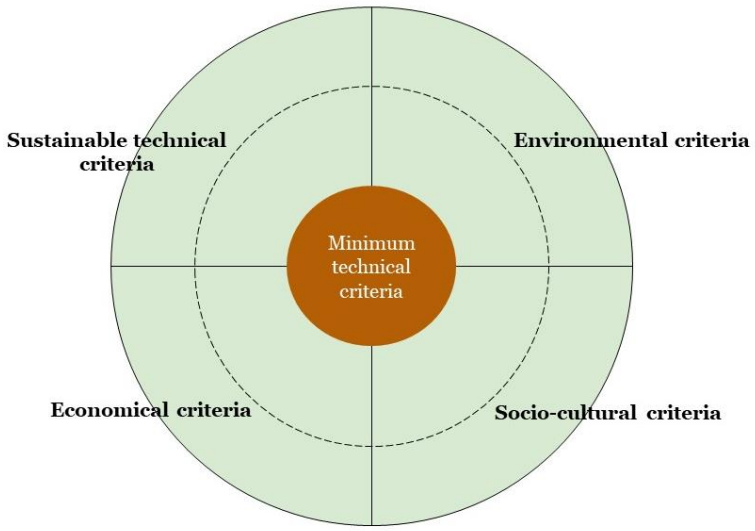

Figure 2 - Conceptual framework for sustainable energy landscapes with the four dimensions of sustainability for energy landscapes (Stremke, 2015).

Looking at Figure 2, in the centre of the model are the minimum technical criteria that always apply. As an example, Stremke (2015) mentions the minimum incline of terrain to install PV panels. In the model, a dashed line is shown. The dashed line represents the definition of sustainability, which is specific to context and therefore to projects (Stremke, 2013; Stremke, 2015). The quadrants show the four main groups of sustainability of energy landscapes. In the top left are *Sustainable technical criteria*. These are related to renewable energy systems. In the top right are the *Environmental criteria* which are about the impact on natural landscapes. The *Economical criteria* on the bottom are about the affordability of the systems and land use competition. Lastly, the *Socio-cultural criteria* are about the values and perception of the landscape according to people. Appendix C shows the criteria that fall within these dimensions to give a better indication of how the dimensions can be embodied in practice (Oudes and Stremke, 2018).

2.2 Area-based approach

Area-based is a term that is used widely in policy, literature and spatial planning instruments (Padt, Boonstra and Reudink, 2008). An area-based approach can also be referred to as area-oriented planning, an area-specific, or a place-based approach (De Boer and Zuidema, 2015). The area-based approach in planning originates from the time a movement to more decentralisation took place in governance (De Roo, 2013). The view that political power should be transferred from high levels of government to levels which are nearer to the people became widely shared. This way, governance was closer to the people who should be involved in the political process, which would enhance local democracy (Andersson and Musterd, 2005). Because of this, governance went more towards area-oriented planning (De Roo, 2013). In the Netherlands, area-oriented policy was introduced by the Ministry of Housing, Spatial Planning and the Environment in the early 1990s. Instead of working sectorally, integral policy became the norm, and intended to integrate environmental and spatial policy. The discourse was that generic goals and policies had to be adapted to the problems and conditions in specific areas. Governments, interest groups, social organisations and market parties were invited to participate in the negotiations on this (Padt, Boonstra and Reudink, 2008).

In dealing with spatial planning challenges in the Netherlands, taking an area-based approach is still increasing in importance (Unie van Waterschappen, Interprovinciaal Overleg and VNG, 2022). Herein, area processes (*gebiedsprocessen*) and area plans play an important role. In area processes, governments and local parties in a certain area work together on the challenges that arise there. The plans they make for this are secured by the provinces in an area plan (*gebiedsplan*) (Ministerie van Landbouw, 2021). Even though the area-based concept is used manifold in practice and in plans, the use of the concept does not always come with a definition of it, and there are still debates on what area-based planning means in practice. Specifically, the level of steering from the central government differs in every context (Padt et al., 2008).

In using this concept, the question arises what an 'area' entails. Area-based planning is often mentioned in the context of social urban problems, in which urban neighbourhoods are taken as 'the area' (Andersson and Musterd, 2005). The Regional Energy Strategy (RES) of the Netherlands, also takes an area-based approach as a basis. In that context, it is stated that the chosen perspective, such as landscape, energy system or land ownership, determines the demarcation of the area. Based on this area demarcation, it is examined which other challenges and interests are involved in the area (Nationaal Programma RES, n.d.).

According to Boonstra & Frouws (2005), area-based planning integrates local and regional economic, ecological and social policies to solve specific local problems. They add that in area-based planning, generating legitimacy at the local level is important, through community involvement, mobilisation and empowerment. This participation aspect is also important in the definition by De Boer and Zuidema (2015), who define area-based approaches as "*reaching integrative solutions based on utilising and balancing local potentials, needs and stakeholder interests*" (De Boer and Zuidema, 2015, p.7). De Boer and Zuidema add another dimension, when they explain taking an area-based approach is about looking at "*Local and regional circumstances, such as the characteristics of the landscape, climate and the economic activities taking place*" (De Boer and Zuidema, 2015, p.1). Also in the RES, taking an area-oriented approach is defined as a working method in which the characteristics, tasks and possibilities of an area are at the centre (Nationaal Programma RES, n.d.). This definition is in accordance with the statement from Oudes et al. (2021) who suggest that the development

of energy landscapes should start with reasoning from the landscape and then looking at how sustainable energy supply can contribute to this.

Following from these definitions, the concept of area-based approach has several dimensions. Figure 3 has been drawn up to clarify what academic definitions of area-based will been used as guiding principles in this research.

Figure 3 - Definitions and elements of an area-based approach in planning

2.2.1 Area-based approach and sustainability

A link between the sustainability of SELs and taking an area-based approach can be identified from the definition of a sustainable energy landscape. The definition implies that for a sustainable energy landscape, the main identifier is that it should look at renewable energy that is locally available. Next, the definition implies that the landscape quality, biodiversity, food production and other life-supporting ecosystem services should not be compromised on (Stremke, 2015). In order to achieve this, it is thus necessary to identify what the current landscape quality, biodiversity and ecosystem services are. Picchi et al. (2022) also state that an ecosystem services trade-off assessment enhances the development of sustainable energy landscapes. Only then, energy landscapes can be created that sustain qualities and values of cultural landscapes and sustain activities in the future (Stremke, 2015). This second definition also has a very strong socio-cultural dimension, because it mentions values of cultural landscapes. This socio-cultural dimension is not clearly mentioned in the first definition but is included in the model. Picchi et al. (2022) also state that using a participatory session enhances the development of sustainable energy landscapes.

In itself, the dimensions of sustainability as identified by Stremke (2015) already have area-based elements. To provide an example, one element in the socio-cultural dimension, is to preserve sites with cultural heritage value. In the economical dimension, creating local and regional jobs is mentioned as an example.

3. Methodology

This research aims to explore how an area-based approach can play a role in developing SELs sustainably. In this research, a qualitative approach is used to be able to understand the different dimensions that are at stake. To answer the main research question, this research takes an exploratory approach. The goal is to understand how an area-based approach can be embodied in the development of SELs, and how this might affect the different dimensions of sustainability of such an SEL. In order to research this, the area-based concept is explored broadly.

This research was commissioned by civil servants working at the municipality of Súdwest-Fryslân, who are in the initiation phase of developing a climate park in the municipality. The conceptual idea for a climate park in the municipality, encompasses the idea to combine sustainable energy applications with other systems and tasks in a park-like environment (Gemeente Súdwest-Fryslân, Go with the Flows and Universiteit Twente, 2022). The civil servants have provided me with questions related to developing a climate park that they were interested in answering. These questions related to multifunctionality of SELs, development processes, and sustainable development. In this research, these questions are reflected in the sub questions. The main question, however, is not based on the stakeholders' influence, but follows from previous literature, as was stated in the introduction. To conclude, it is important to note that the methods and data gathering of this research is partly influenced by the stakeholders.

The following paragraphs will introduce the methods used in this research, followed by an introduction on the cases of the case study, the data analysis and the research ethics.

3.1. Methods

3.1.1 Interviews

The first method this research employs are semi-structured interviews. Interviews were conducted with experts that have played a leading role in the development of an SEL. Interviewees were reached by an email, through contact information found online. The interviews were conducted online through Microsoft Teams, or through a phone call. An interview guide was used in the interviews, making the interviews semi-structured, so the interviews maintained flexibility (Dunn, 2016). The guide was co-produced with the stakeholders from the municipality that this research is commissioned by. It can be found in Appendix A. Dunn (2016) notes that it is useful to prepare for the interviews thoroughly beforehand and be well-informed about the subject. In order for this to be true, I studied relevant knowledge that was at hand on the different case studies. Furthermore, according to Dunn (2016), geographers who use interviewing should be careful to claim that they have discovered the truth about a series of events or that they have distilled the public opinion with the interview data (Dunn, 2016). It is important to note that the data gathered from the interviews discovers what is relevant in the project according to the informant, thus these answers may be limited compared to the overall picture.

Table 1 shows the different SELs that are used as case studies, and the accompanied interviews that are done with representatives from the SEL. All interviewees had a leading role in the development of the SEL.

#	SEL	Position interviewee	Organisation
1	Energietuin Assen-Zuid	Project employee	Natuur en Milieu Federatie
2	Energietuin De Noordmanshoek	Project	Natuur en Milieu Federatie
3	Energielandgoed Wells Meer	Administrative project manager	Municipality of Bergen
		Project secretary	Municipality of Bergen
4	Klimaatpark Kerkendijk	Directeur Nederland Opgewekt	Nederland Opgewekt
5	Zonnepark De Dintel	Project manager	Rho adviseurs
6	Zonnepark Bankhoef	Project manager	Pure Energie
7	Energietuin Assen-Zuid	Project manager	Municipality of Assen
8	Solarpark de Kwekerij	Project manager	Municipality of Bronckhorst
9	Klimaatlandschap Waadhoeke	Process coordinator	Weusthuis en Partners - Municipality of Waadhoeke

Table 1 - Overview of the cases and interviews

As is visible in the table, interviews 1 and 7 were both conducted on the case study of *Energietuin Assen-Zuid*. This is because the first interviewee could not answer all the questions that were needed in order to gather the data, because of their recent introduction to the position.

A 9th interview has been conducted with a representative from the municipality of Waadhoeke, a municipality in Friesland which is a bit more progressed compared to the municipality of Sudwest-Fryslan in developing a large-scale SEL. The case of Waadhoeke is not taken as a case in this research because there is no specific area appointed to develop the SEL yet. The interview was solely conducted to understand the process of starting with the development of an SEL. The data will thus not be used in the results of this research.

3.1.2 Document analysis

This research uses a document analysis complementary to the interviews for the case studies. Document analysis is used in combination with the interviews as a means of triangulation - 'the combination of methodologies in the study of the same phenomenon' (Bowen, 2009). Documents from the different cases were gathered that can be found online, or that were provided by interviewees. Mainly project proposals, landscape integration plans (*landschappelijke inpassingsplannen*), and interview articles from news sources have been

used. From these documents, much data could be gathered that fit into the themes of the analysis (Appendix B). Excerpts and quotes were categorised for the different case studies and subsequently for the different codes (Appendix B). This enabled complementation of the data from the interviews, as the documents provided supplementary information on the topics that were discussed in the interviews. Furthermore, in order to answer the first sub question and to look into surfaces and functions of the SELs, maps were used that were found online. These can also be considered part of the document analysis (Bowen, 2009).

3.2 Case study

Social science is not about producing general, context-independent theory, but concrete, context-dependent knowledge. Case studies are particularly well suited to produce this knowledge (Flyvbjerg, 2006). This research employs a case study approach. The diversity of the cases, with their different contexts, gives value to the exploratory nature of this study. For this study, 7 diverse cases of SELs are investigated, which are all located in the Netherlands. Only cases in the Netherlands have been selected because the Dutch spatial planning context is very specific, which might influence the development of the SEL (Roodbol-Mekkes, van der Valk and Altes, 2012).

To find the case studies, an online search has been done using the different concepts that fall under SELs, which are further outlined in Chapter 4. The case studies have a diverse nature, in that they all embody a different definition of an SEL. Also, there are differences in what kind of party (public or private) has had the biggest role in developing the SEL, and there are large differences in the size of the SELs. This diverse nature is chosen in order to fully understand how different SELs develop in their context. The following criteria have been adhered to for all case studies:

Criteria for the case studies

1. The SEL is located in the Netherlands
2. The SEL combines at least two different functions into the landscape
3. In the development of the SEL, the local context is taken into account
4. The SEL is developed or in the last stages of development

Figure 4 - Criteria for the case study

The second criterion implies that next to the function of energy generation, the SEL has another function. This is related to what Oudes and Stremke (2021) call 'frontrunner' projects. These are projects that provide benefits besides electricity generation.

The third criterion also requires a more detailed explanation. Before selecting the cases, online information has been searched for, for the different cases. For all cases, this data showed that they had special attention to the local context. Either this was a focus on the local community, the local landscape, or local nature. For example, for solar park Bankhoef it was mentioned that the plan for the area was made in collaboration with local residents, companies and organisations (Energiecoöperatie Leur and Pure Energie, n.d.). For Wells Meer, it is mentioned that ´it is very important that the *energielandgoed* fits into the current landscape´ (Gemeente Bergen, n.d.).

Only in case study 3, the solar energy systems are combined with other renewable energy systems. This energy landscape also incorporates wind turbines in the landscape. Wind energy landscapes can be conceptualised as a 'layer' type of energy landscape, and they allow for concurrent use of the land (Pasqualetti and Stremke, 2018). In this case, the solar energy systems still present the predominant land use.

In Figure 5, the geographical distribution of the cases can be seen. It can be observed that there are no cases located in the west of the Netherlands. The provinces the SELs are located in, are more sparsely populated and there is land available for these kinds of developments more often (Holland Solar, n.d.).

Figure 5 - Geographical distribution of the case studies in the Netherlands, indicated with numbers based on Table 1

3.3 Data analysis

A thematic analysis was used in this research to analyse the data gathered through the interviews and document analysis. Thematic analysis, with the help of coding, helps to organise a group of repeating ideas, and enables answering the research questions (Vaismoradi et al., 2016). Coding has been done by assigning the statements a certain colour in Google Docs. Afterwards, the statements have been categorised per case and code so that the excerpts could be traced back easily. Appendix B shows the coding scheme that has been used to analyse the data gathered in the interviews. The questions in the interview guide were based on the research questions, and thus the codes are in line with this. The codes have been developed both deductively and inductively. Especially the themes ecological, economical, sustainable-technical and socio-cultural are based on the theoretical framework as developed by Stremke (2015). The other themes are more focused towards the research questions.

3.4 Research ethics

Research, and especially qualitative research involving humans, has ethical implications (Guillemin and Gillam, 2004). To establish an ethical conduct of research, informed consent was used for the participants including an explanation of what the research is about, and how the interviewees play a role in it (Dowling, 2016). The interview participants consented in recording the interview and sharing the outcomes of the interviews for purposes within this research programme. In the consent form it was also made clear that if a participant does not want to take part in the research anymore, they can take back their consent at any point during the research period. Furthermore, the data does not name participants' or other names, only their function in a broader sense.

The code of conduct for research integrity is adhered to (Algra et al., 2018). The interviews were conducted in Dutch to make the interviewee feel comfortable and for them to be able to express everything more easily. Risk of mistranslation of the data is minimised by checking the data after translation of quotes. In case the translation did not capture the full meaning of the quote, the quote remained in Dutch.

Ethical implications also relate to positionality within the research (Hay and Cope, 2016). According to the definition of Dowling (2016), I am an outsider to the interviewees because I am not similar to the informant in many aspects. The case studies I will be conducting are located in different regions from the one I am familiar with. Also, I am not involved in project development myself. It has to be noted that the fact that this research is commissioned by a municipality changes my positionality. The access to sources, information and partly a focus is influenced by working together with this stakeholder. Their interests influence this research.

4. Results

Now that the cases have been described, the research findings can be discussed. First, the concepts that fall under the notion of SELs will be discussed. Secondly, the development process of such SELs will be explored, followed by how an area-based approach can be embodied in the development of SELs. Lastly, this will be linked to how SELs can be developed sustainably. These chapters will altogether provide answers to the sub questions of this research.

4.1 Defining SELs

Within the broader concept of SEL, different concepts can be distinguished that fall within this larger concept. SELs are energy landscapes in which there is specifically made use of solar energy for electricity generation or heat provision (Pasqualetti and Stremke, 2018). Still, this definition leaves a lot of room for differences within the landscapes. The following Dutch concepts that fall under the notion of SELs have been analysed in this research:

1. *Energietuin* (Energy garden)
2. *Energielandgoed* (Energy estate)
3. *Klimaatpark* (Climate park)
4. *Zonnepark* (Solar park)
5. *Solarpark* (Solar park)

Figure 6 - Enumeration of the concepts analysed in this research

The concepts will be discussed in separate paragraphs to go more into detail. The concept of *Zonnepark* and Solarpark are combined here and will be called solar parks, as solar park is the English translation of *zonnepark*.

Overall, the SELs that are taken as a case study range very much in size. The smallest one is 7.1 hectares in size, while the largest one covers 444 hectares. This is not dependent on the typology used but can differ within the concepts also. For example, solar fields in the Netherlands range from 2 to 119 hectares (RTVNoord, 2019).

4.1.1 Energietuin

The *Energietuinen* (energy garden) project is a Dutch initiative which aims to combine recreation, nature, and clean energy (Stremke, 2019; Energietuinen, n.d. -b). Currently, there are four *energietuinen* in development in the Netherlands. The concept was developed and kept by the *Natuur en Milieufederaties,* together with the *Nederlandse Postcodeloterij*, and defined by them as:

> *"An energietuin is a multifunctional place where more happens than just generating green energy. It is also a place where nature flourishes. People can recreate there and learn about sustainable energy. And just as important: we design and make the Energy Garden together with the environment. This should create an experienceable landscape that provides added value for the area."*
> *(Energietuinen, 2022)*

For this research, interviews were conducted on two separate *energietuinen*: Assen-Zuid, south to the city of Assen, and De Noordmanshoek, which is to the north of Wijhe. Interviewee 1 elaborates on what an *energietuin* is according to her:

> *"The energietuin is an area where solar panels are combined with strengthening nature and biodiversity, […] so you shouldn't see it (the solar park and the energy garden) as two things."*

Interviewee 2 mentioned, the idea for *energietuin* De Noordmanshoek is that:

> *"Everything we need as a society, but in a new, sustainable way, is in it."*

Energietuin De Noordmanshoek is developed by a local foundation, in collaboration with the local government and a representative from the *Natuur en Milieufederatie*. In the definition of the concept *energietuin* also lies a strong focus on the societal context, because the gardens are meant to be designed and realised together with people from the specific neighbourhood, municipality, owners and other involved parties. A very clear vision for the *energietuin* was established by the working group. The interviewee mentioned the ideas from the local foundation largely comply with the concept of *energietuinen*. The local foundation De Noordmanshoek has also incorporated plans for housing within the *energietuin*, which is officially not a function that fits into the definition of *energietuinen*. However, interviewee 2 mentions:

"But the Noordmanshoek is also a project of a local foundation who also have their ideas, and that [...] matches in ambition, but it is not exactly the same picture."

Other than the housing function, the functions that are developed on the two landscapes largely overlap. Both *energietuinen* focus on adding natural elements in the landscape, provide educational tours, and recreational routes. Also, both initiatives aim to make the landscape publicly accessible, but this proves difficult in both cases. Interviewee 2 mentions:

"It is true that with the solar field, it was too difficult to make it fully accessible, so there is now a gate there that we only open on occasions. This is mainly for insurance purposes."

4.1.2 Energielandgoed

As of yet, there is one *energielandgoed* in development in the Netherlands. It is going to be located in the municipality of Bergen, at the border of the nature reserve de Maasduinen, called *energielandgoed* Wells Meer. An Energielandgoed is defined, according to them, as:

"In an energielandgoed, sustainable energy is generated on a large scale, for example with solar panels and wind turbines. It is an accessible landscape where there is also room for recreation. Consider, for example, a viewpoint, cycling and walking routes. In addition, the landscape can be used for education and innovation. For example, with informative tours of the area and the development of new forms of sustainable energy." (Gemeente Bergen, n.d.)

Interviewee 3 explains that the name also largely refers to the spatial characteristics of the area:

"That (the history of the landscape) is why the choice was made for the idea of a straight avenue through the landscape, with innovative fields and also space for activity and a visitor centre. That is why it is also called an energy estate."

Thus, the concept relates to the history of the area, which has influenced the plan for the area for the future.

4.1.3 Klimaatpark

The concept of *klimaatpark* (climate park) is applied to one of the cases. The company Nederland Opgewekt develops climate parks and have so far developed several *klimaatparken* throughout the Netherlands. They define the concept themselves as:

"A climate park is a combination of different parts, such as biodiversity, water storage, food forest, vegetable garden, recreation and solar panels. The solar panels provide clean energy and a source of income. These revenues then ensure that the surrounding of the climate park is constructed."
(Nederland Opgewekt, 2022)

Interviewee 4 mentioned that in the climate parks, at least 30% of the area is used for other functions than solar infrastructure. The *klimaatpark* that is taken as a case study in this research is located in Someren, in the province of Noord-Brabant.

4.1.4 Solar park

Three of the cases are identified as solar parks. As mentioned before, many of the current solar parks are aimed at achieving the highest possible production, which means as many panels per hectare as possible. However, recent publications highlight the need to also integrate opportunities for biodiversity and other landscape functions into the solar parks (van der Zee et al., 2019). Interviewee 6 describes the view on this from a developer perspective:

> *"With us and with more and more initiators, landscape integration, adding ecological value, or different multiple use of space is not a point of discussion at all. We would like to do that. However, what you see is that sometimes it is almost reversed. It has to achieve all kinds of goals, and if it can also generate a little energy at the same time, that's great. While all those other things you want to achieve can only be achieved if you also have a healthy financial project."*

Solar parks can range from largely solar infrastructure on grasslands, to open landscapes combined with other functions. The three case studies in this research that are called solar parks are solar park Bankhoef, solar park de Dintel and solar park de Kwekerij. The parks differ very much in their surface area and functions. Also, the spatial design of the three solar parks differs. Whereas the solar panels in solar park de Kwekerij are positioned with much more space in between them, as visible in Figure 7, they are positioned much closer to each other at solar park Bankhoef, as can be seen in Figure 8. This makes that at solarpark de Kwekerij, people can walk in between the panels.

In a solar park with a considerable distance between the rows, there is room for grassland richer in herbs (van der Zee et al., 2019). All three solar parks are designed enabling this. The national '*Zon op Land*' code of conduct currently applies a minimum of 25% uncovered area of the project area (viewed from above) (Tiekstra, 2021). All three solar parks meet this minimum requirement readily.

Figure 7 - Solar park de Kwekerij birds-eye view (Sterkenburg, 2018)
Figure 8 - Solar park Bankhoef birds-eye view visualisation, without incorporation of landscape integration and ecological measures (Pure Energie and Energiecoöperatie Leur, 2020)

Even though the spatial configuration differs between the parks, in their communication they all focus on the multifunctionality of the parks. For solar park de Kwekerij is mentioned:

> *"The park provides an enormous diversity of species, it contributes to climate resilience, social cohesion has grown, and people with a distance to the labor market work there. It is therefore also of social value. That's four birds with one stone." (Boonzaayer, 2019)*

Furthermore, all three solar parks focus on being of ecological value. For example, this is done by adding natural elements and green. Interviewee 6 explains how this is done at solar park Bankhoef:

> *"Between a number of solar fields [...] there will be a hidden hedge. [...] Then you will actually have a shelter over the entire length of that field, where the badger in particular can pass [...] and then on both sides of [...] that ditch [...] 2 metres of herb-rich grassland."*

4.2 Multiple land-use

All SELs that were used as a case study in this research focus on combining different functions. The term function is used, in line with research by Oudes and Stremke (2021), which indicates a capacity to deliver a certain service. The amount and variety of different functions, and how these different functions are combined, differs per SEL. When extra financial resources were available, there was more room to have less of a focus on the renewable energy systems, and more on the other functions of the SEL. This is in line with research by Oudes, van den Brink and Stremke (2022) who state that adjustment of the solar energy systems enables making energy generation compatible with other functions. Interviewee 7 explains how the finances greatly impacts the determination of the functions:

> *"There was already an issue financially. [...] It already has more consequences, say for [...] the greenery, for example, those are more costs that you normally do not have with a solar panel. And we did have the advantage that the initiators knocked on the door of [...] Province of Gelderland. And they also realised that this could become a very special park. They also made a financial contribution. For extra green, so to speak."*

In order to distinguish between the different functions and their spatial configuration, the following graphs visualise how much space the different functions take up in the landscape. First, the surface area of the functions of the *Energietuinen* are presented.

In Figure 9 can be seen that next to the solar infrastructure, a large part of the surface area is taken by greenery in *energietuin* Assen-Zuid. Solar panels will be combined with a variety of planting, walking routes, picnic areas, viewpoints and education. Different parts of the SEL will get a different type of planting (Energietuinen, n.d. -a).

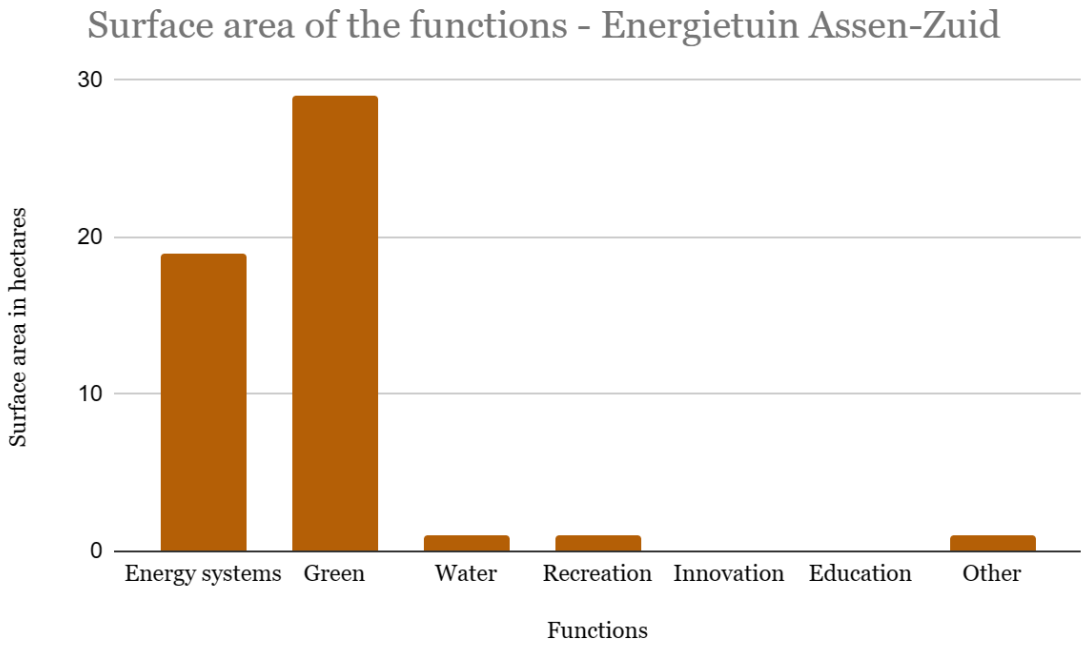

Figure 9 - Surface area of the functions at Energietuin Assen-Zuid (Energietuinen, n.d. -a, Energietuinen, n.d. -c)

As for De Noordmanshoek (Figure 10), there are plans to create a food forest, walking and cycling paths, viewpoints, and recreational spots (De Noordmanshoek, 2022b). The 'other' functions are the development of housing, a picking garden, and a camping ground. These functions take up most of the space and are a part of the plan because of the wishes of the local foundation De Noordmanshoek (Interview 2).

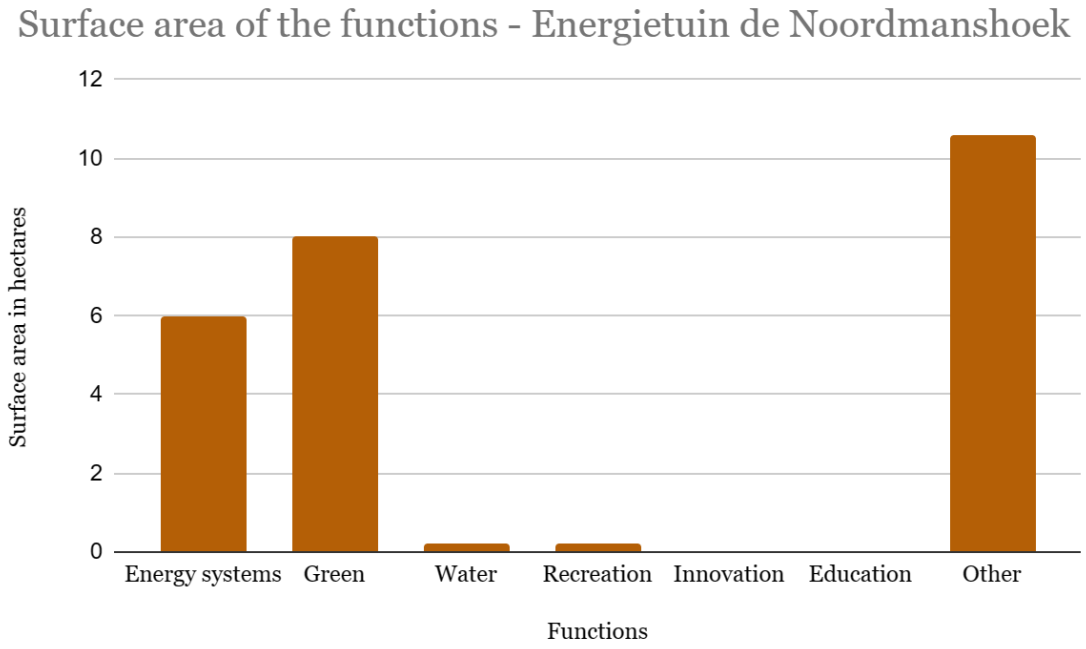

Figure 10 - Surface area of the functions at Energietuin de Noordmanshoek (Wageningen University and Research and Energietuinen, n.d.)

When looking at the allotment of the different functions of the *Energietuinen*, it is visible from the graphs that green elements take up more space in the landscape than the energy systems. Spatially, the aim for *energietuin* Assen-Zuid is that there will be green patches and gardens in between the rows of solar panels. However, for De Noordmanshoek, the solar energy systems are more located in a separate park. It can be said that spatially, the solar infrastructure is more integrated with other functions at *energietuin* Assen-Zuid than at De Noordmanshoek.

Next, the surface area of the functions of the *Energielandgoed* and *Klimaatpark* are visualised. For *Energielandgoed* Wells Meer (Figure 11), it is visible that most of the surface area is used for solar infrastructure. Here, 265 of the 444 hectares consists of solar panels and in between the solar panels four wind turbines are located. Next to the plots of solar panels is room for greenery and recreational routes, which also still covers a large part of the landscape. Furthermore, the SEL will consist of a visitors and innovation center, innovation fields which consist of innovative solar energy installations, and historical elements like a sheepfold (Gemeente Bergen et al., 2019).

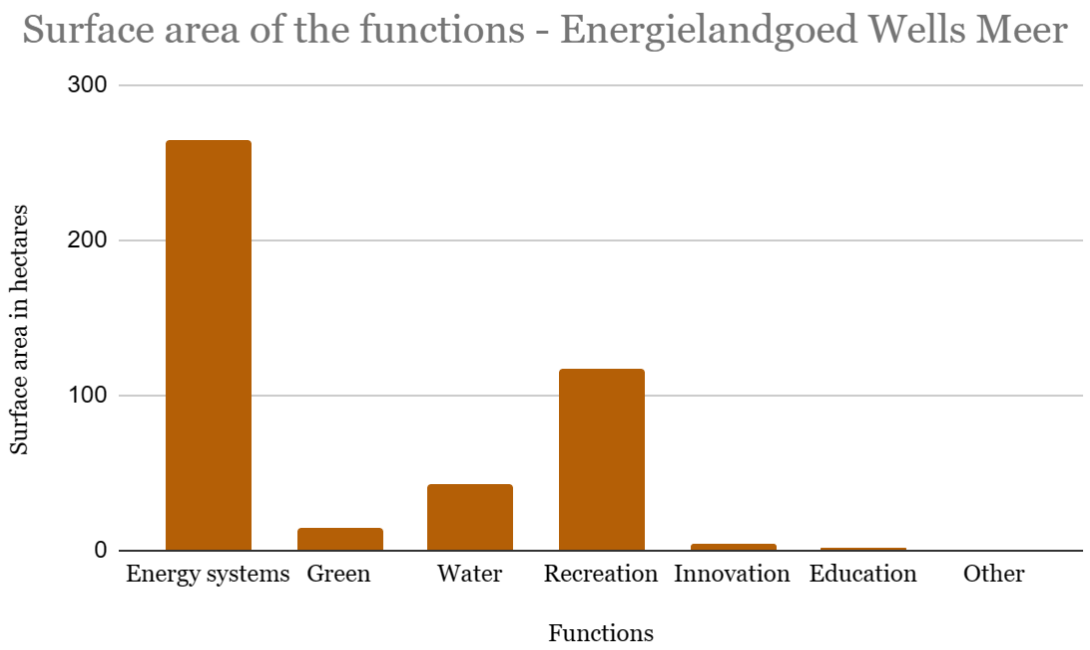

Figure 11 - Surface area of the functions at Energielandgoed Wells Meer (Gemeente Bergen et al., 2019)

For *Klimaatpark* Kerkendijk (Figure 12), most part of the landscape is used for solar panels, and some of it is used for coverage, the community garden, and fruit trees (Nederland Opgewekt, 2023). As mentioned before, the 30% rule is applied here, which makes sure 30% of the area is used for other functions than solar panels (Interview 4).

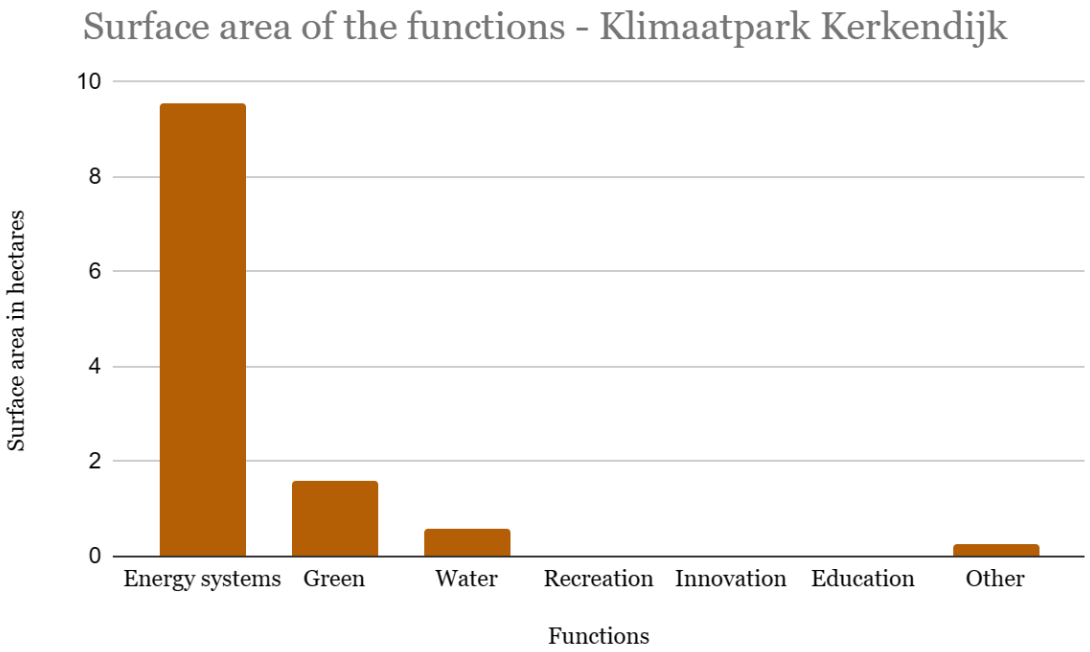

Figure 12 - Surface area of the functions at Klimaatpark Kerkendijk (Nederland Opgewekt, 2023)

Lastly, the surface area of the functions of the three solar parks are visualised. At solar park de Dintel (Figure 13), energy systems are combined with a lot of greenery. The SEL also functions as a water storage area. The park is located outside a dike and forms part of a flood area. This function had to be maintained and the layout of the park had to be adapted accordingly. The solar panels were therefore placed at a height (Tiekstra, 2021). Interviewee 5 elaborated on this:

> *"It was outside the dike, so this zone is also designated for water storage. Firstly, and secondly, the water board cannot guarantee that you will keep your feet dry here, because [...] it could flood. This means that technically it had to be taken into account that the park could be flooded. On the other hand, there was also a clear requirement from the water board [...], this has a certain water storage capacity, and that should not be lost."*

Water can thus be stored underneath the panels. This explains why the water storage function is not visible in Figure 13.

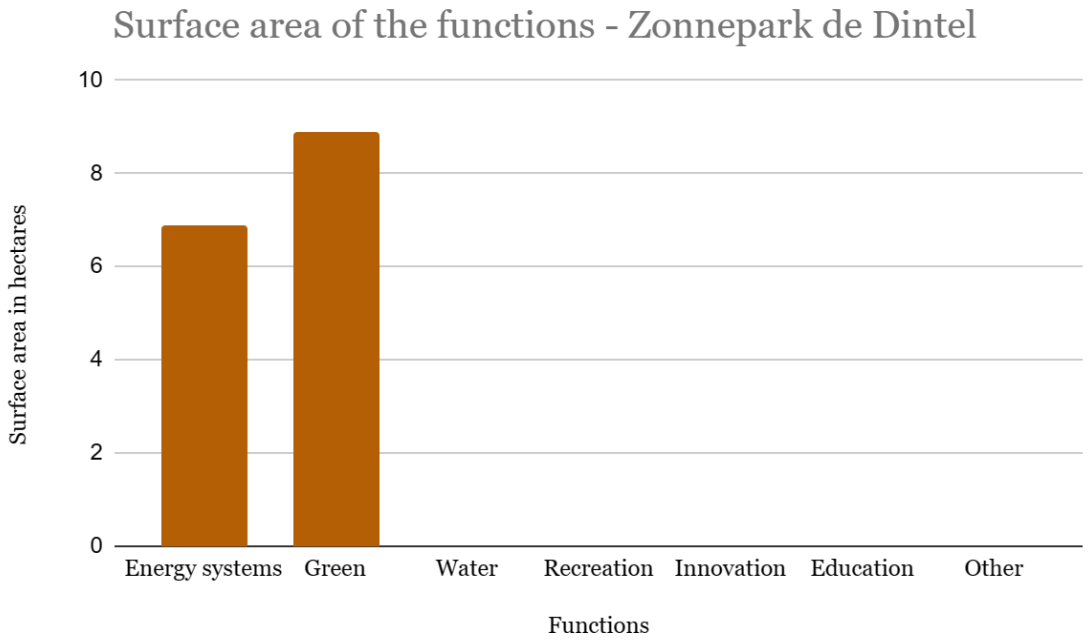

Figure 13 - Surface area of the functions at Zonnepark de Dintel (Tiekstra, 2021)

At solar park Bankhoef (Figure 14), there will be a strip of approximately fifteen metres wide with a hedge, thickets, herb-rich grassland and pollard willows around the entire solar park (Energiecoöperatie Leur and Pure Energie, n.d.). There is an extra focus on greenery and water retention because the solar park is located in an ecological connection zone (Energiecoöperatie Leur, Pure Energie and BügelHajema, 2020). A plot of approximately 3.5 hectares will be added immediately southeast of the plan area. No solar panels will be installed on this plot, but this will mainly consist of herb-rich grassland with extra clover (Energiecoöperatie Leur and Pure Energie, n.d.). In Figure 14, this plot is calculated along, which is why a large part of the solar park consists of greenery. Interviewee 6 explains about the extra plot:

> *"The badger lives in that area and we already took that into account in the plans, but the province is quite strict about that. […] So in the end we had to add a few hectares, which they call a compensation plot, […] set up as an optimal foraging area for the badger."*

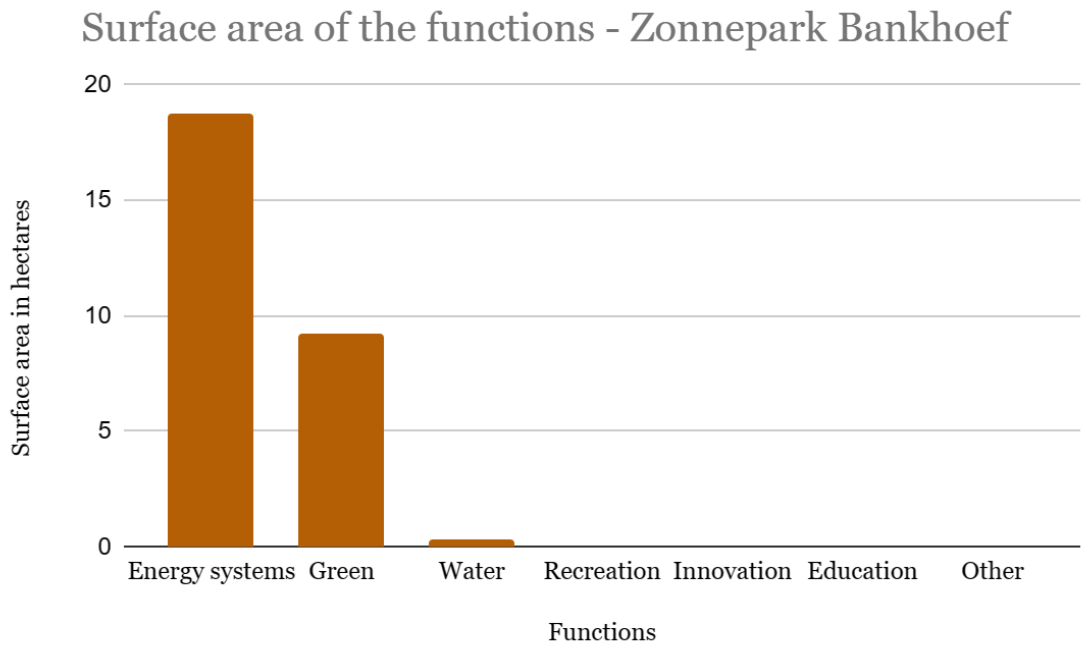

Figure 14 - Surface area of the functions at Zonnepark Bankhoef (Pure Energie and Energiecoöperatie Leur, 2020)

As is visible from Figure 15, a lot of the surface area at solar park de Kwekerij is dedicated to greenery. Next to this, there are some small pools of water, walking paths and recreational areas with picnic tables and playgrounds (Boonzaayer, 2019).

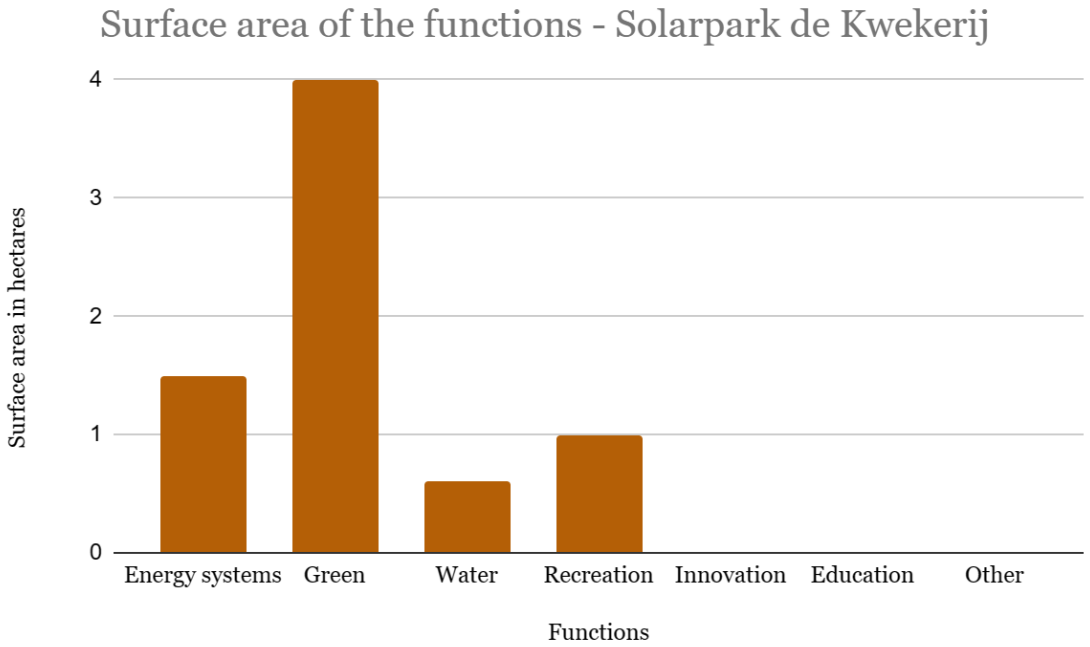

Figure 15 - Surface area of the functions at Solarpark de Kwekerij (Provincie Zuid-Holland, n.d.)

When looking at the plots from the three solar parks it is visible that the functions that are present in all of them are solar panels and greenery. However, functions of an SEL are not always visible in the spatial allotment of the functions. Educational functions of the SELs, for example, often do not take up space in the landscape itself. For Wells Meer we can see in the graphs that the educational function does take up space, since an information centre is planned. However, for the other SELs, no surface is reserved for this function, as with solar park de Dintel:

> *"Lessons can be provided by the initiator at primary schools, where students can become acquainted with the generation of sustainable energy and solar energy in an accessible and interactive way, which includes a field visit."*
> *(Tiekstra, 2021)*

Furthermore, the water storage functions of *klimaatpark* Kerkendijk and solar park de Dintel can also be considered as 'invisible functions'. Underneath the panels, water is stored in wet periods, thus, no space is reserved for this, but it is an important function of the SELs.

In line with research by Oudes and Stremke (2021), the share of land allocated to multifunctionality differs greatly between cases. Independent on the name of the SEL, the functions that were seen most in the cases, next to energy production, are water storage, recreation, and greenery.

4.3 Development of SELs

In the light of this research, it is important to look into the development process because it clarifies what kind of approach is taken in the development. Since this research investigates to what extent such an approach is area-based, and in what form, this chapter highlights from the data the factors that influence this. Naturally, developing an SEL starts with the initiative. Thus, firstly it is important to distinguish between the parties that initiated the SELs. Linked to the initiative, is the aspect of ownership. Furthermore, the development process also largely depends on the stakeholders that are involved in the project. These factors will be discussed in the following paragraphs.

4.3.1 Initiating parties

When looking at initiating parties, first it is helpful to distinguish between private and public initiators. An overview of the initiators and owners of the SELs can be found in Appendix D. Private initiators need their project plan to align with the policies of the governmental bodies, while public parties might build their plans on these policies from the start. Also, municipalities and provinces have to assess applications for permits from project developers. Interviewee 6 explains what this was like for a private initiator:

> *"18 Plans were submitted, and our plan was chosen and then we could move on to the permit application. Some things still had to be adjusted and especially with the province, […] we had to consult for a long time."*

For *energielandgoed* Wells Meer, solar park de Kwekerij and *energietuin* Assen-Zuid, the first initiation was with the municipality. In these three cases, it started with the wish from the municipality to generate renewable energy to reach their sustainability goals. In the case of Wells Meer, the development started with the notion that the municipality wanted to try and cluster the generation of sustainable energy. Interviewee 3 explained:

> *"So, then the idea came up: we want to steer it ourselves. Concentrate everything and not throughout the whole municipality. So, we have established a policy for that as well. We have the omgevingsvisie and that also includes a sun and wind vision. And that also states that we want to concentrate it in one place, so not throughout our entire municipality."*

The interviewee explains that even though the main reason for development was renewable energy production, the intention was always that it was not just the generation of energy, but also extra nature development and also a solar park (Interview 3). In the case of solar park de Kwekerij, the starting point was already characterised by the aim to combine nature with renewable energy systems. Afterwards, the aim was established to do this together with the local community. In the case of Energietuin Assen-Zuid, interviewee 7 mentioned:

> *"The municipality had taken the initiative to build a solar park. We called it a solar park because we were not talking about an energietuin at the time."*

The municipality, however, did state the following aim at the starting point of the development process in the first plan:

> *"Energy-neutral Assen is not only about achieving the greatest possible yield from solar energy. Social support and education also play an important role. The development of a solar park must be managed in such a way that it does not affect the quality of the landscape but enhances it." (BügelHajema, 2020)*

When *de Natuur en Milieu Federatie* eventually joined in the development for *energietuinen*, the focus was on keeping the priority of developing nature as important as the priority of generating renewable energy.

For three of the cases - climate park Kerkendijk, Solar park de Dintel and Solar park Bankhoef - initiation was with a private project developer. Interviewee 6 explains how the initiative came into being:

> *"The idea actually originated with us and the landowners. We have been in contact with each other for years there for that area [...]. And we took that up and also looked at spaces offered in the policy of the province and the municipality, and investigated whether we thought this would be a suitable place, and so the idea originated."*

For de Dintel, it was also the case that the aim of the municipality and the aim from the developer aligned. Interviewee 5 tells:

> *"The municipality wanted to have its own vision, because it also has ambitions when it comes to climate and energy and, on the other hand, also wanted to steer all those applications in the right direction. On the other hand, you also see that landowners and solar developers are very actively looking for locations, [...]. That came together here."*

In the case of climate park Kerkendijk, it was an owner of a piece of land who offered his private land to the developer Nederland Opgewekt. Together, they developed the climate park.

For only one of the cases - De Noordmanshoek - it was the local community who initiated the project. In this case, the municipality of Wijhe owned a piece of land which was supposed to develop into a business park. Since there was no demand for this anymore, a number of residents stood up and asked whether they could make a plan for the area themselves. Interviewee 2 mentioned:

> *"They said, well, then we want to make a green and sustainable area here. And the municipality then said, yes, that is okay, but on the condition that it yields the same rent as it does now, because now it is leased by farmers [...]. And that's how a residents' initiative came into being."*

The interviewee explained that the idea to implement renewable energy systems in the landscape only developed later on, because developing a solar park was the solution to the landscape yielding the same rent. Eventually, a local energy cooperation was involved, and a

working group was formed on the development of *De Noordmanshoek* (De Noordmanshoek, 2022a).

The findings show that in some cases, the initiative started with the aim of producing renewable energy and reaching climate goals, while in other cases, the initiative started with a wish for the local community or wishes of different parties coming together. It also showed that in some cases, the initiative started from the wish to make a multifunctional landscape, while in other cases the focus was still solely on solar infrastructure at the start.

4.3.2 The development process

After the initial goal was established, in most cases, a site was selected. Site selection always needed to be done in agreement with the municipality. Interviewee 5 explains how this was done for solar park de Dintel, which shows linkage opportunities were taken into account:

> *"It is located in an area where wind energy is already present and it also borders a large agro-industrial complex, such as a sugar factory site that is slowly expanding, and they are also working on sustainability. There is also a greenhouse area, so in that sense the municipality thought it fit with that in terms of function and landscape, plus that it is also technically useful to use the power cables that are already there anyway: cable pooling."*

Only in De Noordmanshoek, as elaborated on in 4.3.3, site selection started before establishing the aims of the development. For some cases it was true that the initial planned land-use function for the site was not necessary anymore. For example, the plot at de Kwekerij was initially planned for housing, and the site at Assen-Zuid was initially planned for a business park. In both cases, societal trends made that this land-use function could change. In most cases, the current land-use, which was almost always agricultural, had to disappear for the SEL.

After selection of the site, the design phase started. In most cases, this started with an investigation of the site, both physically and socially. In many cases, first a landscape integration plan (*landschappelijk inpassingsplan)* was made, which takes into account the cultural heritage value of the area, landscape and natural elements. Such a plan relates to the development process since often a decision is required to deviate from the zoning plan. For this, a 'good spatial substantiation' must be drawn up discussing the relevant policy frameworks and environmental aspects. Which permits are actually required depends on the location and the municipality it is located in (Noordover and Walgemoed, 2018). An example from a case in which such landscape integration took place was climate park Kerkendijk, interviewee 4 elaborates:

> *(Dutch) "Je hebt de fysieke inpassing, de sociale inpassing en de financiële inpassing. En met die fysieke inpassing gaat het erover, kun je als je een gebied ook nieuw inkleedt, ruimte toewijzen aan functies die in het gebied nodig zijn. Dat je dus daar eigenlijk een reservering van maakt, in het fysieke ontwerp, om echt een bestemming te maken."*

In all cases, an initial sketch was made for the site after the investigation of the site. Usually this was firstly done by a landscape designer. The local community and other stakeholders afterwards also had a say in the design, usually in a design session. For example, for solar park de Kwekerij, interviewee 8 explained:

> *"In the end, a kind of sketch was made of a very naturally arranged park. […] That idea was then further developed, also with the help of the environment. We involved the neighbourhood in this sketch […] they could think along […] and we were wondering about their view of the design and what could possibly be done more or could be done better."*

For all cases, the participation of the local community and other stakeholders looked different throughout the process. However, participants overall indicated that they thought participation from local residents was very important in the development. Interviewee 4 explains how they took this into account in the development process:

> *"The greatest difficulty is actually being able to 'sell' the change in their living environment to the neighbourhood, as I call it. Actually, gaining acceptance for that change. So that people say okay it will be different, but I'm not afraid of that anymore, I'm willing to accept that change. That's the biggest challenge."*

Interviewee 3 indicated that in the project of SEL Wells Meer, also a lot of energy was invested into participation with local residents. The following was stated in the masterplan for the development:

> *"The municipality of Bergen wants to realise this project in close involvement with the residents. In the steps to date, frequent consultations have taken place with representative groups, such as a sounding board group, a brainstorming group and an expert group. In addition, public information evenings were held, and residents were asked to provide input for a large-scale survey."*
> *(Gemeente Bergen et al., 2019, p.17)*

From the interviews it became clear that indeed these sessions and surveys took place. From the start, the vision of the municipality was to create the SEL 'From and for Bergen' (*Van en voor Bergen*). This was embodied in the process by involving the local community throughout all phases.

When the design is definite, the zoning plan needs to be confirmed by the municipality. For the solar parks, this usually happens with an environmental permit for deviating from the zoning plan for a certain period. This certain period is 25 years, since solar parks are always placed temporarily (Oudes, van den Brink and Stremke, 2022). For the SELs that were initiated by municipalities, a separate zoning plan needed to be established. After this, objections could be submitted by residents and stakeholders. For solar park Bankhoef and Energielandgoed Wells Meer this happened, as became clear in the interviews. The representative from Solar park de Kwekerij mentioned they were rather unique in that they did not receive any objections to the plan:

"And in the end, no objection was received against that permit. And that is now quite special. But the area has of course had the destination housing. So, well, maybe luck, they were special circumstances."

The development process of projects of this scale usually consists of phasing. The development in phases of all the cases is shortly summarised in Figure 16.

Figure 16 - Phases of development of an SEL (Based on Gemeente Bergen et al., 2019; Nederland Opgewekt, 2022; Pure Energie and Energiecoöperatie Leur, 2020; interviews)

Phase 0 is very much about assessing whether it is possible to develop an SEL. Phase 1 follows, in which the area is investigated in terms of the landscape. In phase 2, the project plan is designed in collaboration with relevant stakeholders and the local community. In phase 3, the plan needs to be accorded by the responsible authorities. In phase 4, the site needs to be prepared for building and possible objections need to be considered. Phase 5 is characterised by building the site and phase 6 embodies the management and exploitation of the SEL.

4.3.3 Stakeholders in the development

The development of solar parks can sometimes lead to discussion about the use of the scarce space, where conflicting stakeholders' interests and public priorities may arise (Reed et al., 2017; Van der Zee et al., 2019). The process greatly determines how different interests are dealt with. In all interviews, it became clear that local parties were involved as a stakeholder in the development. Stakeholders that were mentioned were local Institutes for nature education and sustainability (*IVN*), residents' organisations, (provincial) natural management organisations, the Dutch food forestry association, waterboards, and community garden associations. The working group of the projects eventually had to decide on what wishes of the involved parties could be granted.

In the context of the *energietuinen*, from the document analysis and the three interviews, it became clear that the *energietuinen* really focus on combining the different functions in the landscape in an integrated way. They do this especially by having one representative from the *Natuur en Milieufederaties* in the project team, who ensures the process and project is kept integrated by involving all relevant stakeholders and making sure the different functions get enough attention in the development. Interviewee 2 elaborates on their role:

"It is my role to ensure that the project that is there really falls within the definition of an energietuin, so both the process side of participation and integrated design and the outcomes, which improves biodiversity, for example. So, my role was to safeguard that."

Still, there was the conflicting interest from the energy cooperation and the Energietuinen in De Noordmanshoek, since the solar field was already developed when the energy cooperation received the permit to develop it. Then, the solar field development and the rest of the *Energietuin* somewhat became separate processes. Also in other cases, conflicting interests could be identified. Mainly, this conflict arose between residents living near the SEL, and the developers. This will be elaborated on in Chapter 4.4.3.

In the end, all interests need to be balanced out in a certain way in the process. Interviewee 6 mentions the process of developing solar park Bankhoef eventually was very much focused on one stakeholders' interest in the landscape. This related to the governmental focus on the foraging area for the badger. Interviewee 6 explains:

> *"At a certain point, only one interest was considered, the ecological aspect. This actually disrupted the process with [...] two local residents."*

4.4 Area-based approach

In the theoretical framework, the definition of an area-based approach was provided. An area-based approach integrates local and regional economic, ecological and social policies, it takes into account local potentials, needs and stakeholder interests, and it integrates local and regional circumstances (Boonstra & Frouws, 2005; de Boer and Zuidema, 2015). This chapter will look into how all these factors have played a role in the development of the SELs taken as case studies in this research.

4.4.1 Functions

First of all, local governmental policy can have an influence on what functions the SEL should have. As mentioned before, solar park de Dintel had to function as a flood area. The reason for this was policy from the municipality and the water board. Another case in which governmental policy has played a role in determining the functions of the SEL, is solar park Bankhoef. From interview 6 it became clear that provincial policy determined that a compensation plot had to be added to the SEL.

In some cases, local needs and stakeholders' interests also had an influence on the choice of functions of the SEL. In some cases, the wishes of the local community strongly influenced the choice of functions in the SEL. This was the case for De Noordmanshoek, Kerkendijk and de Kwekerij. Interviewee 4 explained that by talking to the local community about their wishes for the plot, they came up with very concrete ideas for the climate park:

> *"And so there you actually see that the physical space requirement was whether they could garden together. So [...] we suggested to those initiators of that allotment, we can also turn it into a social project, by turning it into a community garden."*

In some cases, smaller elements were added for the local residents, like a walking path, benches or a playground (interview 6 and 8).

4.4.2 Design

In the design of SELs, landscape integration plays the most important role. In line with Van der Zee et al. (2019), landscape integration should always be tailor made. Drawing up a *landschappelijk inpassingsplan* is often obligatory for a solar park, and locally, municipalities draw up their own policy on solar energy systems, which sometimes also includes guidelines on their design (Noordover and Walgemoed, 2018). In one of the cases, local policy had an influence on the design of the SEL. In this case, it was ecological policy. Interviewee 3 explains:

> *"To the south side of the energielandgoed, the national park is located, where we want to ensure that nature has space there, so we are not going to do anything there and then we want to see if we can make the stream more natural, so that you can also do something extra."*

This is in line with Van der Zee et al. (2019), who state that no permit will be granted for a solar park in a Natura 2000 area or within the National Nature Network, because this will almost always be at the expense of the area of important nature types.

In all cases, local needs and stakeholder interests were taken into account for the design, as local residents and stakeholders were able to have a say in the design of the SEL. Especially in *energietuin* De Noordmanshoek, the wishes of the local community had an influential role. Interviewee 2 explains inhabitants had a clear view on the design of the project area:

> *"When we asked what people thought was important, then it was mainly the view from the dike and that it should be given a very green lay-out. So actually, they wanted to see them mainly green and not so much all kinds of other things."*

In this case, residents wanted the open landscape to be kept open. In other cases, people would rather not be confronted with the solar infrastructure. This is a general trend in developing SELs, which makes that often, a hedge is planted around a solar field (Van der Zee et al. 2019). In several cases of the case study, inhabitants from the area were concerned about the external view of the SEL. For example, in the case of *Energielandgoed* Wells Meer, solar park Bankhoef, *Klimaatpark* Kerkendijk, and solar park de Dintel, inhabitants from the area appointed this as a concern in participatory sessions. In the following ways, the owners have met the wishes of the community:

Interviewee 3, *energielandgoed* Wells Meer:

> *"One resident said, yes, I want a kind of small dike around my plot, so that I can look around, but not that I have a direct view of those solar panels. So, he had drawn something himself and we did it together with a landscape agency, […] if we are going to implement it, we will also realise it."*

Interviewee 5, solar park de Dintel:

> *"There have been quite a few conversations between the initiators and people from Dinteloord. Although it is quite a bit outside the village, the people from Dinteloord, especially the village association, felt really involved. […] There have been quite a few conversations about what you could do with the interior to make it more pleasant if you go for a walk or cycle there. […] Just by also*

going to the place to ask whatever they want, and what opportunities they see. And that has also been tried to take this into account in the design."

While most of the concerns about visibility come from inhabitants that live close to the SEL, the last quote implies that also residents from further away want to have a say on what happens in the landscape surrounding their living area. In the case of solar park de Dintel, this was not expected by the developers. In SEL Wells Meer, there was already a distinction between the extent to which residents would be engaged, based on how far from the project area they are. Interviewee 3:

"We had different groups, but we always had rings, so ring 1 was all the people who really have a view of the estate, so either they live in the middle of it, next to it and they are not behind a forest [...]. They have received the most communication [...]. And with people who are directly adjacent to it, for example with their garden or who have a direct view of it, [...] we offered to do landscape integration. And that could be anything, that could be an extra hedge, a few trees."

In some cases, local and regional circumstances also influenced the design of the SEL. In solar park Bankhoef, the location of the landscape in an ecological connection zone adapted the design. Interviewee 6 explains:

"At this location, efforts are being made to strengthen an ecological connection. It is therefore important that the layout of the solar park contributes to this. This can be done by planting landscape elements, as also mentioned in the vision on solar energy."

Interviewee 8 elaborates on how local landscape features were also integrated in the design for Assen-Zuid:

"The landscape architect mapped the area, regarding the strong points and what should be paid attention to. And she made the design based on that, so that design already had a lot of room for nature and greenery and so on."

Based on this, for Assen-Zuid, the design for the SEL was made. Also in all other cases, regional circumstances relating to the landscape and ecology played a role in the design. These regional circumstances were first assessed and then a plan was drawn up to see what elements could be added, to integrate the SEL into the local landscape and ecological structures. This then becomes part of the *landschappelijke inpassingsplan*. Local and regional circumstances can also relate to the cultural landscape and cultural heritage. For example, preservation of sites with cultural heritage value was also done very deliberately in the case of Wells Meer. Interviewee 3 elaborates on this:

"The landscape elements that are present are quite decisive, they almost all remain intact. Except for the dirt roads that now run through it. They [...] will change. But at the location where the old country house used to be, will be a visitor centre approximately on that spot. So, the road structure around it will also remain intact. And the Molenbeek, which runs through it, will also remain."

Also, in *energietuin* Assen-Zuid, this was the case, as interviewee 1 explains:

> *"They have looked at what there is in the area. For example, the north side of the area has been laid out in a very parcelled landscape. There are many wooded banks and the like where many birds live, so that is the basis for that area. [...] A great deal of attention has been paid to the structure of the landscape. The panels are also set-up in these lines, the direction of the panels. Taking into account the wet spot of the area. [...] If you look at the landscape [...] it fits well into the landscape."*

4.4.3 Acceptance

According to De Boer and Zuidema (2015), initiatives that are well embedded in the existing physical and socio-economic structures are more prone to acceptance by the local community. Taking an area-based approach can eventually thus also influence whether an SEL is accepted, and in what way. Van der Zee et al. (2019) mention four factors that can influence the acceptance; the extent to which local residents are involved in the project, their economic participation, the alternative land-use of the project area, and the visibility of the SEL.

First of all, for the acceptance of a solar park, it makes a difference whether local residents are involved in the process (Van der Zee et al., 2019). In earlier chapters has already been discussed to what extent local residents are involved in the cases. Secondly, embedding the SEL in the local economy can have an effect on the acceptance. Van der Zee et al. (2019) state that for the acceptance of a solar park, it makes a difference whether residents benefit financially. Economic participation adds to the idea that the residents are also partly owners of the SEL. Interviewee 3 states:

> *"It has been said from the start that it will be an estate of and for our residents, so it is also the intention that people can participate."*

In the case of solar park Bankhoef, an extra step is taken in financial profits for the locality, as part of the profit is reinvested into the local community (Interview 6). De Boer and Zuidema (2015) also found that resistance to renewable energy systems was due to the fact that the installation was situated in their region without them having anything in return for it. In this case, the local population merely faces the social costs instead of also the benefits. In most cases from the case study in this research, people could participate economically, which might counteract this resistance. However, even though this can improve public support, this does not yet guarantee it (De Boer and Zuidema, 2015; Van der Zee et al., 2019).

According to Van der Zee et al. (2019), the chosen location for the SEL can also have an influence on its acceptance. They state that when the landscape was valued more highly in its previous state, before it was developed into an SEL, the negative perception will increase. Often, a more natural environment then seems less suitable than an agricultural area (Van der Zee et al., 2019). Interviewee 6 also confirms this for the case of Assen-Zuid:

"People already knew, that made things a bit easier, […] that there would be industrial estates otherwise."

The last element van der Zee et al. (2019) indicate as to be influencing the acceptance is the visibility of the SEL. In principle, they argue, the less people are confronted with solar parks, the better. This was also reflected in some of the cases, where residents preferred not to see the energy installations. However, Van der Zee et al. (2019) also state that landscape integration is always tailor-made, because this issue of visibility does not mean that it is by definition the best solution to put hedges around it, especially not in an open landscape. This can also be concluded from the findings, as for example at solar park de Kwekerij, the solar park is located very close to a neighbourhood and is quite visible. However, still the neighbourhood approves and sees its added value (Interview 7).

In some cases, there was still resistance against the SELs in that the local residents did not appreciate them, even when the SEL was in many aspects well embedded in the local context. Interviewees mention a general dislike of solar fields as a reason for this. Interviewee 4 for example mentions that people show resistance when the word 'solar panel' is mentioned and relates this to monofunctional solar fields and the resistance against them. Interviewee 2 also mentions that in the case of the Noordmanshoek, even though the area will be filled with other functions, still there is resistance from the community against the solar field. According to Rogers et al. (2018), community-based renewable-energy projects with high levels of public participation, like De Noordmanshoek, are more likely to be accepted by the public than top-down development of large-scale schemes. Even though the initiative of De Noordmanshoek can be called community-based, still it is not completely accepted by all of the community. This might be related to the fact that the solar panels were already installed more separately from the rest of the project area, as interviewee 2 implies:

"There is resistance, even now when we have a meeting about the whole. People say 'Yes, but the solar field, there should be no solar field'."

4.4.4 Process

In taking an area-based approach, the development needs to have embedded ways in which the local context is assessed and taken into account. Thus, taking an area-based approach in developing an SEL also has an influence on the development process. Chapter 4.3.2 already touched upon the most important elements in the development processes. From the results it became clear that in the process, the three dimensions of the area-based approach are embedded in the development processes, looking at the initiative, site selection, and the involved stakeholders in the process. Yet even though elements of an area-based approach were found, the results have not touched upon the overall nature of the projects.

Previously, it has been established that the ownership determines to what extent the development accommodates the local wishes, needs and priorities. Looking at a more general characterisation as such, *Energietuin* De Noordmanshoek was initiated by the community, it has high levels of participation from the community, the local interests had priority throughout the whole process, and the local community has decision-making power. Anyone who is willing, can join cooperation De Noordmanshoek and bring in their ideas (De Noordmanshoek, 2022a). The working group has even been given a formal role as a legal entity in the further planning of *Energietuin* De Noordmanshoek (De Noordmanshoek, 2019). In line with the definition from Rogers et al. (2008), the installation of one or more renewable energy technologies in or close to a rural community, with input from members of that community can be called a community-based project. With regards to De Noordmanshoek, the only difficulty in this regard is that the local community is not the owner of the site (Interview 2). Thus, they do not have full decision-making power. Still, for this SEL it can be argued that the process is area-based in itself in that it completely starts from the wishes of the local.

From the results, a categorisation can be created regarding the extent to which an area-based approach is taken. For this, the ownership is taken into account, and the extent to which an SEL is embedded in the existing physical and socio-economic structures. This categorisation is summarised in Figure 17.

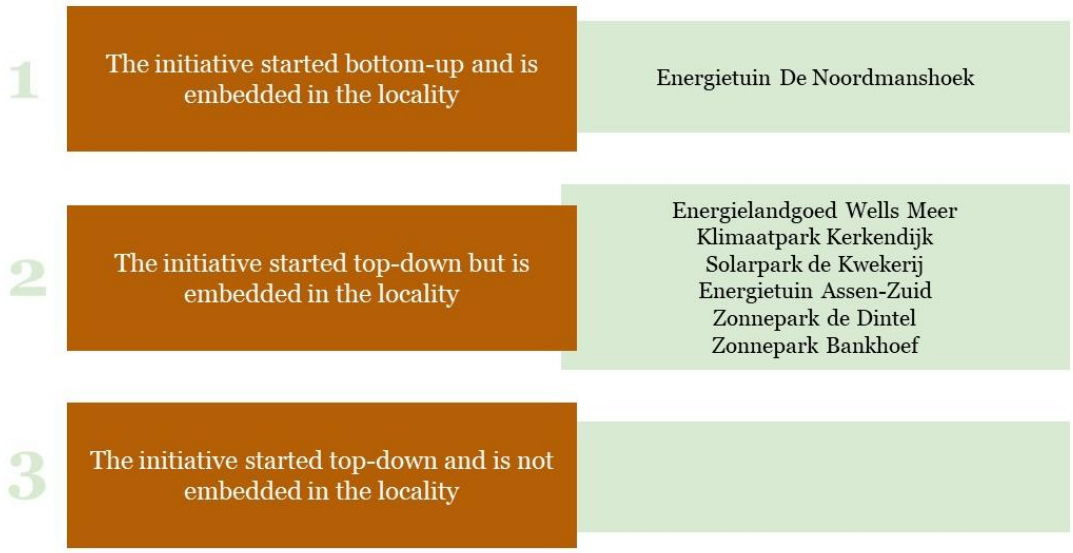

Figure 17 - Distinction between levels of area-based approaches (author)

4.5 Sustainability in SELs

In the previous paragraphs the elements of an area-based approach have been established that are, or can be, embodied in the development of SELs. These elements are linked to the functions and design of the SELs, to the process of development, and their acceptance. Relating these results back to the framework from Stremke (2015) on sustainable energy landscapes, it is clear that there are many ways in which an area-based approach can have an influence on the technical, environmental, socio-cultural, and economical dimension of the sustainability of SELs. For example, in the case of Klimaatpark Kerkendijk, the community

garden was an added value to the neighbourhood. The community garden was developed by granting wishes for the local community. With it, the potential for recreation is improved, and therefore it improves the socio-cultural dimension of sustainability. The same goes for the improvement of recreational possibilities because of the development of solar park de Kwekerij. In solar park de Dintel, the SEL provided investment into the local community with the revenues of the SEL, which improves the economical dimension of sustainability. As a last example, the case of Assen-Zuid shows how the SEL can, by assessing and integrating the landscape, strengthen historical features with the SEL and in this way improve the socio-cultural dimension of sustainability.

In Table 2, more elements of an area-based approach have been pointed out that have been identified in this research. The Table shows whether and how these elements can be linked to the dimensions of sustainability in SELs as identified by Stremke (2015).

Area-based approach elements found in the data and their relation to the sustainability dimensions			
Area-based approach element found in the data	**Description**	**Case**	**Sustainability dimension**
Utilizing and balancing local potentials, needs and stakeholder interests (De Boer and Zuidema, 2015)			
Wishes of local residents	Local wishes influencing the functions	Assen-Zuid De Noordmanshoek Wells Meer Kerkendijk De Kwekerij	+ Socio-cultural
Wishes of residents living close to the SEL	Wishes relating to visibility, influencing the design	Assen-Zuid De Noordmanshoek Wells Meer Kerkendijk De Dintel Bankhoef De Kwekerij	+ Socio-cultural + Environmental
Wishes of residents living further away	Wishes relating to recreational opportunities	De Noordmanshoek De Dintel	+ Socio-cultural
Involving a local landscape management party	(*Landschapsbeheer* or local Institute for nature education and sustainability (IVN))	Assen-Zuid De Noordmanshoek Kerkendijk Bankhoef	+ Environmental
Involving local stakeholders	Involving local interest groups (sounding board or residents'	De Noordmanshoek De Dintel Bankhoef	+ Socio-cultural

	association)		
Local economic participation	Local financial participation to strengthen the sense of local ownership	Assen-Zuid De Noordmanshoek Wells Meer Kerkendijk De Dintel Bankhoef	+ Economical
Local economic interest	Money invested back into the local community	De Dintel	+ Economical
Local exploitation	A local energy cooperation exploits the energy	Assen-Zuid De Noordmanshoek Wells Meer Bankhoef	+ Economical + Sustainable technical
Local management	People from the area manage the greenery	De Kwekerij	+ Economical
Involving local residents for biodiversity monitoring		Assen-Zuid Kerkendijk	+ Environmental
Integrating local and regional economic, ecological and social policies (Boonstra and Frouws, 2005)			
Local policy	Policy from the water board influencing the functions	De Dintel Kerkendijk	+ Environmental
	Policy on an ecological connection zone	De Dintel Bankhoef	+ Socio-cultural + Environmental
Local and regional circumstances (De Boer and Zuidema, 2015)			
Taking into account alternative or previous functions	Minimising the loss of agricultural land	Wells Meer	+ Environmental + Economical
Developing habitat for animals established in the area		Assen-Zuid De Dintel Bankhoef De Kwekerij	+ Environmental
Integrating local vegetation		Assen-Zuid De Noordmanshoek Wells Meer Kerkendijk De Dintel Bankhoef	+ Environmental

		De Kwekerij	
Integrating cultural historic elements		Assen-Zuid De Noordmanshoek Wells Meer Kerkendijk	+ Socio-cultural
Looking at linkage opportunities with other energy systems		De Dintel	+ Sustainable technical

Table 2 - Area-based approach elements found in the data and how they relate to the sustainability dimensions (based on document analysis and interviews)

From the table can be concluded that area-based elements have mainly influenced the socio-cultural and environmental dimensions of the SELs. The sustainable technical dimension has been affected the least, by taking an area-based approach. A direct link to the socio-cultural dimension of sustainability has been touched upon by the respondents often, when they were asked what the SEL really contributed to the locality. In the case of solar park de Dintel, interviewee 5 explains how the developers took into account the landscape in the landscape integration plans, and how this added to the sustainability of the landscape:

> *"We looked at the characteristics of the existing landscape, and the characteristics of the existing piece of nature that was already there, so that we could connect to it. And so that what would be made new for the integration of the park really added value for the existing nature."*

Solar park de Kwekerij is of great recreational value for the local community. Interviewee 8 linked this directly to the fact that the local community was involved closely in the process. This shows how an area-based approach element directly relates to the socio-cultural dimension of sustainability, where one of the criteria is to improve potentials for recreation and ecotourism (Stremke, 2015). Interviewee 8 elaborates:

> *"They can also make great use of the park. The children can play there. Parents are allowed to walk the dog. They are allowed to organise a neighbourhood party and a picnic bench has been placed there as a developer and as a municipality. And then they can do all sorts of activities. So, it also has added value for the neighbourhood, so to speak."*

5. Discussion

Now that the data has been analysed and the findings have been displayed, the different research questions can be answered. The practical implications of these findings will be discussed and related to literature. Afterwards, the methods and data collection will be reflected on.

5.1 Concepts

Although the definition of energy landscapes is still very broad, it is helpful to distinguish specific SELs to understand the aspects of the concept better in practice. The concepts of *klimaatpark*, *energietuin*, solar park, and *energielandgoed* have been explored in more detail as concepts that fall under the 'umbrella term' of energy landscapes, in this case solar energy landscapes. Looking at the first research question, not only the different concepts that were researched differ between them, also the SELs that fall under the same concepts differ to a great extent. In some cases, the names of the concepts already touch upon the main focus of a certain SEL. For example, *energietuinen* focus on greenery, and *energielandgoed* focuses on historical elements in the landscape. Even though such similarities can be found within the concepts, the SELs differ greatly in their spatial configuration. It becomes clear that the concepts linked to the different SELs do not categorise them in a strict way. This is in line with Pasqualetti and Stremke (2018) who already pointed out that energy landscapes can be found in many varieties.

This research has looked into cases of multifunctional SELs in which solar energy systems were not always the predominant land use. Oudes, van den Brink and Stremke (2022) have previously developed a typology of solar energy landscapes in which they distinguish between an energy dimension, an economic dimension, a nature and a landscape dimension in SELs. All of these dimensions can be distinguished in the case studies. This research however indicates that there is more to be added to these dimensions. The function of housing or a community garden, that were found as functions in this research, do not fit into the dimensions as categorised by them. Thus, it is helpful to broaden the definition of SELs, and create a more dynamic typology.

5.2 Functions

According to Oudes and Stremke (2021), SELs share the aim to achieve other benefits besides electricity generation, like reducing visibility or habitat creation. In all cases in this research, it was true that the SELs were developed with the primary aim of electricity generation. However, the examined SELs all use a combined spatial arrangement of solar infrastructure and other functions. In the case studies it was found that functions of SELs can be combined, designed, and used in many different ways. The functions of renewable energy production, greenery, water retention, recreation, innovation, education and others (housing, community gardens, camping places) have been distinguished in these cases. The functions that were seen most in the cases next to energy production are water storage, recreation, and greenery. This contradicts the statement from Van der Zee et al., (2019) that there is still little attention for the combination of solar parks with biodiversity.

It became clear that the extent to which surface area was used for other functions than solar infrastructure greatly depends on the vision with which the SEL was developed, on the

initiator, and on the financial means that were accessible to realise these other functions or objectives. When extra financial resources were available, there was more room to have less of a focus on the renewable energy systems, and more on the other functions of the SEL.

Sometimes, the combinations were deemed as unexpectedly successful by the participants, for instance in combining water storage with solar energy systems. Spatial configurations of multifunctional SELs have been researched before (Oudes and Stremke, 2021; Oudes, van den Brink and Stremke, 2022). However, invisible functions that have been identified in this research have not yet been distinguished in literature. In many of the cases, the invisible functions such as water storage and educational functions were not visible in the spatial allotment of the SELs, but in these cases they were seen as a valuable addition to the landscape by the developers.

5.3 Development process

The first important theme regarding the development processes was the initiation and ownership of the SELs. These factors for all cases, greatly determined what characterised the SEL. In the end, the owner of the SEL can decide on which wishes are granted, and which are not. Research does not often state the importance of this relationship. Oudes and Stremke (2021) only reflect on implications of ownership in their research very briefly, but they do not reflect any further on the importance of it on the development. However, this research has indicated that it does have strong implications for the functions and the design of the SEL. Figure 17 has helped in identifying the extent to which an SEL can be called area based. This framework can potentially be helpful in future research using the concept of an area-based approach.

Another important theme in the development process was the stakeholders. According to De Boer and Zuidema (2015), area-based planning approaches are especially suitable if there are multiple local objectives and interests. From the results it became clear that multiple local objectives and interests were indeed present in all SELs, where sometimes these objectives and wishes were contradictory. According to Flacke and de Boer (2017) it is best to engage with local stakeholders and communities from the very early planning phases onwards, to avoid difficulties in the development. However, difficulties sometimes arose also later in the process, even though expectations were already set from the start. The vision from the start greatly influenced the SEL in the end, regarding what was implemented and their exploitation.

The third theme was the phasing in the development processes. A model (Figure 14) was established to identify these different phases, which broadly fit to all cases. What was not included in this model, were the points in the process where input was asked from stakeholders, residents and other organisations. Participants overall indicated that participation from local residents was very important in the development. This is in line with Picchi et al. (2022), who state that it is important for local inhabitants to identify and express preferences. This also makes a difference for the acceptance of a solar park (Van der Zee et al., 2019). In the results it also became clear that residents living close by but also further away liked to have a say in the design of the SELs. From this follows the question about area-based, on what is actually considered as ‘the area’. In some cases, it is not clear where the boundary is. In defining the concept of an area-based approach, this is something that will always remain dynamic.

5.4 Area-based approach

It became clear that using an area-based approach can have an impact on the functions, design, acceptance, and the process of development of an SEL. Previous research has found that projects seem easier to develop and implement if they directly use locally available potentials and are well matched with existing land use functions (De Boer and Zuidema, 2015). However, processes that have to be set up in order to define the local potentials and wishes, do take more time in the development process. This can for example be embodied in landscape assessments, sessions with local nature organisations and participatory sessions with the local community. The results have also proven that local embedment of SELs is often integrated into the development processes of SELs; in starting the development with looking at local policy that is at stake, in design sessions with residents and stakeholders, and in drawing up landscape integration plans (*landschappelijke inpassingsplannen*). According to De Boer and Zuidema (2015), linking energy initiatives with their physical and socio-economic context is important in creating better societal support and social capital. Picchi et al. (2022) relate this to the sustainability of SELs, and state that using a participatory session and an ecosystem services trade-off assessment already enhances the development of sustainable energy landscapes.

As reflected in chapter 4.4, De Boer and Zuidema (2015) have argued for a direct relationship between local embedment and the acceptance of an energy initiative. Community acceptance, and the accompanied Not-In-My-Backyard (NIMBY) notion, has been a large theme in the field of developing SELs (Flacke and de Boer, 2017). This was reflected in the data, since the developers were aware of local resistance to renewable energy in general. The theme of 'appreciation' was developed deductively from the data because participants often mentioned that local economic participation, or granting residents' wishes, was done to increase the acceptance of the SEL. De Boer and Zuidema (2015) have stated that initiatives that are well embedded in the existing physical and socio-economic structures are more prone to acceptance by the local society and less vulnerable to failure. However, for some cases in this research, local residents still made objections to the plans even though there was a focus on local embedment. For others, it became clear that residents indeed accepted the plan. Nevertheless, a direct relationship cannot be drawn between the local embedment and the acceptance since it is not clear whether other factors have played a role in the acceptance, and to what extent. The acceptance of the SEL in some cases also related strongly to the alternative function of the landscape, if an SEL would not have been developed. In some cases, the plot was already unexploited. However, for some, the current functions of the landscape had to disappear for the SEL, which was then in all cases an agricultural function. The findings were in line with Van der Zee et al. (2019) who state that the higher the value of the landscape in its previous state, the less the SEL will be valued. Overall, these results show how context-dependent the development of SELs, and their local trade-offs and acceptance are. This last statement is supported by research from De Boer and Zuidema (2015) and Walker et al. (2010), who also found that it only makes sense to see initiatives in their own context.

De Boer and Zuidema (2015) argue that the biggest problem with large-scale energy projects regarding their acceptance does not seem to be their spatial and environmental consequences in itself, but mostly the framing of the projects as isolated from the local context. Since case studies were selected that already had a focus on embedding the SEL in the local context, the projects were already framed as embedded in the local context. The cases can thus be taken as examples in which they were not framed as isolated from the local context.

5.5 Reflection on methods and data

This research bridged some knowledge gaps in the literature, obtaining new knowledge in terms of conceptual insights and, yet encountered a number of limitations during the case study application. The cases that were taken only included SELs from the Netherlands. Since the spatial context of the Netherlands is very specific, the results have limited implications for contexts other than the Dutch (Roodbol-Mekkes, van der Valk and Altes, 2012). When implications for such a research need to be implemented to other contexts, research needs to be done in the development of SELs in contexts outside that of the Netherlands. Furthermore, the cases only included a focus on solar power plants, which makes that the full notion of energy landscapes is not touched upon. Also, only frontrunner projects were taken as case studies, which do not compare to 'regular' SELs or solar power plants. Further research could look at energy landscapes in a broader sense in order to understand in what way an area-based is embodied in regular projects or energy landscapes in a broader sense.

It is also important to note that the SELs in the case study were not always fully developed. This makes it uncertain whether the development will, in the end, be like it is planned regarding their spatial configurations, design, function, and added value to the local context. Investigating the cases that were not yet fully developed at a later time, helps in concretizing the results.

Regarding the data gathering, data is only gathered from the developer's themselves and their perspectives on the developments. Residents and other stakeholders in the SELs were not contacted, while a lot of statements are about them. The timeline for this research did not enable broadening the scope so that this view could be included. Future research should, however, include their view to understand the full scope of the implications of the SELs.

Lastly, it is good to reflect on the findings that answer the main research question, which are summarised in Table 2. This table is exploratory in nature, and the results summarised in this table reflect the findings from the interviews and show in what cases the area-based approach elements are found. Thus, a disclaimer needs to be added on the completeness of these results regarding in what SELs the elements are reflected in. Furthermore, the effect of the area-based elements on the sustainability dimensions gives a general overview of the effects of the approach. When an element proves to be beneficial to environmental sustainability, it often proves unfavourable to the economical sustainability, as it harms the economic feasibility. This is in line with the statement from Oudes, van den Brink and Stremke (2022), who state that adjustment of the density of the solar panels enables making energy generation compatible with other functions, which might thus result in a loss in terms of economic feasibility. However, since this can differ very much per SEL and per context, only the positive effects are shown in the table. Further research can add to this overview.

6. Conclusion

Renewable energies are the future, and an important cornerstone of global and national climate change policies (Bianchi and Ginelli, 2018; Flacke and de Boer, 2017). At the same time, it is one of the grand sustainability challenges of the century (Picchi et al., 2022). The energy challenge modifies the landscape, and the changes are not always positively accepted by human society (Bianchi and Ginelli, 2018). Also in the Netherlands, regions have drawn up

ambitious targets for energy transition (Oudes and Stremke, 2018). However, it is argued that there is a lack of sensitivity to local, regional and societal interests (De Boer & Zuidema, 2015). Instead, researchers state an area-based approach is needed in developing energy landscapes. In an area-based approach, the focus is on embedding in the physical and socio-economic domains (De Boer & Zuidema, 2015). How this can be achieved specifically in the context of developing SELs has been explored in this research. Through a case study approach, the research has explored how in different contexts, an area-based approach has been embodied in developing SELs. Stremke's (2015) theoretical framework was used as the theoretical framework for this thesis, together with the definitions of an area-based approach as identified in research. For the analysis of the interviews and documents, themes were developed on the basis of the theoretical framework. The results were then related to the theoretical framework, and this helped in identifying what factors of an area-based approach had an impact on the sustainability of the SELs.

The analysis enabled answering the main research question, which was the question how an area-based approach can play a role in developing solar energy landscapes sustainably. As outlined in the theoretical framework, developing energy landscapes sustainably, by definition, already means taking certain things from the local context into account. This research has however made the relationship between the concept of area-based and the concept of sustainability in SELs more concrete. From these results can be deduced that elements of an area-based approach as distinguished in Figure 3 can be traced back to the researched cases. It has been found that the area-based approach was mostly embodied in taking into account local policy, local heritage values, local vegetation, and resident's wishes. In the results, a categorisation was created regarding the extent to which an area-based approach is taken. For this, the ownership is taken into account, and the extent to which an SEL is embedded in the existing physical and socio-economic structures. The categorisation provides a guideline to using an area-based approach and could be used for further research on this topic in other contexts.

The data has proven that an area-based approach can influence the functions of the SEL, the design of the SEL, their acceptance, and their development process. With this, it also influenced the sustainability of the SELs, mainly with regard to the functions of the SELs and their value in the different dimensions of sustainability for the locality. The elements of an area-based approach can then be related to these dimensions, as is done is Table 2. From this table it can be concluded that mostly the socio-economic and environmental dimensions of sustainability are impacted by taking an area-based approach. The sustainability of the SEL with regard to the different dimensions was shaped mostly through taking into account the wishes of the local residents, and integrating elements from the local landscape and ecology into the SEL. These were also the elements that were touched upon most often by the respondents, when they were asked what the SEL really contributed to the locality. However, all four dimensions of sustainability, as indicated by Stremke (2015), can be impacted by an area-based approach in a certain way. However, when an element proves to be beneficial to environmental sustainability, it often proves unfavourable to the economical sustainability, as it harms the economic feasibility. This shows the development of SELs often comes with trade-offs.

By working area-based, working integrally instead of sectorally becomes the norm. De Waal and Stremke (2014) argue that if we are to strive for long-term sustainable renewable energy

provision, the transition should be approached across disciplinary boundaries. Working area-based can thus play an important role in this. From the results can be concluded that working integrally is often still a challenge in creating an integrated SEL, because often, still the solar energy systems are seen as a separate entity. This is also because the solar energy systems need to be surrounded by a fence. This way, they are treated as separate from the rest of the landscape.

6.1 Relation to wider debates and recommendations

Researchers have argued for the need to approach the development of energy landscapes area-based. However, the practical implications of this had not been defined yet. This research has explored the notion of SELs further, connecting it to their sustainability and an area-based approach embedded in their development. In line with De Boer and Zuidema (2015), this research has added to the body of research that tries to understand how the physical and socioeconomic landscape characteristics influence the sustainability of energy landscapes. It gives value to the body of research that explores the notion of an area-based approach used in planning in the Netherlands. Since this research has provided a starting point in understanding the ways in which the concept is used, more research is needed on how the number of developments that take an area-based approach can be increased.

The typology on the area-based approach presented in this paper gives direction to and provides ingredients for decision-making on energy landscapes. In the planning and designing of renewable energy systems and landscapes, the involvement of environmental designers is increasing (Picchi et al., 2022). This research helps in addressing how the development process of SELs can be designed in a way that it takes into account the local context in all its assets. In line with De Boer and Zuidema (2015), it has been a part of the ongoing research agenda that tries to understand exactly how physical and socio-economic landscape conditions influence the development, success and possible upscaling of sustainable energy initiatives. This also relates to how, practically, this research will be helpful for the municipality of Súdwest-Fryslân in developing a climate park. For this development, it can provide insights into how different functions can be combined in an SEL, what is important in the development process, and in what ways the SEL can be embedded in the local context. In order to be relevant to that context, a study needs to be done into the local context of the municipality and combine that with the findings from this research.

Research is needed to increase the knowledge on how SELs can be developed area-based in order to further achieve environmental, sustainable-technical, socio-cultural, and economical sustainability. Furthermore, policy support is needed to facilitate developing multifunctional SELs that are embedded in the local context. This is especially relevant in the developing SELs integrally, since this still remains a challenge. Such support is key to achieve sensitivity to local, regional and societal interests in developing energy landscapes, to in the end reach climate goals.

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Appendix A - Interview guide

Inleiding

Wat is uw functie?

Het landschap

Waar en hoe is het idee voor het energielandschap ontstaan?

Wie is / werd eigenaar van de grond?

- Waarom?
- Was dat meteen zo?
- Wie zou het moeten zijn?

Was er vraag naar / een idee voor een heel andere functie van het grondgebied?

Welke functies worden gecombineerd in dit energielandschap*?

Qua oppervlakte, hoeveel nemen de verschillende functies in in het totale landoppervlak?

- Is er een functie die wordt / werd behandeld als het meest belangrijk?
- Hoe zijn ze geïntegreerd in het landschap?

Wat is de verhouding publiek en privaat?

- Wat is publiekelijk toegankelijk?)

Het proces

Hoe zag het proces van het ontwikkelen van het energielandschap* eruit?

- Wat was de eerste stap?

Hoe zijn de doelen voor de verschillende functies integraal behandeld in het project?

Is er bij het ontwikkelen van het energielandschap* gebiedsgericht gekeken?

- Wat betekent dit?
- Hoe werd het cultuurlandschap meegenomen in de ontwikkeling?
- Wat wordt er gewaardeerd aan/in dit gebied?
    - Hoe is dit vertaald naar het energielandschap?

Wat heeft het energielandschap echt toegevoegd aan de omgeving?

Belanghebbenden

Welke partijen hadden een rol in de ontwikkeling?

- Wat ging er daarin goed?
- Wat kan er daarin beter?

Hoe participeert / participeerde de omgeving?

- Heeft dit gezorgd voor meer acceptatie van het energielandschap*?
- Hoe zijn de wensen van de inwoners vertaald naar het gebied?

Afronding
Als laatste, als u één ding mag noemen wat van belang is bij het ontwikkelen van zo'n energielandschap, wat zou dat zijn?

**energielandschap*: the specific concept is changed for the different interviews, according to what concept the interview is about

Appendix B - Coding scheme

Sub-question	Theme	Code
1	Definition	Defining SEL
2	Process	Process
2		Ownership
2		Stakeholders
2		Initiative
4	Functions	Functions (of the SEL)
5	Ecological	Ecology
5	Economical	Profits
		Financing
		Financial Community engagement
		Alternative function
5	Sustainable technical	Safety
		Accessibility
		Renewable energy
5	Socio-cultural	Landscape
		Community engagement
		Appreciation

Table 2 - The themes and codes used for the analysis

Appendix C - Dimensions of sustainability

Dimension	Criteria
Sustainable technical	Make us of renewable energy sources
	Employ locally available energy
	Aim for a diversified energy system
	Aim for a self-sufficient energy landscape
Environmental	Reduction of harmful emissions
	Do not compete with food production
	Preserve/improve biodiversity
	Preserve other ecosystem services
Socio-cultural	Attractive landscape
	Preserve sites with cultural heritage value
	Maintain (or improve) potentials for recreation and ecotourism
Economical	Access to affordable energy
	Minimise land-use competition
	Create local and regional jobs
	Maintain/improve secure energy supply
	Economic feasibility

Overview of the four dimensions of sustainability and their criteria (Oudes and Stremke, 2018)

Appendix D - Initiators and Owners of SELs

#	SEL	Initiator	Owner of the land	Owner of the solar infrastructure (after development)
1 & 7	Energietuin Assen-Zuid	Municipality of Assen	Municipality of Assen	Wind Unie Energiecoöperatie Duurzaam Assen
2	Energietuin De Noordmanshoek	Community of Wijhe	Municipality of Wijhe	Energiecoöperatie Goed Veur Mekare
3	Energielandgoed Wells Meer	Municipality of Bergen	Municipality of Bergen	Energielandgoed BV
4	Klimaatpark Kerkendijk	Nederland Opgewekt	Private landowner (Joep Veldkamp)	Nederland Opgewekt
5	Zonnepark De Dintel	ZonXP	Municipality of Steenbergen	ZonXP
6	Zonnepark Bankhoef	Pure Energie	Owners of the De Heerlijkheid estate (Located closeby)	Pure Energie Energiecoöperatie Leur
8	Solarpark de Kwekerij	Municipality of Hengelo	Municipality of Hengelo	Willem-Bernard Investeringsmaatschappij B.V.