Designers, architects and planners must begin to anticipate the far reaching changes we are facing in connection with climate change. What if we take action and actively participate in the transition from fossil-fuel driven society towards a more sustainable society?

This paper intends to discuss some of the spatial opportunities and consequences of a sustainable energy transition in relation to climate change and depletion of fossil-fuels. At the same time, it provides a broad overview of issues and challenges at hand whilst designing sustainable energy landscapes on a regional scale.

INTRODUCTION

The challenge is clear; carbon dioxide emissions must be minimized and remaining fossil-fuel reserves sustained as long as possible. Such fundamental paradigm change does, of course, not only involve professionals dealing with large-scale spatial design. However, the imperative transition from natural gas, crude oil and coal towards renewable resources bears great opportunities for professionals concerned with both natural science and artistic imagination. All too often, architects and designers are faced with the fact that aesthetic needs - one of the traditional key concerns of our professions - rank well behind a number of ‘basic needs’. This has been described in the so-called ‘pyramid of needs’. American psychologist Abraham Maslow states, that psychological needs, safety, social needs and the need for esteem must be fulfilled before humans begin to appreciate beauty.[1] We believe that sustainable thinking, including the here discussed energy transition, must become an imperative factor while designing the human environment. In doing so, the professions dealing with spatial design can remain relevant and take responsibility for places elsewhere and for future generations. In the following chapter, we will describe some of the manifold connections between energy as a prerequisite of life on earth and the environment as the focus of our studies. Because energy harvest, storage and consumption manifest themselves in the environment, we believe that energy-conscious spatial design can facilitate the transition towards more sustainable use of resources.

Problem Statement

Today, the Netherlands depend to 60 percent on the import of energy; more than 95 percent of the total energy provision is based on fossil-fuel resources and therefore emits vast amounts of greenhouse gases. An average Dutch family consumes more than 20.000kg of oil equivalents - that is one tanker - for heating, shelter, food production and transportation. Currently, the per capita energy consumption ranks among the highest in the world.[2] This situation is unsustainable both in economical as well as ecological terms. Obviously, energy can be imported to accommodate the increasing demand. However, import of energy does increase the dependency on foreign economies. Above all, a wide range of scientific studies has revealed a significant correlation between the excessive consumption of fossil-fuels and global warming, leading to changing climate and rising sea levels.

Energy Production

As of 2005, a mere fraction of 2.4 percent of the Dutch energy supply is generated by domestic renewable energy sources.[3] Despite the small proportion of renewables in the Dutch energy market, the so-called *groene stroom* has gained unexpected popularity since its introduction in 1995.[4] To meet the increasing demand, energy providers are currently importing renewable electricity from abroad. The vast majority of energy, however, is provided on the basis of fossil-fuels, mainly natural gas and crude oil resulting in a relatively high per-capita-emission of greenhouse gases compared with our European neighbours.[5] Estimating energy demand in the future is not an easy task. Dutch scientists have calculated that the total energy consumption - in the best case scenario - can be reduced between one and two percent per year.[6] A second important parameter is the expected growth or decline of the population, which, ultimately impacts the total energy consumption of the

Ref.1: Maslow, A. H. (1958). A Dynamic Theory of Human Motivation. In: Understanding human motivation. C. Stacey and M. DeMartino (Ed). Cleveland, OH: Howard Allen Publishers: 26-47.

Ref.2: CBS (2003). Energie en water. Centraal Bureau voor de Statistiek.

Ref.3: CBS (2005). Energie en water. Centraal Bureau voor de Statistiek.

note 4: Note: Goene stroom is electricity based on renewable resources.

Ref.5: Globalis (2003). Greenhouse Gas Emissions per Capita. Global Virtual University.

Ref.6: Task-Force-Energietransitie (2006). Transitieactieplan Meer met Energie Task Force Energietransitie.

nation. Verifying energy demand is not the intention of the present study. However, these predictions will have an important role in setting future goals. Specific information on the current energy consumption and population development in the case-study region of South Limburg can be found in the following chapters.

Legislation: EU and the Netherlands

In connection with the increasing awareness of global warming and rising sea levels, a number of initiatives related to sustainability culminated in the adoption of binding directives in the European Union. Among them is the EU Directive 2001/77/EC, which determines that at least 12 percent of the gross national energy has to be based on renewable resources. Furthermore, the EU Directive 2003/30/EC requires 5.75 percent of all fuels to be biofuels. Both directives have to be implemented in 2010.[1 + 2] In spring 2007 European leaders have set even higher targets and committed to sign binding directives for 20% renewable energy and 20% energy savings by 2020. In the Netherlands, the national targets have been specified in the so-called transition plan. The Dutch government strives for a two percent reduction of the overall energy consumption per year. Additionally, it intends to replace 30% of conventional energy production with biomass production, reducing the country's overall CO_2 emission by 50%.[3]

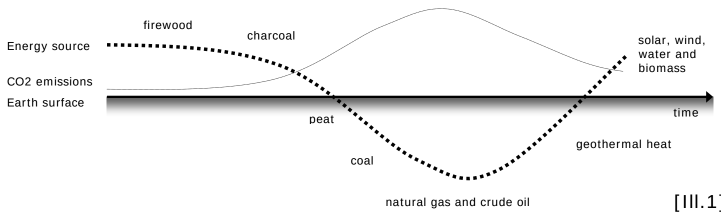
United Nations: Energy Program

The interrelation between excessive energy consumption and environment was, for the first time, officially acknowledged during the United Nations Conference on Environment and Development in Rio de Janeiro (1992). Three key program areas were identified to mitigate the imminent climate change. (1) Energy transition, (2) Energy efficiency and (3) Renewable energy sources.[4] These three objectives represent the starting point of our studies with the goal of rendering pathways for energy autarkic regions in the Netherlands. The following chapters will emphasize the relevance of ecological concepts to the designer of sustainable energy landscapes.

ENERGY AS AN INTEGRAL PART OF THE ENVIRONMENT

Energy: From Past to Present

One can identify two periods of rapid population growth tied to energy procurement. With the development of agriculture, the amount of food and fibers that could be provided by a given area increased. Two centuries ago, the industrial revolution initiated the second rapid increase in world population. Industrialization was driven by fossil-fuel powered machinery.[5] The number of humans on planet Earth has, to some extend, increased due the abundant access to fossil-fuels. Reciprocally, rising populations are demanding more and more energy to build and maintain the artificial environments. The earliest known mean to prepare food was a simple wood-burning fire. Later, wood was supplemented by charcoal and peat to heat human shelters during the cold periods of the year. The excessive extraction of peat along with massive de-forestation created a new situation with competition between different land-uses. The discovery of lignite and black coal provided sought after alternatives. Only from the 19th century on, crude oil and natural gas were extracted from the deeper layers of the subsoil. Essentially, one may assign each resource to a horizontal layer whereas, throughout the past centuries, humans not only gained access to gas and oil stored in deeper layers but also industrialized the extraction process as such, leading to an ever increasing amount of carbon dioxide discharged into the planets atmosphere after combustion of these resources.



[Ill.1]

Ref.1: Directive 2001/77/EC of the European Parliament and of the Council on the promotion of electricity from renewable energy sources in the internal electricity market.

Ref.2: Directive 2003/30/EC of the European Parliament and the Council on the promotion of the use of biofuels or other renewable fuels for transport.
Ref.3: Task-Force-Energietransitie (2006). Transitieactieplan Meer met Energie Task Force Energietransitie.

Ref.4: Strong, M. F. (1992). "Energy, environment and development." Energy policy 20(6): 490-494.

Ref.5: Odum, E. P. Ecology and our endangered life-support systems. Sunderland, Mass.: Sinauer Associates.

[Ill.1] Horizontal zoning of energy sources correlating with emission of carbon dioxides.

Energy Procurement as Land-use

Although are aware of the stress that our lifestyle places on the environment, we have, only recently, begun to reconsider the excessive use of fossil-fuels. The exploitation of earth's savings (e.g. non-renewable energy resources) has resulted in a cost transfer to the environment (entropy) and to future generations (resource scarcity and pollution). The relatively inexpensive access to fossil-fuels even suppressed already existing renewable technologies based on wind and water. Instead, an anthropogenic, large-scale transformation of what were until then natural landscapes took place. Most of today's landscapes in the Netherlands can be depicted as 'fossil fuel' or 'industrialized' landscapes with high energy input and high entropy output for food and fiber production, landscape maintenance and repair. Often, we refer to our environment as cultural or recreational landscape; yet, most of them are simply energy landscapes. We find not only traces of resource extraction but most of all, and far more visible, traces of excessive energy consumption; for instance, highways, high-voltage power lines and monocultures to name only a few omnipresent elements in the landscape of the 21st century. It is important to have a critical look at the landscape we are living in today before we can start negotiating about one or the other renewable technology and the consequences attached to them. Discussing a sustainable energy transition is, above all, balancing energy procurement with other land-uses, such as the provision of food, waste treatment, preservation of biodiversity and housing. Landscape architects, among others, are invited to study available technologies, to weight their impact on the landscape and finally, to render pathways towards a more sustainable human environment.

Energy and Ecology

Ecology is the study of relationships. To investigate the relations between human energy systems and the environment represents in this sense, a study of *human ecological systems*. The quest for a more sustainable interaction with our environment motivates the present study on energy economy at the regional scale. Again, the challenge is clear, but how can we draw alternatives to the existing systems? It is understood, that ecology constitutes one of the most relevant natural sciences guiding the path towards more sustainable society. Ecology is relevant not just because it is a science that deals with the environment, energy and resources, but also because of its integrative and regenerative approach, reflected in a focus on 'system thinking' and 'process ordering.' Due to the long process of evolution, nature has produced very efficient processes integrating energy flows and material cycles. Because ecological systems are self-organizing and intelligent systems, the very processes that take place in an ecosystem may offer a blueprint for more sustainable human environment.[6] A number of recent studies on the laws of thermodynamics have described energy in general and exergy in particular as the keystones of sustainable development.[7+8] The first law of thermodynamics states that energy cannot be created or destroyed; energy can only be transformed from one state to another. It represents one of the premises of our studies. However, given the finiteness of global resources and the environmental consequences of excessive energy consumption, it is suggested to take the second law of thermodynamics into account.[9] This is because the second law relates not only to the quantity of energy but also to its quality, the so-called exergy. *Exergy* is the maximum amount of work a system can perform when it is brought to thermodynamic equilibrium with its environment.[10] Intriguing to the spatial designer is that large amounts of exergy are lost during each transformation of energy, for instance, from coal to steam and then to electricity. The term exergy outlines the opportunities that lie within energy cascading. A number of promising new ideas emerged in the field of industrial ecology; we now require clear spatial design principles to be applied on the large-scale. The built environment of the future is then, not only shaped by traditional spatial planning principles but also by the availability of renewable energy sources and transformation processes present in the region. But let us first return to the human ecological system.

Natural and Built Environment

It is important to emphasize that ecological studies have revealed the manifold interrelations between humans and the environment.

Ref.6: Koh, J. (2005). The Energetic Strategy of Ecosystem Development and Urban/Regional Spatial Restructuring and Regeneration. Grounds for Change: Bridging Energy Planning and Spatial Design Strategies. F. v. Dam and K. J. Noorman (Ed). Groningen: Grounds for Change: 29-37.

Ref.7: Cornelissen, R. L. (1997). Thermodynamics and sustainable development: The use of exergy analysis and the reduction of irreversibility Enschede: Department of Mechanical Engineering, University of Twente.

Ref.8: Dincer, I. (2000). "Thermodynamics, Exergy and Environmental Impact." Energy Sources 22: 723-732.

Note 9: The second law of thermodynamics states that during each transformation of energy from one state to another, energy is "lost" and turned into entropy. Entropy is the part of low-quality energy that can not be used anymore.

Ref.10: Ludovisi, A., P. Pandalfi, et al. (2005). "The Strategy of Ecosystem Development: Specific Dissipation as an Indicator of Ecosystem Maturity." Journal of theoretical biology 235: 33-43.

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general reference for 'Energy Procurement as Land-use'

Reference: MacHarg, I. L. (1969). Design with nature. New York: Natural History Press.

Reference: Twidell, J. and A. D. Weir (2006). Renewable energy resources. London [etc.]: Taylor & Francis.

Ref.1: Carl Steinitz (2002) In: Johnson, B. and K. Hill, (Eds). Ecology and design: Frameworks for learning. Washington, DC: Island Press.

[Ill.1] Similarities between Lynch's city elements and Forman's list of landscape elements. Idea based on Carl Steinitz.

Ref.2 Cherrett, J. M. (1988). "Ecological concepts: A survey of the views of the members of the British Ecological Society." Biologist 35: 64-66.

Ref.3: Odum, E. P. (1992). "Great Ideas in Ecology for the 1990s " BioScience 42(7): 542-545.

Ref.4: Forman, R. T. T. J. (1995). Land mosaics : the ecology of landscapes and regions. Cambridge: Cambridge University Press.

Ref.5: Golley, F. O. (1996). Ecological Concepts, with Implications to Environmentalism and Ethics. Athens, GA: Institute of Ecology, University of Georgia.

Ref.6: Farina, A. (1998). Principles and methods in landscape ecology. London and New York: Chapman & Hall.

Ref.7: Johnson, B. and K. Hill, Eds. (2002). Ecology and design: Frameworks for learning. Washington, DC: Island Press.

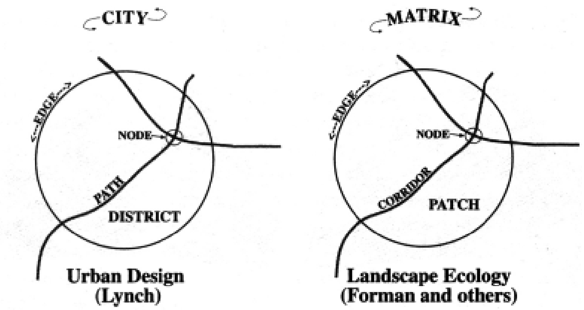
General reference for 'nature and built environment'

Reference: Dramstad, W. E., J. D. Olson, et al. (1996). Landscape ecology principles in landscape architecture and land-use planning. Cambridge, Mass: Harvard University Graduate School of Design, Island Press.

Reference: Johnson, B. and K. Hill, Eds. (2002). Ecology and design: Frameworks for learning. Washington, DC: Island Press.

Reference: Makhzoumi, J. and G. Pungetti (1999). Ecological landscape design and planning: The Mediterranean context. London & New York: E & FN Spon.

In fact, system ecologists have helped to clarify the complexity of processes we have established ourselves within the built environment. Both, landscape and system ecology form a base, from where we can begin improving energy systems on a regional scale. Borrowing from the studies of Carl Steinitz, we can display the similarities between the city, as a human built system, and the environment, as its natural counterpart. He compares the conceptual frameworks of the built world by Kevin Lynch and ecosystems by Richard Foreman. Lynch's system of paths, edges, districts, nodes and landmarks for understanding cities has much in common with the landscape ecology's system of patch, matrix, and corridor as used by Forman and others. Moreover, Steinitz suggests that this similarity underscores the possibilities for joint theory among designers and ecologists which, in turn advocates for the introduction of ecological concepts to the present study focusing on spatial design on a regional scale.[1]



[Ill.1]

LANDSCAPE APPROACH

Ecological Concepts

Since the dawn of the twentieth century ecologists have attempted to define the discipline's key concepts based on long-term ecological studies. In perhaps the most extensive survey, the British Ecological Society asked all members to rank "their" concepts from a list of fifty critical concepts.[2] This list formed the basis and was later expanded by a number of more recently identified ecological concepts.[3+4+5+6+7] Subsequently, each concept has been evaluated for its significance to the present study on energy efficiency at regional scale. Eventually, twenty-seven ecological concepts have been selected and described in-depth. With the help of these concepts, we can connect process thinking (e.g. exergy approach) with spatial design (e.g. energy cascading). The table below states all selected 27 concepts; some of them are closely related to each other and therefore grouped together. During the course of the Regional Atelier 2007, the present ecological concepts have been presented to the participants and discussed extensively. They form a comprehensive but not inclusive foundation for our future studies, a point of origin from where we can derive design principles for more sustainable energy landscapes.

Fundamental Ecological Concepts
- Open system theory
- Life-history adaptation and natural selection
- Human ecology and parasite-host model

Concepts related to Regional Scale
- Hierarchical organization
- Concept of the biome
- Landscape and landscape memory

Concepts related to Energy/Exergy
- Source-sink concept
- Ecosystem autonomy
- Body-size and climate space
- Differentiation of niches
- Biorhythm (also called periodicity)
- Mutualism/cooperation/symbiosis
- Earth-heat balance and energy flow
- Concept of primary production
- Material cycling and decomposition
- Natural disturbance and ecological succession
- Carrying capacity and ecological footprint analysis
- Species diversity and landscape heterogeneity

The Region as Ecological System
Commonly, the interacting complex of organism and environment is identified as an *ecological system* or *ecosystem*. The term *system* refers to an object which is made up of subsystems or components that interact together. Depending on the focus of study, scientists identify the most appropriate scale and describe the chosen ecological system. Consequently, an *ecosystem* is defined as a more or less bounded object made of living organism and environmental components and processes which interact together to make a unity.[8] Each ecosystem is, in some respect, distinct from the surrounding systems. For the present study, the prime interest lies on the regional scale; the arguments are as following:

(1) Material cycles: At the regional scale, most material cycles can be closed as we have access to sufficient resources, an appropriate number of consumers and the technologies needed to recycle matter.

(2) Transportation losses: Physical laws prevent the transport of, for instance excess heat from power plants, beyond the regional scale. This is especially relevant when applying the exergy approach, for instance energy cascades which optimize energy efficiency within the region.

(3) Transportation costs: As resources and energy are distributed over longer distances, both transport costs and greenhouse gas emissions increase depending on the physical characteristics of the medium (e.g. biomass is both bulky and heavy and therefore not suitable for long distance transport).

(4) Scientific focus: The region as a spatial unity has a long history of interest in many professional fields. Landscape architects, ecologists, geographer and regional planers work at the regional scale.

(5) Regional policies: A vast number of policy tools and subsidy programs are established for and applied at the regional scale (e.g. EU regulations).

(6) Added values: Among the many added values to be explored on the regional scale, the economic cycle is of particular interest. The energy economy can, under certain circumstances (e.g. minimum size and population), become a closed circuit. In South Limburg for instance, each year, hundreds of millions of Euros are transferred to pay for the import of energy from the North of the Netherlands or abroad.

Energy Transition at the Regional Scale
The above reasons, among others, suggest investigating the opportunities and restraints for a sustainable energy transition on the regional scale. In addition, the three most relevant ecological concepts for the design at regional scale are outlined below.

(I) Hierarchical organization: The concept of hierarchical organization states that every ecosystem, for instance the Heuvelland (hilly landscape) of South Limburg, consists of levels which may be defined by physical or spatial structure, interactions, flowrates or other selected characteristics. Each of these levels is part of a hierarchy. The form of organization in natural ecosystems can be depicted as nested hierarchy, where control is carried out from the higher to the lower level and vice versa. Being aware of the intrinsic complexity of the environment, the concept of nested hierarchy may help to understand energy flow and material cycles at the regional scale.

(II) Concept of the biome: The biome is a large-scale ecosystem based upon living conditions and resource availability. One can identify the biome with the help of natural vegetation and dominant life forms; it subdivides a continent into smaller regions. Due to the increasing human influence onto the environment, the biome, in today's world, represents a rather abstract concept. Hence, investigating the biome and, more specifically, the *potential natural vegetation* comprises a number of benefits. Natural vegetation consists of the plant species best adapted to the local context, such as climatic conditions and resource availability. By designing with indigenous species we can save vast amounts of energy.

Ref.8: Golley, F. O. (1996). Ecological Concepts, with Implications to Environmentalism and Ethics. Athens, GA: Institute of Ecology, University of Georgia.

(III) Concept of landscape: Landscape is the ecological system where most of the direct interactions between humans and their environment can be studied. In the natural hierarchy, the landscape can be ranked somewhere between the biome on the higher level and the ecotope as the next smaller. Numerous studies on energy yield and flow have been conducted at that scale. In order to maximize energy efficiency in human ecosystems, Ryszkowski and Kdziora emphasize, that an optimum landscape patterns must be established.[1]

Ref.1: Ryszkowski, L. and A. Kdziora (1987). "Impact of agricultural landscape structure on energy flow and water cycling." Landscape Ecology 1(2): 85-94.

Note 2: Second generation biomass refers to the collection and re-use of traditional "waste" products in agriculture, forestry or food processing

general references for 'Energy transitions at the regional scale'

Reference: Steiner, F. R. (2000). The living landscape: an ecological approach to landscape planning. New York: McGraw Hill.

Reference: Hough, M. (1990). Out of place: Restoring identity to the regional landscape. New Haven: Yale University Press.

general references for 'Energy and landscape architecture'.

Reference: Robinette, G. O. and C. McClenon, Eds. (1983). Landscape planning for energy conservation. New York: Van Nostrand Reinhold.

Reference: Thompson, J. W. and K. Sorvig (2000). Sustainable landscape construction: A guide to green building outdoors. Washington, D.C.: Island Press.

Energy and Landscape Architecture

Recognizing the emerging challenges related to greenhouse gas emission, global warming and energy insecurity, the interested reader may wonder how this would affect spatial design in general and landscape architects in particular? The answer is twofold: One the one hand, most consequences of the excessive fossil-fuel consumption will affect human living conditions and manifest themselves in the landscape. On the other hand, the work of landscape architects is based on the knowledge of natural processes, human behavior and aesthetic perception; all of them being affected by the changing climate. Exactly here, at the interface between natural science and architectural imagination lies a great potential dealing with one essential challenge of the future.

Traditional measures of landscape design such as the utilization of natural vegetation for shading can significantly reduce energy consumption for room conditioning and therefore help to minimize greenhouse gas emissions. Investigating the sources of greenhouse gas emission, it has been realized that carbon dioxide is also released from peat soils as they are drained for agricultural use. Large scale deforestation represents another human impact upon the landscape and compromises the sequestering of carbon dioxide through photosynthesis. Throughout the last decades, many scientists, architects and designers have begun to understand the many relations between landscape and energy. Based on this knowledge, landscape architects are working closely with other professions engaged with the built and non-built environment. Among the most appreciated partners in the process of energy transition, we like to name ecologists, civil engineers, hydrological engineers, regional planners, geographers, architects, urban designers, sociologists and economists.

Sustainable Energy Landscapes

Two slightly differentiated concepts can be identified in the discussion on energy transition. At first, all kinds of energy based on *renewable resources* found their way into the scientific debate and public discussion. Only with the rising concern on a socially fair, environmentally friendly and economically feasible future, the focus has shifted and included *sustainable energy sources*. This is primarily due to the fact, that some of the renewable technologies, although reducing greenhouse gas emissions, do harm the environment as well as humans. One often-quoted example is the Three Georges Dam; a massive water reservoir in China which's construction has relocated entire cities with millions of inhabitants. Responsible landscape architects should not only try to maximize the mere energy yield, but must also strive to balance the less-positive aspects of renewable energy generation with other needs and requirements such as food production and recreation. This is what is referred to, when we investigate the potential design of *sustainable energy landscapes*. We are convinced that a great amount of energy can be generated by renewable means without compromising other land-uses, biodiversity and the landscape experience. The capacity for sustainable energy production is affected by geographical location, climate as well as geology and therefore limited. This perception is based on ecological understanding and highlights the urgent need for increasing energy efficiency. Sustainable energy landscapes do not only generate and store energy but also improve energy efficiency by advanced technological and ecological means. Material cycling, energy cascading and second generation biomass production[2] present, among other ideas, valuable approaches which will be investigated for their spatial consequences in the environment. Our objectives are (A) to identify and adapt sound theoretical concepts and (B) to specify practical design principles rendering sustainable energy landscapes visible. Designing sustainable energy landscapes is to envisage an environment which yields, stores, recycles and saves energy by means of advanced spatial planning and improved land use practices without compromising other essential land-uses.[3]

Landscape Strategies

Energy savings and renewable energy technologies have been on the agenda for a long time, ranging from broad public attention during the oil crisis in the 1970's to almost no consideration during the economical boom after the end of the cold war in the early 1990's. Today, we are fortunate to be able and access some of the prior scientific studies and examples improving the energy economy of human ecosystems.

In the city of Kalundborg, for example, a highly diversified network between industry, waste treatment and energy providers has evolved over the past 20 years. This successful Danish example is today being referred to as industrial ecology and scientists are learning how to solve similar problems in other parts of the world. Literature and case-studies highlight a number of strategies which can inform designers and planners throughout the design and decision making processes.

These *landscape strategies* are deeply rooted in the understanding of ecological concepts; they represent powerful ideas capable to inspire the designer of human ecosystems.[4] Let us briefly outline some of the essential landscape strategies for a sustainable energy transition:

(1) Let nature do the work
Facilitating natural processes for the assimilation, transformation and storage of energy.[5]

(2) Optimum levels for multiple functions
Integrate food production with other land-uses such as energy assimilation and recreation.[5]

(3) Matching technology to need
Minimizing subsidized technological "overdesign".[5]

(4) Compact form and densification
Minimizing travel while maximizing contact.[6]

(5) Biorhythm
Enabling different cycles of growth and decline.[6]

(6) Localization
Providing unique solutions based on the nature of the place.[6]

(7) Dynamic, open-ended solutions
Developing flexible systems with greater resistance, for instance diversified energy supply.

(8) Mixed-use, time-share
Minimizing material, space and energy use, e.g. closing regional material cycles and horizontal layering.[3]

(9) Selective, differentiated use of energy and resources
Maximizing efficiency and minimizing entropy creation.[3]

(10) Spatio-temporal approach
Matching demand and supply in time and place.[3]

(11) Integrated approach
Respecting existing conditions in the region.[3]

(12) Strategic planning
Implementation through process orientation instead of final master plan.[3]

Ref.3: Stremke, S. and Koh, J. (2006). Sustainable Energy Landscapes - Inventory of Ecological Concepts and Principles with Relevance to the Design of Sustainable Energy Landscapes. In: SREX Report 2006, Groningen: Groningen University.

Note 4: The term landscape strategy refers to the potential of the landscape conserving, harvesting and storing energy.

Ref.5: Lyle, J. T. (1994). Regenerative design for sustainable development. New York: John Wiley.

Ref.6: Koh, J. (2005). The Energetic Strategy of Ecosystem Development and Urban/Regional Spatial Restructuring and Regeneration. Grounds for Change: Bridging Energy Planning and Spatial Design Strategies. F. v. Dam and K. J. Noorman. Groningen: Grounds for Change: 29-37.

Landscape Approach

Developing an integrative and regenerative approach to (landscape) design encompassing both urban and rural areas is one of the research objectives of the landscape architecture program under the chair of Prof. Dr. Jusuck Koh at Wageningen University. It is important to stress, that the focus lies not only on sustainable energy transition ; the new approach also embraces other, essential issues such as the mitigation of global warming, community participation and the maintenance of cultural landscapes. The emerging *landscape approach* is one way of studying the environment; a scientific method. The landscape approach describes the entire landscape as overlapping patches, each with numerous indispensable natural processes. It recognizes the growing impact of mankind on the natural ecosystems and our responsibility to species other than the human. The landscape approach integrates spatial thinking (location) with the knowledge of ecological processes (material cycling and energy flow).[1] The emerging landscape approach as such is based upon the understanding of relationships in our environment. It advances prescriptive ecological concepts towards landscape strategies needed for an implicit energy transition. This paper is part of a greater initiative to expose spatial designers, landscape architects and planers to the many opportunities arising when ecological knowledge meets architectural imagination. Exactly this symbiosis between the understanding of ecological processes and creative spatial thinking forms the basis for the landscape approach rendering solutions for a more sustainable future.

With this booklet, you are invited on a journey to South Limburg in the year 2037. This is the first attempt to render a sustainable future for the entire region of approximately 670 square kilometer. In collaboration with a team of international students, we have identified a number of essential design principles which can inform and guide the designer of sustainable energy landscapes. All strategies have been applied and visualized for the interested public. We hope that our studies can contribute to the active debate on a sustainable future in South Limburg and other regions.

Note 1: The present description of the landscape approach is to be understood as a “working definition”.