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Enhancing the relationship between the landscape of energy transition and the ecosystem services

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[dedication]

a zio Betto che mi segue sempre

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Summary

Governments adopt strategies to follow the objective Europe 2020 and focus on the development of Renewable Energy Technologies, RET, to improve the transition of the production of energy from fossil fuels sources to renewable energy sources, RES. More than decades before, the energy transition towards renewable energies emerges as a relevant objective of the European governments. The fluctuating prices of oil and the uncertainty on the future supply of fossil fuels open new challenges for communities to actuate an energy transition towards RES. The RET can afflict deeply the landscape structure and by this point of view the energy transition is one of the most relevant drivers in the landscape change of the last three decades. In several cases energy transition may face opposition from regions and communities because of the change that RET produce in local landscapes and related economic, cultural and ecological functions.

This change has been defined as a conflict between the local narrative of the right to the landscape by local communities and the global narrative that aims at a low carbon future. Exploring the relationship between Ecosystem Services (ES) and Renewable Energy (RE), the conflict among a global perspective and a local perspective has been resumed by several authors as a trade-off among provisioning and regulating ES from one side and cultural ES from the other. The overcoming of this conflict can be based on bottom-up processes that enhance the energy transition starting by local organizations of communities that want to reach a self-sufficieny in renewable energy supply. Transition management is possible if we produce innovation at local scale. An ES approach supports the transition management and the envisioning future energy landscapes by offering transparent trade-offs, exposing risks and benefits. If societies produce clean energy it may happen that RET afflict other ES. The main paradigm for the sustainability of a energy landscape is that the introduction of RET should not cause crucial trade-offs among the other ES, this is why this research wants to study this relationship, as several authors have already stressed. By the literature review it is possible to state a general gap of knowledge in integrated approaches in the evaluation of RET, considering diverse RES and ES provided by the landscape and evaluating a trade-off through a participatory process. To fulfill such gap and produce an enhancement of knowledge, this research follows the main objective of introducing a trade-off analysis into a design approach to formulate long-term visions for sustainable energy landscapes. The results we got indicate that it is possible to plan and design with the ES sustainable energy landscape.This process facilitates a sustainable energy transition of communities through a participatory landscape design that reduce the trade-off between the Renewable Energy and the ES supplies.

Chapter 1

Introduction

1.1 Problem description

In 1998 The Kyoto protocol was remarking “ Research on, and promotion, development and increased use of, new and renewable forms of energy” (article a, iv, p.2). The international agenda aims at reducing the carbon emissions. Governments emit action plans to reach the objective of the Directive Europe 2020: to reduce the greenhouse emissions of 20%; to increase the production of renewable energy, RE, up to the 20%; and to increase the efficiency in the use of energy up to the 20% in 2020. They focus on the development of Renewable EnergyTechnologies, RET, to improve the transition of the production of energy from fossil fuels sources to Renewable Energy Sources, RES. More than decades before the energy transition figures a relevant objective of the European governments. Member state energy policies promote green certificates and subsidies for investors in renewable energy plants. At regional and local level, national policies can encounter blocks and obstacles from the local administration and NGOs. This is due to the affliction that RET can generate in landscape and ecosystem services and generally a scarce involvement of local communities and broad social consensus in the management of the energy transition process.
This slowdown in the energy transition can be imputed to an inconsistency of governance regulations at regional and local level promoting an energy transition based on communities self-sufficiency and niches scale innovation in technology and transition strategies.
This thesis will consider this problem in relation to community plan and design of a sustainable energy transition landscape, not in terms of energy savings or reduction and efficient use of fossil fuels, but in terms of RE production and self-sufficiency targets.

1.2 Energy transition and landscape change

Societies need an energy transition to RES to face the future energy supply. The fluctuation of oil and gas prices and the conflicts that generate at international level, encourages communities to plan an energetic autonomy. The exploitation of fossil fuels will terminate in the future, and communities will face energy emergency. New plans for fossil fuels exploitation around the world still undermine the integrity of ecosystems and their services, consequently the landscape and public health. Recently strong oppositions are emerging in Italy for several new fossil plants along the eastern Adriatic coast. Impact assessments are favorable but local communities arise in protests scared by the possible contamination and risks for public health (figure 1.1).

Figure 1.1 New natural gas plants and networks in Abruzzo region in Italy (image source https://augustodesanctis.files.wordpress.com).

Energy transition is unavoidable and necessary and governments sustain the transition towards RES in order to support a sustainable development.

In the outcome document of United Nations Conference on Sustainable Development, "Rio+20", we read at point 12: "We resolve to take urgent action to achieve sustainable development. We therefore renew our commitment to sustainable development, assessing the progress to date and the remaining gaps in the implementation of the outcomes of the major summits on sustainable development and addressing new and emerging challenges." And consequently at point 13 "We recognize that opportunities for people to influence their lives and future, participate in decision-making and voice their concerns are fundamental for sustainable development. We underscore that sustainable development requires concrete and urgent action. It can only be achieved with a broad alliance of people, governments, civil society and the private sector, all working together to secure the future we want for present and future generations." (A/RES/66/288, 2012). The scientific world studying the global clima (IPCC, report 2014) stresses the importance of an energy transition to reduce the anthropogenic carbon emission considered responsible of the global warming. The following image (figure 1.2) shows the direct emission in CO_2 by sector; we notice that the electricity sector contributes in the major part (IPPC, 2014, SPM 4.3). The European Union in line with the United Nations and the IPPC adopted strong policies and set targets for the energy transition, as we will se later in this section.

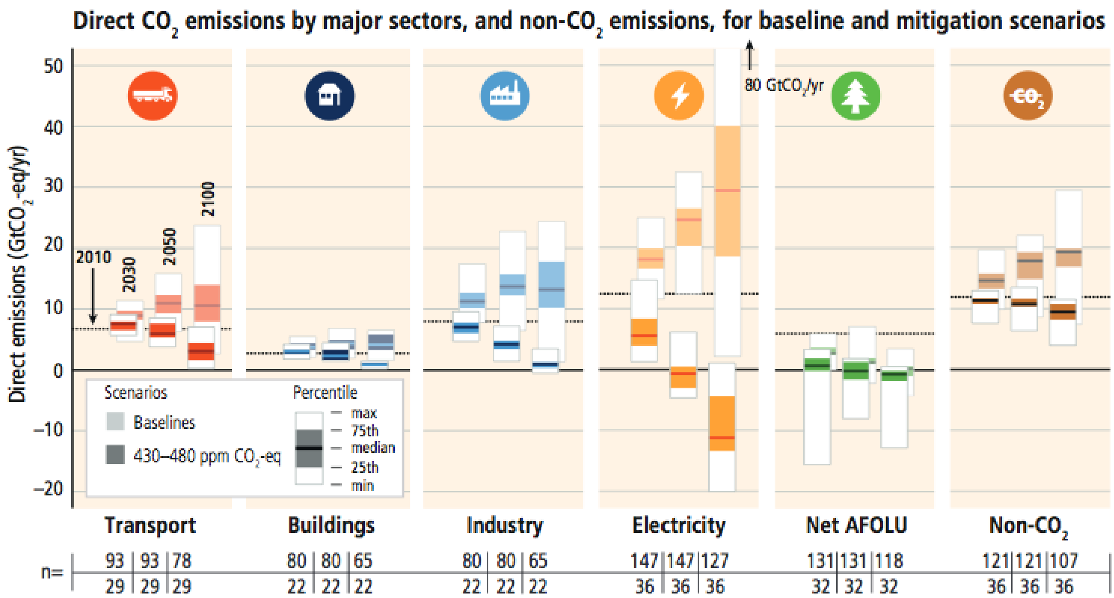


Figure 1.2 The image shows the direct carbon emissions per sector. In light color the actual levels, in dark color the reduction of emission as expected in the mitigation measures to be adopted by policy makers. The electricity production is the major responsible for the emissions, this indicate the relevance of an energy transition for the mitigation scenarios (IPPC Synthesis report 2014, p.28).

The main question remains a sustainable management of this transition, that needs innovation and a bottom-up processes to get legitimacy from communities. Energy transition is a relevant driver of landscape change. The sustainability of renewable energy sources is not only valuable in term of avoided carbon emissions, but also in term of changes that occur in the landscape structure and consequent supply of ES.

Drivers or driving forces are defined as "... the forces that cause observed landscape changes, i.e., they are influential processes in the evolutionary trajectory of the landscape" (Bǜrgi et al., 2004, p.858).

Landscape changes because of the introduction of RET, which become new layers of it (Stremke, 2013).

The Landscape is dynamic (Pedroli et al., 2007, 2013) and changes following the iter of human development. History and archeology shows that the landscape has always been characterized by periods of rapid changes due to specific drivers, natural or human, and long periods of stabilization and consolidation. The frequency and the magnitude of change are important parameters; these directly depend upon the technological means (Antrop, 1997). The more the technology is invasive, the more the magnitude of change increase, as in the case of the energy landscapes. For invasive technology we mean a technology that is intertwined with several landscape layers and dynamics, and this is not necessary related to the spatial extension of footprints. Technologies with a limited spatial footprint can provoke hidden dynamics that result in a landscape change more than sprawled ones. We can think about a calcareous landscape where the installation of a specific technology interrupts or pollutes a subterranean water flow due to an invisible collapse of the subterranean strata. This fact emerges in distance of several kilometers, where the absence or the pollution of water afflicts the vegetation and human activities with the result of a landscape change.

As Selman affirms "Energy production has driven the emergence of distinctive landscapes throughout history, and traditional sites of wind and water power are often important parts of heritage. It is doubtful, though, whether they would have been considered attractive in their heyday" (2010, p. 163).

Anyway the aim of a sustainable landscape development is that the introduction of technology proceeds gradually and with a broad social consensus. This enhances the consolidation of the landscape and its cultural sustainability. Landscape change is unavoidable; the same definition of landscape encloses dynamism and evolution. Populations need time to get costumed with changes in the landscape.

During the consolidation periods the environment gradually incorporates the innovation and very slowly produces a “traditional landscape”, which can be defined as a landscape whose structure is distinct and recognizable by people (Antrop, 1997). Nowadays the technological means applied at the development of RES increase the magnitude of change, while the frequency is strictly depending on policies and regional planning so that some landscapes develop with higher frequency than others protected for their natural or cultural value. This is typical of a conservative approach, that doesn’t allow any compromise, the approach adopted from several Italian regions as seen in the literature discussion, but this is not the approach aimed by the ELC, that looks forward “a perspective of sustainable development, to ensure the regular upkeep of a landscape, so as to guide and harmonize changes which are brought about by social, economic and environmental processes;”(ELC, article1, e, p.10).
Connecting the Antrop definition of landscape change with energy transition, we can affirm that the magnitude of the landscape change during the Sustainable Economy is wider than during the Mineral Economy (Pasqualetti, 2012) because constructs and layers have larger spatial footprints to counterbalance the lower energy content (Stremke, 2013). However, the effects of landscape transformation on site in the mineral economy often exceeded that of the sustainable economy, it is a matter of quantity versus quality of change, we can think about the coal mining landscapes in the Green Metropolis region between Belgium, Netherlands and Germany, that was a whole region providing coal at European scale, of course that landscape was completely transformed from the deep structure to sustain the coal supply.
The interactions between the changing of the landscape and its inhabitants have been theorized by Farina in his Cognitive theory (Farina et al., 2005; Farina, 2006).
According to the author the landscape is a “network of signals and signs” (Farina et al., 2005, p. 236). Signals are received by animals, humans in this case, that get in contact with signs and conscious of the surrounding environment. It is possible to theorize three types of perceived landscape according to the quality of the signal and the status of observer. The neutral based landscape (NbL) is the landscape that is perceived by a passive observer, unable to codify the signal meanings. Von Uexküll postulated the theory of meanings in 1940 (Von Uexküll, 1940).
The Individually based Landscape (IbL) is the landscape that is perceived from the observer able to codify the signals meanings. This ability is due to practice and experience. The difference between the IbL and the Observed based Landscape (ObL) is the mediation of Culture that supports the observer in understand the signals, because he did study before.

The ObL is prerogative of humans. The IbL is common to all the animal races that from practice and experience get knowledge on their own environment. We introduced this theory because could easily support the codification of what happens in the relationship between local communities and RET in energy landscapes. In the case of energy landscapes, intended non sustainable, the introduction of RET causes at time 0 a shift of the perceived landscape, PL, towards the NbL. At time + 1 the experience move the PL towards the IbL, but the contribution of the culture is scarce and the PL doesn't shift so much towards the ObL. In the case of sustainable energy landscape, planned and designed with a broad social consensus and share of knowledge with inhabitants, a time 0 the introduction of RET causes a democratic shift towards NbL, IbL and ObL, this means that culture intermediates and supports new meanings since the beginning, at time t+1, the cultural process and the experience shift the

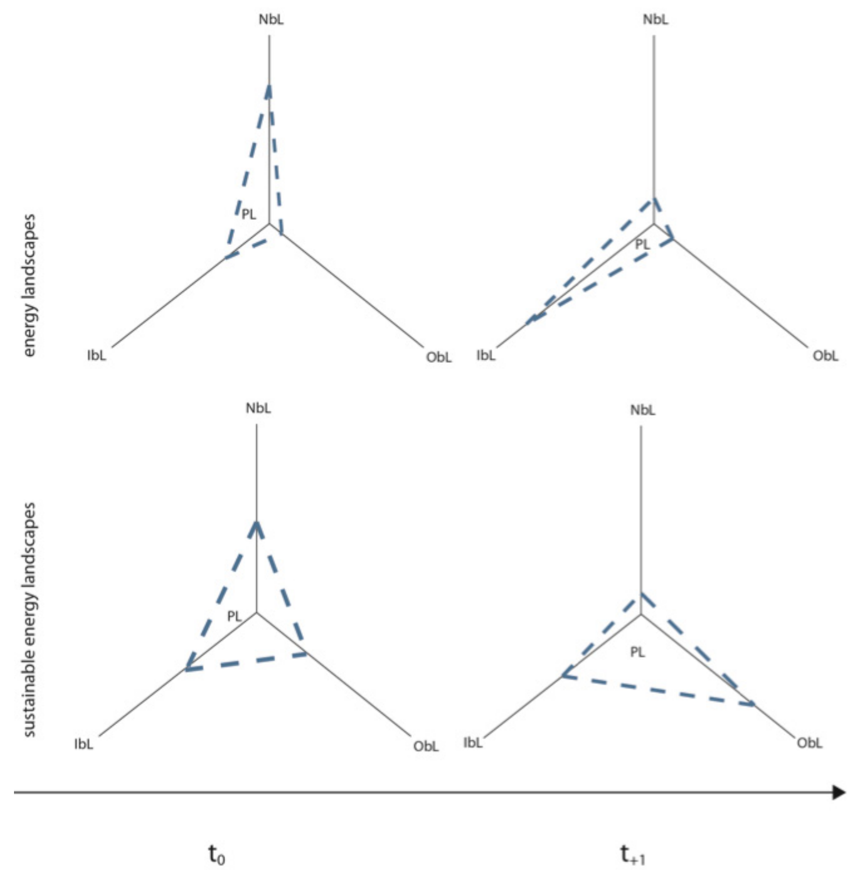


Figure 1.3 The image shows the potential application of the cognitive theory at the energy transition.

IbL at the minimum (figure 1.3).
In several cases Nations face difficulties in actuating an energy transition for oppositions and blocks at regional and local level (figure 1.4).
These are due to the change that RET produce in local landscapes and the risk of affliction of cultural, ecological and agricultural production values and consolidated economic activities connected to these as tourism. As Antrop notes, "the ever faster changes to landscapes are experienced by an increasing number of people as a threat" (2005, p. 188).
Referring to renewable energy landscape Pasqualetti notes that most of people believe that their landscape won't change, it is a sort of faith (Pasqualetti, 2011); they expect permanence in their landscapes (Pasqualetti, 2000). This expectation is at the base of the conflict. Expectation not only in terms of permanence of the landscape appearance but mostly in terms of permanence of the human activities based on the landscape status quo. This expectation for permanence is comprehensible if the installation of RET is perceived as something imposed bottom-up and as something that will bring profit not to the local communities but

Figure 1.4 The recent movement of "Nopowercrop" in the Abruzzo region, Italy. Citizens protest for the top-down imposition of a Biomass power plant in Avezzano (http://www.comitatomarsicanonopowercrop.it/

to the energy companies.

The conflict has been synthesized as a trade-off among provisioning and regulating ES from one side and cultural ES from the other (Van der Horst and Vermeylen, 2011). In order to understand why this conflict arises we should look back at the theories on transition management. We will see in the literature discussion that The Netherlands developed relevant theories to face transition. Why could not the local and global narratives be integrated and find synergy? The question can be properly related to the modality through which governments manage the energy transition. Energy action plans decided at National level are imposed in a top-down process to regions and communities, while we should orchestrate the energy transition starting by the aspirations of local communities, this requires share of knowledge, information and participatory processes. In the following sections we will see how the success of a transition is guaranteed by introducing innovation at local scale, in a bottom-up process where communities influence policies.

1.3 Literature discussion

The first step of this research had as aim an introductive discussion of the literature, in order to frame the problem as stated in the previous section. This literature discussion was organized in two stages, a first one discussing the relationship between RE and policies, the second one the relationship between RE and spatial disciplines.

The relationship between RE and policies was analyzed referring to EU level and two national levels: Italy and Netherland. The two countries were chosen considering the fact that Italy renewable share is actually the 15% of the total use, having the country a weak tradition in transition management and participatory processes, Netherlands renewable share is the 9% of the total use, having the country a strong tradition in transition management and participatory processes, a strong and innovative research in Energy Landscapes at the University of Wageningen, Gelderland. Further after some attempts to individuate an adequate case study in Italy the research gained a contribution to the DEESD project and a case study in the Netherlands.

1.3.1 Renewable Energy and policies

1.3.1.1 The EU level

The European Directive 2009/28/EC EUROPE 2020 remarks that "…member States should therefore support national and regional development measures in those areas, encourage the exchange of best practices in production of energy from renewable sources between local and regional development initiatives…" (3). Still at point 14, the directive underlines "The main purpose of mandatory national targets is to provide certainty for investors and to encourage continuous development of technologies which generate energy from all types of renewable sources". At point 23: "Member States may encourage local and regional authorities to set targets in excess of national targets and to involve local and regional authorities in drawing up national renewable energy action plans and in raising awareness of the benefits of energy from renewable sources." It is possible to resume two main key measures:

1. Diversity of RES supply
2. Involvement of local and regional authorities in the formulation of action plans

The directive 2009/28/EC Europe 2020 substituted the directive 2001/77/CE and the 2003/30/

CE through the directive 2011/77/EC. According to Directive 2009/28/EC EUROPE 2020, action plans have the objective to manage the energy transition at local and regional scale. This means to define stakes and involve actors at local and regional level in order to address specific laws at National level. Action plans and strategies are intermediate means to address the National legislation towards an adequate transition management. What has been the implementation of 2009/28/EC in EU member states? We will examine briefly the main facts in Italy and Netherlands.

1.3.1.2 The Italian case

Italy implemented the directive 2020 and the 2011/77/EC in the DL 28/11 on the development of production and use of RES. The DL 28/11 defines the Italian target to reach the 17% of RE production in 2020 (National Objectives, Art. 3). The DL 28/11 refers to the same authorization procedures as in the DL 783/2009 that in Art. 12 at comma7 remarks that the assessment for the installation of RET must safeguard the biodiversity, the cultural heritage and the rural landscape as described in the law 5 march 2011, n.57 (points 7 and 8) and the DL 18 May 2001, n.228. Art. 14. Further the DL 28/11 delegates the authorization procedure and the guidelines for the installation of RET at Regions and Autonomous Provinces that have to redact their guide-lines. The DL 387/03, that implements the 2001/77/EC, refers to National Guide-lines on the authorization procedures, in reality these have been published in delay in 2010, DL 10 settembre 2010, and this caused relevant problems in the energy transition management between regions and state (Ammanati, 2011). Ammanati affirms: “Over time, although the path towards developing RES has been designed by the European rules, the Italian legislator, on the one side, has put in place uncertain and incomplete rules which were often implemented by both the Constitutional Court and the administrative judges. On the other, the legislator’s activity reveals a high degree of ‘non-compliance’ with the European timing in establishing the steps of the energy policy [...]. The uncertainty in defining regulatory contents and framework has a relevant influence on the investment projects of market operators and, as a final result, an increase of the ‘social cost’ of the system that sums up the economic cost with both the costs of lengthy and exhausting bureaucratic procedures and the eventual costs for users and consumers due to lack of investments and consequently lack of competition” (Ammannati, 2011, p.26-27). This lack of National guide-lines, allowed regions, according to the art.12 DL 387/2003, to create their own regulations

and guide-lines. Regional guide-lines define the areas suitable for RET installation. Some regions as Apulia (2004) proposed design principles to introduce them into the landscape.
In several cases, as for Apulia, Calabria and Molise, regional governments regulated specific procedures for RET authorization that blocked or delayed the realization of RE production targets. The authorization was based on criteria as the type of RET, the spatial footprints and the safeguard of environmental aspects, the landscape and the cultural heritage. In many cases, as for Calabria, the Constitutional Court recognized these authorization procedures too restrictive and not Constitutional because limiting the capacity of Italy in reaching the objectives of European directives (Ammannati, 2011). In other cases, as for Apulia region, the Constitutional Court legitimated some environmental compensation as required from the regional government. Those restrictions limited the access to a free market of RES from investors. The Italian government edited the Action Plan in 2012 (Strategia Energetica Nazionale).
While the EU directive 2009/28/EC promotes the making of Action Plans to regulate the energy transition management at regional and local level, the Italian Action Plan limits the question to general observations in governance section 4.7: the "modernization of the governance". The most significant measures are resumed as following:

1. In line with the Plan of the energy infrastructure at EU scale, based on the experience of EU northern countries, the institution of a public debate is challenging in order to facilitate, even before of the authorization procedures, a sharing of knowledge for the introduction of the infrastructure in the territory and its socio-economical context;
2. The public debate should avoid protest from the local communities, frequently due to a lack of knowledge and information on the infrastructure to be realized and the local impacts;
3. The introduction of a cost-benefit analysis at local/regional/national level is necessary in order to show advantages and disadvantages of the infrastructure especially in relation to what could be the costs of a delay in the scheduled time of realization.

The 2012 Action Plan generally seeks for the involvement of local communities, but it doesn't address in what way this could be operated. In 2014 the share of RE in Italy reached the 32.9% of the electricity consume and the 15% of the total use (Legambiente report, 2014). Data from the last Legambiente Report show that the number of "comuni rinnovabili", the municipalities that got a self-sufficiency energy production based on RES, is increasing. The actual share anyway is due in large part to the hydro-power energy production.

1.3.1.2 The Dutch case

About the situation in the Netherlands it is necessary to remark some relevant measures. The Dutch government updated the Fourth National Environmental Plan in 2001, the NMP-4, “A world and a will”. This introduced and institutionalized the term of “transition” (for the definition, see section 1.5). Transition management was considered a challenge for several Dutch ministries. Transition management with a focus on energy transition originated in policy making at the Ministry of Environment and at the Ministry of Agriculture. Then this became subject of the Ministry of Economic Affairs, the Ministry of Agriculture and Innovation and the Ministry of Environment and Infrastructure (Kemp and Loorbach, 2006). The NMP-4 edition was based on prior research focusing on transition management and innovation system . The transition management approach is useful to reach long-term benefits and not short-term specific objectives (Kemp, 2011). Fragmented policies and institutional deficits as well as short-term thinking are considered as barriers to sustainability and transition management in the Dutch NMP-4 (Dinica and Arentsen, 2003). The efforts of the NMP-4 did not find a real correspondence within the formulation of renewable energy policies. Incoherence, inconsistency and incongruence in the Dutch energy policy are found by Dinica and Arentsen (2001, 2003) and Kemp and Loorbach (2011). The Dutch Energy Policy has been based on green labels or green certificates and subsidies to investors on RET since the 1990’s. At the beginning of 2000 the share of RES in the Netherland was the 1,2% of the total use (Dinica and Arentsen, 2003). Dinica and Arentsen affirm “Dutch policy approach is that being so comprehensive it induced confusion on potential developers, such as private individuals, farmers, small firms, cooperative and local communities, of whom much more was expected in terms of investments […]. Local communities and local governments have strong legal instruments to block the erection of new green electricity facilities. This point has now been recognized in the central government’s announcement to overrule local authorities in case of persistent local resistance. Thus far, it is clear that the green electricity

1. The DTO program, that started in 1993, was anticipating the NMP-4 and developed technological solutions. In 1997 the task group Technology was established and this was involved in the program of NMP-4 under the name of KETI to develop innovations and governance issues. It was in KETI that the concept of transition and transition management was developed (Kemp and Loorbach, 2006).

market in the Netherlands is still in an infant stage of development" (Dinica and Arentsen, 2003, p. 620).
In 2011 the share of RES in Netherlands reached the 4.3%. In September 2013 the SER, a council that advise the Dutch government on socio-economic affairs, facilitated and publishes the "Energieakkoord voor duurzame groei" (Energy agreement for sustainable growth). The SER defined 10 pillars for long-term and mid-term agreements; among these the third pillar encourages "local sustainable energy" (EU Country report, 2013). "There are now hundreds of local energy initiatives. These show in their ideation, plan and realization a strong need for information, knowledge and exchange of knowledge" (SER; 2013, p.37). In section 5 (SER, 2013, Pijler 3: Stimuleren van decentrale duurzame energie) the agreement remarks that municipalities and provinces should produce their own spatial policies to decentralize the supply of RE in close consultation with civil society. Developers and public authorities must handle the "Elverding" approach, an early involvement of stakeholders. The Government will facilitate this by simplification and harmonization of regulations especially in the case of wind energy. For example about heat and cold storage it stresses the involvement of 'owners' associations, energy companies, housing associations, cooperatives, and associations of greenhouse horticulture companies on business sites".

1.3.1.2 Comparing

This discussion on energy policies and regulations both in Italy and Netherland can be resumed as in the following figures (figure 1.5-1.6). Actually the main actors of the energy transition are the energy companies. The policies are built as green labels or green certificates per RES/RET, supporting investors through subsidies. Policies do not address and regulate bottom-up processes. The advantage of Netherland is in having investigated on the processes of transition management and system innovation (NMP-4) that according to Geels (2002, 2004) are successful if based on bottom-up processes involving local contexts, because innovation emerges at niches scale. The last Italian Energy Action Plan starts talking about the involvement of local territories in the energy transition debate, with a cultural slow-down of a decade in comparison to the Dutch situation. If the Dutch approach, through a transition management, is perceived as a development approach, the Italian one is perceived as a

2. Translation of the author

conservative one, and the rules defined at regional level aims at protecting the environment and the landscape and defining design principles to keep the main values against energy plants imposed top-down according to National guide-lines. But the facts say that Italy actually has a higher share of RE on total use than the Netherlands. This must be attributed to wider and uncultivated territories where RET can be installed with limited oppositions, and of course for the hundred years long history on hydro-power which contributes in large part to the actual share of 15%.

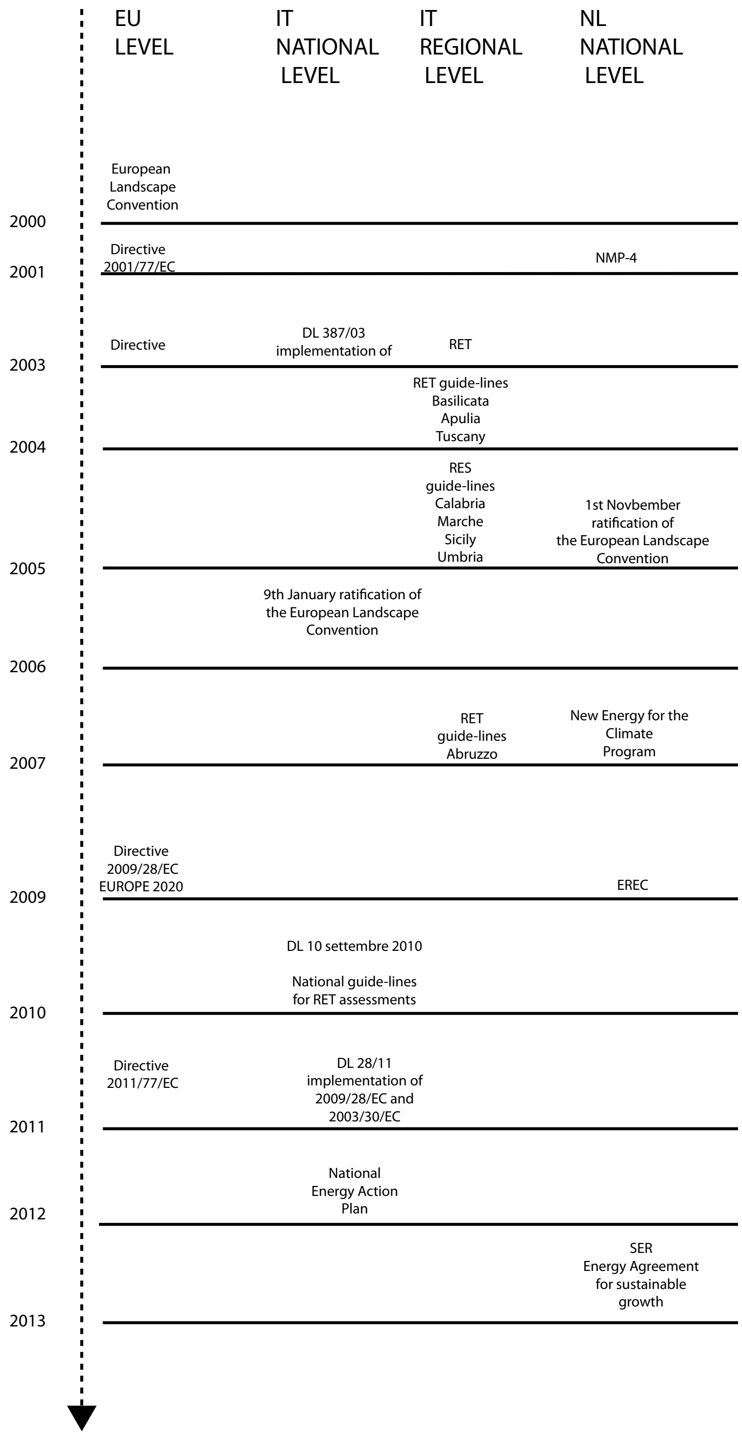


Figure 1.5 Temporal scale and administrative level regulating the energy transition process in Italy with a comparison with the Dutch national level as mentioned in the discussion above.

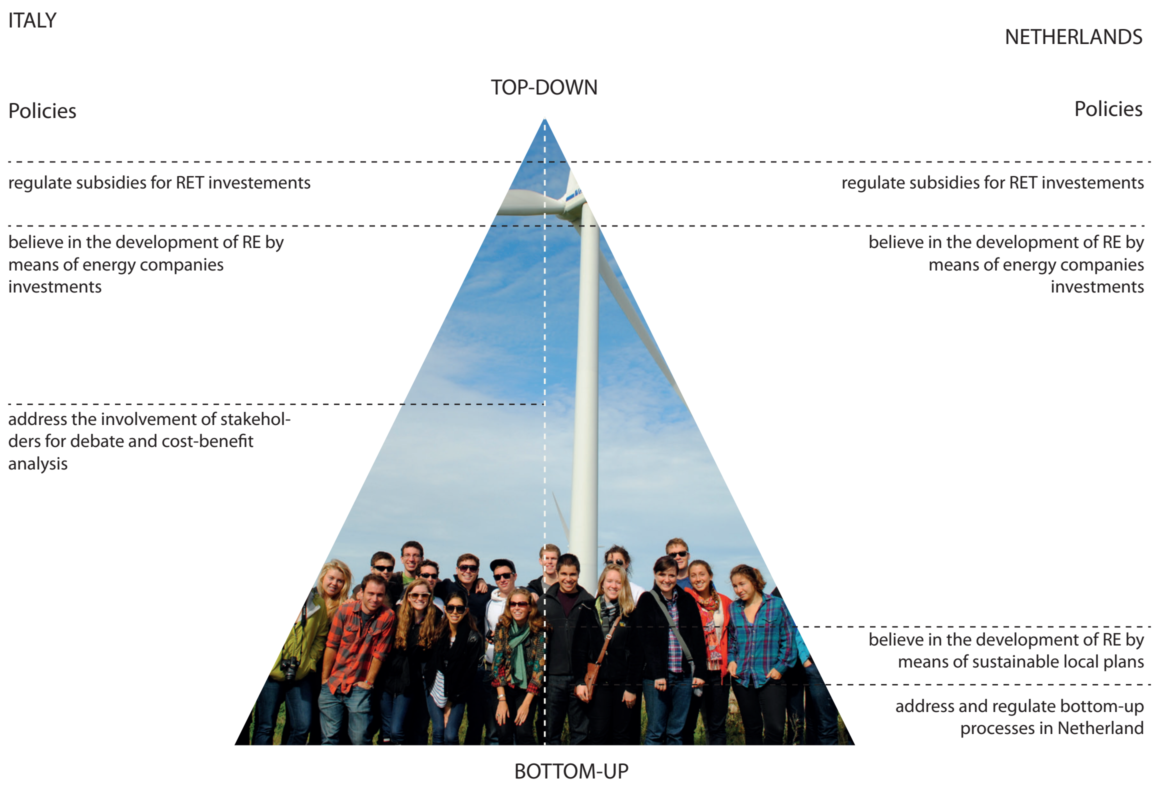


Figure 1.6 The image resumes and interprets the actual situation of policies for both Italy and Netherlands, the pyramid indicates the tendency towards bottom-up or top-down processes.

1.3.2 Renewable Energy and spatial disciplines

In this section we will examine briefly how spatial disciplines relate to the energy transition. The energy transition requires space. When we talk about "space" we move the discussion towards the relation among RET, the environment and their spatial organization. According to Sijmons "because the two perspectives of energy and space largely proceed independently of each other, opportunities are missed to integrate them in an intelligent and desiderable way" (Sijmons, 2014). The spatial organization of renewable energy is a challenge for the transition. If we introduce the human perception in the perspectives of energy and space, we move from the spatial dimension to the landscape dimension or perspective (Blaschke et al., 2013). The European Landscape Convention defines the landscape as "... an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (ELC, article 1,a, p.9). Therefore a landscape perspective cannot bypass the human perception.

The notion of energy landscape comes from geography and landscape ecology: "Energy landscape is a landscape whose image and herewith the functions (natural, productive, residential, recreational, cultural, etc.) have been significantly affected by the energetic industry" (Frantál et al., 2014, p.2). This definition, focuses on the impact of RET on the landscape, and doesn't address in what way these should be studied in a development perspective. Actually the notion of energy landscape became a recurrent topic in the academia in the last 15 years and still is quite ambiguous (Stremke, 2015). Pasqualetti (2012) structures the concept of the energy landscapes in construct and layers, the layers are part of the physical landscape while the constructs can he physical or socio-cultural.

By a landscape architecture perspective Sven Stremke defined the concept of energy landscape in the following way: "Energy landscapes, in other words, are not always distinct spatially bound landscapes such as the coal mining landscapes in Lusatia, Germany. In most cases, the energy landscape is nothing but one of the many layers of complex, multi-faceted and heterogeneous landscapes" (2015, p. 2). This concept supports a Landscape Architecture perspective where the energy landscapes are one of the layers part of the landscape, if we read the landscape in a multi-layer approach (Mc Harg, 1967).

In the last two decades renewable energy landscape dynamics have been studied by geographers and landscape ecologists for the impact of RET on the human perception of the landscape. Studies as Ladenburg and Dungaard (2009) or Gee and Burkhard, Meyerhoff et al. (2009), Drechsler et al. (2009), were investigating how the perception of wind farms could afflict the cultural values of the landscape using visual parameters typical of the visual landscape theories and environmental psychology (Zube et al., 1982, Zomm, 1984; Kaplan et al., 1990; Nassauer, 1995; Scott and Canter, 1997; De la Fuente et al., 2006; Kaplan and Kaplan, 2009). Natural scientist and environmental planners were also interested in assessing the relationship between RE and ES (Burgess et al., 2012; Coleby et al., 2012; Blasckhe et al., 2013; Howard et al, 2013). Land use/Land cover is the spatial reference system that most of studies adopt to evaluate this relationship, but a landscape perspective is frequently envisioned in theory but missing in practice. This provokes difficulties when we want to use scientific knowledge in landscape planning and design. If these studies produce data sets on renewable energy landscape dynamics, we wonder what is the utility of these data if not used for energy landscapes planning and design. The knowledge on landscape dynamics is necessary in order to envision future scenarios in renewable energy landscapes. In the proceedings from the Congeo Conference "Exploring new Landscapes of Energy", held in Brno, Czech Republic (2011), we read "New deliberative, interdisciplinary and integrated approaches are needed to manage the required transformation process and to create a vision for change across publics and different stakeholder groups, sectoral and administrative boundaries, which constitute the scope of landscape planning and decision making process" (Frantàl, 2011). "The creation of a vision" as in Frantàl words can be handled through the formulation of integrative, both in process and substance, landscape scenarios.

Policies and spatial disciplines agree in the need of defining approaches to manage the energy transition both from an energetic and spatial point of view. The contribute of spatial disciplines as Landscape Architecture seems to be not relevant if not in a top-down approach, while the involvement of stakeholders and the definition of future scenarios seem to be relevant for a successful energy transition.

Strategic spatial planning together with landscape design appear nowadays as suitable disciplines in performing such objective by means of orchestrating trans-disciplinary approaches through regional design capable to envision future scenarios and to consider uncertainties. Strategic spatial planning focuses on processes and "implies that some decisions and actions are considered more important than others" (Albrechts, 2006, p. 1155). Strategic spatial planning deals with formulating strategies shared by local stakeholders to solve critical situations along with development perspectives. Differently than classical planning, it considers the presence of external forces afflicting development. According to Healey *et al.* (2009) "Strategies encourage a momentum towards some directions rather than others. In the public sphere, they are thus political acts, challenging established power dynamics and mobilizing energy to move in different directions, although there are all kinds of ways in which such strategies are grounded in formal political jurisdictions. Because such strategies are social products formed to do governance work, they raise difficult political questions about their legitimacy and accountability." (p. 442). Stremke *et al.* (II, 2012) remark, "spatial planners embrace scenario thinking, but have little information about how to give shape to a desired future. While landscape architects may posses the skills to design desirable physical environment, but fail to incorporate critical uncertainties in the design process" (p.313).

In the last decade we witnessed an increasing consciousness in Landscape Architecture on the role of landscape architect in assisting populations in the energy transition management (Minichino, 2014). Stremke et al. evidenced how it is possible to build a methodological framework that affords energy transition management when we joint Strategic Spatial Planning and Landscape Architecture, intended as planning, design and management (Stremke, 2012, II). The authors matured a framework, the *Five-step approach*, based on the formulation of scenarios for Sustainable Energy Landscapes (SEL). These are defined 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 and Dobbelsteen, 2012, p.4).

The Five-step approach enhances a strategic spatial planning approach (Dammers et al. 2005; Albrechts, 2004) by means of translating strategies, actions and actors, into spatial interventions and concrete design strategies. The definition of SEL includes as sustainability parameters the ES. The Five-step approach seeks for planning and design of renewable energy landscapes that provide optimal levels both for RE and other ES. According to Inverson-Nassauer and Opdam "Environmental benefits have been part of the intent of design in landscape architecture and planning since the 19th century" (2008). This quote reveals in the specific word "intent" the actual situation. In most of cases environmental benefits are still an intent in landscape design and planning and there is a detachment between quantitative and qualitative data produced in scientific research and concrete application of those in problem solving and practice. This is also true with regard to the energy transition and the planning and design of renewable energy landscapes where such "intent" is manifested but rarely finds concrete applications in a trans-disciplinary approach. As remarked at the beginning of this section, knowledge from ecology, environmental planning ad landscape ecology should be integrated into landscape planning and design and this necessity emerges clearly also in the planning and design of sustainable energy landscapes. We will see how the ES approach represents a challenge for the practice of energy transition. In the following flowchart (figure 1.7) we represented the complex of spatial disciplines and how the different knowledge flows can be combined towards the plan and design of sustainable energy landscapes.

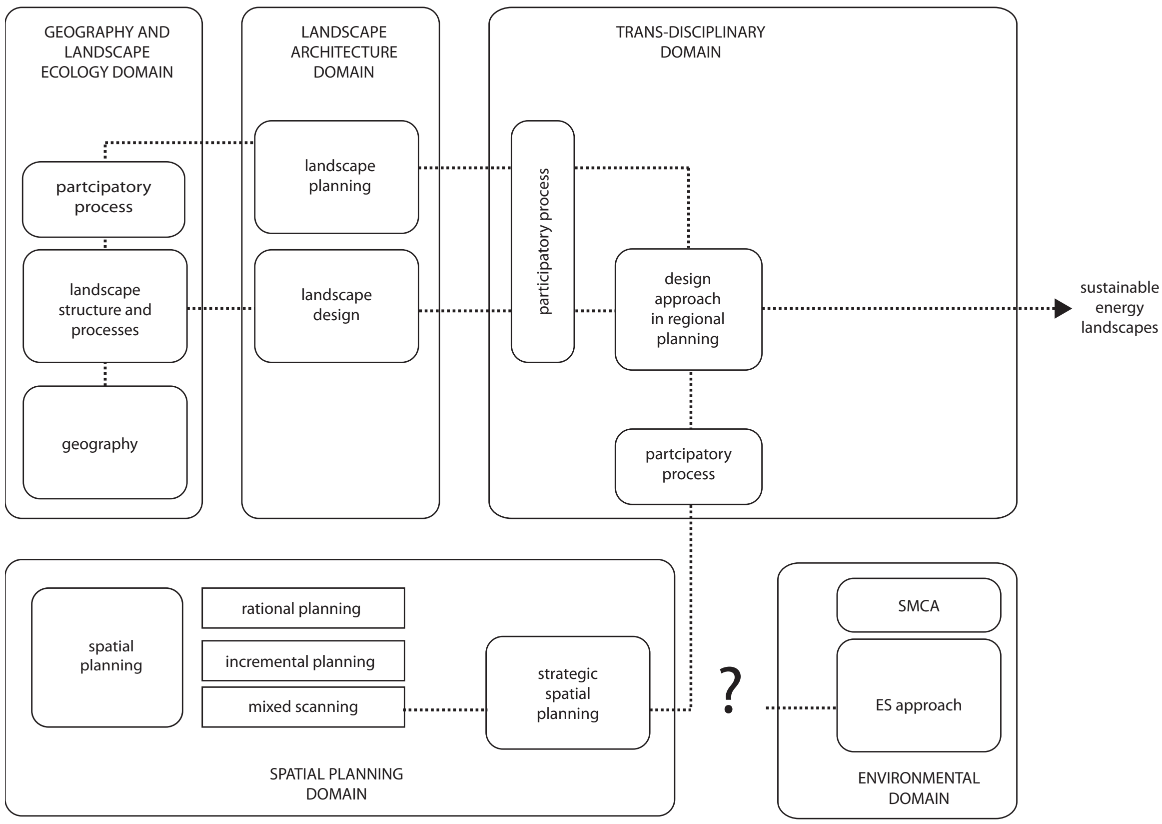


Figure 1.7 The flowchart represents the contribute of spatial disciplines to the study, the plan and design of renewable energy landscapes towards the sustainability. A trans-disciplinary approach address sustainability and the question mark indicates the knowledge gap amd the challenge to make an ecosustem services approach part of this trans-disciplinarity.

1.4 Knowledge gaps

We now state the knowledge gaps. The following flowchart (figure 1.8) shows the logical sequence that this thesis will follow. From the initial literature discussion we detect some knowledge gaps. In policies we note that specific regulations for community based energy transition are missing, even if local sustainable energy initiatives are promoted. We moved through spatial disciplines to find valid and relevant approaches able to afford such transition management, we found it in Landscape Architecture. Design approaches at regional scale, based on participatory processes at local scale can manage the energy transition, but frequently they do not integrate data from applied sciences as Landscape Ecology and Environmental Planning, data on trade-off between RE and ES. In chapter 5 we will focus on the trade-off between RE and ES and we will investigate how this can be evaluated in a landscape perspective.

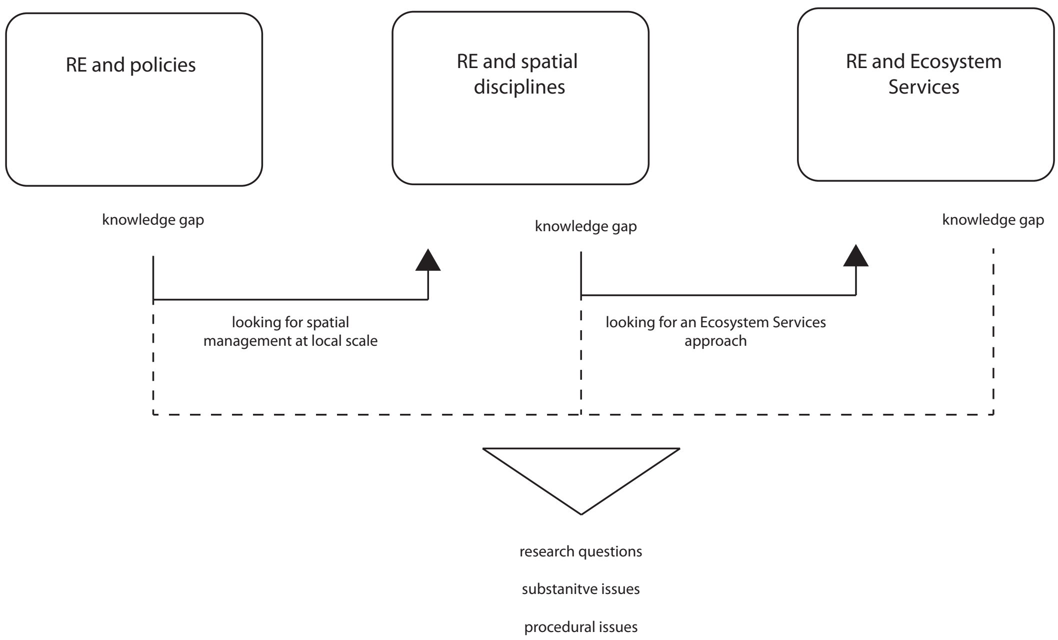


Figure 1.8 Flowchart illustrating literature review and knowledge gaps.

The gaps of knowledge we identified are resumed as following. Policies and spatial disciplines have been investigated in the first preliminary overview, the ES have been investigated as literature review reported in chapter 5:

RE and policies

1. Absence of -Policies regulating bottom-up processes and community based energy transition

RE and spatial disciplines

2. Absence of- design approach for planning energy landscapes including ES assessment

RE and Ecosystem Services

3. Absence of- integrated approaches where multiple ES are studied in relation to diverse RES, in a landscape perspective and through participatory processes.

1.5 Goal and research questions

The research seeks to implement the plan and design of the energy landscapes in order to perform optimal levels in both supply of RE and ES. In this perspective we can identify two sub-goals: 1) To design an efficient framework to evaluate the trade-offs among the supply of Renewable Energy and the supply of Ecosystem Services, 2) Introduce and test this framework in planning and design an energy landscape case study in a trans-disciplinary approach. Therefore the main research question is:
How to implement the plan and design of the energy landscapes in order to perform optimal levels in both supply of RE and ES?
Considering the problems and the knowledge gaps that emerged from the preliminary literature discussion,the following research questions were formulated:

1. What are the parameters for landscape sustainability in the energy transition era?

2. What is the contribute of planning and design the landscape to energy transition?

3. What are the approaches and ES categories in RE assessment?

4. What are the methods for assessing synergies and trade-offs among ES and what are the spatial reference systems?

5. How can Cultural ES be assessed in trade-off with other ES and what the spatial reference systems?

6. How ES and RE relate to one another from a landscape perspective?

7. What is the added value of an ecosystem services approach for planning and designing sustainable energy landscapes?

8. How does energy landscape design affect the supply of ecosystem services?

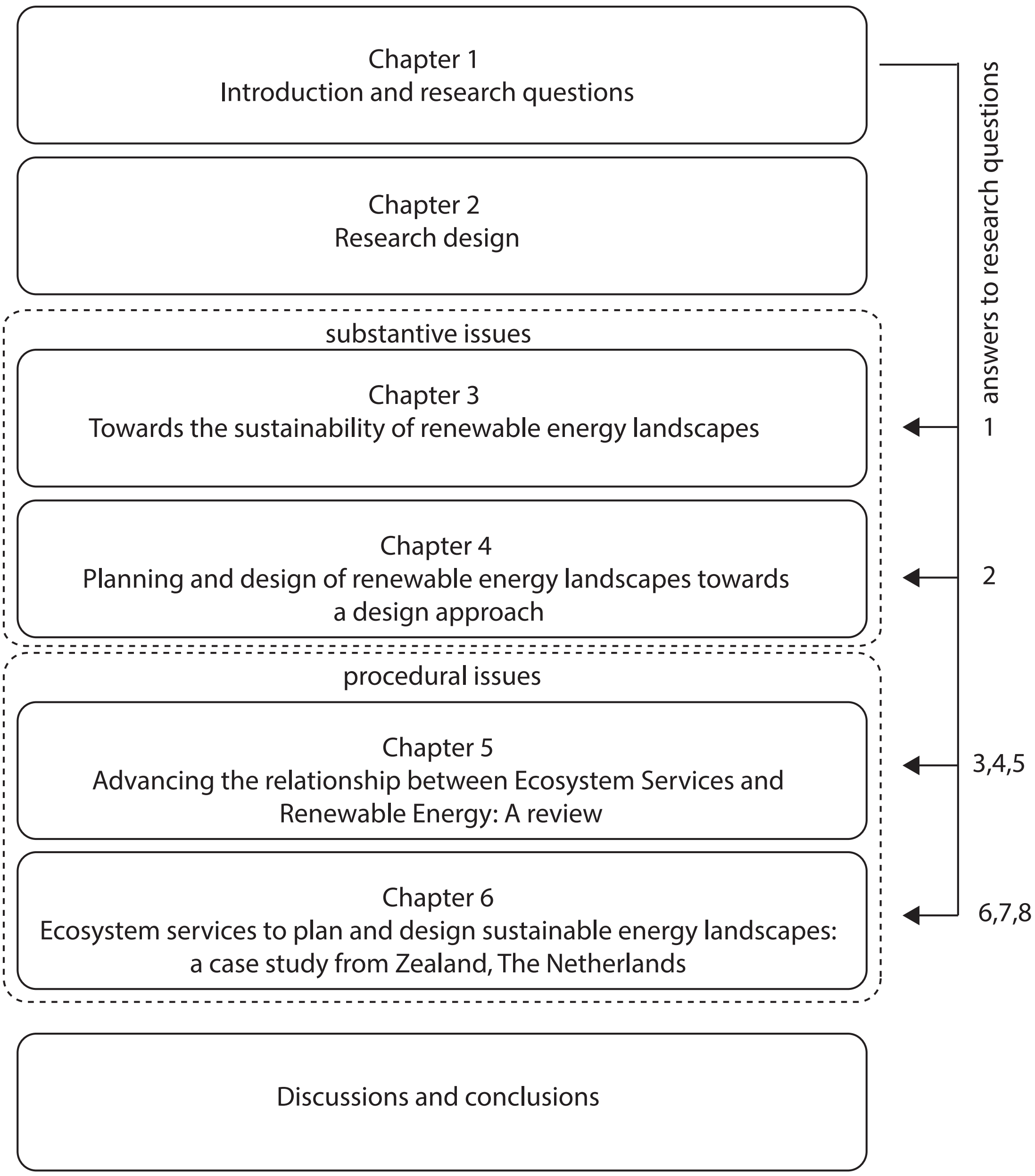


Figure 1.9 The structure of the thesis.

1.6 Organization of the thesis

This thesis is organized in 6 chapters (figure 1.2). In chapter 1 we introduce this research, explaining the state of the art and concluding with the knowledge gaps. In chapter 2 we present the design of this research: what are the philosophical worldview, the strategies of inquiry and the methods applied. Chapter 3 and 4 report about the main substantive issue in relation to renewable energy landscapes: the theories that help in reading and understand them, the planning and design approaches with the reference to some design projects and provide an answer to the research questions 1 and 2. Chapter 5 and 6 report the advance of procedures for the planning and design of sustainable energy landscapes as in the objectives of this thesis. These chapters correspond to the theoretical and application investigations of this research. Chapter 5 is based on a paper which is under review by the Ecosystem Services journal, and that was conceived, mature and developed by the author of this thesis together with colleagues from Wageningen University, NL. The chapter reports the literature review on the relationship between RET and ES. Chapter 6 is based on a paper, which is to be submitted to the Landscape Journal before the defense of this thesis, and that was elaborated and developed by the author of this thesis together with colleagues from LAR and Alterra, Wageningen University and Research, NL. Questions 3, 4 and 5 are answered in the chapter 5, questions 6,7 and 8 in chapter 6 of this thesis.

In the discussions and conclusions final chapter we resume the theoretical and application results defining future effort in the research for planning and design of sustainable energy landscapes. The nature of the composition of this thesis, including two scientific peer-reviewed papers, may cause some repetitions of concepts and definitions.

1.7 Definitions and vocabulary

In this section we give an account of definitions of phenomena, concepts and disciplines.

Transition

In general, a transition can be defined as a long-term, continuous process of change during which a society or a subsystem of society fundamentally changes. A transition can be described as a set of interconnected changes, which reinforce each other but take place in different areas, such as technology, the economy, institutions, ecology, culture, behaviour and belief systems. A successful transition is a spiral that reinforces itself, driven by multiple causalities and co-evolution. A pre-requisite for transitions to happen, is that several developments in different domains at different scale-levels come together to reinforce each other. (Rotmans and Kemp, 2003)

Sustainable Energy transition

Sustainable Nergy Transition is aimed at achieving environmentally sustainable energy systems throuhg increasing energy efficieny, promoting Renewable Energy Sources and Sustainable Transport (Strong, 1992; 1993; Solomon and Krhisna, 2011)

Embodied Energies

Represent all the energies and greenhouse emissions which are related to a given landscape (Nadai and van der Horst, 2010)

Energy-conscious planning and design

Energy-conscious planning and design deal with locating energy sources and sinks in the landscape and establishing cascades that distribute residual energy from sources to sinks in order to decreases the need for primary energy. Developing diverse and landscape-specific renewable energy systems provides a multiplicity of sources having more proximate relationships with energy sinks. Reduced distances between source and sink are advantageous for making best use of renewable energy carriers with lower energy density. Energy-conscious planning and design is location specific and it remains difficult (if not impossible) to devise the solution that fits all conditions.(Stremke and Koh, 2011).

Community Energy Planning

Community energy planning is defined here as comprehensive and integrated energy planning at the community scale, taking supply, transmission/distribution, and demand into account. A community vision can be used to define a desired system that includes both sustainability and community perspectives and also makes the most efficient use of energy by matching energy supplies to energy services (Scroth et al., 2013).

Landscape
Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (ELC, Art. 1,a).

Energy Landscape by an Impact Assessment perspective
Energy landscape is a landscape whose image and herewith the functions (natural, productive, residential, recreational, cultural, etc.) have been significantly affected by the energetic industry (Frantál et al., 2014).

Energy Landscape by a Landscape Architecture perspective
Energy landscapes, in other words, are not always distinct spatially bound landscapes such as the coal mining landscapes in Lusatia, Germany. In most cases, the energy landscape is nothing but one of the many layers of complex, multi-faceted and heterogeneous landscapes. (Stremke, 2013)

Sustainable energy landscapes
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 and Dobbelsteen, 2012).

Ecosystem services
Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and diseases; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non material benefits (MEA, 2005).

Interdisciplinarity and Transdisciplinarity
Interdisciplinarity refers only to integration of different academic disciplines around one problem-solving oriented project. Transdisciplinarity implies integration between academics and non-academics such as policy makers and (local) stakeholders. Both are important and necessary in landscape research, management and planning (Antrop and Van Eetvelde, 2010).

Landscape Architecture
Landscape Architecture is a discipline concerned with the conscious shaping of human environment. It involves planning, design and management of the landscape to create, maintain, protect and enhance places so as to be functional, beautiful and sustainable, and appropriate to diverse human and ecological needs (ECLAS definition, 2009).

Chapter 2

Research Design

2.1 Introduction

In this chapter we delineate the design of the research (figure 2.1). The research presented in this thesis was conducted in part as my contribution to the DEESD project, Sustainable Energy and Ecosystem Services. This research was set in Netherland and commissioned by the Province of Zealand, the Dutch Ministry of Infrastructure and the Environment and several regional stakeholders, to the University of Wageningen, Landscape Architecture Chair Group (LAR), and the Alterra research institute. I joined LAR in 2014 in two stages: the first in spring for an Erasmus Placement program; the second in autumn involved in the last step of DEESD project. The research project involved landscape architects and environmental planners, and the last step included a participatory process with the community of the island of Schouwen-Duiveland, in the province of Zealand. In the preceding steps, different people had been engaged in the research that pursuit different approaches, strategies and methods. Anyway the design of the research of the last step followed a quite linear research design. As researcher in Landscape Architecture I was interested in enhancing procedural knowledge for landscape planning and design through a case study. The European Council of Landscape Architecture Schools (ECLAS) defined three main typologies of research that can be conducted by landscape architects:

a) Planning and design research; aiming to improve landscape architecture theory and methods (e.g. planning and design processes), drawing conclusions from doing case studies, from analyzing projects, landscapes plans, etc.

b) Research by planning and design: the analysis of complex spatial strategies by producing and evaluating scenarios, making and evaluating new typologies that are based on new needs (of the public), finding solutions for a social or spatial problem by making and evaluating several proposal, scenarios, etc.

c) Research for planning and design – research in social sciences, ecology, or other disciplines, in order to apply them to landscape planning and design, e.g. landscape classification, surveying the needs of the public, perception of landscape values, etc.

d) Integration of the above mentioned approaches.

According to the ECLAS typologies, the work here presented can be considered a "Planning and Design research" (a) as well as a "Research by planning and design "(b) but the main objective can be considered as a "research for planning and design"(c). An integration of the three typologies is anyway essential when facing complexity. In particular the three main gaps of knowledge were detected through different research typologies. The first knowledge gap "Absence of policies regulating bottom-up processes and community based energy transition" was stated through the research typologies (a) and (b), from the analysis of theories, policies and projects. The second knowledge gap "Absence of design approach for planning energy landscapes including ES assessment" was stated through the research typology (a). The third and main knowledge gap "Absence of integrated approaches where multiple ES are studied in relation to diverse RES, in a landscape perspective and through participatory processes" was stated through the research typology (c). To reach the main objective o this research, the elaboration of the methodological framework and the application part, both (a) and (c) were necessary in order to define a methodological framework that would joint Landscape Architecture approaches with approaches coming form other disciplines in order to support the planning an design of the landscape.
Both (a) and (b) are used in answering the research questions 1 and 2 and it was a research typology useful to set the "stage" of this research and to interpret the different context and theories in order to conceive the methodological framework.

2.2 Philosophical worldview

This research adopts strategies and methods in more than one philosophical worldview (Creswell, 2007). In an Advocacy/participatory worldview this thesis conceive the first literature discussions. According to Kemmis and Wilkinson (1998) participatory processes are recurrent in this worldview, because it helps individuals or communities to the right of self-development, avoiding imposition of injustice structures in a top-down approach as in the case on NIMBY and RET. The inquiry is conducted with participants. This research examines "important issues of the day" (Creswell, 2007, p.227), as the transition to low carbon energy, and the inquiry is preliminary intertwined with policies and the political agenda. We support the sustainable energetic development of local communities.

We can consider our research also in a Social Constructivist worldview in the way it seeks for the complexity of the view and it is not focused on few aspects. A second reason is the fact that the application part of this research is based on a workshop and it is typical of this worldview to count on the participants view. It is further typical of constructivist researchers to study the context where participants live and work and facilitate the interactions among individuals and the understanding of the phenomenon object of the study. The interpretation of participants view is a fundamental step of the research.

This research adopts also a Pragmatic Worldview. The pragmatism emerges as a problem solving worldview; it deals with applications that find solutions to emerging problems. Research that finds solutions to specific problems emerged at societal or institutional level can be considered a pragmatic research. The emphasis is on the problem and not on the method, pragmatists apply different worldviews and investigate and use all the approaches available to solve the question, it is a way to derive useful knowledge.

The formulated research questions reflect different worldviews. The first question "what are the parameters for landscape sustainability in the energy transition era" reflects both an advocacy/Participatory and Social Constructivism worldviews, the parameters for landscape sustainability are analyzed to advocate the rights of local communities through the understanding of the complex phenomena. The second question "what is the contribute of planning and design the landscape to energy transition" is conceived in a Pragmatic worldview in the way we want to know what could be the support of the landscape architecture in order to respond to the question 1. The research questions from 3 to 7 (see section 1.4) develop the research question 2 in a cascade approach and all are formulated in a Pragmatic way, we want to know what approaches in the ecosystem services assessment better support Landscape Architecture in contributing to the solution of the problem that afflicts local communities in the energy transition. The main objective is pragmatic, we are called to implement a process and at the wider scale this process is first an Advocacy process, then Social Constructivist, using participation. Resuming the research starts from Advocacy/Participatory positions, looks at the question in a Constructivist way and proceeds as a pragmatist in order to reach the objective and provide answers to the emerged questions.

2.3 Strategy of inquiry and methods

Our research adopts a Qualitative strategy, and responds to classical qualitative questions starting with "what" and how". We need to know what phenomena and dynamics we investigate, what theories, concepts and methods are necessary to build our theoretical framework and how to build a method. We need to know what are the trade-off and synergies between RE and ES and how the stakeholders give value to them. A Pragmatic worldview is usually based on a mixed strategy of inquiry using both quantitative and qualitative data. According to Creswell "In qualitative research, the intent is to explore the complex set of factors surrounding the central phenomenon and present the varied perspectives or meanings that participants hold" (2007, p. 129). The strategies of inquiry of this research are composed of three distinct research actions that can be categorized as following (Deming and Swaffield, 2011):

1. Interpretative strategy
2. Modeling and correlational strategy/Dynamic Simulation Modeling
3. Engaged action research/Participatory Design

Interpretative strategy is a "constructionist approach to understanding" (Deming and Swaffield, 2011, p. 152). The interpretative strategy was relevant in investigating the landscape phenomena that involve communities and result form energy transition, trying to relate evidence with theories and interpret them. The methods are Discourse analysis of secondary sources, the literature review phases where it is necessary to interpret and categorize to implement our knowledge in order to formulate a theoretical framework. The Modeling strategy adopted in this research uses a "Spatial Correlations" approach in the formulation of the theoretical framework and merges environmental planning, landscape ecology and landscape architecture, relating social, economical, cultural and ecological dynamics to the design of the landscape.
"As a research strategy in itself, modeling is a process in which the representation of landscape or some aspect of landscape in simplified terms enables new knowledge to be generated" (Deming and Swaffield, 2011, p. 88).
A Dynamic Simulation Modeling strategy (Steinitz, 2003) is adopted in the application of the Five-step approach designed by Stremke et al. (2011, II), when stakeholders define spatially renewable energy scenarios and ecosystem services through siting RET and discussing the landscape design. According to Steinitz et al. (2003), this modeling strategy is

defined as decision-choice. This deals with building alternative possible futures based on the combination of policies. Scenarios constitute “a set of policy choices and their biophysical consequences” (Deming and Swaffield, 2011, p. 107).
Finally the case study application of this research is a Participatory Action Research (PAR). Kindon et al. affirm “Both researchers and participants reflect on, and learn from, this action and proceed to a new cycle of research/action/reflection.” (2008, p. 93) and indeed what we faced was a learn by doing process. In the following table (table 2.1) we resume the key characteristics of PAR.
Methods and tools of PAR can be: mapping, interviewing, questionnaires surveys, focus groups, photography, video, GIS. In our research workshop we applied a participatory mapping and a focus group. The focus group on the landscape design can be framed on the strategy of inquiry of Participatory Design in Service Learning (Deming and Swaffield, 2011). This involves researchers and end users in visioning landscape design processes that support the community needs.
In qualitative research it is possible to check the reliability of the findings paying attention to specific procedures that should be followed during the research steps (Creswell, 2007). The reliability strategy adopted in this thesis is the “triangulation”. In the triangulation we check the convergence of evidence from different sources, included stakeholders in the Engaged action research/Participatory Design.
Triangulation checks when different sources state the same assumption, when the values expressed by stakeholders coincide with the values expressed by precedent research on the same topic and location, when in expert panels we check our findings and intuitions with expert on the specific aspect. This research considered peer-reviewed sources and this increase the reliability.
The qualitative approach of this research doesn’t account for any generalization but seeks for the replicability and the enhancing of the method in similar situations in order to advance in the planning and design of renewable energy landscapes with the ES. The application described in Chapter 6 is a test of the method to clearly present and distinguish what we learned and was successful from the limitations we encountered and what we missed. The discussions at the end of Chapter 6 expose the limits and future effort in order to enhance the replicability and the advancing of the method in future research.

Table 2.1 The key characteristics of PAR, adapted from Kindon et al. (2008, p. **91).**

• Aims to change practices, social structures, and media which maintain irrationality, injustice, and unsatisfying forms of existence
• Treats participants as competent and reflexive agents capable of participating in all aspects of the research process
• Is context-bound and addresses real-life problems
• Integrates values and beliefs that are indigenous to the community into the central core of interventions and outcome variables
• Involves participants and researchers in collaborative processes for generating knowledge
• Treats diverse experiences within a community as an opportunity to enrich the research process
• Leads to the construction of new meanings through reflections on action
• Measures the credibility/validity of knowledge derived from the process according to whether the resulting action solves problems for the people involved and increases community self-determination

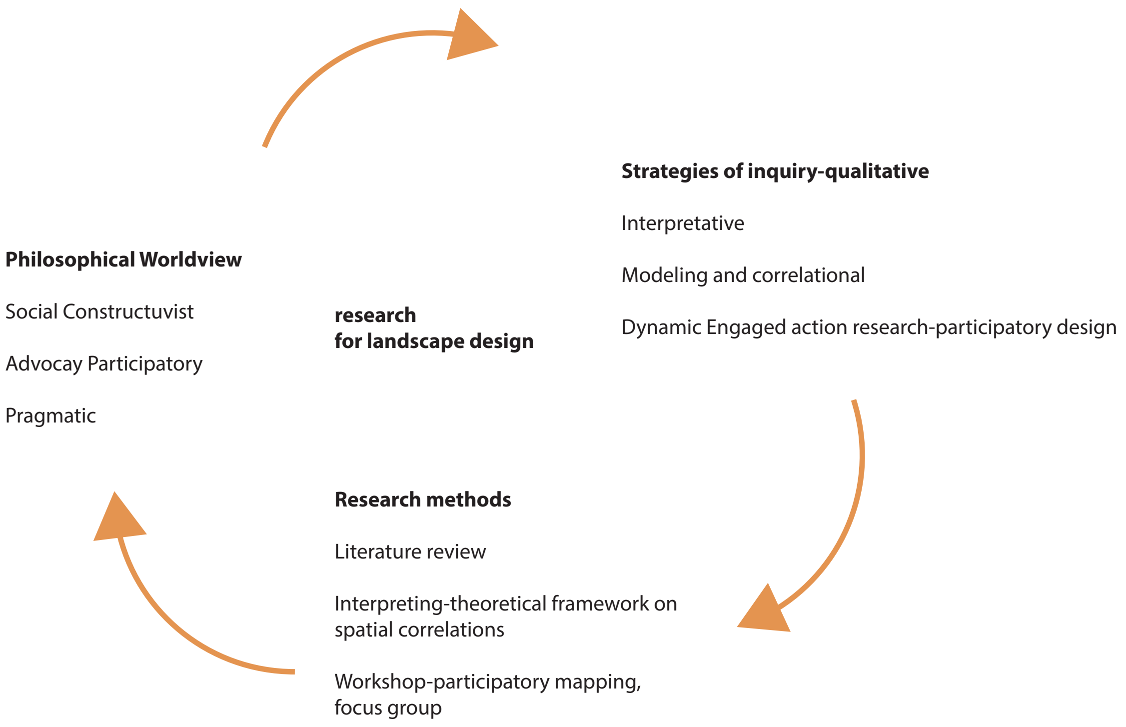


Figure 2.1 The flowchart summarizes the design of the research presented in this thesis. Adapted from Creswell (2007).

Chapter 3

Towards the sustainability of renewable energy landscapes

3.1 Energy landscapes

In this section we will provide some definitions of energy landscape, and examine the development of the energy landscapes through the time.

"Energy landscape is a landscape whose image and herewith the functions (natural, productive, residential, recreational, cultural, etc.) have been significantly affected by the energetic industry" (Frantál et al., 2014, p.2). This is the definition mostly shared among geographers and landscape ecologists whenever their focus is on the impact of energy on a *status quo* in the landscape. Howard et al. (2013) gave a definition of Energyscapes: "the complex spatial and temporal combination of the supply, demand and infrastructure for energy within a landscape"(p.19). Howard et al. work as natural scientist, in the definition of "energyscape" they try to enclose a landscape perspective, but concretely in their application they adopt a set of land use classes as spatial reference system. The definition of energy landscape can be tricky depending on the perspective or strategy lens. The definition of Energy Landscape as in Frantàl for example doesn't mention a human perception, as in the European Landscape Convention (2000). Defining the energy landscape without including the population's perceptions and cognition is not challenging (Blasckhe et al., 2013). "When applying the landscape concept to the energy domain one challenge is that landscape research embraces a multiplicity of topics: history as well as ecology, thoughts as well as actions, and also the physical environment. By way of contrast, energy research has so far been mainly driven by technical, science and engineering concepts" (Blasckhe et al., 2013. p. 9).

Stremke (2013) resumed the multiple facets of the notion of energy landscape and indicated the main aspects discussed by the authors (figure 3.1). The author also gave an explanation of how the concept of energy landscape could be interpreted if we seek for a sustainable energy transition: "Energy landscapes, in other words, are not always distinct spatially bound landscapes such as the coal mining landscapes in Lusatia, Germany. In most cases, the energy landscape is nothing but one of the many layers of complex, multi-faceted and heterogeneous landscapes" (2013, p. 2).

This concept suggests that the study, the planning and design of the energy landscapes cannot be avulse from the complex of the landscape these are part of. The difference within the Frantàl definition is in the assumption of different perspectives. In Frantàl the perspective is of an impact assessment that studies a landscape *status quo*, which is afflicted by the energetic industry, while in Stremke, the simple affirmation that the energy landscape is on of the several layers means that this is part of the evolving process of the landscape and reflects its complexity. This thesis perspective reflects the energy landscape concept as in Stremke. This concept is also part of the perspective of Pasqualetti, a geographer, one of the key authors for the definition of energy landscape. The author structures the concept of energy landscapes (2012), he makes distinction between constructs and layers (figure 3.2). The constructs are the spatial footprints of energy technology and networks. The layers are the landscape externalities, the complex of the changes occurring in the landscape, that can be divided into three types: direct, indirect and mitigation. The direct layers are all the expected changes to the landscape due to technology as mining scars, pumping equipment, their costs are internalized and scheduled. The indirect layers are all the unexpected changes as local pollutions and effects on the vegetation, acid rains, and their costs are consequently

Concept	Author(s)	Energy	Renewables	Demand reduction	People	Planet	Economy
Wind-energy landscapes	Moeller	● (black)	● (black)		● (black)		
Landscapes of energies	Nadai and van der Horst	● (black)	● (black)		● (black)	● (gray)	
Landscapes of carbon neutrality	Selman	● (black)	● (black)	● (black)	● (black)		● (gray)
Sustainable energy landscapes	Stremke	● (black)	● (black)	● (black)	● (black)	● (black)	● (gray)
Renewable energy landscapes	Van der Horst and Vermeylen	● (black)	● (black)		● (black)		● (gray)
Third-generation energy landscapes	Noorman and Roo	● (black)	● (black)	● (gray)	● (gray)		● (gray)
Energy Landscapes	Blasckhe et al.	● (black)	● (black)		● (black)	● (black)	● (black)
Alternative energy landscapes	Jørgensen	● (black)	● (black)	● (gray)		● (black)	
Energy landscapes of the sustainabe economy	Pasqualetti	● (black)	● (black)		● (black)	● (black)	
Energyscapes	Howard et al.	● (black)	● (black)	● (black)	● (black)	● (black)	

Figure 3.1 Multiple facets of the notion of energy landscapes and main aspects discussed by the authors (in black) or simply aknowledged, but not discussed (in gray) or not considered at all (empty) (adapted from Stremke, 2015, p. 3

not prevented and represent externalities. The mitigations are the changes in the landscape due to mitigation design as recreational lakes and parks, camouflage techniques.

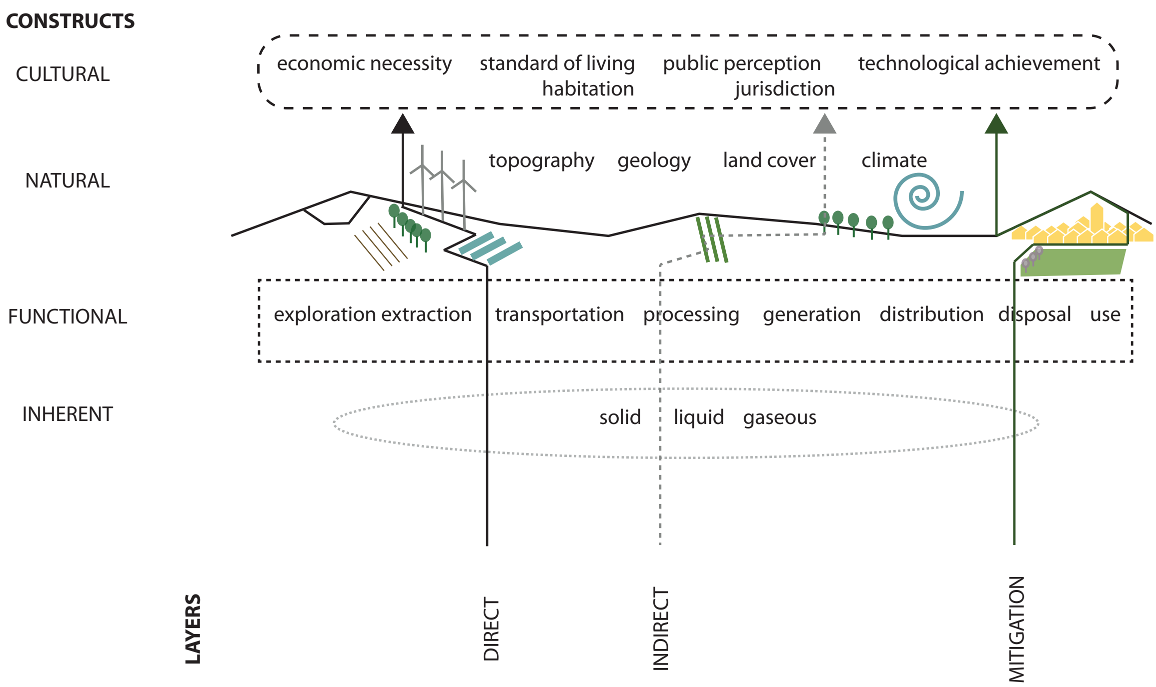


Figure 3.2 Constructs and layers of energy landscapes, from Pasqualetti (2012).

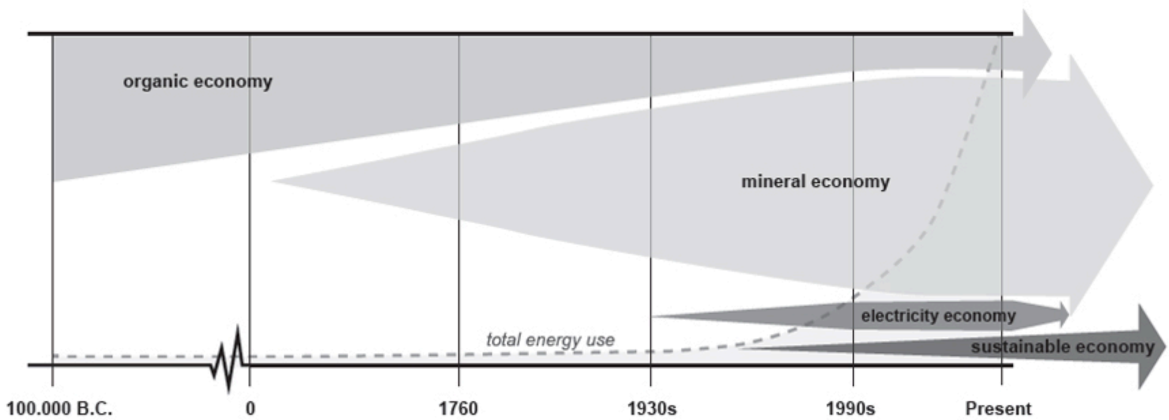


Figure 3.3 Evolution of the energy landscapes (Stremke, 2013, p.2).

Further Pasqualetti defines four historical stages of energy landscape (EL): the EL of the Organic Economy, the EL of the Mineral Economy, the EL of the Electricity Economy and the EL of the Sustainable Economy (figure 3.3).

In the energy landscape of Organic Economy the main sources of energy were wood, wind and water. The historical landscapes of windmills and water mills represent a typical example; the power of water and wind was converted in mechanic power (figure 3.4). Wood was harvested to produce heat. Pasqualetti affirms, "the Golden age of energy landscapes began when the nascent mineral economy grew into the industrial revolution" (Pasqualetti, 2012, p. 16). The energy landscape of the mineral economy owns well delimited footprints: coal, gas, and oil represent mineral, or carbon fossil sources. According to the author the first exploitation of coal in Europe is dated 1113, in Belgium, but its use was not so common till the 18th century. The use of coal as energy source allowed and supported the industrial revolution of the 18th century through the discovering of coal and its high energy potential. Coal mines constitute nowadays entire landscapes through their constructs and layers. Miners new cities were set in proximity of coal fields, is the case of Carbonia founded in 1937 in southwest Sardinia, in Italy, as an ideal and modern city for miners (figure 3.5).

Carbonia represents a wide energy landscape indirect layer. The exploitation of coal generated the first relevant conflict between energy benefit from humans and ES. Regions as central England, south Wales, Belgium, the Ruhr in Germany experimented the first threat to human health and quality of life, we all know very well the polluted England of Charles Dickens. The trade-off between energy production and industrialization and ES as air -flow or water-flow regulations reached quickly high peaks. In the mid 19th century the discovering of fields of natural gas in Middle East and United States started creating new landscapes, those of drills and transformation. Gas and oil improved the quality of life refurnishing houses of the first source of light through gas and oil lamps. Nowadays the gas and oil infrastructures embodies in the societies imaginary heavy sources of air pollution. Oil refinery plants are an energy landscape direct layer that afflicts extended areas; the most clamorous Italian example is Priolo area, close to the city of Syracuse, in Sicily (figure 3.6). It has been proved that the fumes coming from the refineries are responsible of diseases in the surrounding communities due to air pollution. The refinery caused a high-trade off with the air-flow regulation and the cultural value of one of the most rich in archaic archaeology coastal landscapes of Italy. The third landscape that the author defines is the energy landscape of the Electricity Economy. Nowadays landscapes are intensively intertwined with the direct layers

Figure 3.4 Two Italian energy landscape of the Organic Economy. Wind mills at salt works, Marsala, Sicily (photo courtesy Filippo Innocenti, 2011) and water wheels with their conducts at Longiarù, Val Badia, Alto Adige (photo source panoramio.com, 2015).

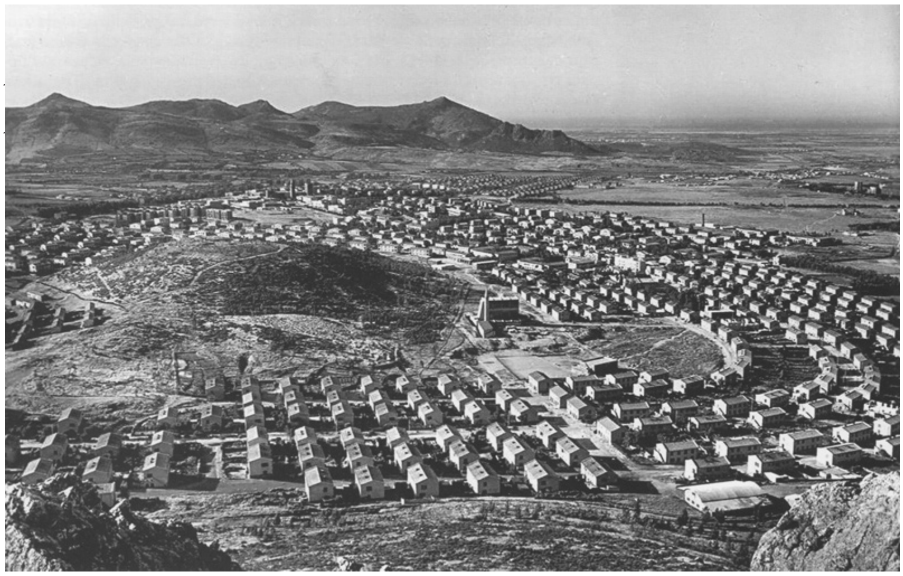


Figure 3.5 The city of Carbonia, founded in 1937 as miners modern city during the Fascist period (image source http://thule-italia.com/wordpress/carbonia/nggallery/page/2, 2012)

Figure 3.6 The energy landscape of the refineries of Priolo, seen from the peninsula of Thapsos, cradle of the homonymous culture of the 15th-13th centuries bC (photo of the author, 2012).

of this energy landscape. Transmission lines cross our everyday life, cutting the perception of the landscape (figure 3.7). The energy landscape of the electricity economy is founded on the energy landscape of the mineral economy when power stations burn fossil fuels. The fourth stage on the evolution of energy landscapes is the "Energy Landscapes of the Sustainable

Figure 3.7 The direct layer of a transmission line as underlined by landscape architects in the analysis of the landscape perception, Guastalla, Emilia Romagna. In this case the line afflict the quality of the perception. (image of the author, 2006).

Economy" (Pasqualetti, (2012). Sustainable economy is based on RES wind, water and sunlight, as in the organic economy, but technology evolved and starting by the mechanic power we can produce electricity, bio-gas or bio-fuels. For RES the Natural Construct is determinant because geology, morphology, climatic conditions, land cover determine the conditions for an optimal energy production and modify the extension of the direct layers, as equipments adapt to the situations to get the most efficient energy production. The spatial footprint of RET are much more wider and this is due to their lower energy content, renewable energy landscapes require space, but we should not think about RE landscapes in the same terms as for the other energy landscapes. Hydropower is a combination of solar energy and gravitational energy (Pasqualetti, 2012). The direct layers of this technology are an agent of landscape change since the beginning of the last century, when hydropower became the main industry for the production of electricity. One of the first hydropower stations in

Italy was built in Tivoli, in Lazio region (1884). The reservoir, in the middle of the town, modified the landscape and altered one of the most famous landscapes of the "Grand Tour" totally afflicting the water supply of the famous "Cascatelle" (figure 3.8). Italy has a strong tradition in hydropower technology ad the share of renewable energy is in large part due to this RET. The wind power emerged in the 1980's and Pasqualetti defined it as a new era. One of the first countries developing wind power was Denmark (Ladenburg, 2008, 2009). Wind RET have a larger spatial footprints and this is because each turbine has a relatively small capacity in generating energy. A turbine of 3 MW needs approximately 13 ha of space. The contemporary landscape of wind power requires large spaces (figure 3.9). Turbines' height can vary depending on the power and this means that wind power landscapes are "eye-catching" (Pasqualetti, 2012) and for this reason are the most opposed by regional

Table 3.1 Constructs and layers of the energy landscapes of sustainable economy (adapted from Pasqualetti, 2012, p. 41)

	Direct Layer	Indirect Layer	Mitigation Layer
Water	reservoires	altered downstream, ecologies, agriculture	
Wind	roads, turbines installa-tion movements, flickers	altered property values (up and down), night time impacts, altered farmlands, drained lands	
Geothermal	visual, roads, drilling pads	altered vegetation, impact on surrounding land use, conversion of existing land use	disposal sites for sludge from pollution abatement
Solar	roads, lareg areas, reflec-tions	changed appearance of open land, improvement of the impacts of fossil fuels	distributed deployments, repositioning to protect endamgered species
Biomass	roads, enlarged agricultural areas, new and different shaped buldings, conver-sion of pasture lands	effects on nearby land uses resulting form odors, reloca-tion of farm workers	

Figure 3.8 In the image above the landscape of the “Cascatelle” at Tivoli as in a picture from Giacomo Caneva (1840, image source www.mutualart.com), disappeared after the installation of the Hydropower station (image of the author).

governments and local communities. The wind power generation increased constantly in Italy during the last decade. This was due to high subsidies from the Government to promote the installation of wind farm by energy companies (figure 3.10).
Wind parks are emerging as relevant features for landscape design and landscape architects are involved in the design of wind landscapes (Zanchini, 2002; de Waal and Stremke, 2014). Geothermal technologies are site specific, occupy the specific site of drilling, but the complex network of conducts can deeply afflict the landscape perception, especially when the technologies are located in extensive natural landscapes as in Iceland or United States (Pasqualetti, 2012). In Italy geothermal plants are particularly developed in the Tuscany where the highest potential in Italy is located. In the image (3.11) the historical geothermal power landscape of Larderello, Tuscany. During the organic economy the biomass was harvested both as primary or secondary production to produce heat from combustion. Nowadays in the sustainable economy technology allows to cultivate energy crops to produce bio-gas. The biomass energy landscapes are constituted by intensive cultivation of crops as maize and sugars canes, these require a huge amount of fertilization ad water to keep an efficient capacity of generating energy. The landscape of energy crops doesn't look so different than food production landscapes. Pasqualetti (2012) affirms that these landscapes have always been intensively cultivated, as in the case of Brasil, that nowadays produces the 30.1% of ethanol of the world, so that the landscape perception has not changed so much even if these landscapes increased in size and this is a relevant issue in relation with the food production (figure 3.12). Further bio-gas stations have not a huge impact. Solar RET research develops quickly. Nowadays we have four main technologies: photovoltaic panels (PV), parabolic troughs, concentrated solar power (CSP) and solar boilers. The extension of the spatial footprints of solar RET depends on the latitude and the medium cloudiness. PV can be installed at several scales and actually represent the easiest way to generate renewable electricity and are becoming a "commonplace landscape features" (Pasqualetti, 2012, p. 39). Families can install PV on their roofs and in general the technology is versatile and can be applied on several devices as sound barriers along motorways (figure 3.13). At a wider scale Photovoltaic panels (PV) parks are emerging as intensive landscapes and regional governments adopt design strategies to introduce them into the landscape.

Figure 3.9 Wind turbines in Andalucia, Spain (photo of the author)

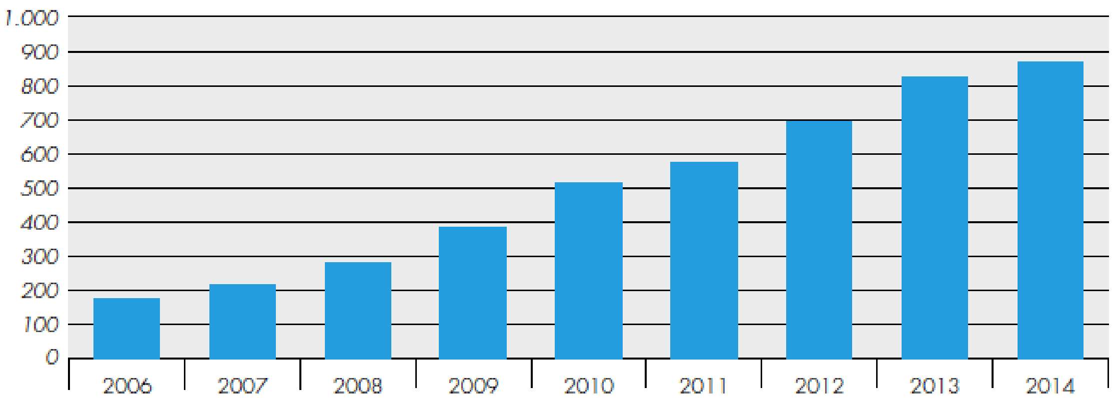


Figure 3.10 The trend in wind energy power generation in Italy expressed in MW per year (Legambiente, 2014, p. 97)

Figure 3.11 A picture of the geothermal landscape at Larderello, Tuscany, where the direct layers of the energy landscape are really evident (photo courtesy Marco Ferrari 1998).

Figure 3.12 A picture of a Energy crop landscape in South Africa (photo source Zntastik -Commoswiki (2005).

Figure 3.13 Solar landscape along the motorway A 22, Isera, Trentino province, Italy (photo of the author). The solar barrier is located in the famous “Marzemino” wine production area. Farmers that operate wine tourism consider the barrier a landscape detractor.

3.2 Transition management: regimes and niches

In the urbanized regions of the Western World, especially in Europe, the functions supported by land use are in competition. In decision-making process ecological functions such as biodiversity, the supply of ES, or social functions as recreation, landscape identity are seen in conflict with the development of Technology (Termoshuizen et al., 2007).
According to Kemp and Loorbach the key elements of a transition management can be resumed as following:

1. Long-term thinking (at least 25 years) as a framework for short-term policy;
2. Backcasting: the setting of short-term and longer-term goals based on long-term sustainability visions and short-term possibilities;
3. Thinking in terms of more than one domain (multi-domain) and different scale levels (multi-level); how developments in one domain (level) gel with developments in other domains (levels); trying to change the strategic orientation of regime actors;
4. A focus on learning and the use of a special learning philosophy of 'learning-by-doing';
5. An orientation towards system innovation;
6. Learning about a variety of options (which requires a wide playing field).

(Kemp and Loorbach, 2006, p. 12)

According to Geels (2004) three levels are necessary to understand system innovations (figure 3.14). In a bottom-up perspective first we have the niches, then the socio-technical regimes and the socio-technical landscapes. Niches represent communities with their culture, habits, cognition and socio-economic spatial systems strictly related to the local landscape, " the locus of established practices and associated rules that stabilize existing systems"(Darnhofer, 2014, chapter 2, p. 3). Regimes represent the regulation of niches in terms of policy, user preferences, markets, and technologies and are more stable than niches. Regimes are regulated and coordinated at national level according to the socio-technical landscape that reflects external trends as EU directives. A multi-level perspective sees the transition as a non-linear interaction among the three levels. The success of a transition is guaranteed by aligning the three levels and by opening through regimes regulations, windows on the niches where innovation can be formulated. This is possible if the socio-technical landscape makes pressure on regime to open such windows. Geels explains why the innovation necessary to face transition, can be conceived at niches level: “In niches not all rules have yet crystallized. There may be substantial uncertainty about the best design heuristics, user preferences, behavioral patterns, public policies, etc. There may also be uncertainty about the social network. The network of experimental projects is often contingent. Some actors participate in this project, but not in another. There are no clear role relationships, interlinked dependencies and normative rules” (2004, p. 913). Recently Pinto-Correia et al. (2014) applied this transition management model to study the “countryside consumption” as a driver of change in agricultural and land-based activities in Europe. The research studies how the increasing of countryside use for recreational activities, generated a shift in land management objectives from food production to recreation. Producing innovation at niches scale, in this case farming, facilitates the transition management. The same application can be conceived with the energy transition as driver of landscape change. The increasing of countryside use for RE production activities generates a shift in land management objectives from food production and recreational activities to energy production. This shift must be managed producing innovations and solutions at niches level.

The management of energy transition as a system innovation addresses a bottom-up process where the niches are the local communities with their actors and landscape socio-economic spatial systems. According to Rotmans “social actors can stimulate, slow down or even block a transition, so it is worthwhile to map their various action perspectives” (2001, p. 25). This quote by Rotmans is relevant; indeed he remarks the importance to map with stakeholders their perspectives. Further Kemp and Loorbach observe: “Transition management consists of a deliberate attempt to work towards a transition offering sustainability benefits, not just environmental benefits but also economic and social benefits. The basic steering philosophy is that of modulation, not dictatorship or planning-and control. Transition management joins in with ongoing dynamics” (Kemp and Loorback, 2006, p. 9). Resuming, a bottom-up process, modulation and a broad concept of sustainability represent three principles of the management of every transition that will be taken in account in the development of this thesis.

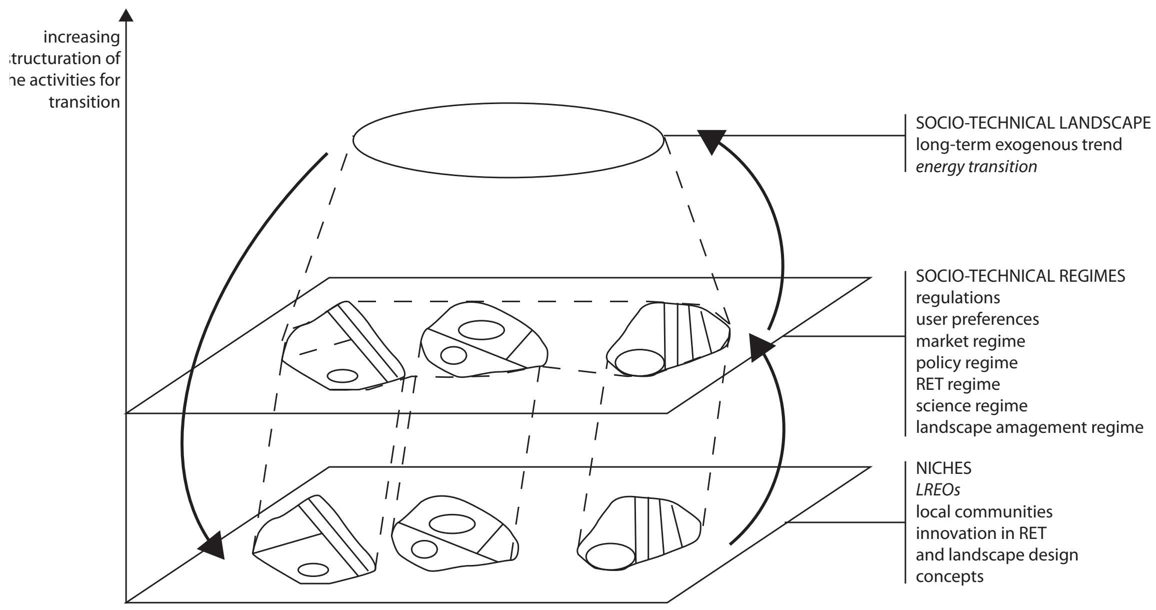


Figure 3.14 Niches and regimes in energy transition, adapted from Geels (2002).

3.3 Local Renewable Energy organizations: the case of Samsø

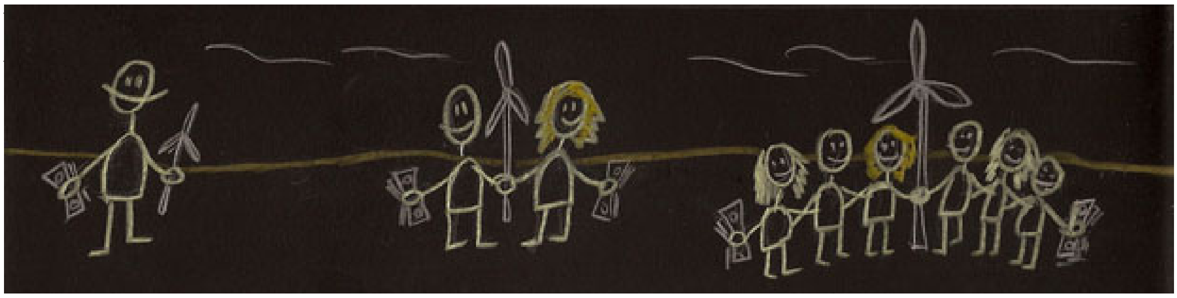
In 1997 the Danish ministry announced a competition for local communities and islands. The object was the challenge to get the 100% of renewable and self-sufficiency. The competition rules require a master plan describing the available RES and a proposal for transition management.

The island of Samsø won in 1997. The 10 years report updates the situation and enounces future efforts after the first ten years, scheduled as test period. The main aspects considered are the heating system, the production of electricity, the tourism and education, the environment and the economics and employment (Jørgensen et al., 2007).

Nowadays the island of Samsø can affirm that the success of the plan is due to the bottom-up approach (Spear, 2014). The heat is generated through the combustion of second-generation biomass form agriculture in the four district heating plants that supply heat to houses. Farmers receive subsidies on the amount of harvested biomass. The island agriculture grows corn, potatoes and raises cattle.

The electricity is generated through 11 onshore wind turbines, nine owned by farmers and the other by 500 people living in the island (figure 3.15-3.16). The municipality and farmers own the ten offshore wind turbines; one turbine is property of the installing enterprise. Solar

Figure 3.15 The landscape at Samsø (photo courtesy Marceilo Medeiros, 2009).



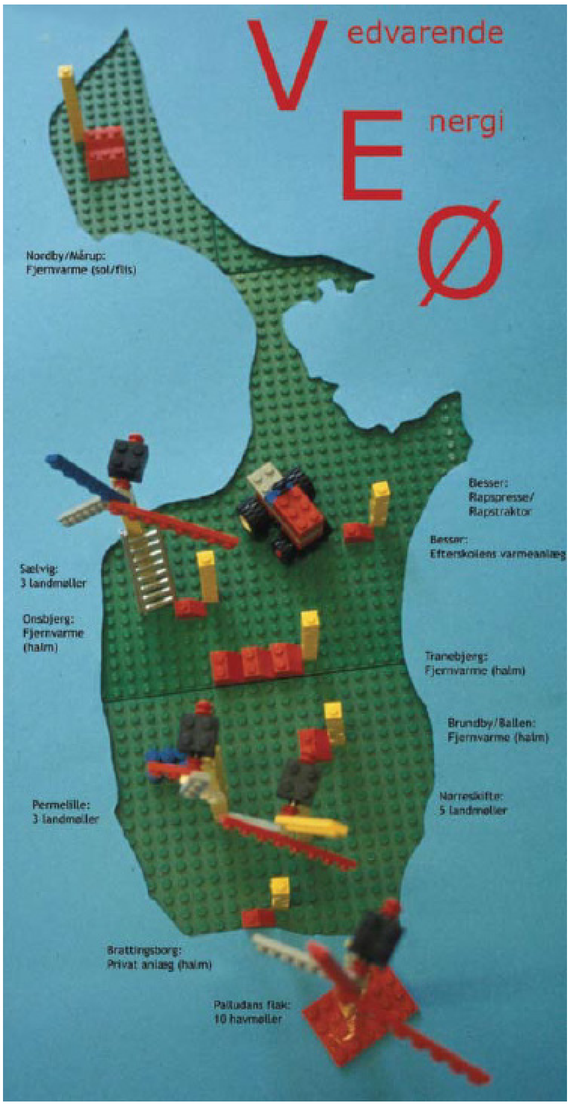


Figure 3.16 The regime of ownership at Samsø represented in a drawing on a blackboard and a symbolic map of the building of the energy landscape (images source http://energiakademiet.dk/en/vedvarende-energi-o/) and a "lego"map of the renewable energy island, Søren Hermansen (image source Jørgensen et al., 2007).

panels on buildings provide energy for public and private devices as public transports and cars.

Tourism and education are fundamental activities of the island that literally invented an energy tourism (figure 3.17) and founded the Energy Academy where researchers and Universities convey in discussing renewable energies and sustainability issues (De Waal and Stremke, 2014).

The plan improved the environment by means of reduction of sulphur dioxide, nitrogen dioxide and particles in the atmosphere and their deposit on arable land and inland water (figure 3.18).

The employment due to the energy plan showed an increase in local enterprises involved in the installation of plants and devices and an increase of employment related to the Samsø Energy Academy and tourism related activities (Jørgensen et al., 2007). Actually Samsø reached the self-sufficiency in energy supply and improved its economy and the environment. Spear (2014) remarks that each wind turbine was positioned in a democratic approach; each inhabitant was involved in the decision.

Figure 3.17 The slogan designed by the Samsø Energy Academy. Through the Academy the island invested in image and energy tourism and nowadays is a research centre on renewable energies .

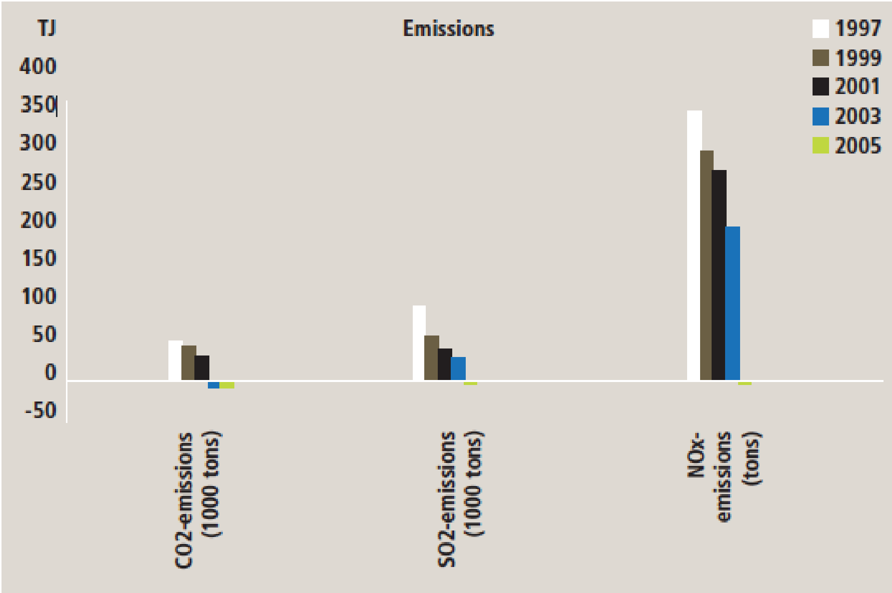
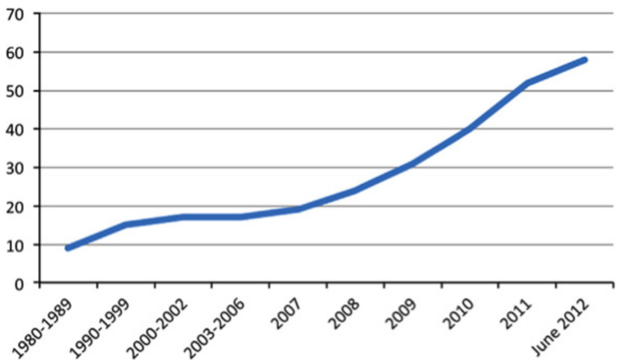


Figure 3.18 The image shows the reduction of CO2, SO2 and NOx emissions between 1997 and 2005 (Jørgensen et al., 2007, p.34).

Very recently a research from Boon and Dieperink showed the increase of bottom-up independent actions of local communities that want to actuate their energy transition. These actions are defined Local civil society based Renewable Energy Organizations, LREOs, while the Italian *Legambiente* publishes each year the graduatory of the municipalities that got the self-sufficiency in energy supply (figure 3.19).
LREOs are based on local sustainable energy, they represent a relevant phenomenon in the energy transition panorama, but still we don't know so much about them. Boon and Dieperink (2014) showed these phenomena for the first time in literature. They tried to unravel the logics, the factors that stimulated these organizations in facing autonomously the energy transition (figure 3.20). The authors affirm that a decentralization movement through LREOs allows steps further in the share of renewables and an acceleration of the energy transition. Policy makers should stimulate the share of knowledge through NGOs for further applications of LREOs experiences, if this is a way to address more efficiently the energy transition in a bottom-up process. The present energy system is designed as a centralized system while communities show to aim at a self-sufficiency and independency from top-down energy corporations. A reduction of energy consumption (heat, electricity and transportation) and local participation should have been the priorities of the plan proposal. The master plan

should first make use of available technologies, but innovation in the way of organizing, financing and owning RE project was expected (Jørgensen et al., 2007). In the following chapter we will see what approaches in landscape planning and design can better support local initiatives and the energy transition management. In the following chapter we will see what approaches in landscape planning and design can better support local initiatives and the energy transition management.



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PR	COMUNE	N_AB	ST mq	FV kW	EOLICO kW	MINI IDRO kW	GEOT kWt	BIOGAS kWe	BIOMASSA kWe	TLR MWht/a
BZ	BADIA	3.369	75	1.566		2.325		115		19.221
BZ	BRENNERO	2.093	11	717		5.000				9.226
BZ	BRUNICO	15.523	840	5.771		3.960		1.500	990	66.882
TN	CAVALESE	4.014	520	1.131		160			1.065	37.352
BZ	CHIUSA	5.132	11	1.410		1.490			200	18.346
BZ	DOBBIACO	3.376	1.350	1.591		1.783		132	1.800	67.216
TN	FONDO	1.400	700	1.335		900				5.500
TN	FIERA DI PRIMIERO	533	53	45		136			990	23.000
BZ	GLORENZA	880		1.114		32		70		11.369
BZ	LACES	5.144	53	5.059		1.440			755	18.000
BZ	LASA	3.949	1.260	9.698		933			6.500	15.801
BZ	MONGUELFO-TESIO	2.804	9	1.308		1.176		100		22.099
AO	MORGEX	2.069	51	195		1.100			6.580	22.099
AO	POLLEIN	1.528	39	450		42			4.200	4.430
BZ	PRATO ALLO STELVIO	3.400	2.200	6.943		4.082		150	990	14.765
BZ	RACINES	4.369	43	1.776		5.255			145	30.018
BZ	RASUN ANTERSELVA	2.878	28	1.978		1.480			910	24.605
UD	RESIA	1.101	20	59		1.200				4.382
BZ	SESTO	1.952	486	257		154				23.229
BZ	SILANDR	5.998	1.563	7.565		900			2.470	37.110
TN	SIROR	1.285	54	57		40			8.800	23.951
BZ	SLUDERNO	1.823	960	1.972		306		750	520	16.113
SO	SONDALO	4.281	95	181		160				28.982
BZ	STELVIO	1.215		215		125			540	10.421
SO	TIRANO	9.238	132	3.319					2.000	61.312
BZ	VALDAORA	3.056	34	2.996		547			688	23.667
BZ	VAL DI VIZZE	2.761	26	4.443		2.084			1.100	47.583
BZ	VARNA	4.236	40	5.452		490			1.140	22.898
BZ	VIPITENO	6.419	2.434	2.758	40	3.215	18			64.930

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Figure 3.19 Above the increasing trend of LREOs in the Netherland as reported in Boon and Dieperink (2014, p. 298); below the 2014 graduatory of the 100% self-sufficieny in RE supply municipalities in Italy (Legambiente 2014).

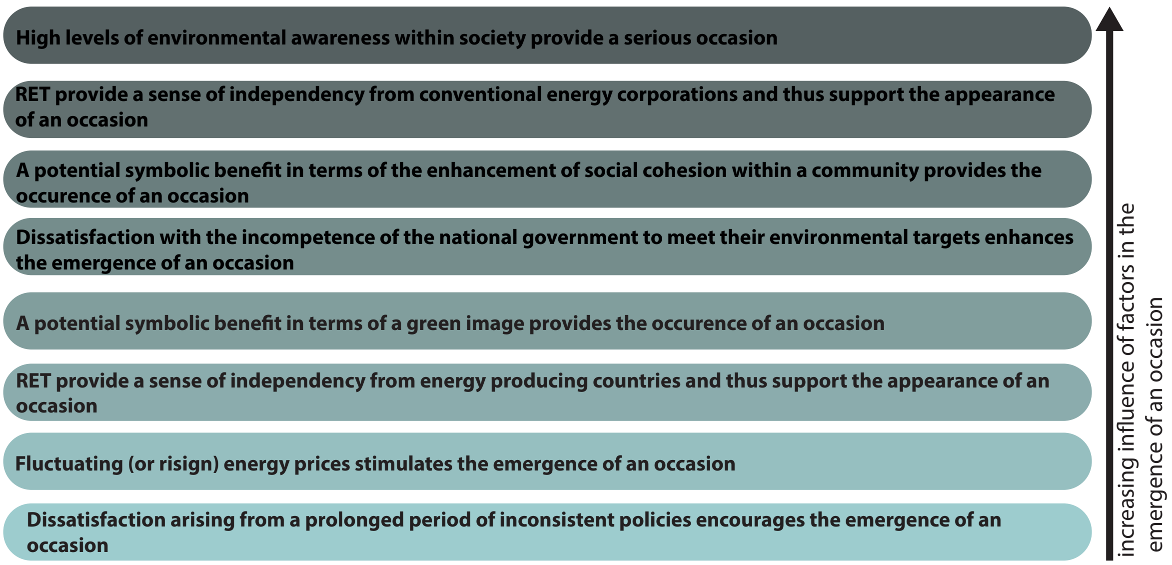

Figure 3.20 The image shows the factors that influence the emergence of an occasion for LREOs, adapated from Boon and Dieperink (2014, p. 302).

Chapter 4

Planning and design of renewable energy landscapes towards a design approach

4.1 Planning and designing renewable energy landscapes

In this section we will discuss the role of landscape planning and design in energy transition management. More specifically if the energy transition management can be afforded in a sustainable way by local communities, what is the contribute of landscape planning and design?

Sijmons et al. (2014) in the introductory section of their recent publication pronounced, even if not proclaimed, a sort of manifesto of what spatial designers want to do with energy transition: “we want to let the energy sector see the spatial dimension of their work field. And we want to show spatial designers that the energy transition is a genuine design challenge. For citizens, business and officers, we want to present the transition in energy and space as a social issue that is important and unavoidable, difficult yet promising” (2014, p.11-12).

In order to understand in what way planning and design contribute to a sustainable energy transition, first we need to clarify what is the difference of tasks between planning and designing the landscape. Traditionally, landscape planning and design have different tasks but share the same substantial and process values (van Haaren et al., 2014). Landscape design finds new solutions to the change of the structure of the landscape. The task of Landscape planning is to manage the change of the land use and its ecological, cultural and economic functions, in order to preserve biodiversity, sustainability and beauty (Termorshuizen et al., 2007). According to van Haaren et al. “Landscape design deals with projects that focus on change, in which the objective is to develop new solutions. In contrast, the tasks of landscape planning are generally overseen by government agencies and their objectives are much more precautionary in nature and focus on safeguarding, supporting, or re-establishing landscape functions and ecosystem services” (2014, p.162). Different is the definition of landscape design from Inverson Nassauer and Opdam: “ we define design as intentional change of landscape pattern, for the purpose of sustainably providing ecosystem services while recognizably meeting societal needs and respecting societal values” (2008, p. 635). ES are directly included in the definition, and the main task of sustainability is considered a design affair. Landscape design is a connection between landscape planning and society in the way it traces landscape patterns that are the spatial dimension of processes (Inverson Nassauer and Opdam, 2008).

We can distinguish three categories of value in planning and design the landscape: substantive, process and methodological values (van Haaren et al., 2014). Each landscape school devoted its theories to some values or others. These values are prioritized if we consider planning processes or design ones. The following figure (figure. 4.1) shows those proportions of values. The ES can be considered in the substantive value of sustainability, which is prioritized more in planning than design. By this fact we would argue that sustainability, in the sense of keeping on the supply of the ES should be a planning affair but as we see other authors as Inverson Nassauer and Opdam (2008) consider ES a design affair, as the ES supply is directly influenced by the landscape structure (Haines-Young and Potschin, 2011).

In the same image we traced a square for design approach in landscape planning. How can a design approach in planning be defined? According to van Haaren et al. "Embracing a landscape design approach in landscape planning offers opportunities to achieve site objectives, for example by using design to brand a local community's landscape identity in a visually compelling way or by incorporating the design process in a charrette to develop a regional vision with local stakeholders" (2014,p.166). As we show in the following figure (4.1) a design approach interpolates design and planning.

But is energy transition management a design approach task? If energy transition must "not cause crucial trade-offs for the other Ecosystem Services" (Stremke and Dobbelsteen, 2012, p.4), according to Inverson Nassauer and Opdam (2008) this is a design task. And if energy transition would have to involve local communities in innovation system and the production of regional visions (De Waal and Stremke, 2014), this is a design approach task.

In order to proceed with the objective of this section we should return to the literature on renewable energy landscape and the research of Sijmons et al. (2014) in particular.

Sijmons et al. (2014) described five dimensions of energy transition: economic, political, technical, infrastructural and emotional. In their research, the authors developed a design approach to carry the energy transition in a sustainable way. Sijmons in particular focuses on the necessity of a design approach to afford the emotional transition (Sijmons et al., p. 410).

A design approach is multi-scalar, it varies from the regional to the local and building scales. The formulation of scenarios involving all the spatial scales is an essential instrument in order to face uncertainties and focus on particular landscape layers that can be influenced by the energy transition. The involvement of stakeholders in participatory processes is

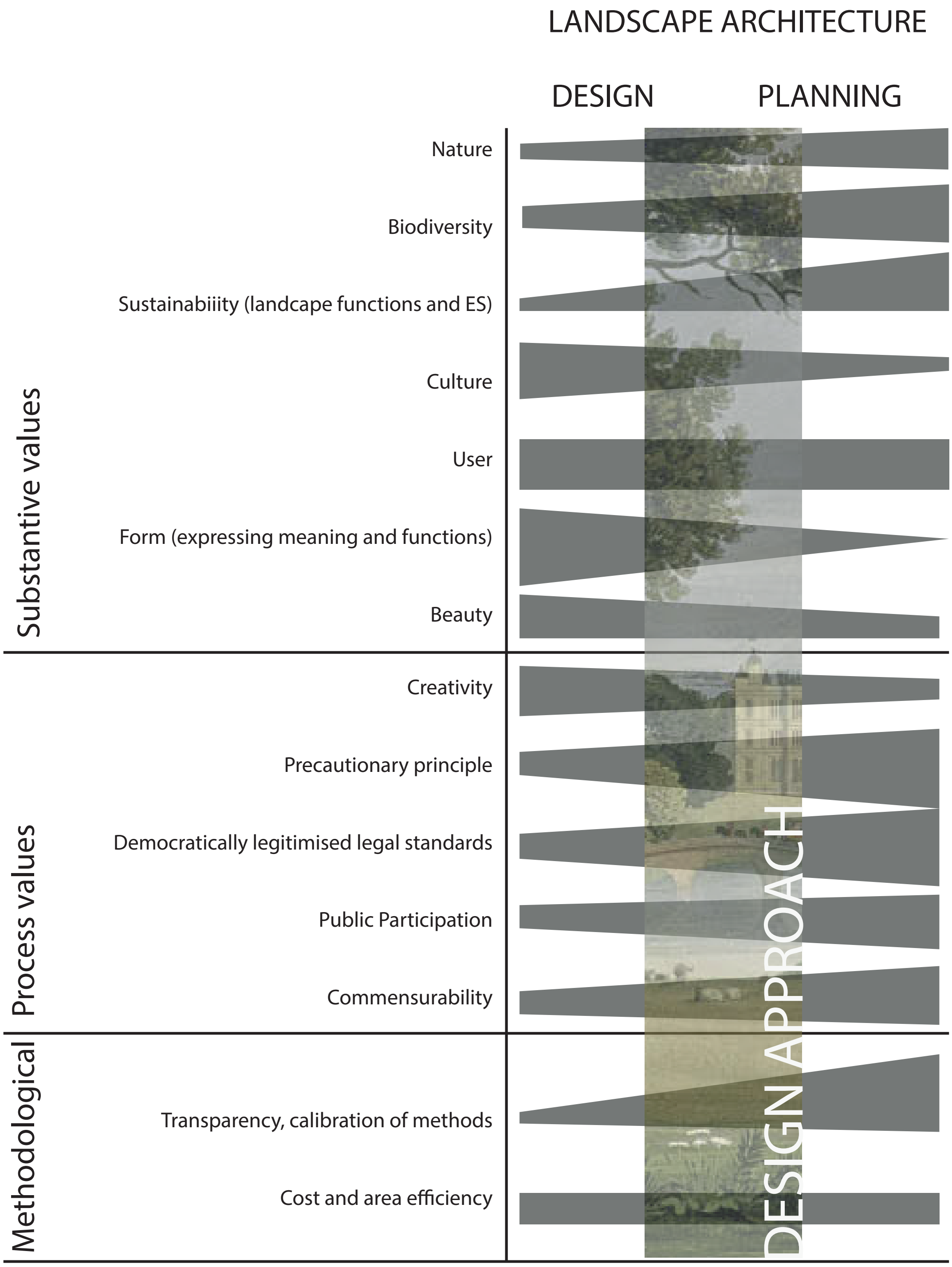

Figure 4.1 The image shows the values priority for planning and design, and introduces the "design approach" which contemplates values both from design and planning. Adapted from Haaren et al. (2014, p. 164).

mandatory, according to the European Landscape Convention (2000).

A design approach (McHarg, 1967; Stremke, 2010; Van Haaren et al. 2014) has some added values: "making invisible or hidden ecological processes "visible"; reconciling people with a "new" landscape, for instance with unaccustomed features such as wind turbines; or raising consciousness about land degradation problems" (Van Haaren et al., 2014, p.167). Resuming a design approach supports the aesthetic and the communication with stakeholders.

The contribution of a design approach to the energy transition should be seen in a regional context in order to address regulations at regime level. Relevant and sustainable design have been realized in the last decade, problem solving and focused on singular contexts, but a landscape design limited at the local scale, even if innovatory and sustainable can contribute to community energy transition but hardly can influence regime rules if not conceived as a regional project (figure 4.2, 4.3, 4.4 and 4.5). A design concept (Sijmons, 2014) can address similar context solutions at regional scale and become a regime rule and influence policies at the techno-social landscape level (Geels, 2004). This is why a design approach should be at regional scale to facilitate the energy transition, this is coherent with the transition management theory (figure 4.6, 4.7). Stremke affirms "A regional approach can assist in synchronizing energy-conscious interventions that take place on various locations and at different scales. A regional approach to energy transition also has the potential to bridge the gap between (inter)national targets and local initiatives. At the regional scale, long-term strategies and short-term actions can be integrated effectively to transform today's fossil fuel depending physical environment into sustainable energy landscapes" (Stremke, 2010, p.108).

The increased complexity of market and social flows, the reduction of distances due to the development of transports, the globalization require a scale that encloses the local and looks at the complex of flows at wider scales as the mega-regional one (Thun and Velikov, 2012). The flows of the distribution of benefits from ES can be trans-regional or even global. Regional scale, or even mega-regional scale as in the case of the Conduit Urbanism project by Thun and Velikov, rtvr, Toronto, Canada (figure 4.7) represent a challenge for the energy transition of communities that must be framed in the complex global network. Design approach at regional scale, or regional design, is the main approach Landscape Architecture is challenging nowadays to face the envisioning of complex social, ecological, economic future landscape scenarios. The design concept or design strategy becomes a planning tool.

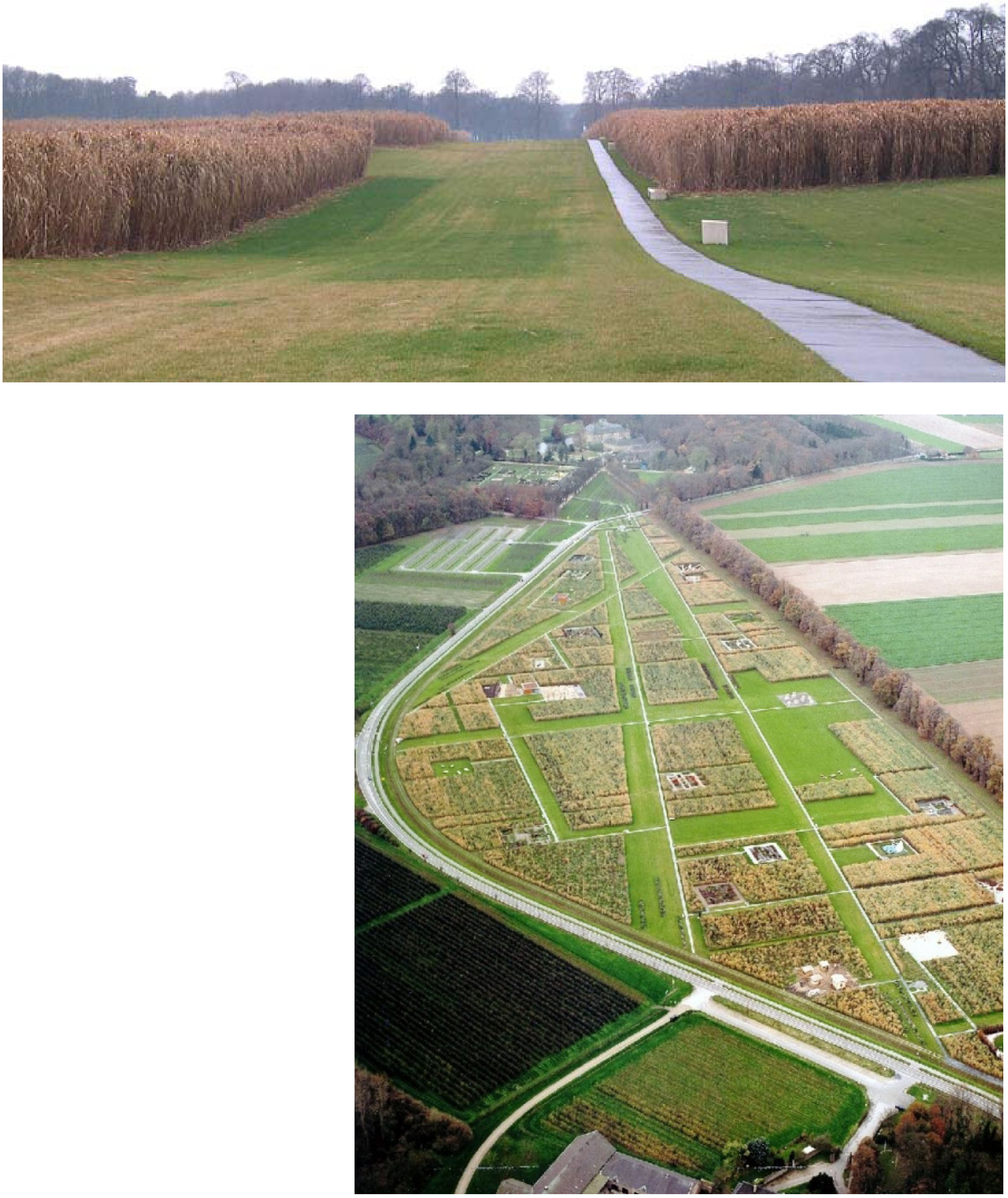

Figure 4.2 Renewable energy landscape design for the New Garden of Dyck Castle by Stephan Lenzen / RMP Landschaftsarchitekten. The historical garden layout has been reproduced by planting *parterres* of Miscanthus sinensis, these enhance both the energy production, the cutting of the grass and the combustion provide energy for the entire castle and cultural heritage and recreation ES. This is a sustainable energy landscape design (image source http://worldlandscapearchitect.com/)

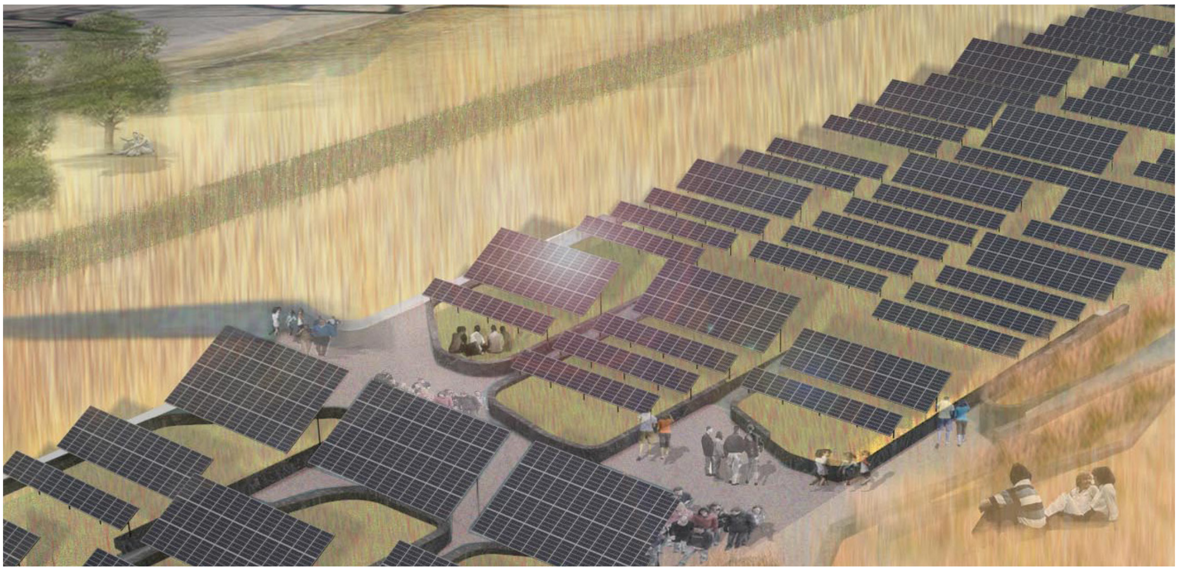

Figure 4.3 The Solar Herray at UB Campus, Buffalo University, New York state by Walter Hood landscape architects. The UB solar installation's 5,000 photovoltaic (PV) panels will generate solar energy for 735 student apartments at UB, reducing the university's carbon emissions by more than 500 metric tons per year. This landscape design creates new recreational and educational spaces. This is considered a design concept because will lead other similar experiences throughout the region. (image source, http://www.buffalo.edu/news/releases/2010/04/11249.html).

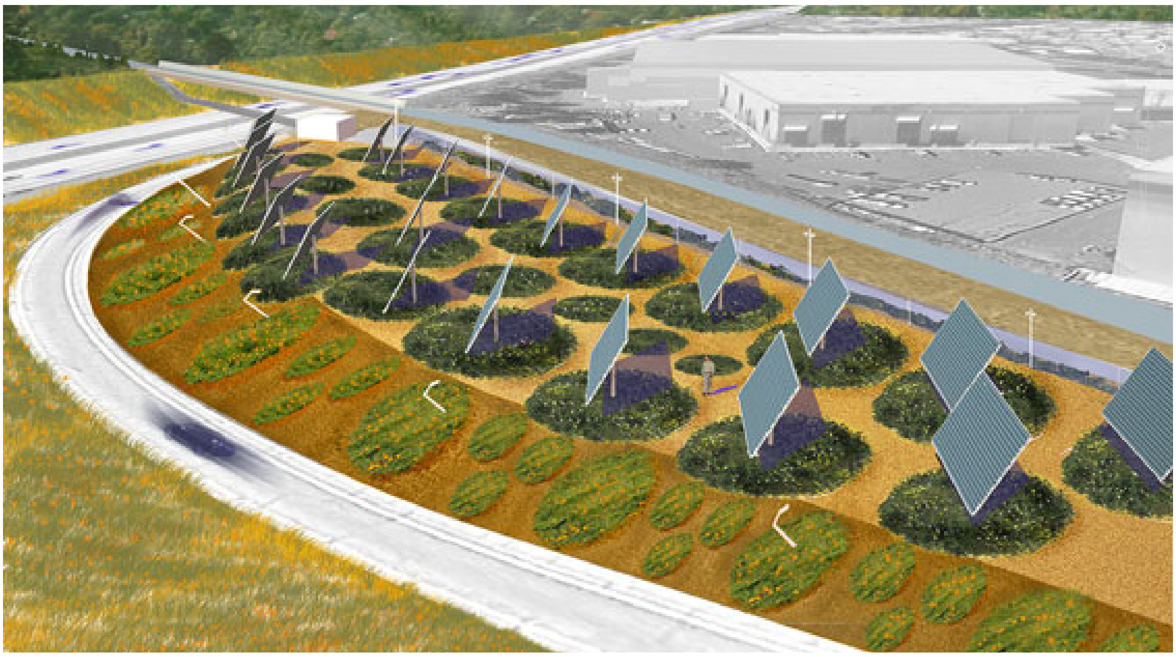

Figure 4.4 The Sacramento Solar Highway. The design from the Firm Bionic was realized in 2012 and is conceived as a solar energy landscape developed along the motorway enhancing regulating ES, reconnecting ecological corridors for wildlife fauna lost with the landscape fragmentation due to the infrastructure network.

Figure 4.5 Some designs from the edition 2014 of Land Art Generator (LAGI) in Copenhagen. Above the 2nd place winner *Quiver* by Mateusz Góra, Agata Gryszkiewicz, Poland, supplying 550 MWh (223 MWh bio, 327 MWh WindbeltTM); below *Balance/Imbalance* by Hideaki Nishimura, Japan, supplying 720MWh. LAGI initiative supports the development of RET bu conceiving innovative landscape design that crreates a new narrative, new ecological and cultural functions in energy landscapes (images source www.landartrgenerator.org).

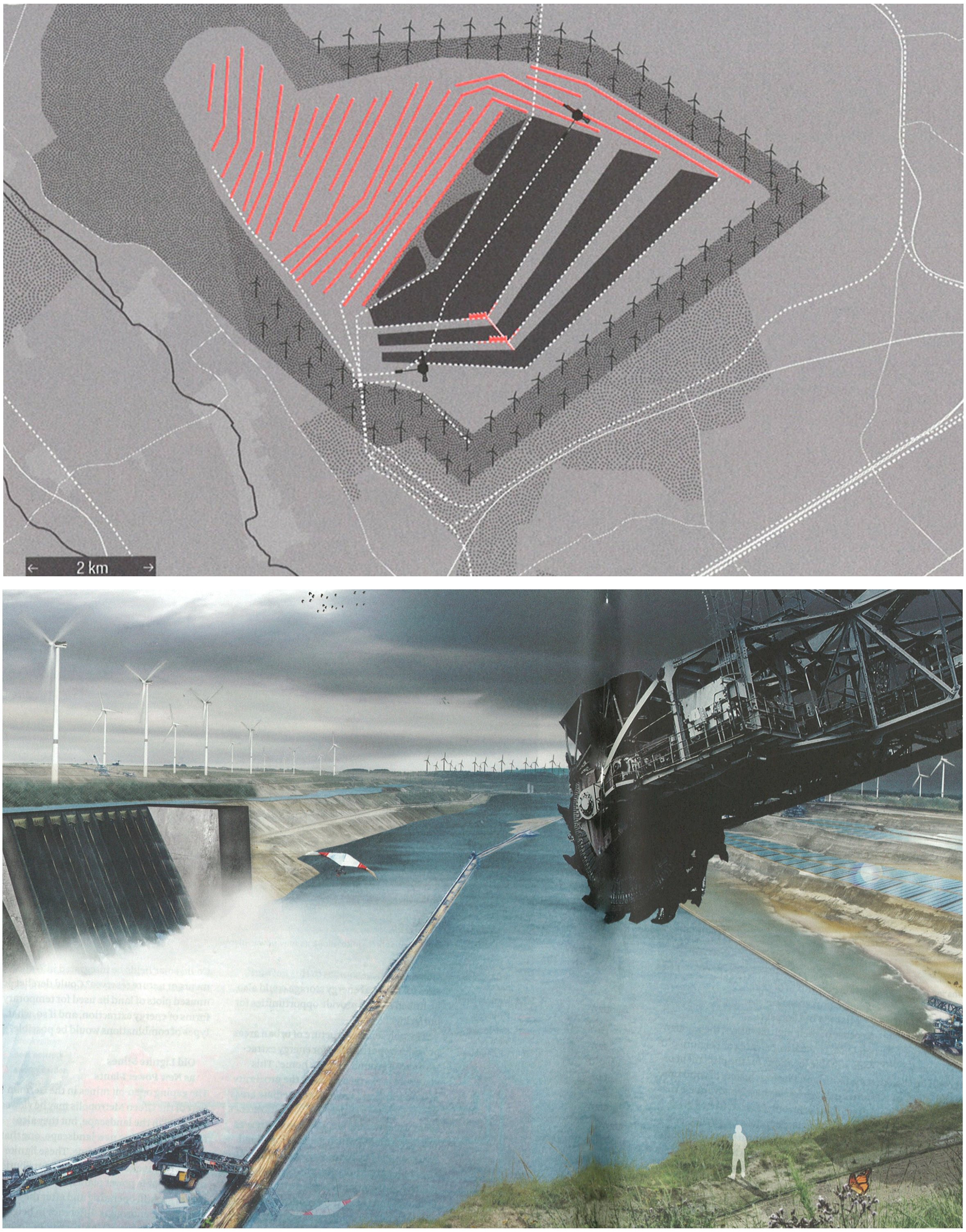

Figure 4.6 A renewable energy scenario for the Green Metropolis region (Netherlands, Belgium and Germany). Lignite mines as new power plants in the Green Metropolis Master Plan, 2009. The spatial energy concept uses the old coal mines caves to produce power from water and enhances the recreation and water regulation ES, produces wind energy and biomass from the forest and solar energy on fields. This design strategy can be applied at regional scale in similar contexts (image source Sijmons et al. 2014, p. 295).

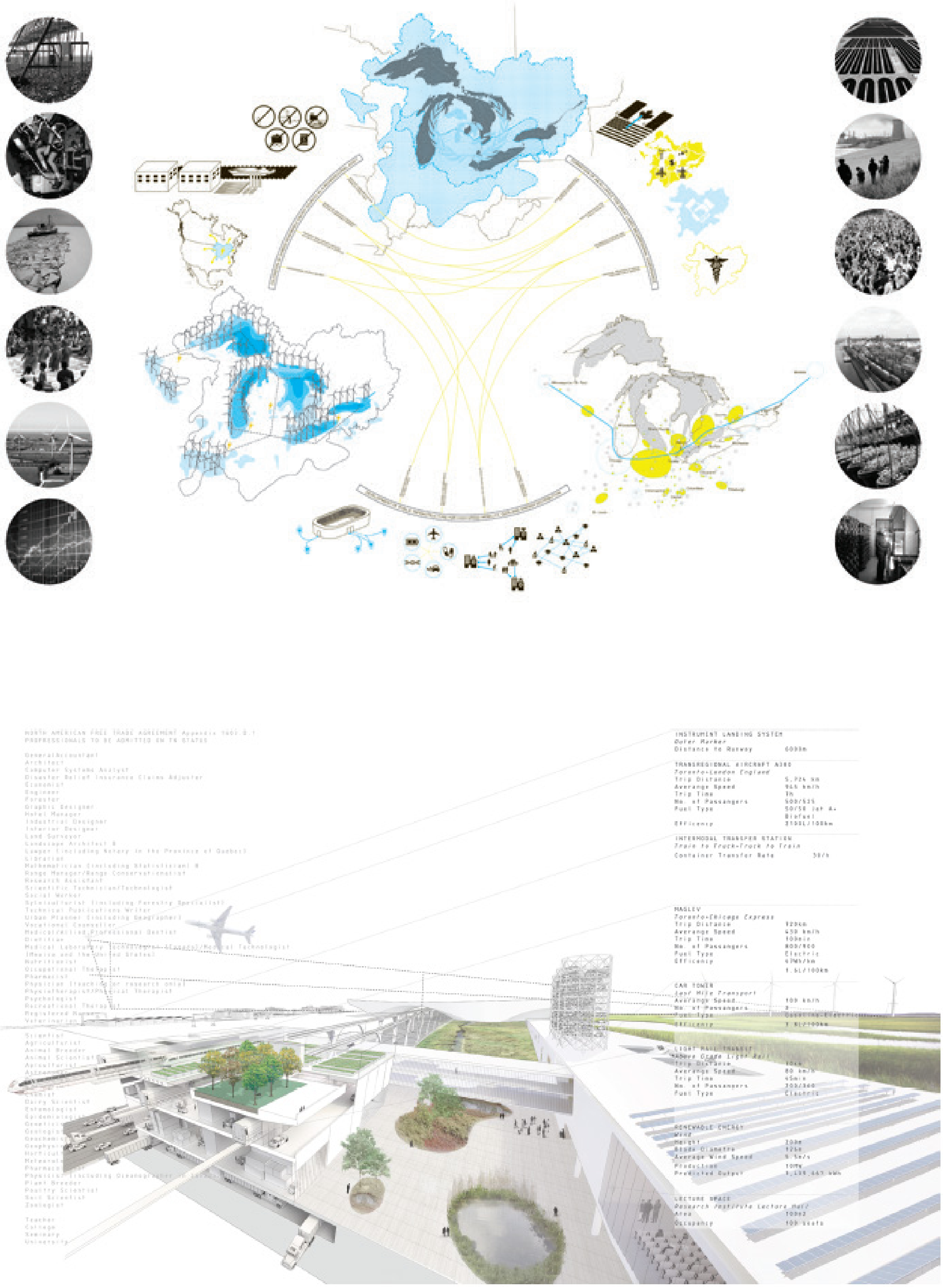

Figure 4.7 The *Conduit Urbanism* project developed by Thun and Velikov, rvtr, Toronto, Canada imagines future scenarios for the sustainable development of the Great Lake Region bewteen Canda and USA. The design concept develops the infrastructural network as an appropriate layer for the energy landscape, combining the energy supply with other cultural and ecological ES (image source www.rvtr.com and Thuin and Velikov, 2012, p.269).

4.2 Sustainable energy landscapes and Ecosystem Services

Sustainable Energy Landscapes, SEL, have been defined 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 and Van den Dobbelsteen, 2012, p.4).

Stremke (2015) developed several criteria for sustainability (figure 4.8). These can be divided in four main dimensions: sustainable technical, environmental, socio-cultural and economical criteria. There is in addition a minimum of technical criteria as for example the wind potential o the area if you want to install a wind turbine. These minimum technical criteria are represented in the EPM. The re-cycling of the dismissed RET materials for example is a sustainable technical criteria, or the color and reflection of the turbines to reduce the impact on the bird routes. The reduction of carbon emissions, the reversibility of the RET interventions in the landscape, or the mitigation of the potential affliction of RET on the regulating ecosystem services such as water regulation or landscape connectivity are environmental criteria. The perception of RET in the landscape from valuable areas for

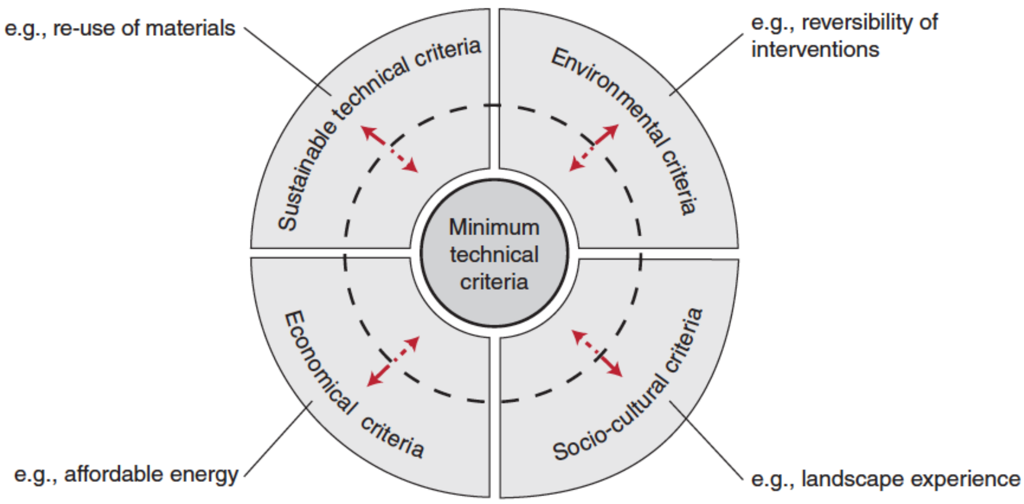

Figure 4.8 The four dimensions of sustainability criteria (Stremke, 2015, p.6).

recreation or landscape identity, or the realization of new attractive landscape experiences as at Dyck Castle or at LAGI are socio-cultural criteria that must be weighted with stakeholders. The access to affordable energy as well as the land use competition as the risk of affliction of remunerative agricultural or tourism activities deeply connected with the status quo of the landscape are economical criteria. All these criteria can be in trade-off each other, and should weighted by stakeholders.

All the four dimensions of criteria, apart from the minimum technical criteria, can be resumed as in the SEL definition "life-supporting ecosystem services". In order to proceed in our dissertation and to introduce the following chapters we can define three main measures in the SEL definition, the first one is that RET must not compromise the supply of other ecosystem services and this measure is based on the four dimensions of criteria, but by a local community perspective, seeking for a sustainable and self-sufficient energy system, is relevant to state other two measures,

RES must be locally
RES must be diverse as much as embodied in the landscape

The notion of embodied energy "comes into consideration when we try to represent all the energies and greenhouse emissions which are related to a given landscape (Nadai and van der Horst, 2010, p.148). The authors also affirm "the notion of embodied energy is also performing our landscapes in the sense that it will guide us in thinking and shaping what we might consider as acceptable landscapes in the future" (Nadai and van der Horst, 2010, p.148).

The concept of ES was developed around 30 years ago, when conservationists started calling the nature contribution to human well being as ecosystem services (Spangeberg et al., 2014). The following definition was provided in the Millenium Ecosystem Assessment report in 2005: "Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits" (MEA, 2005, p. 3). The provision of these services is directly dependent on the ecological functioning of the ecosystems (Kandiziora et al., 2013) according to a cascade model designed by Haines-Young and Potschin (2011) where the integrity of the ecosystems is the main parameter to evaluate the capacity of ecosystems to supply services. This is relevant for the objective of this thesis, to enhance energy-conscious landscape planning and design through an ES approach we should evidently examine the relationship between RE and ES in other words how RET can afflict ecosystem integrity and the landscape structure. There are at least three classifications for ES (MEA 2005; TEEB, The Economics of Ecosystems and Biodiversity, 2010; CICES, 2011) and ES are commonly divided in three main themes or categories: provisioning, regulating, and cultural services. The original MEA classification also considers supporting or habitat services, those services that allow the supply of other ES. These relate to the ecological functioning of ecosystems and the physical structure of the landscape (MEA, 2005). Recently the CICES classification 2011, edited by the European Environment Agency (Haines-Young and Potschin, 2011) introduces the class of Renewable Energy in the Provisioning Services theme (table 4.1). The challenge is to manage RE and other ES supply as a direct trade-off mechanism between ES.

Stremke et al. (II, 2012) conceived an approach, the *Five-step Approach* for envisioning sustainable energy landscapes. The approach is based on the definition of SEL. The Five-

Table 4.1 The CICES classification. The table shows the themes and the classes with the introduction of the Energy Class (Haines-Young and Potschin, 2011, p.3).

CICES Theme	CICES Class	TEEB Categories			
Provisioning	Nutrition	Food	Water		
	Materials	Raw Materials	Genetic resources	Medicinal resources	Ornamental resources
	Energy				
Regulating and Maintenance	Regulation of wastes	Air purification	Waste treatment (esp. water purification)		
	Flow regulation	Disturbance prevention or moderation	Regulation of water flows	Erosion prevention	
	Regulation of physical environment	Climate regulation (incl. C-sequestration)	Maintaining soil fertility		
	Regulation of biotic environment	Gene pool protection	Lifecycle maintenance	Pollination	Biological control
Cultural	Symbolic	Information for cognitive development			
	Intellectual and Experiential	Aesthetic information	Inspiration for culture, art and design	Spiritual experience	Recreation & tourism

step Approach applies a design approach in regional planning and formulates long-term visions (Healey, 2009) based on policies and available RES at local scale (figure 4.9).
In chapter 6 we will talk about the application of the Five-step approach in our case study and explain in details the methodological framework. In the previous chapter we touched

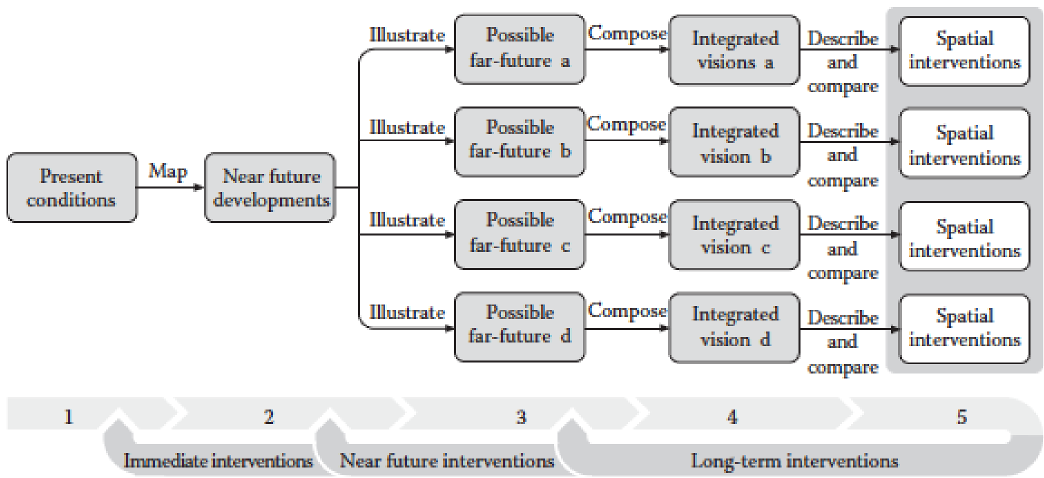

Figure 4.9 The methodological framework of the Five-step approach (Stremke, 2012, p. 100).

on the importance to "act locally", keep in mind the slogan of the Samsø Energy Academy "think local – act local". Literature on ES services also remarks the importance of managing ES trade-off at local scale (Bennett, 2009). Now we want to discuss the third measure: RES must be diverse as much as embodied in the landscape.
In order to develop a sustainable and self-sufficient energy system, a community must make use of all the available RES, as much as embodied in the landscape "we need to learn planning and designing again in such a way that local resources are optimally seized before any import from elsewhere" (Van den Dobbelsteen et al., 2012, p. 72). Diversity of RES and optimization of the energy fluxes in an energy-conscious spatial planning and design are indeed necessary. The optimization of energy fluxes is based on the Second Law of Thermodynamics (Stremke et al., 2011). The formulation of Energy Potential and heat Maps, EPM (figure 4.10), can facilitate an energy-conscious spatial planning and design.
In the figure 4.11 the case of the "Green Campaign" as reported from Van den Dobbelsteen et al. (2012, p. 86). The plan is for the municipality of Hoogezand, in the province of Groningen,

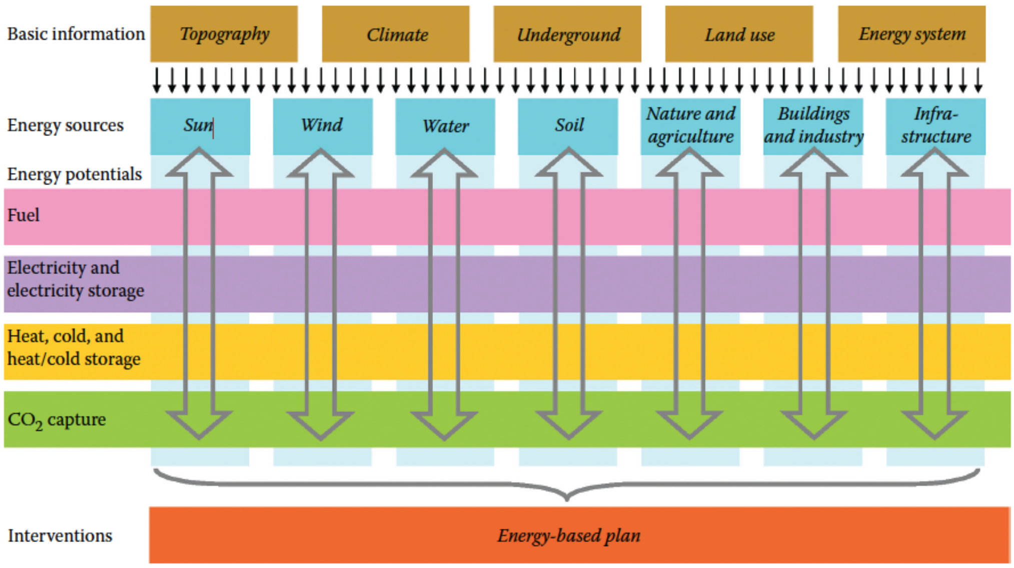

Figure 4.10 The composition of energy potential maps (Van den Dobbelsteen et al., 2012, p. 75).

Netherlands. The image show clearly the multi-layer perspective of EPM, each layer report the potential supply of energy from the different RES, the potential of harvestable biomass, the residual exploitable heat as the vertical heat exchange up to – 50 m, the aquifers heat—cold storage and the geothermal a -3000 m.

Having discussed the three measures of sustainability in the definition of SEL we can conclude that the Five-step approach satisfies the measures 2 and 3 in step 1, but doesn't include an ES assessment. The disengagement between the applied science on ecosystem services and the landscape planning and design is here again evident. Further there is the challenge for a "mature design science" to enhance the understanding of how the landscape change influences the landscape pattern and the processes and the effect on the ES (Inverson Nassauer and Opdam, 2008). Ecosystem services are emerging as a key approach for landscape planning sustainability (Termorshuizen et al., 2007; de Groot et al., 2010). This is also valid for energy landscapes, the introduction of ecosystem services in the planning and design of energy landscapes represent a challenge (Coleby et al., 2012; Howard et al., 2013; Stremke, 2015). In the following chapters we will address this challenge by means of literature discussion and case study.

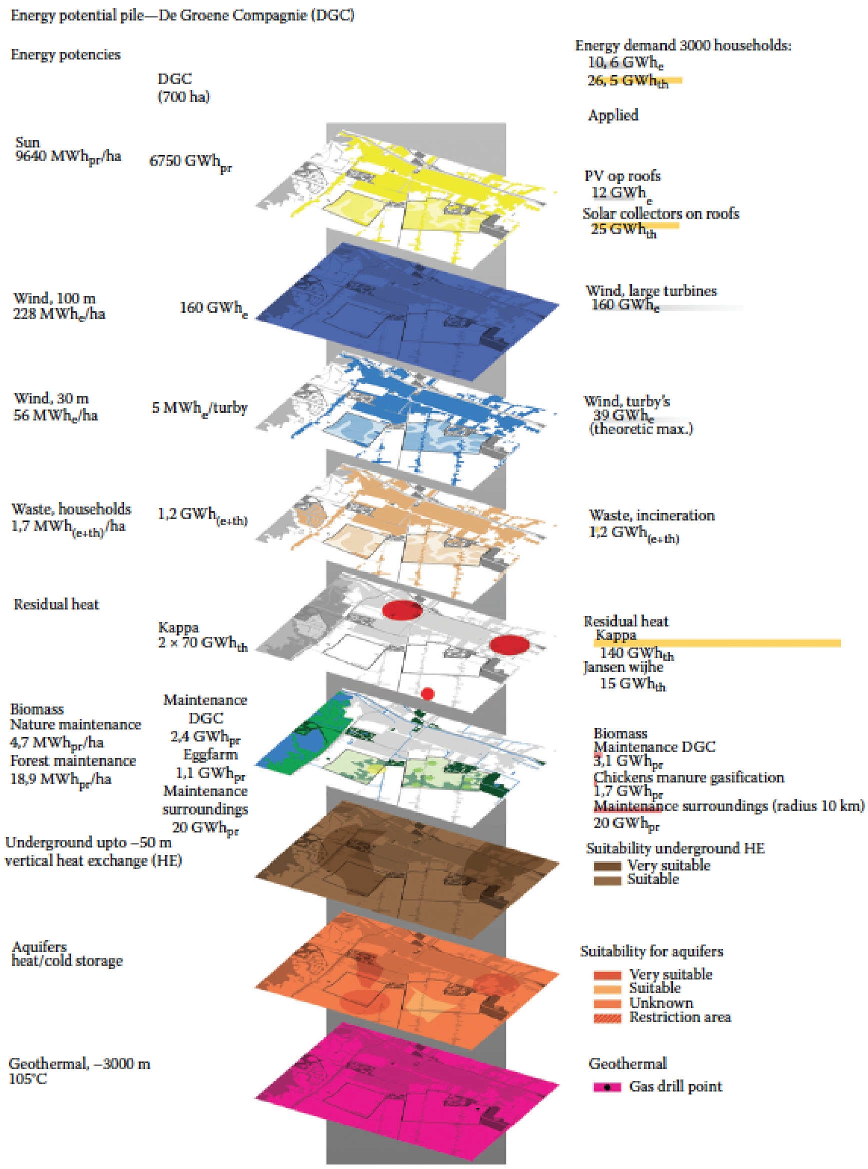

Figure 4.11 The image shows a multi-layer perspective of Energy potential and heat maps (image source Van den Dobbelsteen et al., 2012, p. 86)

Chapter 5

Advancing the relationship between Ecosystem Services and Renewable Energy: A review

5.1 Introduction

The energy transition to renewable energy (RE) is unavoidable to plan and design a sustainable development (Rio+20, 2012; IPCC, 2014). This requires technologies that present wider footprints on the landscape than the fossil fuels ones (Stremke, 2014). This means that Renewable Energy Technologies (RET) consistently modify the structure of the landscape and its functions.

The change of landscape and related socio-cultural, ecological and economic functions causes blocks and oppositions at regional and local level. Considering an Ecosystem Services approach, with regard to sustainable energy transition, the conflict between the global perspective (mitigating climate change by utilizing renewable energy) and the local perspective (landscape values) has been synthetized as the trade-off between provisioning/ regulating ecosystem services categories and cultural ecosystem services category (Van der Horst and Vermeylen, 2011). Rodriguez et al. defined the "trade-off "among ES: "Ecosystem services trade-offs arise from management choices made by humans, who intentionally or otherwise change the type, magnitude, and relative mix of services provided by ecosystems. Trade-offs occur when the provision of one ES is reduced as a consequence of increased use of another ES. Trade-offs can be classified in terms of their temporal and spatial scales, and their degree of reversibility." (2006, p.28).

One of the main conditions for the sustainability of energy landscapes is that the introduction of RET should not cause crucial trade-offs for ecosystem services (Coleby et al., 2012; Stremke 2014). The aim of this paper is to investigate the existing knowledge on the assessment of RE in a landscape perspective and see what Ecosystem Services (ES) categories and how are included in the assessment. For landscape perspective we mean an assessment that refer both to the spatial and socio-cultural dimension of the landscape and that involve local stakeholders. In this paper we will make distinction between Renewable Energy Sources (RES), RET and RE. For RES we mean the renewable energy sources such as, sun, water, wind, biomass and geothermal, while RET are the technologies necessary to produce energy from these sources. A photovoltaic panel (PV) is the technology that allows the production of energy from the source sun, this technology has spatial footprints in the landscape. RE is the output of the process, the energy produced by renewable sources through a particular technology. When we investigate the relationship between RE and landscape, in the broader sense we mean that we put on the balance two forms of human benefit, the supply of renewable energy and the supply of ecosystem services provided by the landscape. In a more particular sense we analyze the impact of RET on the ES supply.

The specific angles of this review are: investigate the knowledge on the approaches used to assess RE in a landscape perspective and see what ES categories are considered and what the involvement of stakeholders; investigate the knowledge on the methods to assess synergies and trade-offs among ES, in particular what spatial reference systems are adopted, what the involvement of stakeholders; investigate the knowledge on how Cultural ES can be assessed in trade-off among ES, in particular what spatial reference systems are adopted, what the involvement of stakeholders. These three angles determine three search stages.

Starting by these three specific angles of investigation, the following three research questions, one for search stage, were pursuit by means of a literature review:

1. What are the approaches and ES categories in RE assessment?
2. What are the methods for assessing synergies and trade-offs among ES and what are the spatial reference systems?
3. How can Cultural ES be assessed in trade-off with other ES and what the spatial reference systems?

The paper is structured as follows: the Section 2 sets the stage of the review, providing key definitions and references on energy transition, landscape change, RE and ES. In the third section we present the method and materials for the literature review, and the selection of the relevant papers. In the fourth section we present the results for each stage and research question that are then discussed in section five. In the conclusions we answer the research questions and define the challenges for future research. The paper makes use of abbreviations not in the field for the terms as in the footnote* .

* EL, Energy Landscapes
ELC, European Landscape Convention
LI, Landscape Infrastructure
RE, Renewable Energy
RES, Renewable Energy Sources
RET, Renewable Energy Technologies
SEL, Sustainable Energy Landscapes

5.2 Key concepts and definitions

Landscape changes because of the introduction of RET, which in turn become new elements of it. History and archeology shows that landscape has undergone periods of rapid changes due to specific drivers, natural or human, and long periods of stabilization and consolidation. The frequency and the magnitude of change are important parameters, which depend directly on the technological means (Antrop, 1997). During so-called consolidation periods the environment gradually incorporates the innovation and very slowly produces a ‘traditional landscape’, which can be defined as a landscape whose structure is distinct and recognizable by people (Antrop, 1997). Nowadays the technologies associated with RE supply, increase the magnitude of change, while the velocity of change depends on policies and planning. Hence, some landscapes develop with higher frequency than others preserved for their natural or cultural value. This is typical for a conservative approach, which doesn’t contemplate any trade-offs among values. A non-conservative approach (e.g. sustainable development) accepts trade-offs as discussed for example in the European Landscape Convention (ELC, 2000, article1e, p.10). As Selman affirms “energy production has driven the emergence of distinctive landscapes throughout history, and traditional sites of wind and water power are often important parts of heritage” (2010, p.163), so that some energy landscapes from the past today provide some ES.

Nowadays Energy Transition can be opposed by local communities that don’t want their landscape to change due to the introduction of RET. Already more than 10 years ago, referring to the so-called renewable energy landscapes, Pasqualetti stated that most people believe that their landscape won’t change, it is a sort of faith (2011a), they expect permanence in their landscapes (2000).

The notion of energy landscape (EL) was originally defined in physics and biophysics but in the last decades has been used in geography and landscape ecology to define “a landscape whose image and herewith the functions (natural, productive, residential, recreational, cultural, etc.) have been significantly affected by the energetic industry” (Frantál et al., 2014, p.2). Anyway the notion of EL is quite controversial and it depends on the point of view, according to Stremke, the energy landscape can also be defined as one of the several layers composing a landscape (Stremke, 2014).

Energy landscapes are composed of constructs and layers (Pasqualetti, 2012). Constructs are the physical forms of RET, included networks, while the layers are defined as their impact on the landscape and supported ES. Constructs and layers can create different forms of energy landscapes. Generally speaking, RE landscapes have much larger spatial footprint than fossil fuel landscapes because most renewables have lower energy content compared with fossil fuels (Stremke, 2014).

Nadai and Van der Horst affirm "the energy landscape crossroads may very well help us work this through (RET assessment, A/N) by offering an unprecedented lens for observing unprecedented landscape processes" (2010, p.147). These recent approaches developed through a landscape perspective help us to think about RES as local sources embodied in the landscape (Nadai and Van der Horst, 2010) .

A landscape analysis is the first step in evaluating EL. An analysis of each layer that constitutes the landscape through a multi-layer approach (McHarg, 1967; Steiner, 1991; Ducchart, 2007) can facilitate the understanding of the relationship among RE and ES trough the understanding of the landscape infrastructure (LI). Both ES and RES are provided by the ecosystems and delivered through the LI.

Haines-Young et al. (2011) remarked the importance of the landscape perspective, or "place", in order to seek for sustainability through the ES framework. Over the last decade, studies focused on the relations between ES and land use/land cover and the LI, in order to understand the main dynamics of trade-offs.

Burkard et al. (2009) for example studied the capacity of land use/land cover and specific landscape attributes to supply ES. This capacity was expressed as qualitative values per land use/land cover classes. Bennet et al. (2009) remarked the importance to study trade-off among ES at the local scale, avoiding generalizations because still we are not aware of what are the ecological link mechanisms that can relate two ES.

Syrbe and Walz (2012) studied spatial indicators for the ES supply and considered landscape metrics, the LI and specific features of the historical landscape as relevant indicators. Moving back to renewable energy landscapes and ES, Coleby stressed the challenge to introduce an ES approach into the Environmental Impact Assessment of RET (Coleby et al., 2012). Sustainable Energy Landscape (SEL) has been defined 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 and Dobbelsteen, 2012, p.4). This definition contemplates an ES assessment, and seeks to introduce it into the assessment of RE supply (Coleby et al., 2012). De Groot et al. (2010) studied the ES approach as a potential tool in strategic spatial planning and landscape design, and this suggests that in relation to RE the contribute could be even more fruitful (Howard et al., 2013).

The provision of ES is directly dependent on the ecological functioning of the ecosystems (Kandiziora et al. 2013) according to a cascade model (Haines-Young et al., 2012) where the integrity of the ecosystems is the main parameter to evaluate the capacity to provide services. As Plieninger et al. affirm, "few studies have addressed, through exploratory scenarios, how local actors perceive the impacts of landscape changes on ecosystem services provision, and how they define their scope for action against the multitude of landscape drivers" (Plieninger et al. 2013, p. 2). To study the relationship between RE and ES we should evidently look at how RET can afflict such functioning. RE is considered in trade-off with ES (Burgess et al., 2012; Coleby et al., 2012). Recently in a report produced by the European Environmental Agency (Haines-Young and Potschin, 2011), RE is classified as provisioning ecosystem services. This is challenging in the way we could manage the RE assessment integrally through an ES approach, a direct trade-off between ES supply (Rodriguez et al., 2006). This would allow measuring synergies and trade-off among energy production services and other services supplied by a specific landscape, as stressed in the definition of SEL (Stremke and Dobbelsteen, 2012). In this context, Gee and Burkhard (2010) question "What is more important, the market value of electricity generated by offshore wind farming or the symbolic value of the sea to local residents? Ultimately, these are decisions that need to be taken by society through transparent and inclusive dialogue" (p.357). RET may compromise the delivery (both in quality and quantity) of ES and the risk of such trade-offs must be recognized if conflicts between different policies and goals are to be avoided (Howard et al., 2013).

5.3 Methods

The literature research was structured into three sub-sequent stages (figure 5.1). The search was based on online databases* using keywords string and Bolean characters as "keyword" AND "keyword". The search was limited to the years 2005-2014 and to scientific articles published in English. The period has been set according to the key references as presented in the introduction. Grey literature was not considered. After the filter of specific research fields, (figure 5.1), the papers were first screened for title, then abstract and full text according to a potential contribution to answer the research questions. The first stage of the research was conducted from July 2013 until June 2014, the second and the third stages both in late 2014. The filtering of the second and third paper search was not based on further "limits" due to the limited amount of returned papers.

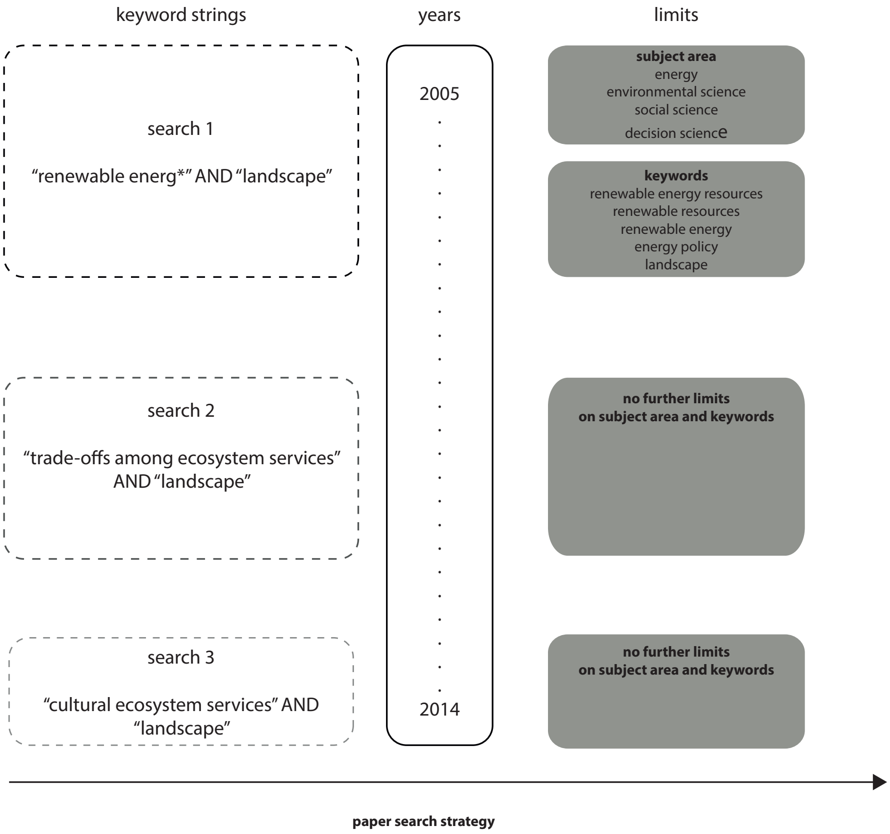

Figure 5.1 Flowchart of the search strategy.

*scopus.com and sciencedirect.com

The papers were clustered per criteria according to the following table (table 5.1).

Table 5.1 The papers were clustered according to the criteria in the table. The three columns on the right indicate the criteria use for each stage, search 1-3.

criteria	clusters	search 1	search 2	search 3
Method of inquiry	expert	■	■	■
	participatory	■	■	■
Spatial Scale	national	■	■	
	regional	■	■	
	local	■	■	
ES categories	provisioning	■		
	regulating	■		
	cultural	■		
	regulating, provisioning	■		
	provisioning, cultural	■		
	regulating, cultural	■		
	provisioning, regulating, cultural	■		
Strategy of inquiry	quantitative		■	■
	qualitative		■	■
	mixed		■	■
RE and Landscape approach	impact assessment	■		
	partially integrated approach	■		
	integrated approach	■		
	general attitude	■		
	energy potential	■		
Spatial reference	land use/land cover		■	■
	land use/land cover and caculation of metrics			■
	landscape infrastructure and features		■	■
	social maps		■	■
	bio-physical structure of ecosystems		■	
Particpatory mapping	yes		■	■
	no		■	■

Method of inquiry: the criterion clusters papers where the assessment parameters and their relative weights, values and judgments were decided only by expert or involved stakeholders. This is relevant to understand the level of involvement of communities in decisions pertaining ES values. Does the selection of parameters expect to stakeholders, to expert or to stakeholders through the support of experts? This criterion addresses the question of the trans-disciplinarity.

Scale: the criterion clusters papers where the study was set at national, regional or local scale. The criterion is relevant to understand at what spatial scale the relationship between

RE and landscape and trade-offs among ES are evaluated.

ES categories: the criterion clusters papers according to the categories of ES that have been used in the assessment. The criterion is relevant to understand what ES categories or combination of them have been considered in the assessment of RE in a landscape perspective. The combinations are regulating-provisioning, provisioning-cultural, regulating-cultural or all the three categories together.

Strategy of inquiry: the criterion clusters papers depending if they applied a quantitative strategy, a qualitative strategy or a mixed strategy (Creswell, 2007).

RE and landscape approach: the criterion clusters papers according to five different possible approaches (figure 5.2). *The impact assessment approach* focuses on the impact of a specific RET on a specific ecosystem service. *The partially integrated approach* develops the research in a more complex way than the impact assessment, considering the impact of one RET on at least two categories of ES and the reciprocal effects. *The integrated approach* pursues a more complete way, considering the reciprocal effect between diverse RES and corresponding RET and all categories of ES. *The general attitude approach* focuses on the attitude of stakeholders towards RE in relation to one RES in general or specific RET pertaining specific social, cultural and economic aspects. *The energy supply approach* focuses on the calculation of potential energy supply through specific RET in different landscape scenarios.

Spatial reference: the criterion clusters studies according to the spatial reference system they adopted (figure 5.3). These can be:

Land use/land cover, if they use CORINE or national or regional land use/land cover classes in relation to the supply of ES and their trade-off;

Land use/land cover with the calculation of landscape metrics, if they calculate values of landscape metrics in relation to the supply of ES and their trade-off;

Landscape infrastructure and features, if they refer the supply of ES and their trade-off to the physical structure of the landscape, as green and blue network, roads, and specific local features;

Social maps, if they refer the supply of ES and their trade-off to maps representing social use of the landscape;

Bio-physical structure of ecosystems, if they refer the supply of ES and their trade-off to the bio-physical structure of specific ecosystems and not to the complex f the landscape.

Participatory mapping: the criterion clusters studies depending if the method led a participatory mapping of ES supply or not.

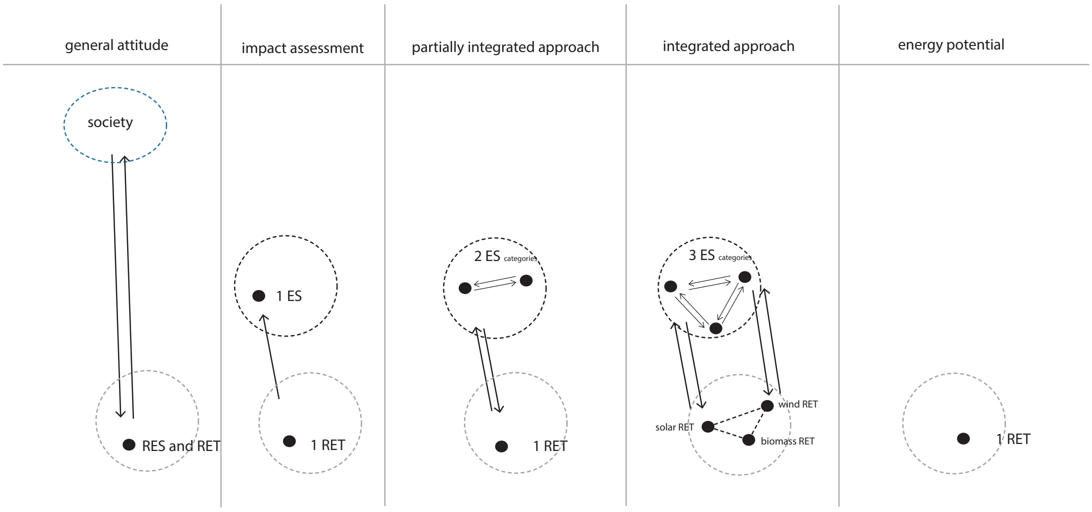

Figure 5.2 The images shows the logic behind the clusters of the RE and landscape criterium. RET are the real agent of trade-off between RE and ES. Some studies investigate the impact of specific RET, for example, PV on fields, others consider the attitude towards different technologies per RES, for example in the case of wind RES individual turbine or offshore wind parks. In the integrated approach diverse RES as sun, wind and biomass are considered and specific RET, for example for sun, PV on fields, for wind, individual turbine and for biomass, combustion of second generation biomass from fruit-groves management.

Figure 5.3 The image illustrates the differences between the clusters of the Spatial reference system criterium.

5.4 Results

The results of the three stages of papers search are reported in the tables below (2,3,4). We report the number of papers per journal and the corresponding years of publication.

Table 5.2 First stage: Distribution of 50 papers published between 2005 and 2014 relating to search keyword string "renewable energy" AND "landscape" per journal and per year.

Journal	N. Of papers	Years of publication
Annals of the Association of the American Geographers	1	2011
Annals of Tourism Research	1	2010
Applied Energy	3	2012, 2013
Biomass and Bioenergy	3	2009, 2012
Bioresource Technology	1	2011
Ecological complexity	1	2010
Energy policy	12	2005, 2007, 2009, 2010, 2011, 2012
Environment and Planning A	1	2009
Environmental impact assessment review	1	2009
Environmental management	1	2013
GCB Bioenergy	2	2012, 2014
Geoforum	1	2014
Global Nest Journal	1	2013
Hungarian Geographical Bulletin	1	2010
International Journal of Tourism Research	1	2010
Journal of Environmental Assessment Policy and Management	1	2009
Journal of Environmental Planning and Management	2	2012
Land Use Policy	2	2008, 2010
Naturschutz und Landschaftsplannung	1	2009
Ocean & Coastal Management	1	2009
Renewable Energy	5	2007, 2011, 2012
Renewable & sustainable energy reviews	4	2007, 2009, 2011
Tourist and Management	1	2013
Urban Lawyer	1	2010
Wiley Interdisciplinary Review: Energy and Environment	1	2012

Table 5.3 Second stage: Distribution of 38 papers relating to search keyword string "trade-offs among ecosystem services" AND "landscape" per journal and per year.

Journal	**N. Of papers**	**Years of publication**
Agriculture Ecosystems and Environment	2	2011, 2012
Biomass and Bioenergy	1	2011
Comptes Rendus Biologies	1	2011
Ecology and society	1	2006
Ecological economics	4	2007, 2009, 2014
Ecological complexity	2	2009, 2010
Ecological indicators	8	2012, 2013, 2014
Ecological Modelling	1	2014
Ecology Letters	1	2009
Ecosystem services	2	2012, 2013
Journal Ecology	1	2011
Landscape Online	2	2010
Landscape Ecology	4	2009, 2011, 2013, 2014
Landscape Research	1	2012
Landscape and Urban Planning	4	2010, 2012, 2013, 2014
Sustainable Science	1	2010
The Ecological society of America	1	2009

Table 5.4 Third stage: Distribution of 18 papers relating to search keyword string "cultural ecosystem services" AND "landscape" per journal and per year.

Journals	**N. Of papers**	**Years of publication**
Ecology and Society	1	2013
Ecological economics	2	2012, 2014
Ecological indicators	5	2012, 2013, 2014
Ecosystem services	4	2012, 2013, 2014
Environmental Science & Policy	1	2012
GAIA	1	2010
Landscape Ecology	2	2013, 2014
Land Use Policy	2	2012

In the following section we present the results of the review distinguished per research question.

5.4.1 What are the approaches and ES categories in RE assessment?

The following table shows the results of the first stage of the review, and the number of studies per *RE and landscape approach*. The majority of studies adopted a *General attitude approach*.

Table 5.5 The results of the first search stage: the total of 47 papers per type of RET and ES approach

Impact assessment	Partially integrated approach	Integrated approach	General attitude	Energy supply
16	10	1	18	3

In the following diagram (figure 5.4) we combined the *RE and Landscape* approach cluster with the *ES categories* cluster. It is possible to see how the three ES categories, cultural ES (C), provisioning ES (P) and regulating ES (R) and combinations are distributed among the five types of approaches. As it is possible to note, CES represent the simple majority among all the studies, and more than half in the *Impact assessment* approach and *General attitude* approach. The combination of regulating and cultural ES result the second simple majority among all studies and in *Partially integrated approach*. The *Integrated approach* resulted in one paper (Howard et al., 2013).

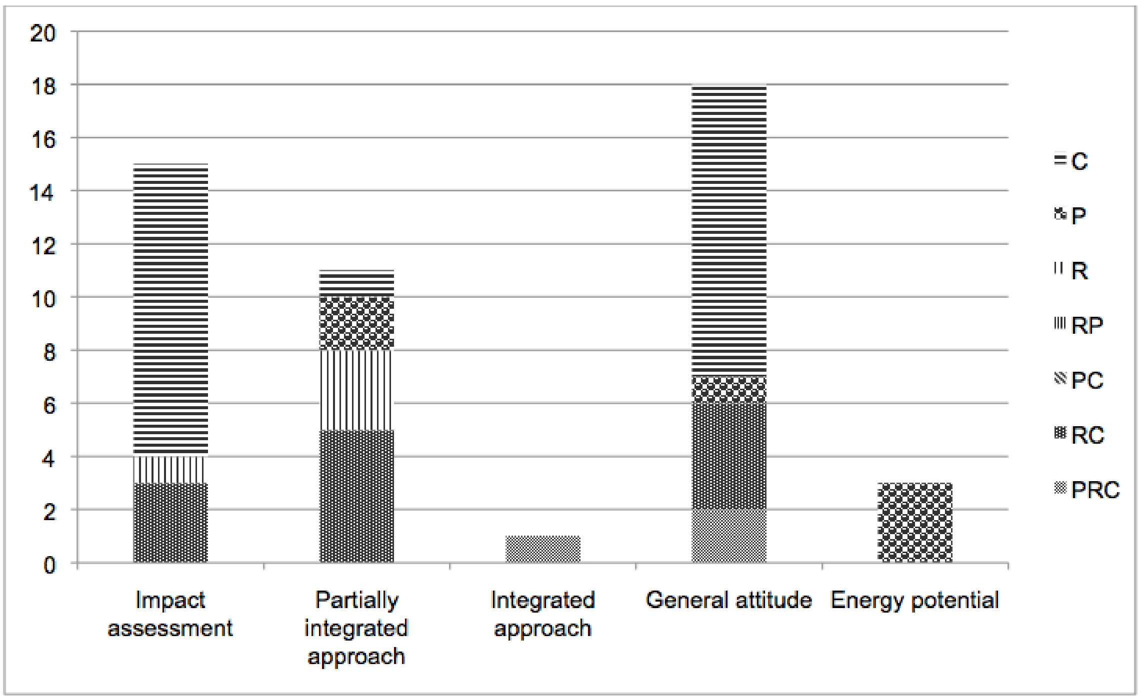

Figure 5.4 *ES categories* and combination per *RE and landscape approach.*

In the following diagram (figure 5.5) we combined the results of *RE and Landscape approach* cluster with the *Spatial scale* cluster.
The regional scale represents the majority. The studies at regional scale in majority applied a *General attitude approach*. The studies at local scale in majority applied an *Impact assessment approach*. In such cases it is possible to individuate specific environmental or social parameters. *The Integrated approach* was applied at local scale (Howard et al., 2013).

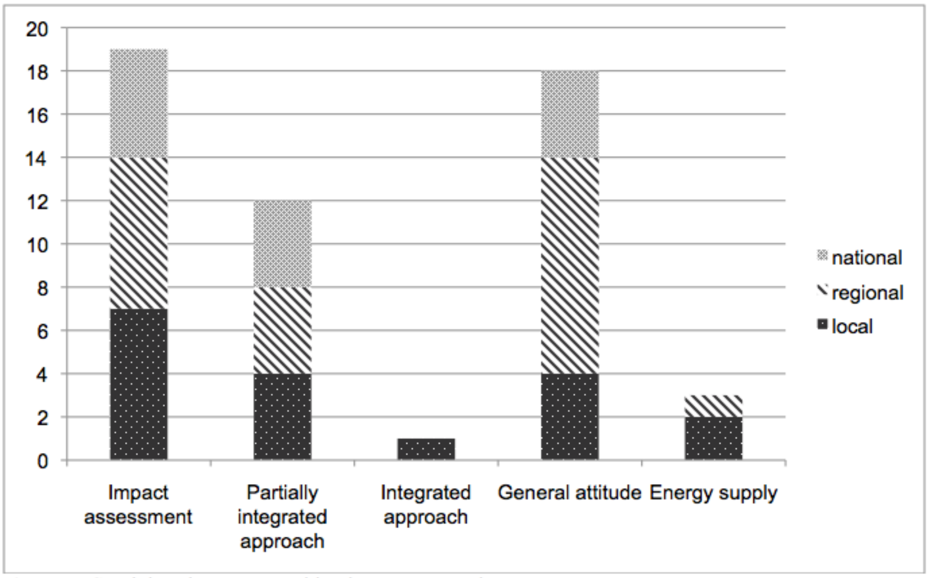

Figure 5.5 *Spatial scale* per *RE and landscape approach*

In the following diagram (figure 5.6) we combined the results of *RE and Landscape approach* cluster with the *Method of inquiry*.
The majority of studies asked to stakeholders to express their personal attitude towards RES/RET. Frequently researchers needed to understand what values people would attribute at possible risks in relation to RET installation. These values helped determining parameters and respective weights for the assessment. More than half of studies that applied a *General attitude approach* realized surveys and edited questionnaires and posed opened question to citizens. The other studies orchestrated workshop with direct involvement of stakeholders.
The Integrated approach study (Howard et al., 2013) also encompassed stakeholder in a workshop. It is striking that more than half of the studies clustered in the *Impact assessment approach* adopted methods of inquiry exclusively based on experts.

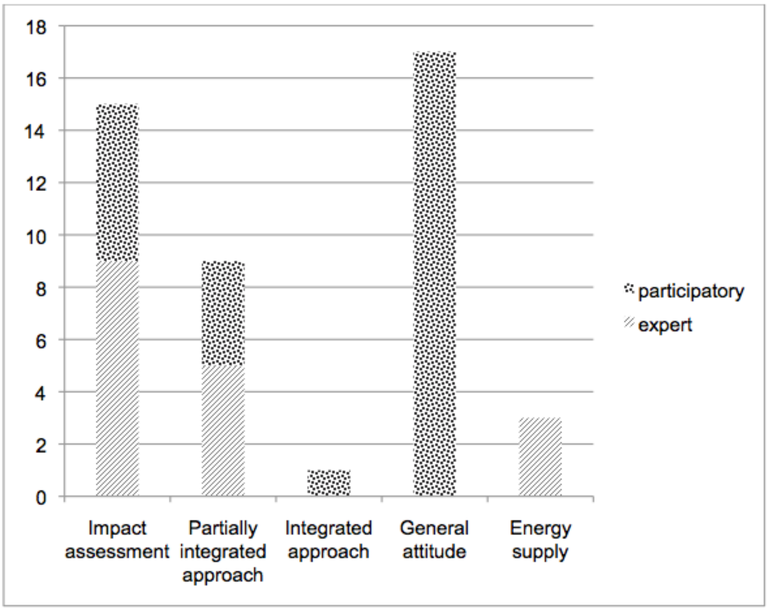

Figure 5.6 The selection of parameters per *RE and landscape approach.*

The *General attitude approach* cluster enclosed the majority of papers. These investigate what people think about RE, what their general attitude is with regard to landscape changes, and what attitude they have towards improving their neighborhood through RET installations, as in the case of farmers as potential investors in biomass (Cope et al., 2011). In these studies it is not possible to individuate specific parameters, but general values attributed by people to specific aspects. Relevant is the study from Ladenburg (2009) that realized a questionnaire to understand the attitude of stakeholders towards offshore wind farms, using the experience a priori of stakeholders as a parameter. This is used in assessing how prior experience can get people used to and more positive towards RET presence in the landscape (Antrop, 1997). These studies considered the visual impact, through parameters measuring the "threat" (Antrop, 2005). Landeburg and Dubgaard (2009), for example, measured the preferences of coastal users regarding the siting of offshore wind farms through the willingness to pay (WTP) to reduce the visual impact. The study from Warren and Birnie (2009) revealed that public ownership positively influences the attitude of stakeholders. The authors distinguished group of stakeholders in order to understand how the socio-cultural background influences their attitude towards RES/RET. Cope et al. (2011) studied the attitude of farmers to cultivate biomass in synergy with other ES. In this case socio-cultural and biophysical processes were assessed in trade-off with the supply of dedicated energy crops. The second majority is represented by studies that applied a *Partially integrated approach*. The majority of these evaluated both regulating and cultural ES in trade-off with RE supply. They worked on frameworks where cultural aspects and environmental aspects could be analyzed together through the formulation of strategic scenarios. We report the most relevant studies. In Bergmann et al. (2008) stakeholders had to choose between scenarios based on different weights of the attributes “landscape impact”, “wildlife impact”, “air pollution” and “new jobs opportunities”. In Meyerhoff et al. (2010) the authors produced some scenarios for onshore wind power with the height of the turbines and wind farm size as variable parameters. The invariable parameters were the impact on animal species, the avoided carbon dioxide emissions, the minimum distance of turbines from residential areas and the monthly surcharge on power bills. Recently Westerberg et al. (2013) adopted a choice experiment to evaluate trade-offs among the increase of costs installing wind farms offshore at specific distances, and the decline of tourism along the coast. Burgess et al. (2011) created a framework to assess trade-offs between local RE supply on the one hand and the food, feed and wood production supply on the other hand.

The *Integrated approach* cluster enclosed the study from Howard et al. (2013) where the authors created a framework to find out the relationship among the supply of RE from biomass with the supply of several ES, overcoming an impact assessment approach. Their approach incorporated the landscape in terms of structure and processes viewed from an energy perspective that could help solving the problems of the complex dynamic system. Through a questionnaire to stakeholders they created a values database at regional scale based on a land use GIS map, where all ecosystem services where mapped together with the local energy demand. The implication of RE, in this case energy from biomass, was considered in different scenarios to satisfy a number of government-defined targets for RE generation.

5.4.2 What are the methods for assessing synergies and trade-offs among ES and what are the spatial reference systems?

The following table (5.6) shows the results of the second stage of the review. Of the total 38 papers, seven were literature reviews and definitions of theoretical frameworks. The analysis of the results was applied to papers reporting case study applications.

More than half of papers reporting a case study application approached the assessment of synergies and trade-off among ES in a Qualitative strategy.

Table 5.6 The results of the second stage search distinguished if literature reviews and theoretical framework elaboration or case study applications. Studies of case study application are clustered per strategy of inquiry.

Review and theoretical frameworks	Applications in case study		
7	31		
	qualitative strategy	mixed strategy	quantitative strategy
	18	11	2

The two studies that adopted a quantitative strategy Grêt-Regamey and Kytziab (2007) and Nelson et al. (2009) calculated the economic value of multiple ES by means of costs-benefit analysis. The studies that adopted a qualitative strategy used open-ended questions as "what is the capacity of a specific land cover to supply ES" and "how to determine spatial trade-offs among ES ". They expressed the capacity of the landscape to supply services or the level of potential synergy/trade-off among ES using ranges of values (scores) in a specific scale (e.g. Burkhard et al., 2009; Howard et al., 2013; Grunenwald and Bastian, 2015). The studies that adopted a mixed strategy were calculating values of landscape metrics or ecological functioning parameters to be compared with the qualitative assessment of ES (e.g. Frank et al., 2012; Grêt-Regamey et al., 2013). In the following diagram we combined the Strategy of inquiry with the Method of inquiry, expert or participatory (Figure 5.7). The majority of studies were based on experts, more than a half in Mixed strategy cluster. The studies based on participatory processes represent more than a half in the Qualitative strategy cluster and the majority of them organized participatory mapping of ES. Studies by a Quantitative strategy were base exclusively on experts.

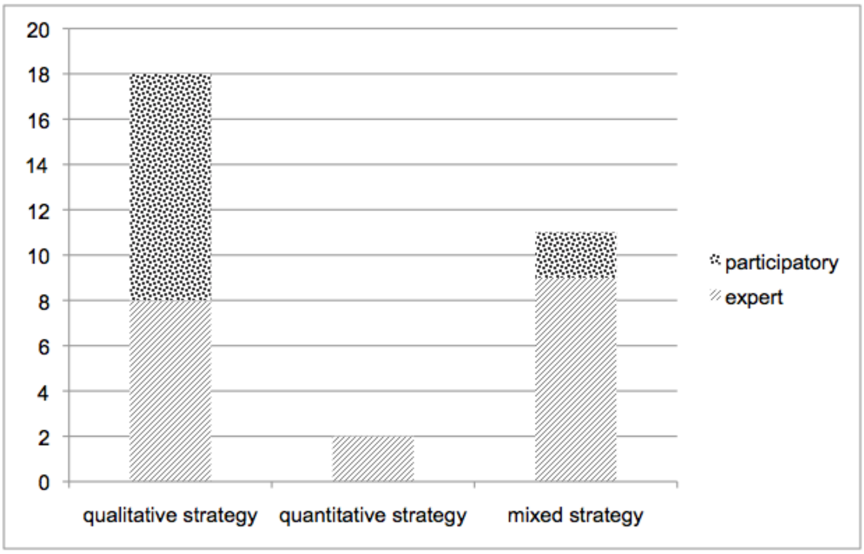

Figure 5.7 The diagram shows the *Strategy of inquiry* per *Method of inquiry* (expert or participatory).

In the following diagram (figure 5.8) we combined the *Strategy of inquiry* clusters with the *Spatial reference* clusters. The majority of studies adopted the landscape infrastructure as spatial reference system, that is adopted in more than half of the studies in the *Mixed strategy* cluster (e.g. Frank et al., 2013). The second majority is represented by studies that used the LU/LC as spatial reference system and this presents the only one applied in the *Quantitative strategy* cluster. Few studies, more in the *Qualitative strategy* cluster than the *Mixed strategy* cluster, made use of social maps (e.g. Fagerholm et al., 2013; Ungaro et al., 2014).

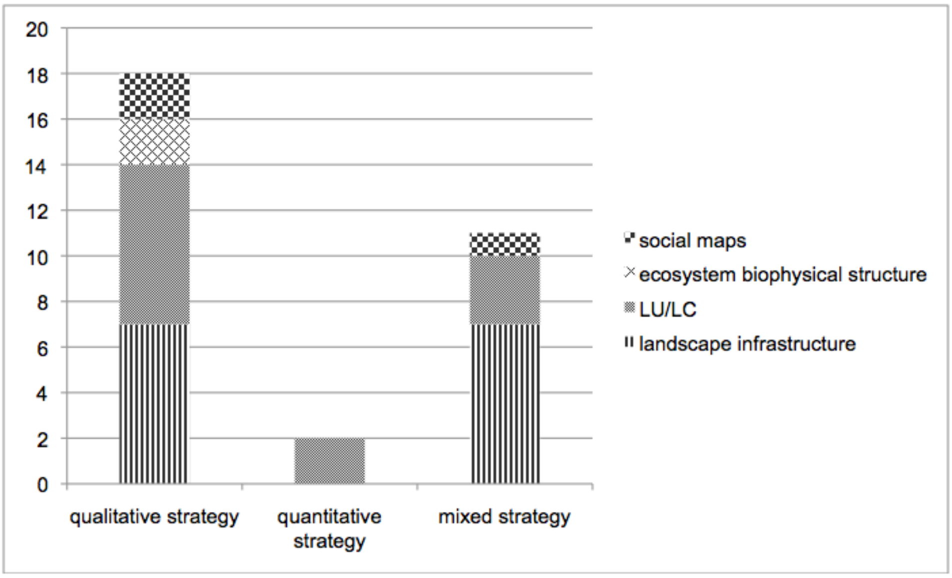

Figure 5.8 The diagram shows the *Strategy of inquiry* per *Spatial reference*.

In the following diagram we combined the *Spatial Reference* with the use or not of participatory mapping in participatory methods of inquiry (figure 5.9). More than half of the studies that adopted the landscape infrastructure as spatial reference system also organized a participatory mapping activity with stakeholders (e.g. Brown and Reed, 2012; Fagerholm et al., 2012), on the contrary less than a half of the studies that adopted LU/LC as spatial reference systems, and reasonably the total of the studies that used social maps.

About the spatial scale more than half of the studies was set at local scale. Among all the returned studies we can notice three studies presenting a specific method to assess trade-offs. Jackson et al. (2013) built a GIS framework (Polyscape), which was designed to explore spatially explicit synergies and trade-offs among ES to support landscape management. This framework was based on LU/LC and stakeholders were asked to define thresholds acceptable for ES supply trade-offs. The authors classified relevant trade-off options that we report in the following table (5.7). Kandiziora et al. (2013) applied a matrix approach for trade-offs. Authors produced a set of matrices relating the biophysical structure and the ecosystem function, the ecosystem function and ecosystem services, the ecosystem services and ecosystem services and in the end the ecosystem services and human well being. Synergies or trade-offs are indicated in the matrix cells as arrows indicating an increase/decrease of the supply or the necessity of more detailed assessments. Laterra et al. (2012) expressed

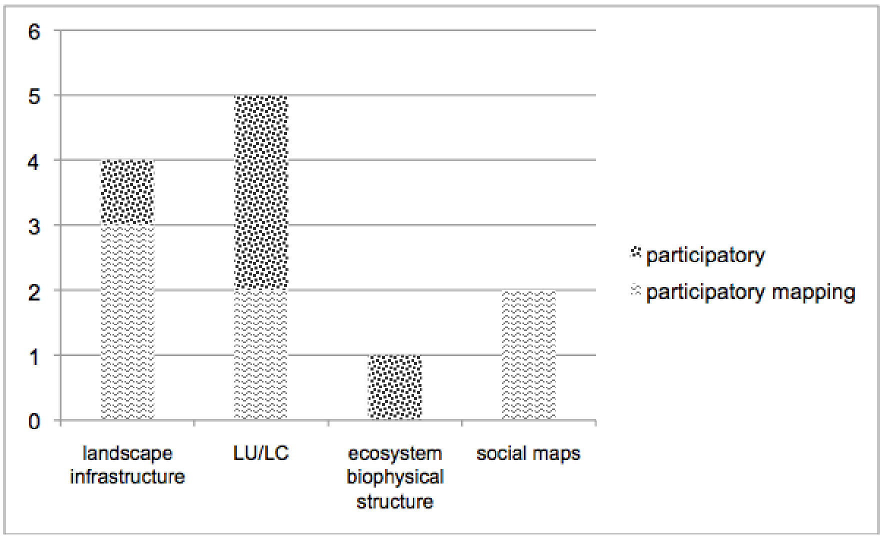

Figure 5.9 The diagram shows per *Spatial Reference* cluster the number of studies that adopted a participatory mapping of ES in relation to those that used a participatory method of inquiry but didn't ask to stakeholders to map ES hotspots.

the supply of ES through values of landscape metrics and with the application of a Pearson correlation index it was possible to detect ES that could be in potential spatial trade-off or synergy (positive, negative and no correlation among ES).

We cite other studies relevant for the Spatial reference they adopted in order to address a spatial trade-off analysis, but that did not define a proper method for trade-off assessment as explicitly as in Jackson et al. (2013) or Kandiziora et al. (2013).

Burkhard et al. (2012) used indicators for both landscape metrics and ecological functioning. These indicators described structures and processes for the capacity of the landscape to supply ES. Based on information deduced from indicators, the authors mapped the capacity of LU/LC to supply ES in relation to the ecological integrity of ecosystems. Studies that used the LU/LC as spatial reference were based on the assessment of the capacity of landscape and ecosystems to supply ES (Burkhard et al., 2009). In Burkhard et al. (2012) the real benefit was evaluated through maps of potential supply and social demand

Table 5.7 trade-offs options, adapted from Jackson et al. (2013, p.79).

(a) synergistic opportunity for change (highly beneficial impacts could occur from appropriate change in both service categories)
(b) positive impact of change represented by dark green (one service will be positively impacted by change while the other is neutral)
(c) trade-off or negligible impact from change represented by amber (change is likely to either be neutral in both services or positive in one while negative in the other)
(d) negative impact of change represented by dark red (one service negatively impacted by change while the other is neutral); most forms of change would not recommended
(e) synergistic benefits in current land use represented by bright red; change is likely to degrade both services and high consideration should be given to protecting the status quo

for specific services.

Studies that adopted the LI as spatial reference system, integrated the use of LU/LC with the information on LI (introducing its measurable features as tree lines, edge-rows etc.). Verweij et al. (2012) introduced the data on the LI into a decision support system. Frank et al., 2012, used the measure of landscape metrics and landscape linear features in Multi-Criteria Decision Analysis for strategic spatial planning. Ungaro et al. (2014) used social maps and considered the presence of specific landscape features in buffer areas as indicators of hotspots for potential services supply. In 2009, Fisher et al. introduced the concept of benefit flow: a service can be supplied in a place but people can benefit of it in another place. Bagstad et al. (2013) designed a framework for modeling spatial correlations between the supply of ES, that accounted for the spatial mismatch between ES and their beneficiaries (i.e. benefit flow), this was built on maps of ES source location, sink location, and flows or carriers. The spatial reference is LU/LC and the calculated landscape metrics.

About studies clustered in Participatory method of inquiry and that led a participatory mapping Brown and Reed (2012) and Fagerholm et al. (2012) experimented and enhanced a method where they asked participants to describe their landscape values by the means of locating dots for places where they benefit from ES or where they think an affliction could occur. Based on the dots in the map, the authors calculated indexes such as density of the different landscape values and defined hotspots for ES benefit areas. The spatial reference system were social maps directly defined by stakeholders; Brown and Reed (2012) also calculated landscape metrics to evaluate the density of the ES supply. Participatory mapping addressed spatial trade-off when stakeholders were siting possible afflictions in the ES supply.

5.4.3 How can Cultural ES be assessed in trade-off with other ES and what the spatial reference systems?

The following table (5.8) shows the results of the third stage of the review. More than half of papers studying the assessment of CES in a landscape perspective were clustered in the Mixed strategy.

Table 5.8 The results of the third stage. The papers reporting case study applications are clustered per *Strategy of inquiry*.

Review and theoretical frameworks	Applications in case study		
13	31		
	qualitative strategy	mixed strategy	quantitative strategy
	5	7	1

These papers were calculating values of indicators on the intensity of landscape management (e.g. agricultural parameters, or landscape metrics (values on diversity, shape indexes etc.) or willingness to pay (WTP) and clustering this values in set corresponding with qualitative values of CES supply. For example if the intensity of landscape management is between a certain amount of fertilizer in ton/ha in terms of agriculture practice how the level of recreation vary in a pre-determined scale of 1-5?

In the following diagram (figure 5.10) we combine the *Strategy of inquiry* per *Method of inquiry*. More than half of the whole studies adopted a participatory process, more than half by a mixed strategy of inquiry, these in particular calculated quantitative values for selected indicators and combined them with values in CES supply defined by stakeholders.

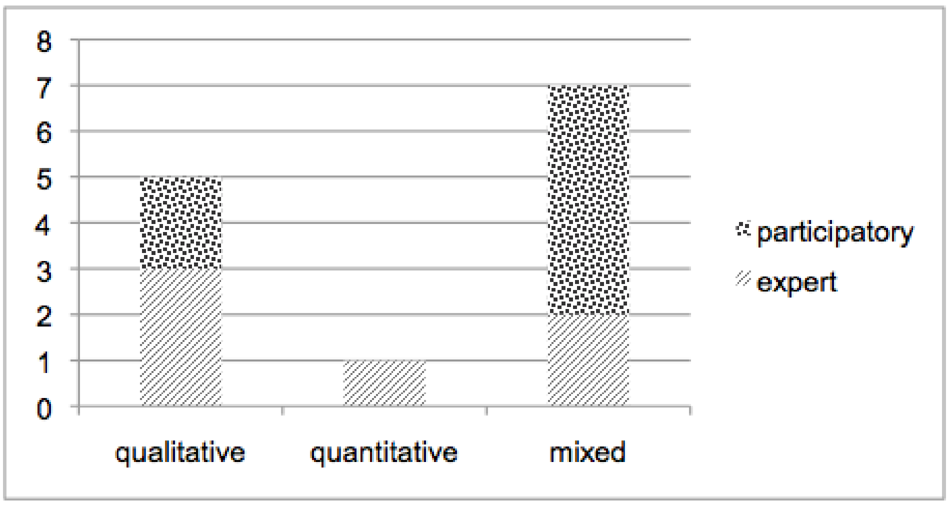

Figure 5.10 The diagram shows the *Strategy of inquiry* per *Method of inquiry* (expert or participatory).

In the following diagram (figure 5.11) we combined the *Strategy of inquiry* per *Spatial reference*. Quantitative studies referred exclusively to LU/LC calculating landscape metrics. Half of the *Qualitative strategy* studies adopted as spatial reference social maps, the *Mixed strategy* studies experimented all the considered spatial references approaches, in minority the LU/LC with the calculation of metrics.

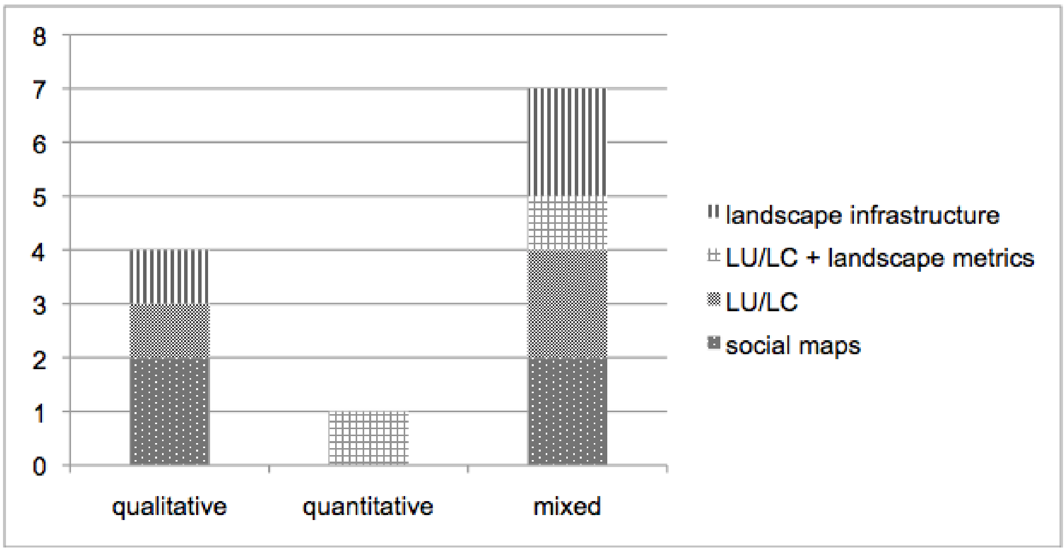

Figure 5.11 The diagram shows the *Strategy of inquiry* per *Spatial reference*

In the following diagram (figure 5.12) we combined the use of *Participatory mapping* with the *Spatial reference* and what emerged is that a *Participatory mapping* was used in studies that referred the CES supply or to LU/LC classes calculating landscape metrics or to the landscape infrastructure and features.

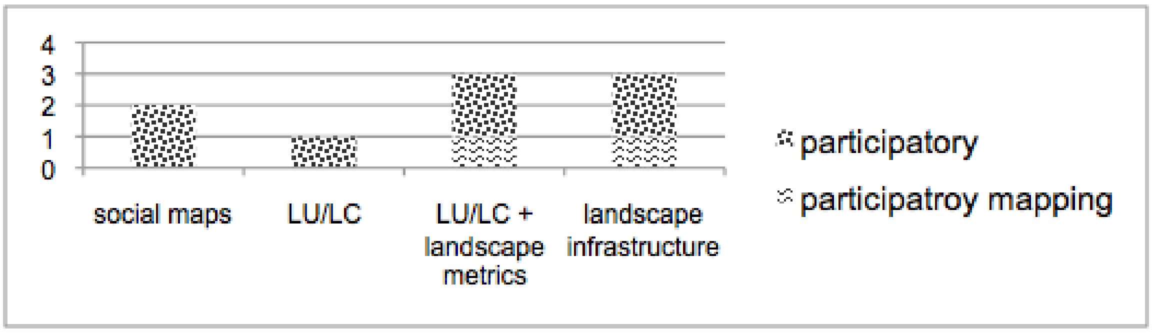

Figure 5.12 The diagram shows per *Spatial Reference* cluster the number of studies that adopted a *Participatory mapping* of CES in relation to those that used a *Participatory* method of inquiry but didn't ask to stakeholders to map CES hotspots.

In Frank et al., 2012 the emerging key issue was the relation of CES supply to specific landscape metrics (values of Shannon diversity index, patch shape index, linear feature such as edge rows, tree lines, walls as). In Norton et al. (2012) field surveyors delineated and mapped areas of different habitat types, recording all linear and point features. In Nalhuelhual et al. (2014) the metrics were calculated in view-sheds resulting by mapping stakeholders' cultural experiences in the landscape. In Tengberg et al. (2012) the legibility of the landscape structure from stakeholders was used as parameter to assess the supply of CES. In García-Llorente et al. (2012) and Van Berkel and Verburg (2014) the authors led participatory mapping workshops. These mapping activities could delineate areas where stakeholders benefit from cultural services or assess the willingness to pay (WTP) for the maintenance of the landscape features that resulted being agent of cultural services.

5.5 Discussion

The strategy employed for the research presented in this paper does not present a systematic review. This is because a "less rigorous and less costly form of evidence synthesis" could answer the research questions*. The questions are open-framed and therefore do not require a systematic review (Collaboration for Environmental Evidence, 2013).

The papers identified during the first stage represent only a part of the literature on the assessment of RE. This was due to the "landscape" keyword in the search string that, as expected, reduced the number of results but addressed our interest in assessing RE in a landscape perspective. The discussion of the topic in very different journals, however, suggests that RE are discussed by many different perspectives. The research questions have been studied making best possible use of the perspectives and in close relation to the landscape assessment.

The studies turned from the review present a scarcity of approaches where a set of diverse RES and associated RET are evaluated for synergies or trade-offs with bundles of services. In many cases, this is partly due to the missing integrated, holistic vision in general, and missing of a landscape perspective in particular. The notion of embodied energy is never found, apart form Howard et al. (2013). When ES and RES/RET relate both to the LI, physical and visual, the results advance in the evaluation of the relationship RE and landscape. Some studies adopt this perspective, but do not consider diverse RES/RET, or consider diverse RES/RET but not in a landscape perspective and therefore fail to advance the assessment. The only case where the study adopt diverse RES/RET in a landscape perspective, is in Howard et al. (2013), where the authors relate RE and ES supply to a set of LU/LC, but not to the LI. Burgess et al. (2011) for example used landscape as a keyword for the paper, but they refer to the landscape as a set of land use combination. Cultural and social aspects, that conventionally better define the landscape dimension (see e.g. ELC, 2000), were not considered. In the papers investigated in the second stage we recognized a new trend in the research. Many studies start to relate to landscape ecology approaches (Iverson et al., 2014), where the LU/LC and the LI compose the spatial reference system. Another significant aspect is the emerging awareness that participatory processes are essential in determining

*Guidelines systematic reviews in environmental management, Version 4.2, March 2013, p.17

hot spots for the supply of ES. Relevant the statement of Burkhard et al. (2012) that a service is more valuable in populated area, where the demand is higher than in other less populated. The LI appears to be relevant if we want to determine the flows of the ES and their relationships (Iverson et al., 2014; Pagella and Sinclair, 2014). Bennet et al. (2009) and Rodriguez et al. (2006) in their review papers stress the importance of the spatial and temporal scale when we consider the relationship among ES, especially if in planning and designing the landscape.

Another relevant aspect, which is emerging, is the importance of the landscape analysis as a prerequisite in the study of ecosystem properties, study that cannot be based only on LU/LC as De Groot et al. (2009) evidence. Further the introduction of participatory mapping of ES as in Raijmond et al. (2009) allowed the enhancement of experiences where stakeholders can assess the actual situation and be able, as in Plieninger et al. (2013) to choose between future development scenarios. There is a consolidation of bottom-up processes where stakeholders are called to plan the future for the ES supply according to their demand. More recently Spangeberg et al. (2014) showed how the cascade model (Haines-Young et al., 2011) can be used as a stairway in a bottom-up process (Müller et al., 2010) and useful for landscape planning, starting properly by the values that stakeholder attributed to services.

A new issue is now emerging and this is the application of the concept of stewardship (Barrett, 1996) to the assessment of ES as Winthrop (2014) evidences. According to the author the concept of stewardship and a local community scale could really improve the ES management. In the papers identified in the third stage an alternative way to approach CES emerges. Milcu et al. (2013) affirmed, “there is a broad agreement that a satisfactory level of understanding of many important facets of CES has not yet been attained” (p. 44). The key issues emerging are: first participatory methods of inquiry and, second, the importance for CES to not be treated independently. Participation is an instrument to enhance the assessment of ES in general and CES in particular, and is capable to improve the understanding of subtle ecosystems and landscape mechanisms that may be not comprehensible by experts but are part of the common knowledge of the community (Fagerholm et al., 2012). However, we are still far away from fully participation of local communities in CES assessments, as this literature review showed. Secondly CES cannot be treated independently because their expression influences the way other services are managed and supplied, and this is really relevant and refers indirectly on the fact that CES can be assessed only through landscape visualizations or virtual experiences (Tangeberg et al., 2014). These representations correspond to scenarios where the supply of regulating and provisioning ES vary according to specific planning, design and management strategies of the landscape. To produce such scenarios the appropriate scales and a correct interpretation of the landscape are needed (Norton et al., 2012). In Norton et al. (2012) for example the aim of the authors was to identify measures for CES that would make them comparable with other ES: "if measures for cultural services are not available for comparison with measures of other ES then the risk is that they will be undervalued or omitted" (p. 450).

The studies that relate social preferences for the landscape to LU/LC and LI, as in García-Llorente et al. (2012) are based on the cultural landscape research in Landscape Ecology. This has been a consolidated way to evaluate social preferences in multi-functional landscapes research in the past decade (see for example Pinto-Correia and Carvalho Ribeiro, 2012; Pinto Correia et al., 2013; Barroso et al., 2012).

5.6 Conclusions

Getting the conclusions of this review what we learned is that the majority of studies approached the question of Renewable Energy and landscape studying the General attitude of people for specific Renewable Energy Sources and relate technologies and in the majority of cases discussing in terms of Cultural Ecosystem Services as identity, ricreation and tourism. Trade-off among ecosystem services is a potential approach in studying the relationship between Renewable Energy and landscape. The majority of studies evaluated trade-offs following qualitative strategies and relating the Ecosystem Services supply to the landscape, which means integrating the spatial reference system of land use/land cover with information on the elements of the landscape infrastructure as green and blue network, roads, linear features as tree lines and edges.

The aforementioned conflict between provisioning/regulating services on the one hand and cultural services on the other hand can be better understood through a landscape perspective, in other words, by relating the supply of Renewable Energy and Ecosystem Services to the land use/land cover and the landscape infrastructure.

Participatory methods of inquiry are necessary in order to identify potential synergies and trade-offs in determined temporal and spatial scales. Through participation local communities can determine proper parameters to assess synergies and trade-offs among Renewable Energy and Ecosystem Services. The notion of "stewardship" considers the importance of creating a new narrative, as a new set of social values, as in the case of the sustainability of energy landscapes (Selman, 2010; De Waal and Stremke, 2014) in order to enhance both Renewable Energy provision and other Ecosystem Services. This narrative would need to combine ecological, cultural, social and economic scenarios to be represented through new advanced landscape visualizations technologies or landscape virtual experiences. Future research efforts entail the introduction of Renewable Energy /Ecosystem Services trade-off assessment in trade-off approach in participatory processes for planning and design sustainable energy landscapes as a challenge to advance the mitigation of conflicts among the local and the global narratives, which frequently emerge (Van der Horst and Vermeylen, 2011). Research is needed to further advance visualization technologies so that stakeholders can assess future scenarios where Renewable Energy Technologies are introduced in the landscapes. This applies in particular for the study of synergies and trade-offs between Renewable Energy and Cultural Ecosystem Services.

Chapter 6

Ecosystem services to plan and design sustainable energy landscapes: a case study from Zealand, The Netherlands

6.1 Introduction

Energy transition to renewable energy (RE) is a relevant driver of landscape change. The renewable energy technologies (RET) develop quickly and modify consistently the structure of the landscape and ecosystems through their spatial footprints.

The sustainability of the landscapes of energy transition is based on the fact that the introduction of RET should not cause crucial trade-offs for ecosystem services (Coleby et al. 2012, Stremke 2015).

To avoid trade-offs or accept them in a development perspective and to reduce uncertainties (Hou et al., 2012), the transition to renewable energy sources requires approaches and methods producing long term visions and strategic decision making in landscape planning and design (Stremke et al., II, 2012). These approaches must be trans-disciplinary and should include an assessment of the trade-off among ecosystem services and RE (review from the authors). Traditionally, landscape planning and design have different tasks that recently van Haaren et al. (2014) clearly resumed. Landscape design deals with finding new solutions to the change of the structure of the landscape. Landscape planning task is to manage the change of the land use and its ecological, cultural and economic functions, in order to preserve biodiversity, sustainability and beauty (Termorshuizen et al., 2007). Ecosystem services are emerging as a key approach for landscape planning sustainability (Termorshuizen et al., 2007; de Groot et al., 2010). Both landscape planning and design have the same substantial and procedural values. A design approach in landscape planning (McHarg, 1967; Van Haaren et al. 2014) has some added values: "making invisible or hidden ecological processes "visible"; reconciling people with a "new" landscape, for instance with unaccustomed features such as wind turbines; or raising consciousness about land degradation problems" (Van Haaren et al., 2014, p.167). In general, design supports the aesthetic and the communication with stakeholders.

Coleby et al. (2012), Howard et al. (2013), Stremke (2014) all stressed the importance of considering the effect that RET can have on the supply of the ecosystem services On this purpose several studies have already been led in environmental and landscape ecology fields.

These can be resumed in five main approaches: *Integrated approaches, partially integrated approaches, general attitude, impact assessment and energy potential* (authors, in review). Van der Horst and Vermeylen (2011) affirmed that the conflict generated by energy transition between a global perspective (devoted to a low carbon future) and a local one (focused on the identity values of the landscape) can be interpreted as a trade-off among provisioning and cultural ecosystem services.

In the literature on RE assessment cultural ecosystem services are recurrent through a *Qualitative strategy* of inquiry, when the researchers interviewed stakeholders to understand their *General attitude* toward renewable energy.

The definition of Sustainable Energy Landscape (SEL) contemplates an ecosystem services assessment remarking that an energy landscape is sustainable if doesn't compromise the supply of other ecosystem services (Stremke and Dobbelsteen, 2012, p.4). Stremke et al. (II, 2012) developed an approach for envisioning sustainable energy landscapes, the Five-Step Approach (FSA). The FSA is a landscape design approach, ore regional design (Stremke et al., I, 2012), this is composed of five steps: 1) landscape analysis, the present energy conditions and the analysis of the energy potential for all the renewable energy sources (RES), 2) the near-future developments, 3) the far future-developments, 4) four possible integrated energy visions based on spatial scale and policies, 5) Energy-conscious spatial interventions. Relating to the approaches as defined by the authors in the literature review the FSA is considered an *Integrated approach*. The integrated approach produces a trade-off assessment of multiple ES, provisioning, regulating and cultural, in relation to diverse RES/RET, as much as embodied in the landscape (Van der Horst and Vermeylen, 2011) as for example in the study from Howard et al. (2013).

From the literature review we remark some relevant future efforts to implement procedural knowledge on the relationship among RET and ecosystem services: 1) the trade-offs among RE and ES can be better comprehended through a landscape perspective, which means spatially relating both to the land use and land cover classes (LULC) and the landscape infrastructure (LI); 2) the most appropriate procedure is a participatory mapping activity where stakeholders map vhot spots for ecosystem services supply and site RET; 3) the assessment of this relationship should be led by stakeholders considering both the spatial and temporal scale; 4) trade-offs among RE and ecosystem services should be included in long term visions for energy landscapes.

The main objective of this paper is to introduce an ecosystem services assessment in the FSA in order to evaluate spatial synergies or trade-off. Three sub-objectives are individuated as following:

a) the formulation of a theoretical framework
b) the set up of a method and testing in a case study
c) the discussion of the results from the case study

The following three research questions were pursuit along the process:

1. How ES and RE relate to one another from a landscape perspective?
2. What is the added value of an ecosystem services approach for planning and designing sustainable energy landscapes?
3. How does energy landscape design affect the supply of ecosystem services?

This paper is composed of six sections. In the following section, two, we share key concepts and definitions and introduce the theoretical framework relating to sub-objective a). In section three, we describe the method, relating to sub-objective b). In section four we report the results of the application in the final steps of the DEESD project, "Sustainable Energy and Ecosystem Services in Schouwen-Duiveland", committed by the Province of Zealand and others to Wageningen University and Research Centre, The Netherland, relating to sub-objective c), while in section five we answer and discuss the research questions. In the final, concluding section we resume results and consider future efforts.

6.2 Key concepts

The provision of ES is directly dependent on the ecological functioning of the ecosystems (Kandiziora et al. 2013), according to a cascade model (Haines-Young et al., 2012) where the integrity of the ecosystems is the main parameter to evaluate the capacity to provide services. Both ES and renewable energy are supplied through the landscape. A multi-layer approach in the landscape analysis (Mc Hargi, 1967; Steiner, 1994, 2012; Hou et al., 2013) helps in reading the complex landscape system. The layers of the landscape can be approximated by a combination of LULC and the spatial organization of the landscape, the LI. The energy landscape is one of the several layers (Pasqualetti, 2012; Stremke, 2014) and we assume that ES source locations or use locations (Bagstad et al., 2013) can also be mapped as layers of the landscape, integrating the landscape analysis with values in ES supply. In the literature on ecosystem services, such areas are often referred to as 'service providing units (SPUs, Syrbe and Walz, 2012). SPUs are areas or elements of the landscape, which include organisms, and abiotic elements (soils, water bodies, atmosphere) contributing to the supply of ecosystem services (Syrbe and Walz, 2012). In literature it is also common to call them ES hot spots (Raymond et al., 2009) in this paper we will call them hot spots.The Renewable Energy Technologies (RET) are the layer of an energy landscape (Pasqualetti, 2012). These allow the supply of RE starting by the renewable energy sources (RES) that a certain landscape can provide. Their introduction in the complex landscape system can change the LULC and the LI. This can be exemplified by energy crops, which substitute food production on arable land or by a row of wind turbines following a dyke. Burkhard et al. (2009) assessed the capacity of LULC to supply ES. Their study was based on CORINE land cover and expert were attributing values to each class, using a range of five values in "relevant capacity" to provide ES (p.6). The supply of ES can be evaluated in relation to LULC and integrated through the spatial reference of the LI (Frank et al., 2012; Kosckhe et al., 2012; Verweij, et al. 2012). The theoretical framework that has been formulated on the basis of literature study (figure 6.1), suggests that LULC and LI influence the supply of both ES and RE.

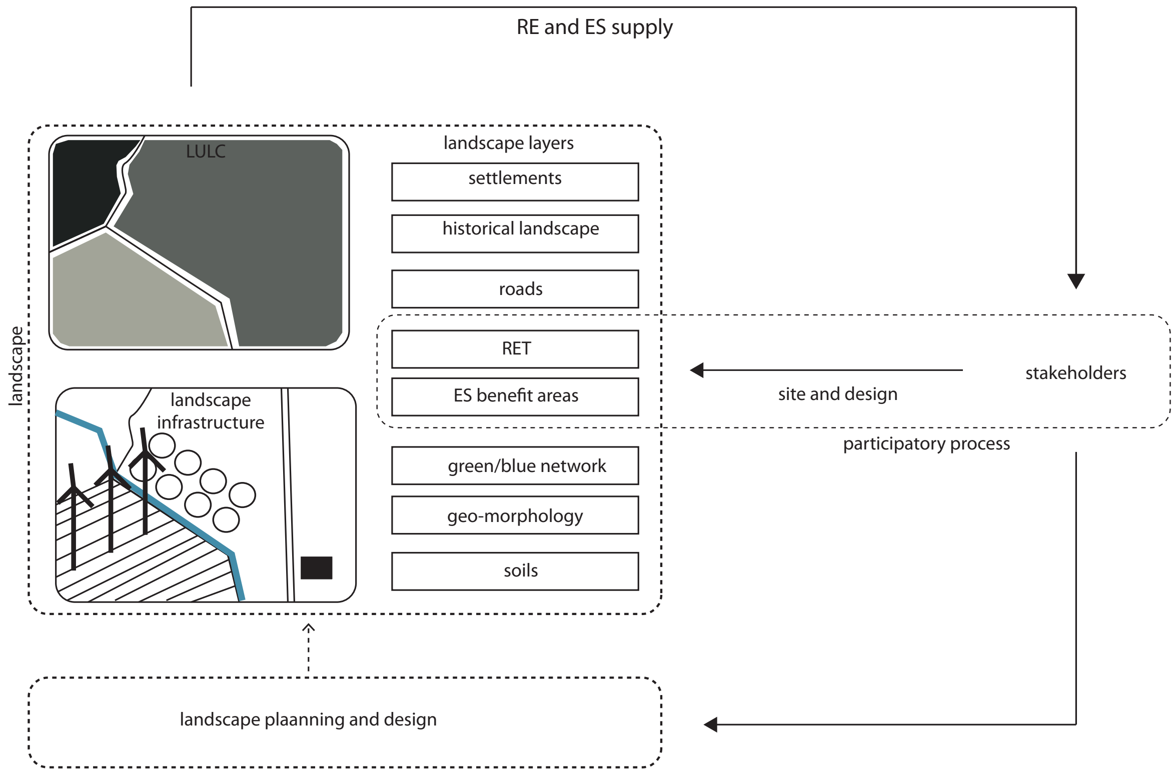

Figure 6.1 The theoretical framework illustrates how the complex landscape system can be analyzed through a landscape layers approach (McHarg, 1967; Steiner, 1994, 2012; Duchhart, 2007; Hou et al., 2013). Several layers describe the different systems that constitute the landscape starting by the soil. The complex systems described by the layers can be approximated in description by LULC and LI features, which in turn influence the supply of ES and RE. Stakeholders can benefit areas or hot spots for ES and site RET, aspiring at their future landscape. The information produced by stakeholders integrates the landscape analysis by introducing two additional layers: a layer presenting the areas where stakeholders perceive to benefit from ES, ES hot spots; a layer presenting the locations where stakeholders would locate RET. This information is useful in landscape planning and design in a loop process.

6.3 Methods and materials

6.3.1 Method

The figure below (6.2) indicates how it is possible to introduce the assessment of trade-offs between ES and RE in the FSA. This is handled through a stakeholder workshop and an expert panel (and correspond to step 1, 4 and 5 consequently). Please note that the FSA already foresees participatory processes in steps 4 and 5 for the formulation of the long-term visions with stakeholders. The FSA flowchart presented in figure 2 represents the application in the DEESD project. This presents the long-term vision Zeeland 2040 in step 3. We will see in the results that this consists in a table with four possible energy scenarios: four combinations of RET to reach the targeted amount of energy as in Zeeland 2040. The FSA normally illustrates four "Possible far-future" scenarios in step 3, these compose the integrated visions in step 4.

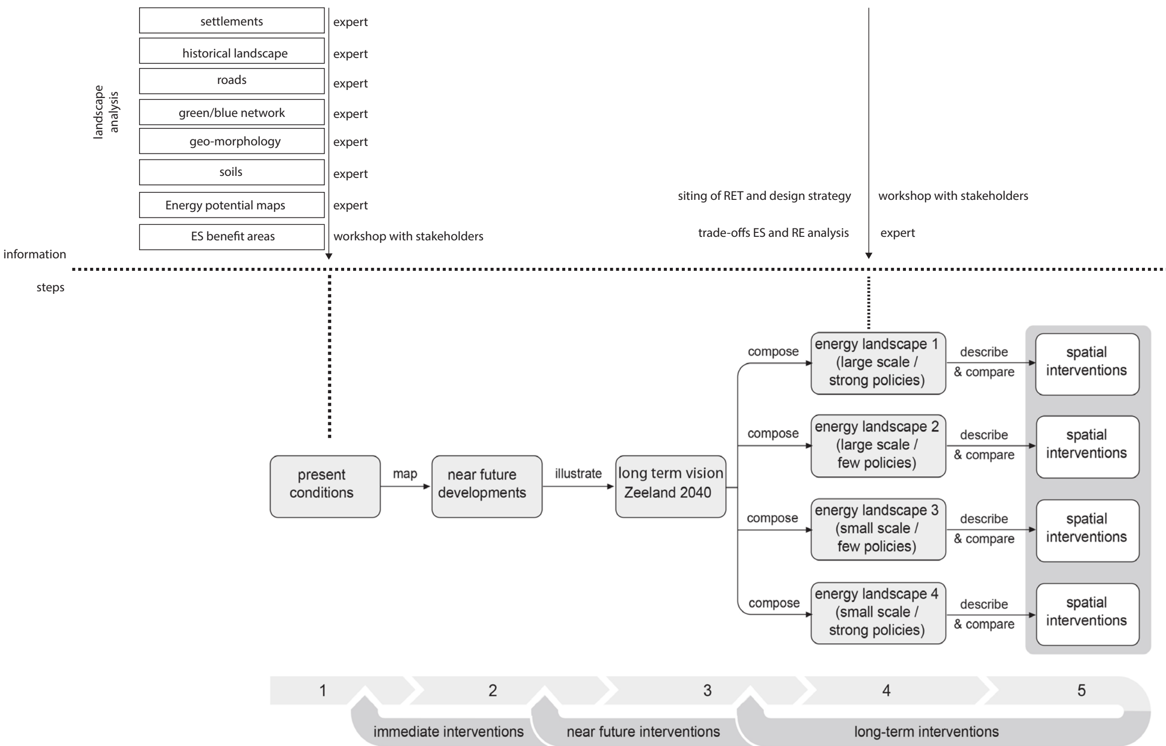

Figure 6.2 The introduction of the trade-off analysis between RE and ES in the Five-Step Approach for the application in the DEESD project where the long term vision Zeeland 2040 substitute the four "possible far-future" scenarios normally illustrated in the FSA.

The actual trade-off analysis is composed of three tasks (figure 3). All tasks were guided by the application in the DEESD project, in a 'learning by doing' process. In this section we will describe the three tasks.

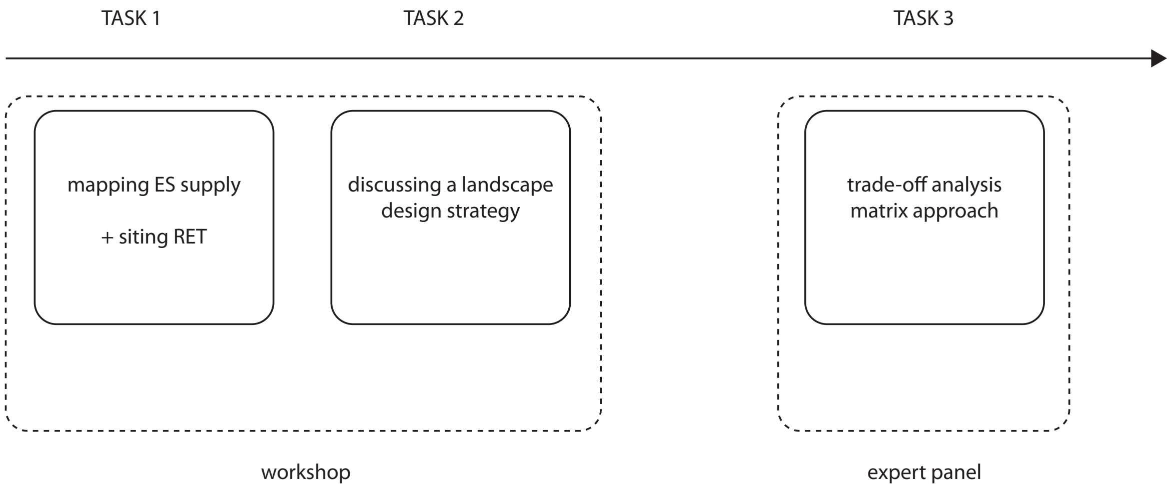

Figure 6.3 The three tasks of the method.

Task 1) *Participatory mapping*

During the workshop stakeholders first map ES use and source locations (in line with step 1 of the FSA), then site RET for each of the four scenarios (in line with step 4 of the FSA). The mapping of ES source or use locations is done using different colors; green for provisioning services, blue for the regulating and red for cultural services (Raymond et al., 2009; Bryan et al., 2010; Brown and Reed, 2012; Fagerholm et al., 2012).

RET are represented by stickers of different color, each one representing a certain amount of renewable energy supply. The objective for the workshop in this first phase is to site all the stickers at disposition to satisfy the required total amount of energy (here, the estimated future energy demand of the island)

Task 2) *Landscape design strategy*

After the mapping activity a focus group allows the exploration of different design strategies, to identify a design that is able to minimize the trade-off between RE and ES supply. This task is determinant to understand how locals would site RET in order to preserve or even enhance values of their landscape as expressed in task 1.

Task 3) *Trade-off analysis*

The third task requires experts putting together the information collected during the workshop. The maps of ES supply (task 1) are drawn on GIS and overlaid. Where the overlay is 50%+1 of the preferences, the resulting area can be considered a hotspot for the supply of the service. The stickers positioned by stakeholders as optimal sites for the different RET (task 1) are reported in GIS shape-files. Each cluster of dots represent the entire preferences expressed. Through a grid representing a land use base unit, it is possible to evaluate the level of density of all the dots (Bryan et al., 2010; Fagerholm et al., 2012). Dots are then grouped as vertices of polygons according to the following criteria:

1. Dots should be in adjacent cells of the grid
2. Dots should represent the 50%+1 of the preferences

It is then possible to individuate the centroids of the polygons. The centroid is used as the center of a circular buffer corresponding to the approximated area needed for the spatial installation of RET.

By overlaying the RET buffers and the ES hotspots, through a matrix approach (Burkhard et al. 2012) it is possible to detect potential spatial trade-off or synergies among RET in coincidence with specific LULC classes and interrelation with the LI.

The matrix is built with LULC and LI features on the y axis and the ES on the x axis.

Each cell of the matrix expresses the spatial trade-off or synergy between a particular ES and a RET on a specific LULC or in relation to a specific feature of the LI. Trade-offs or synergies are expressed by a range of five values (Jackson et al., 2012) as in table below (6.1), based on the judgment of an expert panel. The strength of trade-off and synergy can be based on expert judgment, derived from literature (e.g. the scoring for ‘typical European landscapes’ by Burkhardt et al. (2014), or from observations and model estimates.

Table 6.1 The range of five values in spatial synergy or trade-off between RE and ES (Jackson et al., 2012)

strong trade-off	light trade-off	neutral	light synergy	strong synergy
↘ ↘	↘	→	↗	↗ ↗

6.3.2 Study area

The application was led in 2014 as finalization of the DEESD project, Sustainable Energy and Ecosystem Services in Schouwen-Duiveland, committed by the Province of Zealand and others to Wageningen University and Research Centre, The Netherland. The island, located in the Province of Zealand, presents the typical combination of dunes landscape in the West along the North Sea and a Dutch polder in the East, that has evolved over the past centuries (figure 6.4 and 6.5). It encloses several Natura 2000 sites, as the dunes area and the inland waters, and a huge extension of arable land, coniferous and deciduous forests patches in the dunes landscape and the polder landscape. The island is one of the favorite destinations in Netherland for recreation and seaside tourism.

Figure 6.4 On the right a view of the dunes landscape, on the left the polder landscape at Schouwen-Duiveland. Photo source DEESD Archive, Marjo Van Lierop 2013.

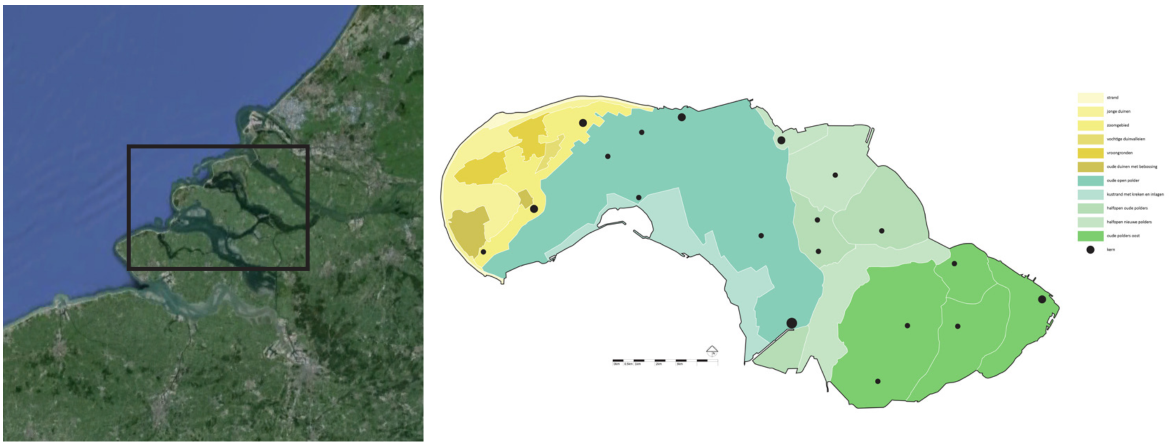

Figure 6.5 The map of the landscape types at Schouwen Duiveland. The areas in yellow ranges represent the Dunes landscape, the area in turquoise on the lower part represents the Inland water landscape. The other areas represent the Polder distinguished per historical period, the older is the greener on the right bound of the island. The black dots indicate the main settlements. Map from the DEESD Archive, author Marjo van Lierop, 2013.

6.3.3 Data sources

The DEESD project started in 2013 .The data sources are reported in table 6.2. The landscape analysis presents the spatial information on the complex landscape system in layers (DEESD, van Lierop, 2013). The figure 6.6 shows for example the map of green/blue infrastructure, relevant to detect those features of the landscape infrastructure useful for the RET and ES assessment.

The research "Sustainable Action Research in the Zeeland Delta, Ecosystem Services in practice" " (Verzandvoort and Smit, 2013, Alterra, Wageningen UR and others) provides a qualitative assessment for the supply of ES based on "landscape user types", a classification of the landscape per use (e.g. the landscape of production class encloses all the agricultural lands). The recreation monitoring Schouwen 2007, is a report on the recreation at Schouwen-Duiveland (Visschedijk et al., 2007, Wageningen UR) provides quantitative data on the number of landscape users for recreational activities and different sites on the island, recorded between the years 1998 and 2006. The RE scenarios SD 2040 is the output of the step 3 of the FSA (Stremke, 2013) and presents four energy scenarios for the island of Schouwen-

Table 6.2 The data sources: The maps for the landscape analysis provides the overlay of spatial information; the report " Sustainable Action Research in the Zeeland Delta, Ecosystem Services in practice " provides a qualitative assessment on the supply of ecosystem services having as spatial reference system the "landscape user types" layer form the landscape analysis at Province level; the ES assessment from the step 1 provide values of ES supply per LULC; the recreation monitoring Schouwen 2007 provides a quantitative information on the number of visitor for different sites on the island, and the number of users for different facilities, this assessment refers to the landscape types; the Re scenarios SD 2040 presents four scenarios of combination of RET with the corresponding amount of energy production per technology, the spatial reference are the maps of energy potentials.

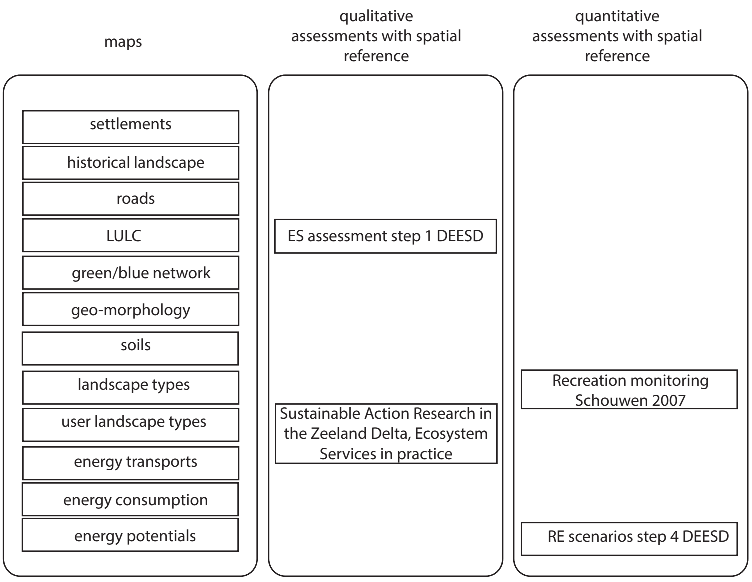

Figure 6.6 The map of the green-blue network at Schouwen-Duiveland. The map is part of the landscape analysis from the first step of the FSA, author Marjo van Lierop, 2013.

Table 6.3 The four energy scenarios formulated in the 4th step of DEESD project vary along two variables: (1) The nature of the renewable energy intervention i.e. large-scale vs. small-scale, and (2) The presence and nature of energy related policies and legislation i.e. strong policies and legislation vs. absence of policies and legislation (Stremke, 2014).

Renewable energy scenarios for SD 2040 (Stremke, 141030)

Renewable Energy Technology (and sources)	units	Baseline 2012 (Klimaat-monitor) all in TJ]	Scenario #I 'Delta Zeeland'	Provision [TJ]	Scenario #II 'Ondernemend Zeeland'	Provision [TJ]	Scenario #III 'Avontuurlijk Zeeland'	Provision [TJ]	Scenario #IV 'Voedselrijk Zeeland'	Provision [TJ]	Notes and references
Nature of renewable energy intervention			Large scale interventions		Large scale interventions		Small scale interventions		Small scale interventions		
Presence and nature energy-related policies &			Strong policies and legislation		Absence of policies and legislation		Absence of policies and legislation		Strong policies and legislation		
Energy source: Water											
(1) Tidal energy plant	#	0	1	315	1	315	1	315	1	315	capacity is 630 TJ (Hendriks, 2014) half accounted for SD and half for GO
(2) Osmotic power plant	#	0	1	470	-	0	-	0	-	0	capacity is 940 TJ but only half accounted for SD (Looman & Verhoeven, 2012)
Energy source: Solar											
(3) PV park on land (field with photovoltaic panels)	ha	0	-	0	100	962.5	-	0	-	0	38,5 TJ/ha on SD (Bostatlas); est. future efficiency 25%; net provision = 9,625 TJ/ha
(4) PV park on water (photovoltaic panels)							10	96			10ha surface for now (this is the size of average PV parks, as reference) 38,5 TJ/ha on SD (Bostatlas); est. future efficiency 25%; net provision = 9,625
(5) Photovoltaic panels on building roofs (PV roofs)	ha	3	(-)	4	(-)	4	120	1'159	120	1'159	38,5 TJ/ha on SD (Bostatlas); est. future efficiency 25%; net provision = 9,625 TJ/ha; roof surface 397 ha (CSB, 2013); 30% of all roofs techn. feasible (120ha)
Energy source: Wind											
(6) 3 MW wind turbines in wind park(s)	#	0	83	2'042	68	1672.8	-	0	-	0	3 MW capacity at 8,5 m/s wind speed (Bosatlas) with 26% operating time = 6834 mWh/yr = 24,6 TJ/yr per turbine (space requirement is about 13ha/turbine)
(7) Individual or small clusters of 3MW turbines	#	9	(-)	14	(-)	14	71	1'760	77	1'908	3 MW capacity at 8,5 m/s wind speed (Bosatlas) with 26% operating time = 6834 mWh/yr = 24,6 TJ/yr per turbine (space requirement is about 13ha/turbine)
Energy source:											
(8) Building-scale closed heat-cold storage (WKO)	ha	0	-	0	-	0	150	<1	150	<1	total built-up area = 1016 ha (CBS, 2010), only feasible in Burgsluis and Bruinisse (150ha) with 25W/m2 (Stremke et al. 2013) = 0,0009 TJ/ha
(9) Large open heat-cold storage (WKO/brondoublet)	#	0	10	45	-	0	-	0	-	0	Per brondoublet average of 1260 MW/yr (heat for 150 houses) = 4,5 TJ/year (IF Technology, 2009)
(10) Geothermal energy plant near Brouwersdam	#	0	1	79	1	79	-	0	-	0	Capacity heat production geothermal energy plant for houses in Brouwersdam (2,5 MW; reference Zierikzee Zuid 0,3 MW; Zierikzee Noord 0,5 MW) with 50% probability = 21.900 MW/yr = 79 TJ (Panterra, 2011)
Energy source: Biomass											
(11) Use of 2nd generation woody biomass in large combined heat-power plant	ha	?	932 ha forest (extensive use)	16	-	0	-	0	-	0	932 ha forest (CBS bodemgebruik, 2010) with 0,042 TJ/ha (Ecofys, 2011) and 40% efficiency CHP plant = 16 TJ/yr
(12) Use of (local & imported) wood and pellets in individual, small furnaces	TJ	58	(-)	58	(-)	58	932 ha forest plus extg. import	66	932 ha forest plus extg. import	66	932 ha forest (CBS bodemgebruik, 2010) with 0,042 TJ/ha (Ecofys, 2011) and 20% efficiency of furnances = 8 TJ/yr
(13) Dedicated energy crops in combined heat power plant (CHP)	ha	0	7900 ha (50% of agricultural land)	419	7900 ha (50% of agricultural land)	418.7	-	0	-	0	Total agricultural land 15881 ha (CBS, 2011); energy corn 0,133 TJ/ha (Alterra, 2008); biogas combusted in CHP (40% efficiency) 0,053 TJ/ha
(14) Use of aquatic biomass in combined heat power plant (CHP)	ha	0					932 ha aquatic biomass production	49			932 ha surface (same as forest, as reference), energy corn as reference because no robust figures on aquatic biomass = 0,133 TJ/ha (Alterra, 2008); biogas inserted in gas network & combusted in micro CHPs (40% efficiency) 0,053 TJ/ha
other energy sources and technologies	div.	48	(-)	71	(-)	71	(-)	71	(-)	71	From Klimaatatlas (e.g. heat recovery from melk cooling) average 50% increase due to technological innovation between 2012 and 2040
Total estimated energy provision by 2040 (estimated consumption by 2040 is 3525 TJ	**TJ**	**117**		**3'532**		**3'523**		**3'517**		**3'519**	

Legend
applied
(-) current locations
minus = not applied
changes 141107

Changes	Date	Motivation
Scenario II, NRG #4: from x to (-)	141103	PV on roofs cannot be considered a large-scale intervention
Various changes indicated in beige	141107	Discussion with fellow DEESD researchers

Each scenario reaches the targeted amount of RE for 2040. The application was conducted on scenario II, Regional Communities, this was chosen based on the expectation that governmental regulation will decrease in the coming decades to give space to decentralized developments in economy and society. Citizen groups and entrepreneurs currently initiate these local developments, e.g. the development of local energy cooperatives. A second motivation for exploring the Regional Communities scenario is that island communities currently retreat from the world economy with the aim to become self-supporting in food and energy provision. This development is also seen in the community of Schouwen-Duiveland, as formulated in the community's strategic vision 'The Future's Tide'(DEESD report step 3 – Verzandvoort et al., 2014).

6.4 Results

The results are presented following each step of the application.
The workshop took place at Zierikzee, the main town on the island in November 2014. The activity was opened to all stakeholders that were joining a Forum day on Zealand 2040. A group of seven couples of stakeholders joined the first session of the participatory mapping. At first a round table on presentations was used to understand participants background. Backgrounds included landowner, provincial officials, landscape heritage and nature organizations, a renewable energy technology company, an official from the regional service of water works (Rijkswaterstaat).
The selected ES were: food production, water regulation and recreational and touristic entourage. These were selected as the most important ecosystem services for this part of the province based on previous research (Verzandvoort et al. 2013), and on an inventory of environmental and economic policy documents from the Province of Zeeland. The technologies for renewable energy production selected for this scenario are listed in table 4 below. In the proposed combination and numbering the total estimated energy provision by 2040 is 3525 TJ per year.

Table 6.4 The number of stickers with corresponding information on RET

RET	Energy production in TJ	Number of stickers
Tidal energy plant	315	1
Wind park with 34 turbines	836.5	2
PV park 10 ha size	96.3	10
Dedicated energy crop 1975 ha	104.75	4
Geothermal energy plant	79	1
Seven small biomass furnaces	58	1

From the participatory mapping of stakeholders we got seven albums, each including a sheet layer with the information on ES and another on RET. A second group of stakeholders was involved in a discussion on how RET could be suited into the landscape of the island. The different design solutions were sketched and discussed with them. In the image below (figure 6.7) we represent the two design strategies discussed by stakeholders: the corridors design strategy and the cluster design strategy. The first pondered the option to design RET along the linear features of the landscape (PV panels on the dykes slopes, wind turbines along the roads and the dams, energy crops as marginal cultures between the dykes and the fields). The second one proposed that RET could be clustered in three large areas around the main urban settlements, *Zierikzee*, *Scharendijke* and *Burgh-Hamsteede*. Stakeholders preferred the cluster design strategy. The reasons emerged can be resumed as in table 4. The first strategy could cause less affliction for cultivated areas, but it was firmly opposed by a group of stakeholders that were affirming that changing the aspect of the linear features of their landscape, as dykes, which are relevant for their landscape cultural value, would not have been sustainable. This option was considered neutral for food provision, but it could cause crucial trade-off with cultural ES. The second strategy on the contrary was afflicting the food production, converting a great extension of arable land and part of grassland into energy crops and solar fields, setting aside the wind park in off-shore, but it was preserving the main cultural value of the landscape, their dykes.

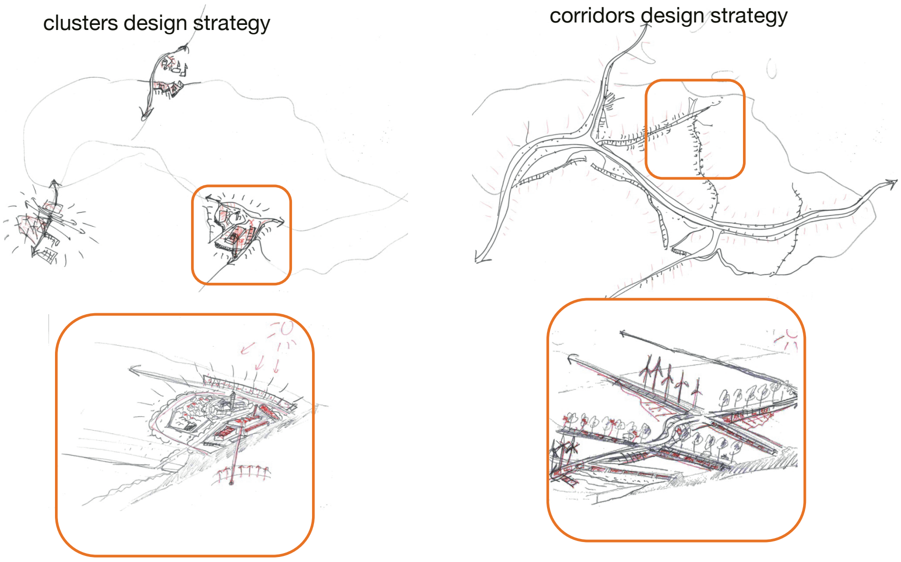

Figure 6.7 The design strategies discussed with the second group of stakeholders.

Table 6.5 Landscape design strategies and ES supply. The arrows indicate if the design strategy cause trade-off or synergy, or is neutral for the three ecosystem services supply.

	Ecosystem services supply		
design strategies	food production	water regulation	recreation
corridors	→	↘	↘
clusters	↘	→	→

The ES supply areas drawn by stakeholders were imported and digitalized on GIS, then overlaid. We got the following map (figure 6.8). The dunes landscape and *Grevelingenmeer*, the interior sea north of the island, represent the hotspots for recreation. The historical center of *Zierikzee*, and the *Delingdijk* also resulted as hotspots for recreation. The hotspots for water regulation were individuated by stakeholders in the coastal areas were the dunes regulate floods and store sweet water, as in the wetlands of *Schelphoek* and the dams on the southern side of the island, facing the *Oosterschelde* inner sea. About the food production, stakeholders considered as hotspots a wide area in the Old Polder Landscape between the villages of *Dreischor* and *Nieuewerkerk.*

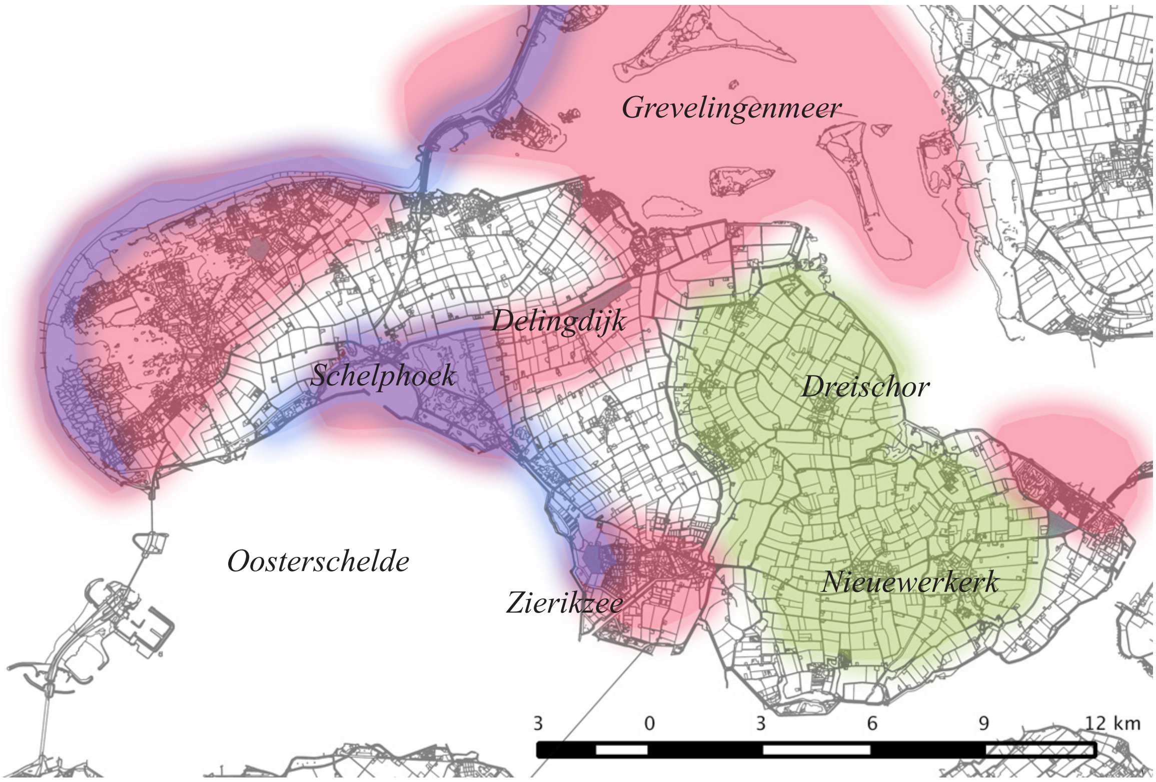

Figure 6.8 Map of the hotspots for ES supply. In green the source locations for food production; in blue the source locations for water regulation; and in red the use locations for recreation.

The sites indicated by stakeholders for RET were reported in GIS points shape-files. We got a grid of 1000 m, resulting from the land pattern medium shape-area of approximately 2,2 ha. Through the grid we could cluster the dots for each RET (figure 6.9) and trace the buffers (figure 6.10).

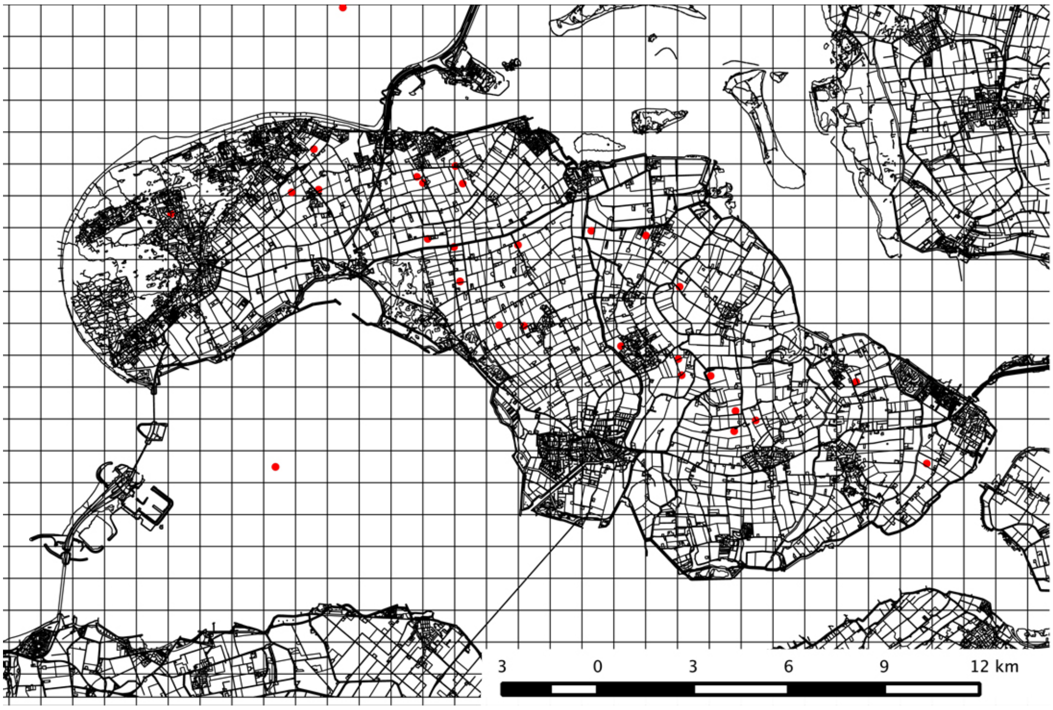

Figure 6.9 Work map. The red dots in the grid represent the preferences expressed by stakeholders for the RET (12) dedicated energy crops loocations.

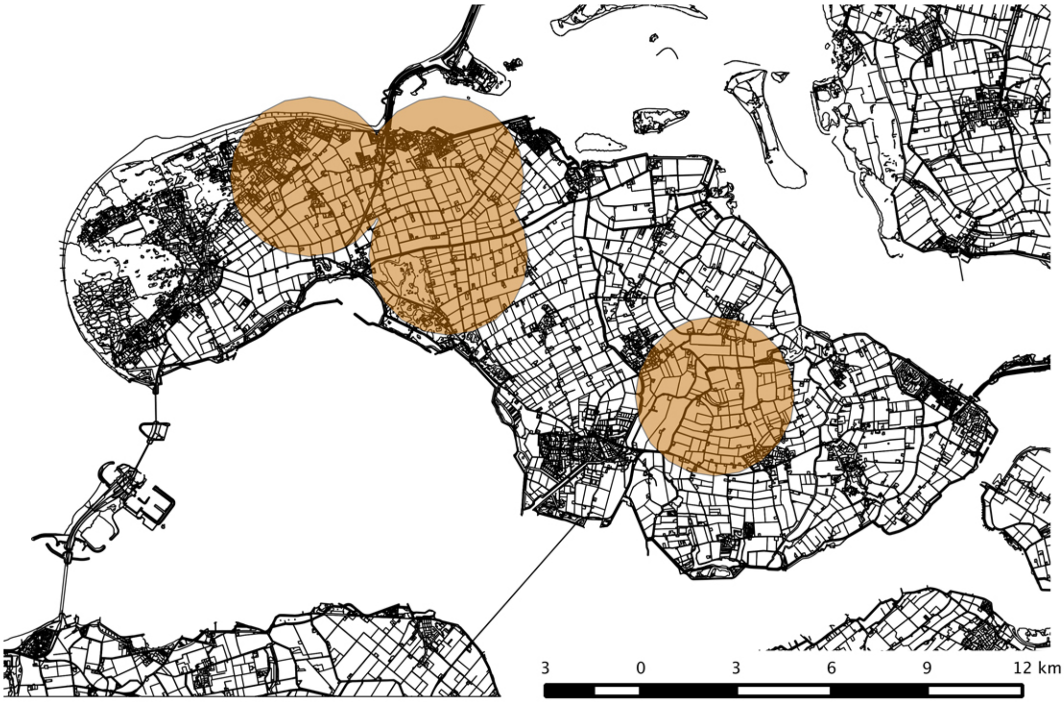

Figure 6.10 Work map. The buffer areas show the preference of stakeholders for the sites of dedicated energy crops and the real area needed to reach the targeted amount of energy.

By overlaying the RET buffers and the ES hotspots it was possible to detect potential spatial trade-off or synergies among RET and ES in overlay with specific LULC classes and interrelation with the landscape infrastructure, LI (figure 6.11). The results show how dedicated energy crops would occupy the major part of the agriculture land of the island. The dedicated energy crops cover a total of 7900 ha, one third is located in the middle of the hotspot for food production. Wind parks have been located off-shore and on the Pijlerdam, where some turbines are already existing. Three solar panel buffers are located close to residential areas, on grassland close to *Renesse*, *Zierikze*e and *Bruinisse*, one close to *Delignsdijk* in open agricultural land, all these locations are enclosed in hotspot for recreation. The Geothermal energy plant and the Biomass furnaces are located in the suburban area of *Zierikzee*. The tidal energy plant is planned in near-future development; this is why all stakeholders sited it exactly on the same location, the *Brouwersdam*.

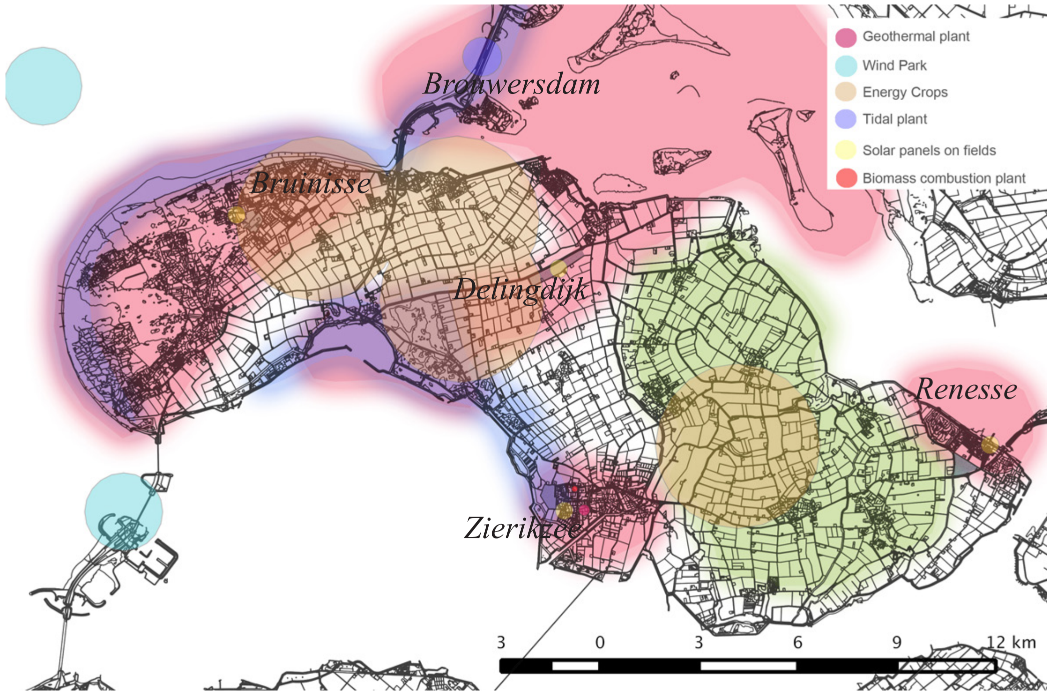

Figure 6.11 The overlay between the RET buffers and the hotspots for ES supply. It is possible to select the LULC classes and the features of the landscape infrastructure where the buffers overlay the supply of food production (green), water regulation (blue) and recreation (red).

The LULC we used are extrapolated from the LGN, Dutch National Land Cover, and Land Use Statistics, (CBS, 2010), while the linear features of the landscape infrastructure were deducted from the maps of the landscape analysis. The areas included in the Natura 2000 sites were automatically excluded and not considered in the assessment, as well as LULC as built-up areas, graveyards and wooded graveyards. In the image below (figure 6.12) we show an example of the results from the trade-off analysis between the RET (12) Dedicated energy crops and food production and recreation ES.

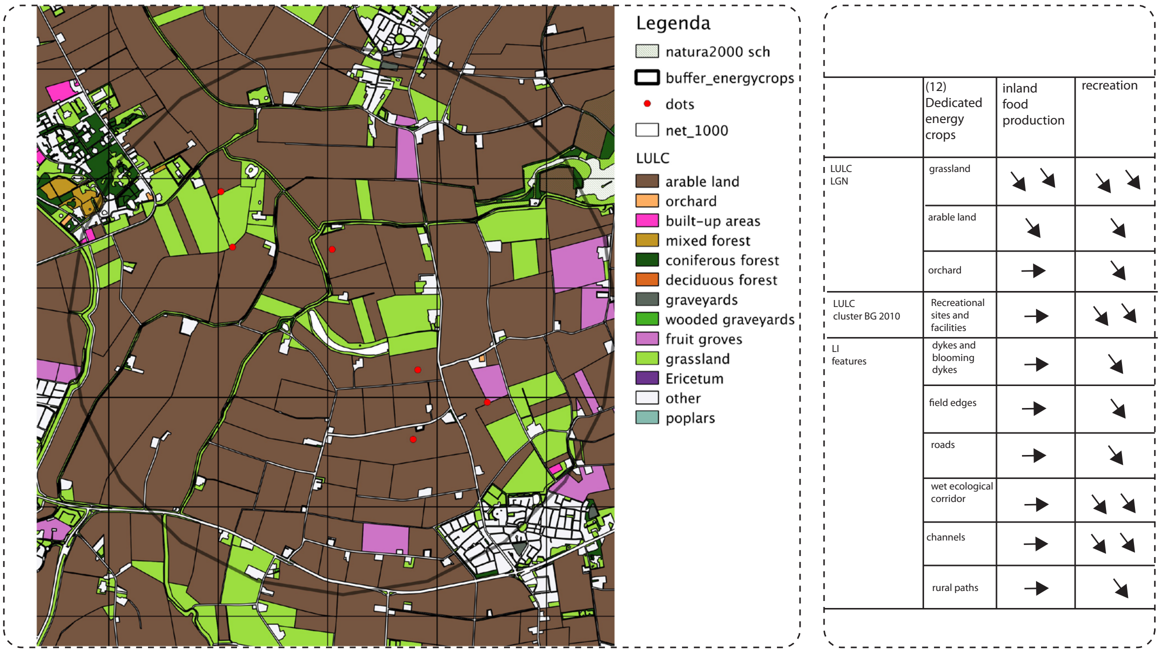

Figure 6.12 An example of the matrix that relate the RET (12) with the food production and recreation ES. The matrix exposes trade-off between the dedicated energy crops (RET 12 of scenario II) and the selected ES. The LULC, LI features and the ES enter the matrix because they are enclosed in the spatial overlay between the RET buffer and the ES hotspot supply.

A high trade-off is observed between the energy crops, that in the specific example would be corn, with food production and recreation, if this would be cultivated in place of the actual grassland. High trade-off or trade-off are also observed for recreation in coincidence of wet ecological corridors and channels, dykes, filed edges and rural paths.

The main criteria for the value assessment were the scarcity of ES supply (Farber et al., 2002). This means for example that the trade-off between the food production and the dedicated energy crop was considered stronger in relation to the LULC grassland than arable land, because in Schouwen-Duiveland the food production from grassland is more rare in comparison to arable land.

Now we can prospect to Schouwen-Duiveland community the discussed spatial interventions and the landscape of the scenario II (figure 6.13-14-15), and the trade-offs or synergies that this can cause (table 6.6).

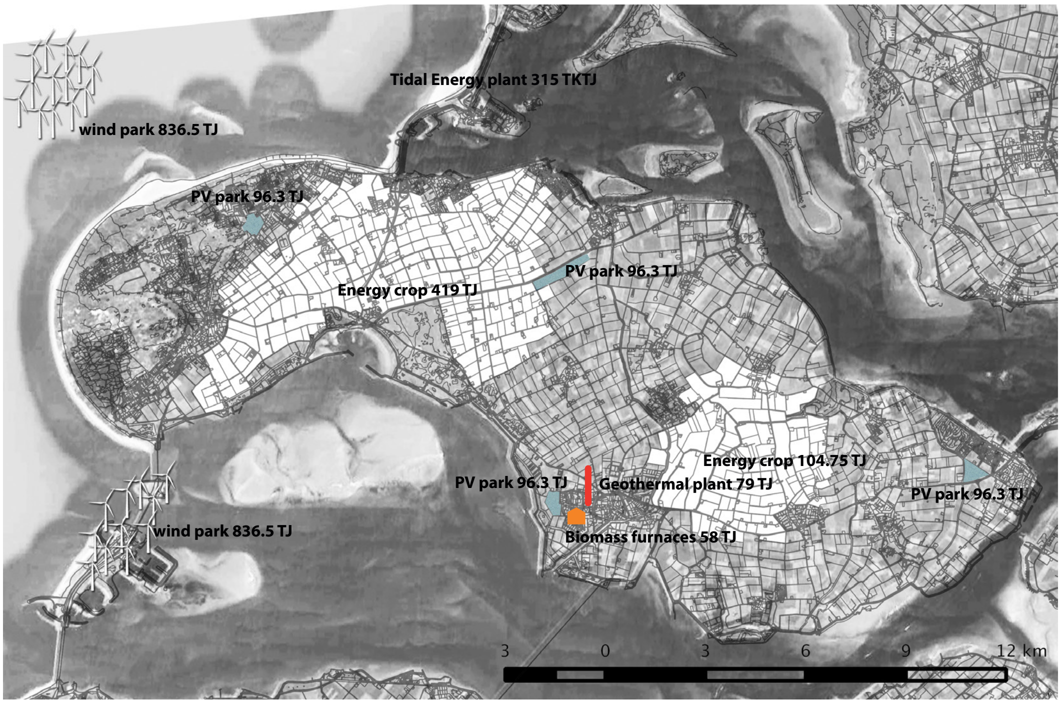

Figure 6.13 The plan of the vision of the Schouwen-Duiveland community for scenario II, Regional Communities.

Table 6.6 The prospected synergies and trade-offs between RE and ES per RET.

	Ecosystem services		
Renewable Energy Technologies	food production	water regulation	recreation
Tidal power plant	↗	↗	
Osmotic power plant	→	→	
PV panels on land	↘	→	↘
PV panels on building roofs	→	→	→
3 MW wind turbines in wind park	→	→	↘
Individual or small clusters of 3MW wind turbines	→	→	↘
Geothermal energy plant and WKO installations	→	↘	→
Biomass from wood	↘	↗	↗
Dedicated Energy crops	↘	→	↘
Biomass from water	→	→	

Figure 6.14 Vision for dedicated energy crops and PV parks

Figure 6.15 Vision for wind parks

6.5 Discussion

This application has been approached in a Pragmatic philosophical worldview (Creswell, 2009, p. 10). The approach was a "learning by doing" (Hou et al, 2013), facing new challenges and merging different theories, approaches and applications. In line with classification proposed by Hou et al. (2013) we encountered three main sources of uncertainty

1) Uncertainty due to modeling methodologies

2) Uncertainties due to natural supply of ecosystem services

3) Uncertainties due to preference settings

Regarding "modeling methodologies" we found uncertainties in input data. The matrix approach was based on experts and trade-offs between RET and ES on the literature. According to Bennet et al (2009), data on trade-offs for ES are valid at the local scale, and their relevance in other context need a proper interpretation. For example Ladenburg and Dubgaard (2007) demonstrated that the willingness to pay to reduce the "visual disamenities" of wind farms, increases with the distance of wind turbines from the shore. Differently Gee and Burkhard (2010) showed the concern of residents of Schleswig-Holstein for off-shore wind farms in the North Sea, because destroy the cultural value of the free horizon of their seaside. These studies demonstrate opposite value for the trade-off between wind turbines and cultural ecosystem services, in the first stakeholders prefer to site wind turbines off-shore as far as possible from the coast line, in the second they would prefer to have turbines in the inner land. This is due to the fact that different landscapes are attributed of different values. In Schouwen-Duivelan the free horizon of the sea doesn't represent a shared value between the stakeholders that participated to the workshop, while a specific view of the inner rural landscape was considered valuable. This clearly shows, in line with Bennet et al. (2009), that trade-off between ecosystem services should be assessed at local scale. It is possible to refer to data sets in evident cases as the trade-off between food production and dedicated energy crops, but even in this case it depends on the design strategy. Expert interpretation, scaling and contextualization of data are required in different applications.

About the "natural supply of ecosystem services" we met limited knowledge on the ecosystem structures and processes at local scale and therefore their potential interaction with RET. This would have required the development of local ES trade-offs evaluation strategies.

We encountered less uncertainty in the dynamics of land use structures and this was due to the landscape analysis that allowed the overlap of several layers and the use of the Dutch National Land Cover Classification.

Concerning "preference settings", the representativeness of the stakeholder assessment can be questioned, due to the limited number of respondents at the participatory session. This was partially compensated for cultural ecosystem services by the fact that results on participatory mapping find confirmation in the" Recreation monitoring report 2007". This shows the most visited and experienced sites between 1998 and 2006, and these are effectively enclosed in the areas traced by stakeholders. Further what became evident during the process, in close relation to cultural ecosystem services, was a lack of analysis of the visual aspects of the landscape. A couple of stakeholders indicated cultural value in a particular view that one can have over one of the polders. This fact reveals the importance of an analysis of the visual aspects when dealing with RET. This information was actually missing in the landscape analysis and could have supported stakeholders in thinking in terms of valuable views of their landscape and consequently in siting the different RET. This emerged of course in perspective of a landscape change, a possible detraction of the landscape value, and maybe this pushed citizens in underlying the value of that view.

6.6 Conclusions

To answer and discuss the first research question - How do Ecosystem Services and Renewable Energy Technologies relate in a landscape perspective - the application of the theoretical framework and the elaboration of a method at Schouwen-Duiveland showed how it is possible to handle Ecosystem Servcies and Renewable Energy in a landscape perspective if we adopt land use/land cover and the landscape infrastructure as spatial reference system. The introduction of the LI in the matrix approach permitted the consideration of the trade-off with those elements of the landscapes as the dykes, not deducible from land use/land cover but still useful to attend to a landscape design strategy. The second question addressed in this paper was -What is the added value of an Ecosystem Services approach in long term visions for planning and designing energy landscapes-. The main results of this application show a number of relevant aspects to be mentioned here. First we would like to discuss the challenge of the proposed theoretical framework. The introduction of an Ecosystem Services assessment into long term visions for the planning and design of sustainable energy landscape indeed is valuable for two reasons. Most approaches to long-term planning and design, such as the Five-step Approach, address uncertainties by producing different scenarios. Uncertainties in landscape analysis and Ecosystem Services assessments are a recurrent topic (Hou et al., 2013). Hou et al. focus on the uncertainties that can afflict the knowledge on the natural supply of Ecosystem Services: "consider different scenarios regarding changes in focal constraints and integrate additional information layers on the natural system's conditions" (2013, p.128). A long term visions approach results successful in managing trade-offs for Ecosystem Services, while an Ecosystem Services approach enhances the formulation of scenarios putting on the decision-making table the values of the landscape as an additional data layer. The results of the workshop and the subsequent analysis suggest that an Ecosystem Services approach can enhance long term visions in planning and designing energy landscape. For example in the case of dedicated energy crops the trade-off with food production is stronger in grassland. If we consider scarcity and diversity of Ecosystem Services supply as parameters, we deduce that being the rural landscape of Schouwen-Duiveland more specialized in arable land, the trade-off would be more crucial both from food production and recreation in relation to grassland and fruit groves than arable land. The same affliction of recreation would be stronger in relation to those landscape features as blooming dykes, channels, which contribute more than others to the recreation in those areas that stakeholders defined hotspots for cultural ecosystem services as along the Delingsdijk. The third question was -How is energy landscape design relevant for the supply of ecosystem services-. During the workshop emerged that the way we design our energy landscape, can deeply influence the affliction or the enhancement of the Ecosystem Services supply. Data on Ecosystem Services can generate more knowledge and facilitate a better understanding that, in turn, can inform appropriate design principles of energy landscapes.

Discussions and conclusions

Concluding this thesis means to reflect on what we have learned and what we can still improve. First we will re-state the answers to the research questions and then we will discuss the main limits arose and define future efforts.

1. What are the parameters for landscape sustainability in the energy transition era?

A landscape sustainability is safeguarded not only in terms of ES supply (Stremke and Dobbelsteen, 2012); the sustainability in the energy transition era is also based on the governance. The sustainability is first due to a sustainable energy transition. The transition must be based on a broad social consensus, must be targeted the quickest as possible, must be based on decentralization and bottom-up processes, where local communities seek for sustainable development and self-sufficiency in renewable energy supply. If these first conditions are satisfied the second parameter is the sustainability in terms of ecosystem services supply, including then all the social, economical and cultural aspects of the landscape such as beauty and aesthetics. But we still remark that the process must be bottom-up, based on a local community seeking for self-development and conscious of the landscape values and functions, expressed as Ecosystem Services supply. An Ecosystem Services approach in the assessment of Renewable Energies is relevant and challenging, since the introduction of Renewable Energy Technologies in the landscape can afflict the supply of Ecosystem Services

2. What the contribute of planning and design the landscape to energy transition?

When a local community seeks for sustainable development and self-sufficiency in renewable energy supply a design approach, ore regional design (Stremke, 2010), guides the community in formulating and envisioning future scenarios where the Renewable Energy Technologies are introduced in the landscape and showing what can be the trade-off between the supply of Renewable Energy and the supply of Ecosystem Services. The challenge of Landscape Architects and their social function is to guide communities in designing their future landscape considering all the uncertainties, in order to keep a good balance and reduce critical trade-off between the Renewable Energy and the Ecosystem Service supply (Minichino, 2014).

3. What are the approaches and ES categories in RE assessment?

In the past decade the majority of studies approached the question of Renewable Energy and landscape studying the General attitude of people for specific Renewable Energy Sources and relate Technologies and in the majority of cases discussing in terms of Cultural Ecosystem Services as identity, recreation and tourism. The second majority studied the impact of specific Renewable Energy Sources and related Technologies on a set of Ecosystem Services, as for example the impact of Biomass primary production on the food production and the water regulation.

4. What are the methods for assessing synergies and trade-offs among ES and what are the spatial reference systems?

Trade-off among ecosystem services is a potential approach in studying the relationship between Renewable Energy and landscape. The majority of studies evaluated trade-offs following qualitative strategies and relating the Ecosystem Services supply to the landscape, which means integrating the spatial reference system of land use/land cover with information on the elements of the landscape infrastructure as green and blue network, roads, linear features as tree lines and edges.

5. How can Cultural ES be assessed in trade-off with other ES and what the spatial reference systems?

Cultural Ecosystem Services can be assessed in trade-off with other ES through qualitative approaches, where stakeholders map the hot spots for cultural services. Potential trade-offs can be assessed only through landscape visualizations. The supply of Cultural Ecosystem Services depend on the supply of all the other Ecosystem Services and their spatial organization.

6. How ES and RE relate to one another from a landscape perspective?

The application of the theoretical framework and the elaboration of a method at Schouwen-Duiveland showed how it is possible to handle Ecosystem Services and Renewable Energy in a landscape perspective if we adopt land use/land cover and the landscape infrastructure as spatial reference system. Both Renewable Energy and Ecosystem Services supplies are provided through the land use and the landscape infrastructure. If we build a matrix and we spatially relate the Ecosystem Services supply and specific Renewable Energy Sources and related Technologies to the land use/land cover and the landscape infrastructure features as the dykes, not deducible from land use land cover but still useful to attend to a landscape design strategy, we can express a potential spatial trade-off or synergy between the Renewable Energy (per specific Source and Technology) and the Ecosystem Service supply. The landscape perspective is safeguarded if the potential spatial trade-off analysis is considered as an informative layer and included in a wider multi-layer landscape analysis.

7. What is the added value of an ecosystem services approach for planning and designing sustainable energy landscapes?

The introduction of an Ecosystem Services assessment into long term visions for the planning and design of sustainable energy landscape indeed is valuable for two reasons. Most approaches to long-term planning and design, such as the Five-step Approach, address uncertainties by producing different scenarios. Uncertainties in landscape analysis and Ecosystem Services assessments are a recurrent topic (Hou et al., 2013). A long term visions approach results successful in managing trade-offs for Ecosystem Services, while an Ecosystem Services approach enhances the formulation of scenarios putting on the decision-making and communities table the marketable or non marketable values of the landscape as an additional data layer in the landscape analysis. The results of the workshop and the subsequent analysis suggest that an Ecosystem Services approach can enhance long-term visions in planning and designing energy landscape. Further allows landscape architects to share a common language with environmental planners to guide communities towards a sustainable development in a trans-disciplinary approach.

8. How does energy landscape design affect the supply of ecosystem services?

During the workshop emerged that the way we design our energy landscape, can deeply influence the affliction or the enhancement of the Ecosystem Services supply. Landscape design deals with finding solutions for the landscape structure and consequently the supply of Ecosystem Services. In the case of Energy landscape deals in finding the best solutions for the design of the energy layers (Pasqualetti, 2012; Stremke, 2014) through the display of Technologies that can afflict the Ecosystem Services supply.

Data on Ecosystem Services can generate more knowledge and facilitate a better understanding that, in turn, can inform appropriate design concept or strategies of energy landscapes at regional scale through a Design Approach.

Let’s now discuss some limits emerged during the application part of this research and define

some future efforts.
In the case study we worked in a trans-disciplinary approach, and the societal aim was to support a local community reaching its self-sufficiency in Renewable Energy supply. From a scientific perspective we decided to investigate Ecosystem Services to enhance the procedural knowledge for the design of sustainable energy landscapes. The application in Zealand taught us how to interact with other researchers that have not the same perspective. In the end we shared a goal and we put it in practice. It was possible to combine a focus group and discuss with locals what best landscape design supports Renewable Energy and Ecosystem Services.

The application reported in this thesis has been approached in a Pragmatic philosophical worldview (Creswell, 2009, p. 10). The approach was a “learning by doing” (Hou et al, 2013), facing new challenges and merging different theories, approaches and applications. The nature of this approach bring at the end on a reflection and synthesis of what can be advance in the future.
We remark some limitations in the organization of the workshop. The workshop was led in half day, concentrating step 1 and 5: the participatory mapping of the Ecosystem Services hot spots, which was missing in step 1; the application of step 5 in siting the Technologies and discussing a design strategy. The workshop should be duplicated according to the steps of the Five-step Approach. A first workshop in step 1, a second in step 5.

An early involvement of stakeholders in the step 1 of the Five-step approach would advance the landscape analysis by introducing the participatory mapping of the Ecosystem Services. Working with stakeholders on the several landscape layers and discuss the capacity of each landscape layer to supply Ecosystem Services would ameliorate the integration between a multi-layer approach and an Ecosystem Services assessment. Further the selection of the Ecosystem Services could be primarily led with stakeholders, then with experts. This could result in having more relevant Ecosystem Services according to local inhabitant than in literature. We selected three Ecosystem Services, food production, water regulation and recreation, but this has been reductive, because looking in a landscape perspective we should consider all the services provided by the landscape, and this can be assured by an early involvement of stakeholders in step 1. If we consider the whole Renewable Energy Sources embodied in the landscape, evidently we should also consider the complex of Ecosystem

Services provided by the landscape.

The use of a Spatial Multi-criteria Analysis software is challenging. Once we have the values of the capacity of the land use/land cover and the landscape infrastructure to supply Ecosystem Services and the maps on the energy potential, we would have the data necessary to formulate scenarios through a software. We noticed in the literature review how some studies developed and put in practice softwares where it is possible to introduce values also for the linear features and characters of the landscape (e.g. Frank et al., 2012). Such software would generate automatically the scenarios combining the values for the Ecosystem Services supply and the values for Renewable Energy Sources and specific Technologies. Of course the effort would be to translate the Energy Potential maps in range of values (e.g. 1-5) per land use/land cover and the landscape infrastructure as capacity through a specific Technology to supply Renewable Energy from the Wind, Sun, Water, Geothermal and Biomass. The introduction of a Spatial Multi-criteria Analysis would occur in the step 4 of the Five-step Approach. Having formulated those scenarios through a software, stakeholders would have to site the Technologies in a second workshop where it would be possible to focus exclusively on the landscape design strategies, the discussion of new narratives and new form of aesthetics and identity. Innovative forms of landscape visualization so relevant to comprehend the trade-off between Renewable Energy and Cultural Ecosystem Services would be necessery (Grêt-Regamey et al., 2013).

When locals seek for energy self-sufficiency, operate already an emotional transition (Sijmons, 2014), they want to adopt Renewable Energy Technologies. This means that the global narrative becomes local, this means to overcome the conflict and be conscious that the changing of the landscape could operate benefit if we subtly design it, giving form to people aspirations. This means to operate a transition management that effectively works because starts by finding solutions and maybe also innovations among the people. Wonderful landscape designs have been edited for Renewable Energy Technologies in the last decade, the LAGI, Land Art Generator, is a clear example, innovation in technology and innovation in the landscape. These tools are fundamental for communities. The trade-off analysis we operated gave as result that Cultural Ecosystem Services are for people more relevant than other Ecosystem Services categories, and this confirmed what we noticed in the literature review. People from Schouwen-Duiveland consider Cultural Services like identity or recreation more relevant than food production. This emerges clearly when they show preference for the design strategy that afflicts food production but preserves the main landscape character. “No wind turbines or PV panels on my dykes “, was the exclamation of a lady during the focus group, but this doesn’t mean that these cannot find other sites in the island. It is a matter of visual perception, this is really relevant in the design of the energy transition. People want to keep some perception and accept to change others. We learned that analyzing the perception of the landscape with locals is a fundamental step; we did not engage with it, this was a strong limitation. What are people preferred views, what vistas can change, what not? Landscape representation counts. In a first workshop in step 1 an analysis of the landscape perception should be led with stakeholders.

This means that we should improve the way we combine scientific data with representation. We edited several data tables in this work, the last on synergies and trade-offs values between Ecosystem Services and Renewable Energy provided by different Technologies. The information kept in these tables is relevant for landscape design. But how can these tables communicate with people? Christoph Girot affirms that Landscape Architecture has always relied on a combination of words and images. If Ecosystem Services become a new trans-disciplinary language to express the values of the landscape, we have to combine images to express them. I wonder if images can really depict such complex dynamics where the supply of Ecosystem Services vary and fluctuate while the aspect of the landscape changes. The landscape change influences not only the visual perception but also the sound and the smell. Everything is in motion. “Landscape Vision Motion” is an anthology edited by Girot and Truniger (2012). The authors reflect on the evolution of the forms of representation of the landscapes, images and maps are not efficient, we should move towards digital media representations, virtual experiences and first of all to video. It is necessary to reproduce landscape experiences as Charles Waldheim remarks in the anthology. These are future challenges for the landscape representation, and this should be put in practice to facilitate local communities in designing their sustainable development and renewable energy self-sufficiency. Such a “digital approach”should be well balanced with more tangible means such as augmented reality, 3D physical models and scale-models as they are commonly used in other fields of practice within the discipline. I imagine dynamic virtual representations where people can experience future energy landscapes and can be digitally informed on how the values of supplied energy and ecosystem services fluctuate in trade-off or synergy depending on where they turn their eyes.

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