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MASTERARBEIT

Planning and Implementing Sustainable Regional Energy Systems

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Abstract

Progressing climate change, growing dependency on the import of scarce resources, and fluctuating energy prices require a fundamental realignment of the energy systems (FVEE 2010, p.3). Only if we manage to restructure our German and European energy system towards a sustainable system can we maintain the quality of life and the welfare for current and future generations (FVEE 2010, p.3). One possible pathway to contribute to the transformation of energy systems is acting at the local level. Several communities in Germany build so-called energy regions with the target to be 100% supplied by renewable resources (100%-EER 2008, p.3). They focus on the sustainable provision of energy from decentralized sources while contributing to the region's economic and social welfare.

It is the intention of this study to contribute to the improvement of the planning and the implementation of sustainable systems in energy regions. For this purpose an instrument is developed, the *Sustainability Balanced Scorecard (SBSC) for Energy Regions*, based on the *Balanced Scorecard (BSC)* by *Kaplan* and *Norton*. Adopted from the originators' target to facilitate the implementation of a corporate strategy, the author of this study makes use of this characteristic to support strategy implementation and local planning processes in energy regions. The enhancement of the instrument to a Sustainability Balanced Scorecard (SBSC) allows considering environmental and social aspects in the strategy implementation (Schaltegger and Dyllick 2002). This second characteristic provides a basis for developing sustainable energy systems.

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List of Abbreviations

100%-EER	100%-Renewable-Energy-Regions
BSC	Balanced Scorecard
CHP	Cogeneration of Heat and Power
DE	Decentralized Energy
deENet	Network for Decentralized Energy Technology
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
Ppm	Parts per million by volume
SBSC	Sustainability Balanced Scorecard
TBL	Triple-Bottom-Line
WADE	World Alliance for Decentralized Energy

1 Introduction

Energy systems in most industrialized countries are facing far-reaching challenges that will evoke significant changes in the way energy is generated and used in the future (FVEE 2010, p.3). The world demand for energy has been growing over the past decades and is expected to continue to rise in the future by 1.6% per year (OECD/IEA 2008, p.38). The world's most vital source of energy, oil, experiences tremendous increases in price, while the global demand is forecasted to increase by 25% by 2030 from the base year 2007 (OECD/IEA 2008, p.38). The fact that finite resources, such as coal, oil and gas, contribute to 85% of the total world primary energy supply may exacerbate the situation (IPCC 2012, p.10). In addition, the national energy supply is exposed to fluctuating and rising prices of oil and gas (UBA 2009, p.5). Simultaneously, the way energy is generated has caused severe adverse environmental impacts, most vivid the increase in concentration of Greenhouse Gas (GHG) in the atmosphere. Climatic change is the consequence of a century of the utilizations of fossil resources (IPCC 2012, p.3). Following the prognosis made by the Intergovernmental Panel on Climate Change (IPCC) there is a 67% chance to keep global average temperature rise below 2 degrees Celsius, if the GHG emission budget of 750 billion tons is not exceeded between today and 2050 (WBGU 2009, p.2).

1.1 Problem Description

These circumstances bring forth the need for a development that comprises the efficient use of resources, changes in the pattern of energy generation and the demand side, as well as the use of alternative resources. In consequence these steps necessitate the creation of new infrastructures. In some countries a transformation to overcome the problems has already begun (BMU 2012). In Germany, a response to the problems, which gained increasing political attention since the beginning of the last decade, can be found under the term *"Energiewende"*, which will be referred to as *"Transformation of Energy Systems"* below (BMU 2011b). In order to facilitate the transformation, enormous reconstruction measures in the current energy systems are required, which challenge actors within the energy sector and other sectors. At the national, regional and local level, energy generators, transmission providers, technology innovators, end users and new industries are involved in this process (FVEE 2010a, pp.23-32). Experts argue that a successful transformation that overcomes today's and tomorrow's challenges requires a development that follows the principles of sustainability (WBGU 2003, p.2).

The conventional energy infrastructure is dominated by centralized large-scale facilities and is based on the use of fossil fuels (WADE 2007). Future scenarios, in contrast, often depict decentralized energy (DE) on small scale and the application of renewable energies (FVEE 2010a, Leprich 2011, IPCC 2012). Experts state that DE will be the key in any plan to build sustainable energy systems (WADE 2007, p.1). The latest report of the IPCC declares that the use of renewable resources will play a central role in the future when pursuing sustainable development (IPCC 2012). It is expected that a significant contribution to the transformation of the energy systems originate from local level due to increasingly decentralized structures (Ethik-Kommission Sichere Energieversorgung 2011, p.27). The *100%-Renewable-Energy-Regions*[1] *(100%-EER)* project was initiated with the target to build energy regions and to promote a transformation of the energy system at the local level (100%-EER 2010, p.3). It can be regarded as a potential path to cope with current problems. The project group declares that for a successful energy transformation profound and operational *Energy Concepts* are required (100%-EER 2010a, p.2). Even though existing concepts are not standardized as of yet, it is recognized as the most common instrument for regions to promote sustainable energy systems (100%-EER 2010a, p. 9 and p.26). Nevertheless, energy concepts provide a broad framework only, but not a detailed planning instrument. The actual implementation of projects occurs locally by regional actors (Moser, Kucharczek and Hoppenbrock, in: Droege, P. (ed.) 2009). So far, only a few types of planning instruments have been applied to support the implementation process of sustainable energy systems within energy regions (see Ch. 2.2.5).

[1] "100%-Erneuerbare-Energie-Regionen"- Projekt (www.100-ee.de)

1.2 Target of the Study

In the following, the focus is on the planning and the implementation process of sustainable energy systems that imply the integration of renewable energies and the creation of value chains within regions. For this purpose a planning instrument will be developed, which provides a normative orientation, contains influencing variables, and supports the planning and the implementation of regional energy systems. The objectives are:

- Facilitating sustainable generation and use of energy
- Enabling the user of the instrument to define and pursue targets typical for energy regions
- Providing a common concept for project planning and for stakeholder coordination

In consequence, an appropriable instrument can be defined as one that supports the accomplishment of these objectives. It integrates social, ecological and economical aspects equally in the development of energy systems (see also the *Triple-Bottom-Line* model in Chapter 2.2.4). It also leads the way ahead and supports the regional planning processes.

A strategic planning instrument that incorporates sustainability aspects into the implementation process is the Sustainability Balanced Scorecard (SBSC). It expands upon the Balanced Scorecard (BSC), developed for organizations, to support the successful implementation of corporate strategies and accomplishment targets. The BSC is not intended to be used to develop strategies and targets, but rather supports the implementation of an existing strategy by bridging the gap between strategic and operative planning (Kaplan and Norton 1997, p. 37, Kaplan and Norton 2001, p. 104). It provides support when managing and aligning activities according to their strategic relevance. It enables the equal ("balanced") consideration of non-monetary and soft success factors that both significantly impact the economic success (Figge, et al. 2001, p.14). This characteristic of the instrument allows the incorporation of sustainability aspects into the strategic orientation (Figge, et al. 2001, p.18, Schaltegger and Dyllick 2002, p.2). Despite the fact that the BSC is a management instrument for organizations, the basic concept of implementing strategies may be applicable to other situations, such as the development of sustainable energy systems within an energy region. *Kaplan* and *Norton* point out the possibility to adjust the instrument's structure to the specific needs of a business unit (Kaplan and Norton 1997, p.33). Two major targets are pursued in the development phase of the instrument; first, providing support for the implementation of the overall strategic target to supply a region with 100% renewable energy, and second, integrating relevant environmental and social aspects. For the purpose of planning and implementing sustainable regional energy systems, the following question will be discussed in this study:

How can the instrument, Sustainability Balanced Scorecard for Energy Regions, be structured to successfully support the planning and the implementation of regional energy systems, while effectively integrating sustainability?

1.3 Structure of the Thesis

The overall target of the study is to develop an instrument to support the planning and the implementation of sustainable regional energy systems. Consecutive to this introduction a framework is provided on the challenges in the energy sector and political response measures in Germany. A literature review addresses transformation processes for national, regional, and local energy systems. As a main component of the second chapter the relevance of current and potential supporting instruments will be reviewed.

In chapter 3, aspects of sustainable energy are studied and characteristics of energy systems at the regional level are analyzed. In this context the interrelation of regional energy systems and community development is highlighted. This third chapter focuses on analyzing the results derived from the survey related to the 100%-EER project. Chapter 4 derives the development steps of the instrument, from defining the strategic target and economic success to integrating sustainability aspects and influencing variables in the SBSC. Chapter 5 discusses the outcome from chapter 4 and the results from the previous chapters before providing an outlook on the future development.

2 Methodology and Literature Overview

Chapter 2 summarizes the problems energy systems are currently facing. An overview is also given on political responses and strategies that are debated or implemented. Furthermore, policies and technological approaches are presented.

2.1 Methodology

The first part of this paper outlines the issues countries deal with in regard to their energy systems. In order to frame this thesis, and help develop the instrument described in chapter 4, multiple secondary sources were consulted in different areas of the literature in the energy sector, which are highlighted below.

International and national institutions and associations publish the main secondary research regarding the challenges in the energy sector. Meanwhile, information that depicts the political framework on the development and the transformation of energy systems in Germany originates primarily from federal and European sources, and national political councils and commissions. The relevant sources used within this study are provided in the table below.

International Institutions	International Energy Agency (IEA) Intergovernmental Panel on Climate Change (IPCC) Organisation for Economic Co-operation and Development (OECD)
National Institutions	Federal Environment Agency[2] (UBA)
Energy Associations	World Alliance for Decentralized Energy (WADE) Renewable Energy Research Association[3] (FVEE)
Federal	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety[4] (BMU) Federal Ministry of Transport, Building and Urban

[2] Umweltbundesamt (UBA)
[3] Forschungsverbund Erneuerbare Energien (FVEE)

	Development[5] (BVBS)
National Political Advisory	German Advisory Council on Global Change[6] (WBGU) Enquete Council Ethic Commission
European Union	European Commission

Table 1 - Primary Sources (Author's own illustration)

Additionally, the majority of the literature that is published on future developments and potential pathways in the German energy sectors was obtained from the German Renewable Energy Association (FVEE), which comprises research results from various recognized German research institutes.

In regard to the implementation of renewable energy and the actions on regional level data was obtained from the project *100%-Renewable-Energy-Regions (100%-EER)* project, coordinated by the Network for Decentralized Energy Technology (deENet) and funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The project facilitates municipalities to pursue their community targets to achieve a 100% energy supply from renewable energies. The project also obtains technical support from the Federal Environmental Agency (UBA). The 129 participating regions cover a population of 18.9 million and an area of 102,608 square kilometers. A survey conducted by the project group in 2009, provides empirical data on participating energy regions. Questionnaires completed by 54 energy regions were evaluated and provide information on regions' targets, actions, and estimations, resulting in an inventory as a basis for further research. Project related research and results from the questionnaire are integrated into the instrument that is developed within this study.

The findings gathered from the literature review help to draw a framework, highlight the key technological aspects in the transformation process, and provide insights into potential future development steps. Information from chapter 3 are integrated in the

[4] Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)
[5] Bundesministerium für Verkehr, Bau und Stadtentwicklung (BVBS)
[6] Wissenschaftliche Beirat der Bundesregierung Globale Umweltveränderungen (WBGU)

instrument. For the purposes of integrating the concept of sustainability into the instrument, the principle economic, environmental and social aspects related to energy are derived from the first report of the Enquete Commission on *Sustainable Energy Supply under Globalization and Liberalization Conditions* from 2001 (Enquete-Kommission 2002). Following the description of sustainability aspects, the characteristics of regional energy systems are addressed. Subsequently, the chapter outlines the linkages between energy and sustainable community development. It outlines economic stimuli within regions and conflicts between energy targets, regional interests groups, and local environmental stewardship. Results from this chapter directly contribute to the content of the instrument developed in chapter 4.

2.2 Literature Overview

The structure of energy systems of most industrialized countries requires fundamental change to overcome current problems. In a business-as-usual approach, the trends in energy are unsustainable in relation to environment, energy security and economic development objectives (OECD 2012, p.20). Low-carbon energy systems apply more diverse energy sources, are more complex and integrated, and rely on distributed generation. Different technologies that are deployed together and interact, decrease system costs, increase the efficiency, and result in a broader range of applied technologies and fuels (OECD/IEA 2012). In the future, low-carbon electricity will be the core of sustainable systems, and consumers of energy will function as energy generators (OECD/IEA 2012, p.3). Some countries have started to build frameworks that trigger a shift towards more sustainable energy. The main German energy targets are to promote a development towards the utilization of renewable resources and to increase energy efficiency (BMU 2011b). The latest report by the *IPCC* has shown that it is possible to generate 77% of the worldwide energy from regenerative resources by 2050 (IPCC 2012, p.131). To prevent a global average temperature rise above 2 degrees Celsius, it is required that energy related emissions do not surpass 750 million gigatons carbon dioxide equivalent by 2050 (WBGU 2009).

In the following sections strategies and corresponding technical solutions for a transformation of energy systems will be reviewed. It can be noted that the German situation is to some extent representative for industrialized countries with similar infrastructure characteristics and that pursue similar targets. The German situation will be the focus of the study and will be used exemplarily when analyzing the structure of energy systems.

2.2.1 Energy Systems in Industrialized Countries

Before the industrialization period, energy systems mainly consisted of local energies from renewable resources. Through the increasing use of heat energy in steam engines at first and later other combustion engines, the utilization of fossil resource gained increasing importance (Steger, et al. 2002). Additionally, the invention of electricity allowed for the generation of energy from various primary energy sources and the simple transportation over long distances, contributing to this development (Steger, et al. 2002).

Nowadays, energy systems of industrialized countries are often characterized by the use of diverse energy carriers. Besides some exceptions, systems are usually reliant on fossil resources as a main source. In Germany, imported oil is the primary energy source with almost 33% (UBA 2011b). Domestic and imported natural gas provide 22% of the primary energy supply. Coal and lignite contribute 23% and originate from domestic as well as foreign reserves (UBA 2011b). Nuclear resources contribute to 11% of the total and are solely from foreign sources (UBA 2011b). In contrast to most other industrialized countries, which plan on the expansion of nuclear energy, the use of nuclear resources will disappear in the German power energy park beyond 2022 due to recent political resolutions (BMU 2012a, OECD/IEA 2008, p.39). The remaining energy is provided from renewable resources, encouraged through financial incentives, which promote the expansion of those alternative technologies (BMU 2011a).

Oil is primarily used after processing it as heating fuel and for the transportation sector (UBA 2011c). Electric energy is typically generated in large facilities from coal and nuclear and often transported over long distances into the distribution network (WADE 2007, p.4). The major disadvantage is the energy losses during the power generation, resulting in an efficiency rate of only 43% in Germany (UBA 2011). Furthermore, electric energy is imported from neighbor countries (UBA 2011, p.4). The use of natural gas allows the installation of cogeneration of heat and power (CHP) plants that are growing in number and can also be used in decentralized units with the advantage to provide heat energy and power (WADE 2007).

The three sectors, industry (27%), private (29%) and transportation (30%) consume almost equal amounts of the final energy (UBA 2011c). The rest (16%) is used by other sectors (trade, commercial and service industry (UBA 2011c).

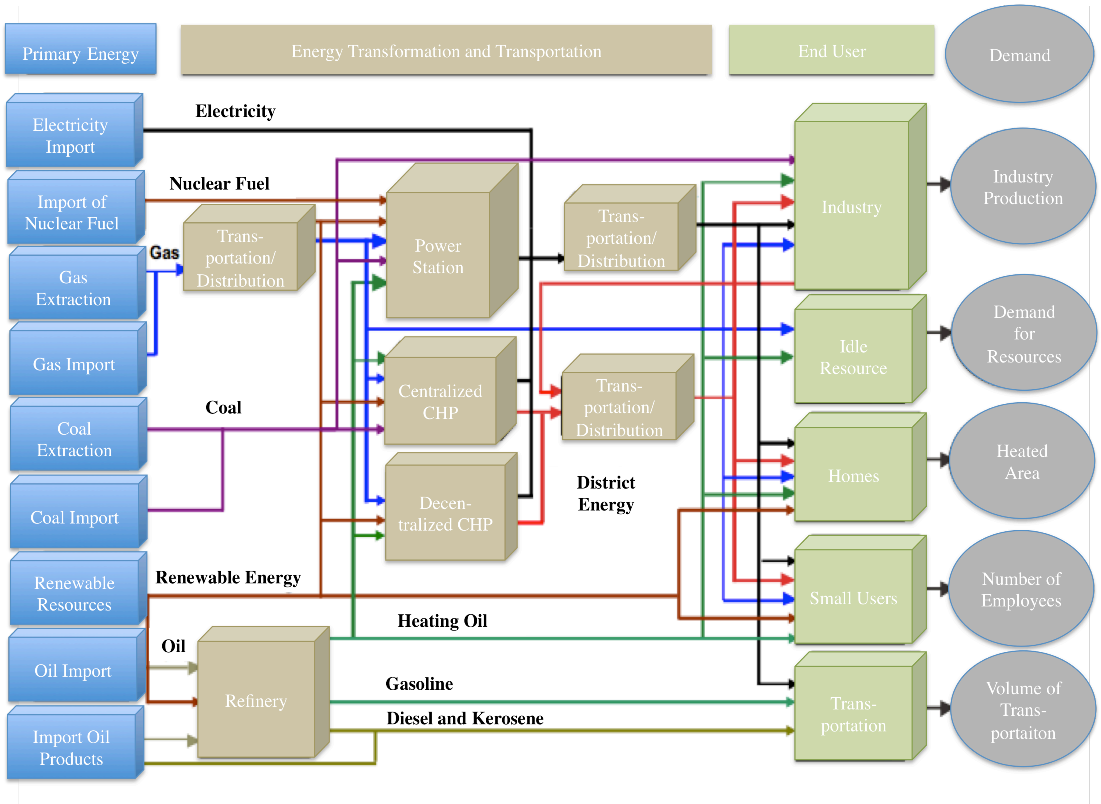

Figure 1 - Basic Structure of an Energy System (J.-F. Hake 2012)

On a larger scale, the use of primary energy in member countries of the Organisation for Economic Co-operation and Development (OECD) in Western Europe is projected to increase. A growth rate of approximately 1% per year is estimated in most OECD member countries (WBGU 2003, p.19). With the exception being the United States of America (USA), it is estimated that the proportion of coal and nuclear will continuously decrease, while the rate of gas is projected to rise by 3% per year (WBGU 2003, p.19).

Accompanied with the increasing use of renewable resources and the step back from nuclear energy, the structure of electric power conversion is about to significantly change, particularly in Germany. Increasingly, electric energy is fed into the grid from decentralized sources, such as photovoltaic panels on roofs of private homes or from large wind and solar parks (Hake, System Analysis 2012). The new challenges to the grid require adjustments and large investments into the renewal and expansion of the national grid (FVEE 2010a, p.63).

Designing future energy systems goes beyond energy generation, transportation, and its distribution to the different end users. In regard to the electric energy supply the term increasingly encompasses smart grid technologies applying digital advanced information technologies to monitor and manage the use of electricity (FVEE 2010a, p.63). The effects are reduced impacts on the environment and minimized costs, while increasing the stability of the grid and managing the availability of energy. The intention is to build up an infrastructure that allows all stakeholders of a grid to operate efficiently (IEA 2011, p.6). Furthermore, through the increasing use of renewable energies with fluctuating availability, storage becomes an essential component of energy systems (FVEE 2010a, pp.63-64).

For the following parts of this study the term *Energy System* refers to the aspects of provision energy services from fossil and renewable resources. It also comprises the design of transportation and distribution infrastructures. Furthermore, energy systems include the installation of smart grid technologies and storage capabilities, as well as end user applications.

2.2.2 Challenges and Political Agendas

Industrialized countries typically have to cope with a wide range of issues in regard to their energy systems. Conventional systems are facing increasing resource prices, instable supply, and are for the most part contradictory with sustainable development (see Ch. 3.1). Thus, they require a reorientation towards sustainable systems in the coming decades to maintain our quality of life and wealth (FVEE 2010, p.3). Originating from the *Brundtland Comission Sustainable Development* is defined as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987, p.43). Most energy systems in developed and developing countries are far from this defined state (Müller, et al. 2011, pp.5800-5810).

2.2.2.1 Increasing Prices Level and Security in Supply

The world total final energy demand has been growing since 1973 by almost 80% (OECD/IEA 2011, p.28). And although the energy efficiency experienced extreme increases, the primary energy consumption is still predicted to grow by 1.2 % per year on average until 2035 (OECD/IEA 2010, p.1). This projected increase is primarily driven by the economic growth of China and India. They account for almost 50% of the growth in world energy demand in the time between 2006 and 2030 (OECD/IEA 2008, p.38). In contrast, the energy demand in OECD countries rises rather slowly. Within this group, the European countries account for almost 35%, with Germany being the biggest consumer with almost 20% (Eurostat 2011).

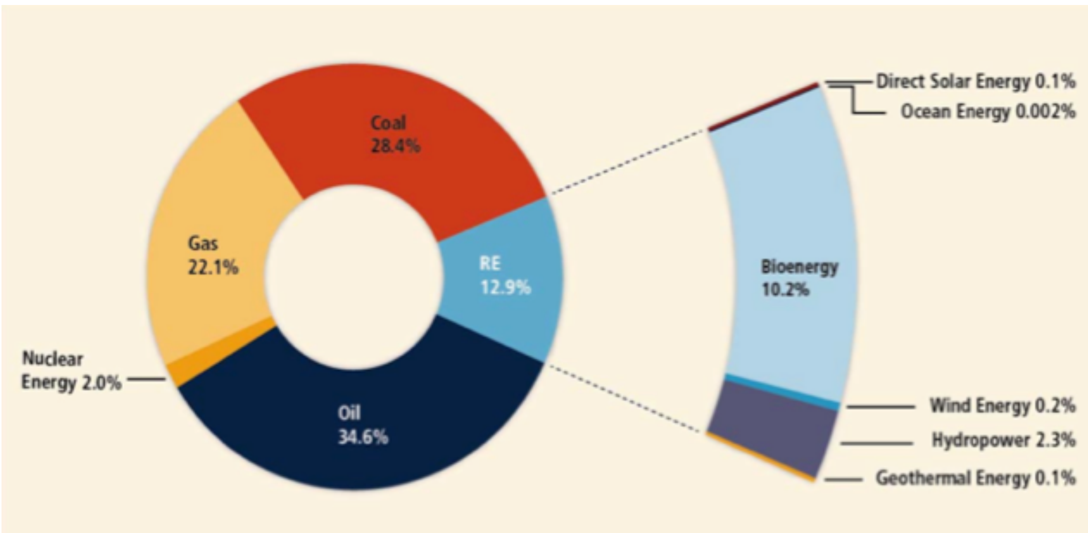

Figure 2 - Share of energy sources in total global primary energy supply in 2008 (IPCC 2012, p.10)

Our current global energy system is dominated by fossil resources, and on a global scale, gas contributes 22%, coal 28%, and oil 35%, to the primary energy supply (IPCC 2012, p.6). Due to the fact that 85% of the primary energy is provided by fossil resources the growth in demand is leading to an increase in energy prices (IPCC 2012, p.10). In particular the price for oil, which is the most prevailing resource, is driven by the increasing world demand on one side, as well as the more costly exploration of the resource on the other side (UBA 2011a). As a consequence of the development of the price level, the interest for alternative resources has been brought forward. The price fluctuation is furthermore affected by the instability of oil and gas imports. The unsteady oil imports associated with price fluctuations, indicate the possible instability in the national energy supply (UMB 2011d, UMB 2011d). Germany will be fully reliant on oil imports beyond 2020 (UBA 2012). This potential threat pushes towards the use of domestic sources.

2.2.2.2 Environmental Degradation and Climate Change

Simultaneously, the way resources were used to deliver energy has caused severe adverse effects on ecosystems. Today's problems result primarily from the high intensity of resource use and a regeneration and adaptation rate of the ecosystem that cannot cope with the increasing impact from anthropogenic activities (Enquete-Kommission 2002, p.15). A global challenge is the GHG concentration in the atmosphere that has reached a level of 390 ppm in 2010, increasing by 1.9 ppm per year on average (IPCC 2012, p.7, IPCC 2007, p.2). In Germany, 80% of the national GHG emissions are related to the generation and use of energy (UBA 2009, p.3). Electric energy is generated by more than 50% from fossil resources and produces 40% of the national GHG emissions alone (UBA 2009, p.3).

The availability of energy and thereby the provision of energy services is the basis for the welfare of a society (Enquete-Kommission 2002, p.37, IPCC 2012, p.2). However, conventional energy systems have been reliant on finite resources since the industrialization period, and are currently exposed to fluctuating energy prices, increasing dependency on imports, and progressing climate change (FVEE 2010, p.3, IPCC 2012, p.10). These circumstances urge for a complete redesign of current systems to maintain the quality of life and welfare of current and future generations (FVEE 2010, p.3).

2.2.2.3 Political Agendas

In 1980, the *Oeko-Institute* used the term *Transformation of Energy Systems* for the first time to target a transformation of energy systems implying a step back from the use of nuclear energy and oil (Krause, Bossel and Müller-Reußmann 1980). In Germany, the development has been further defined substantially during a symposium hosted by the *Federal Ministry of the Environment, Nature Conversation and Nuclear Safety (BMU)* in 2002 (Braun-Wanke, et al. 2002). Since then, the process has gained momentum through numerous political programs and model projects. *Müller et al.* suggest viewing the transformation not just as technical approaches, but "as one process within larger societal transformations, which can either promote or constrain the transformation process of the energy subsystem according to rationales external to the energy subsystem" (Müller, et al. 2011, p.5800). *Müller et al.* argue that in this context and in regard to the different components of systems it is more suitable to refer to it as energy subsystems rather than energy systems (Müller, et al. 2011, p.5800). Nevertheless, in the following it will not be distinguished between subsystem and system, as an energy region operates a local system that consists of numerous subsystems within the region, while being a subsystem of the national system itself. For the purpose of this study we refer to *Regional Energy Systems* as systems, where one or more connected or independent systems at the regional level exist and consist of several municipal and local system units.

In 2003, a study was published by the *German Advisory Council for Global Change (WBGU)*, which identified difficulties in the structure of the energy systems worldwide. Distinguishing between developing countries, countries in transition and industrialized countries, the cornerstones for sustainable energy systems in each case were outlined (WBGU 2003). However, not all industrialized countries created a framework for the implementation of renewable energy, energy efficiency or energy reduction measures. Depending on the national situation or political acceptance varying plans on the development of the national energy systems exist (WBGU 2003). Some countries favor the application of emission reduction technology, such as for example Carbon Capture and Storage (CCS) technology, to enable further combustion of fossil fuels (IEA/OECD 2011, IPCC 2012, p.2). Others may be reliant on nuclear energy as a primary energy source that allows less adverse climate effects (IPCC 2012, p.2). Nevertheless, industrialized countries are facing similar problems, thus, in one form or the other political agendas may contain the same targets. The German government developed an energy concept that targets an energy supply with the following three overall objectives (BMWi, BMU 2010):

- Stability in Energy Supply
- Profitability
- Environmental Sustainability

With the intention to overcome these problems, the plan to expand the use of renewable resources has been brought forward on an international platform and to some extent it has been implemented on national levels (IPCC 2012, p.9). Nonetheless, alternative energies are in some cases still more costly, often causing a lagging development of these technologies. Therefore the economical competitiveness of renewable energy sources under the current circumstances and state of technological development usually obtains financial support (BMU 2011, p.35, IPCC 2012, p.9). In the past few years, the development has been facilitated through incentive programs and has initiated numerous innovative model projects on local as well as on international level. In Germany, political programs have been created, such as the *Feed-In-Tariffs (FIT)*, the *Incentive Program for Heat Energy*, and the *Market Incentive Program* (UBA 2012). They provide the basis for an economically competitive use of renewable energy and energy saving technology. Thereby, the targets are pursued to reduce GHG emissions by 40% by 2020 comparing to 1990’s level and to achieve a share of renewable energies of 18% of the gross final energy consumption (BMWi, BMU 2010, p.5).

2.2.3 Potential Pathways and Influencing Variables

Energy targets provide the basis and direction for the future development. A recognized long-term strategy targets the expansion of renewable energies and improvements in energy efficiency in order to replace conventional energies and satisfy the energy demand in 2050 (FVEE 2010a, pp.23-27).

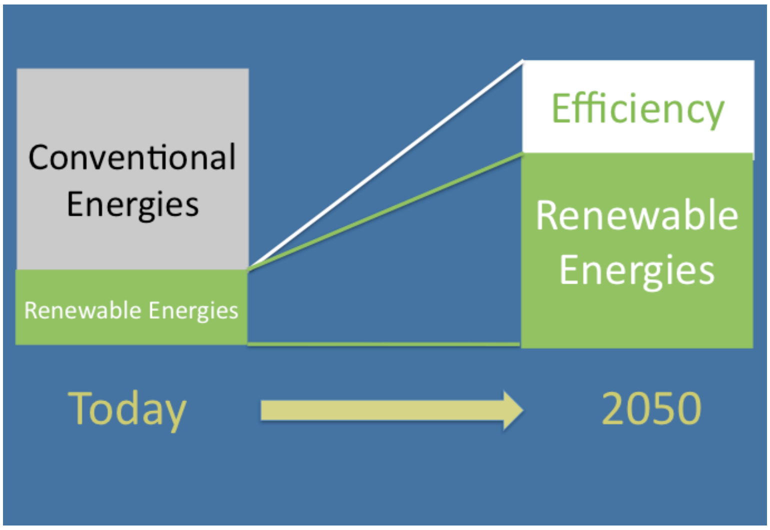

Figure 3 - Pathway towards Sustainable Energy System (FVEE 2011, p. 1)

However the pathway of a transformation is not fully predefined yet due to a number of variables. The progressive integration of renewable energies brings with it the need for system modifications and in parts governs the development. Due to the nature of renewable energies, its extensive use requires structural changes, which concern the design of the energy grid and the pattern of energy provision and utilization (FVEE 2010, FVEE 2011).

It is expected that a significant contribution to sustainable infrastructures can be expected from community level (Ethik-Kommission Sichere Energieversorgung 2011, pp.27-28). In the context of a transformation the actions on regional level play an important role and local actors may take centre stage (FVEE 2010, p.88, FVEE 2010a, p.34).

2.2.3.1 Decentralization, Domestic Resources and Fluctuating Energy Supply

It was illustrated above that political dissents and different plans exist regarding the design of future energy systems. This may emerge from varying system designs. For example, different scenarios were outlined on the design of electricity supply systems. Here, political claims often differ from the economical and technological conceptions (UBA 2009, p.10). Some political plans pursue possibilities that allow the reduction of environmental effects, while widely maintaining conventional structures (IPCC 2012, p.7). To operate in centralized systems with large-scale facilities the development often implies the use of less carbon intensive resources, such as gas, and emission reduction technology. CCS for example absorbs carbon dioxide from fossil fuel combustion and thereby allows a carbon neutral energy generation (IEA/OECD 2011). As it was illustrated above, renewable energies are the key in the future, and sustainable energy systems require measures that go beyond those adaptation measures to reduce the environmental impacts only (Enquete-Kommission 2002).

A wide range of concepts exists on how to implement renewable energies. International projects, such as the DESEERTEC project, promote the generation of electricity from renewable resources far away from the location of use (DESERTEC Foundation 2011). The project idea implies that northern African countries supply local regions and European countries with electric energy. Similarly, cross-border projects that are in planning and in parts already existing are large-scale energy parks in Europe prevailingly based on wind and solar energy, which transport electricity over long distances to the consumer (DIE ZEIT 2010). A simultaneous development is the expansion of decentralized systems, relying on small-scale facilities and generating energy close to the location of its consumption. Those plans reach from private homeowners that feed energy into the grid to regional projects, coordinated by local actors and one or more municipalities (100%-EER 2010).

Decentralization processes concern heat energy, electric energy, as well as the transportation sector with the focus being on the electric energy sector, as it is heavily centralized due to the ability to transport electric energy over long distances (Steger, et al. 2002). However, it should be noted here, that the categorization into heat energy, electricity and fuels becomes loses its importance. Different energy forms increasingly pass conversion processes in future systems due to new forms of storage and transportation (FVEE 2010a). Energy will be provided in any suitable or technologically possible form. New opportunities in energy storage are the reason for converting electricity to other carriers of energy (FVEE 2010a). With the intention to build decentralized structures for electric energy, different plans are being pursued for regional level power grid designs. Actors of the 100%-EER project do not pursue the target to achieve energy autonomy and to be independent, they rather intend to feed into the national grid, collaborate with neighboring regions, and consume energy when needed (100%-EER 2008a). One decisive factor in this regard may be the implementation of smart grid technology. Diverse net technologies of different scopes and characteristics are currently tested. They may be decisive when applied on a broader scale (IEA - Energy Technolgy Network 2007). Not all of them are fully developed yet, but some are already incorporated into existing development concepts (FVEE 2010a, IEA - Energy Technolgy Network 2007).

Certain factors may influence the realization of the transformation of energy systems; hence, the exact pathway is not foreseeable. However, key trends can be observed. In the case of electric energy systems, which are based on the expansion of renewable energies, the following three trends are noticeable (see Figure 4).

First of all, a transformation from centralized to decentralized structures is expected (IEA/OECD 2003, Sachverständigenrat für Umweltfragen 2010). Primarily, the implementation of renewable energies is associated with a decentralization process to a far extent due to the relatively low resource density in contrast to the availability of fossil resources (100%-EER 2010, p.2). Decentralized energy is generally defined as generating energy at the point of use (WADE 2007, p.7). In contrast to conventional energy infrastructures that are primarily dominated by centralized large-scale sites, decentralized systems enable local investments and revenues, assure stability in energy supply, and facilitate independency from foreign resources (WADE 2007, p.1). With decreasing costs of the system components, the rate of decentralization will continue to progress (FVEE 2010a, p.34). However, for a successful transformation an appropriate balance between decentralized and centralized energy has to be found (FVEE 2010a). A major criticism is that single local measures are often not sustainable when looking at the bigger picture. Individual projects that are not integrated into the regional system, miss the chance to make a contribution to the region or feed into the supra-regional grid (Niederle 2008). It was stated before that *WADE* argues that in almost every sustainable energy concept decentralized systems play a key role (WADE 2007). Yet, in contrast to other opponents of decentralized energy, *WADE* relies to a far extent on efficiency gains through structural changes using non-renewable resources (WADE 2007).

A second key characteristic, resulting from the utilization of renewable energies, is the fluctuating electricity supply that conflicts with the structure of conventional large-scale plants (Institut für ZukunftsEnergieSysteme 2011). They are base load energy providers, aiming at full load operation to achieve economic efficiency, and lack flexibility to effectively integrate renewable energies. Wind and solar energy, as the major renewable energies, require adaptable technologies and energy storages to manage excess supply and peak loads (Institut für ZukunftsEnergieSysteme 2011, FVEE 2010a, FVEE 2011). The fact that the conventional systems are in part not compatible with the use of renewable energies, suggests the inability of achieving effective market integration (Leprich 2011). Critics rather support a market transformation that puts renewable energies first, leading to economical inefficiency of the conventional energies (Leprich 2011).

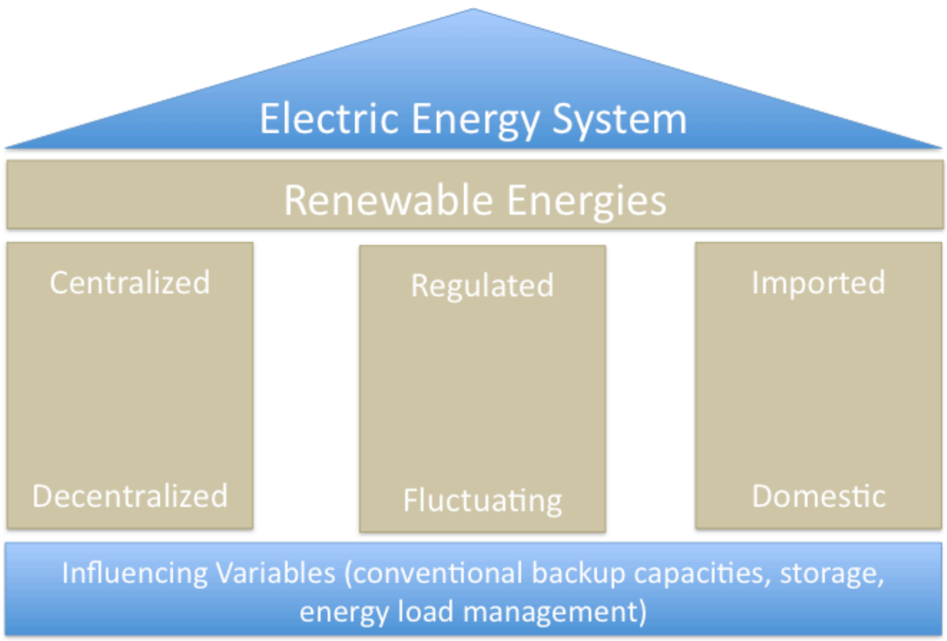

Figure 4 - Future Electric Energy Systems (Leprich 2011)

The third trend that can be noted is a result of the first two. The target to provide energy primarily from renewable energies is usually associated with a decentralization process and the increasing use of domestic resources. In contrast to conventional systems, dependency on imports and world market prices are avoided. Nonetheless, in regard to the available potential the geographic scope is decisive. Although the energetic potential of some regions may be sufficient to sustain themselves, from a national perspective, the energetic potential varies between regions (FVEE 2010a, p.17). Furthermore it should be distinguished between energetic potential, and the technological, and sustainable potential (see Figure 6). Some regions provide insufficient resources, which require compensation from neighboring regions or energy imports. This condition brings forth the need for technologies to manage supply and demand. However, importing renewable resources is not excluded, as it is current practice in the case of biofuels (UMB 2011d).

2.2.3.2 Regional Energy

The potential path for a transformation of energy systems that was outlined above is characterized by a change from a centralized to decentralized structure, the use of domestic resources, and a fluctuating energy supply. These conditions furthermore demonstrate the relevance of actions at the regional level. Most decisions regarding city development, planning of new sites, and networks are made at the municipal level (Enquete-Kommission 2002). Thus, it is expected that communities can initiate various processes that are grounded on the implementation of decentralized energy systems. As defined in the previous section, energy systems within a region can be seen as subsystems of the national energy system. They comprise different spatial levels and actor groups and concern electric energy installations and grids, heat energy systems but also the field of mobility (see Ch. 3.2.1.1). The scope of an energy region is mostly defined by its actors' spatial area of action, geographic constraints, administrative territory or socio-economic factors and involve one or more municipalities (see chapter 3.3).

The 100%-EER project is intended to promote the implementation of renewable energies and facilitate a transformation of energy systems at the regional level. Thereby, energy regions can contribute to the national targets. Their proponents believe that, only if the regional potentials of renewable resources are widely exploited and efficiency potentials are considered, can the national targets for the extensive use of renewable energies and the reduction of energy consumption be achieved (100%-EER 2012a, 100%-EER 2008). It therefore is worthwhile to study energy regions more in-depth in order to better understand the obstacles as well as the success factors related to the planning and the implementation of sustainable regional energy systems.

2.2.4 Criteria for a Successful Transformation

In the previous section, current issues of conventional energy systems and responses were described. It could be outlined that the term *Transformation of Energy Systems* implies ambitions to address these problems and to integrate the concept of sustainability. In consequence, the transformation of energy systems can be considered to be successful, if national energy targets are accomplished while contributing to sustainable development (Enquete-Kommission 2002). In order to ensure a successful transformation, certain criteria have to be defined. They build the basis for the planning steps when implementing regional energy systems, but also to evaluate the outcome overall.

Different political targets are pursued, such as stability in supply, profitability, and environmentally sustainability (BMWi, BMU 2010). Meanwhile, it is controversial, if some targets are of priority or not. The *German Federal Environment Agency* states that the carrying capacity of the ecological system is a limiting factor determining the development of an energy system (UBA 2009, p.11). Hence, the ecological sustainability is a fundamental determinant when developing a concept. Within this framework other optimizations, focusing on the profitability and security in supply, can be made (UBA 2009, p.11). Similarly, the concept of sustainability can be represented in a way where the economy is a function of the human society, and the society is constrained by environmental limits (Porritt 2007). A common approach, often utilized in practice is the *Triple-Bottom-Line* (TBL) model that implies the equally integration of the social, the ecological, and the economical dimension (Hauff und Kleine 2009).

From the three dimensions of sustainability the following basic requirements for an energy system can be derived (Eichelbrönner and Henssen 1998):

- Environmental sound, climate neutral, and prevention of human health risks
- Social justice
- Low rate of risks and malfunctions
- Resource-conserving
- Consumer orientated and enduring stability in supply
- Economical feasibility taking into account external costs
- Accessibility and fair distribution
- International cooperation

They create the limitations to an energy system and thereby build a basic framework for sustainable development. In terms of visualizing sustainable development in a model, these requirements frame the scope of the sustainable and exclude the non-sustainable area (see Figure 5). If a system is not in the sustainable area, certain measures are required to bring it into the sustainable area. Through these measures, the direction of the development can be aligned to the area above the borderline and to sustainable development.

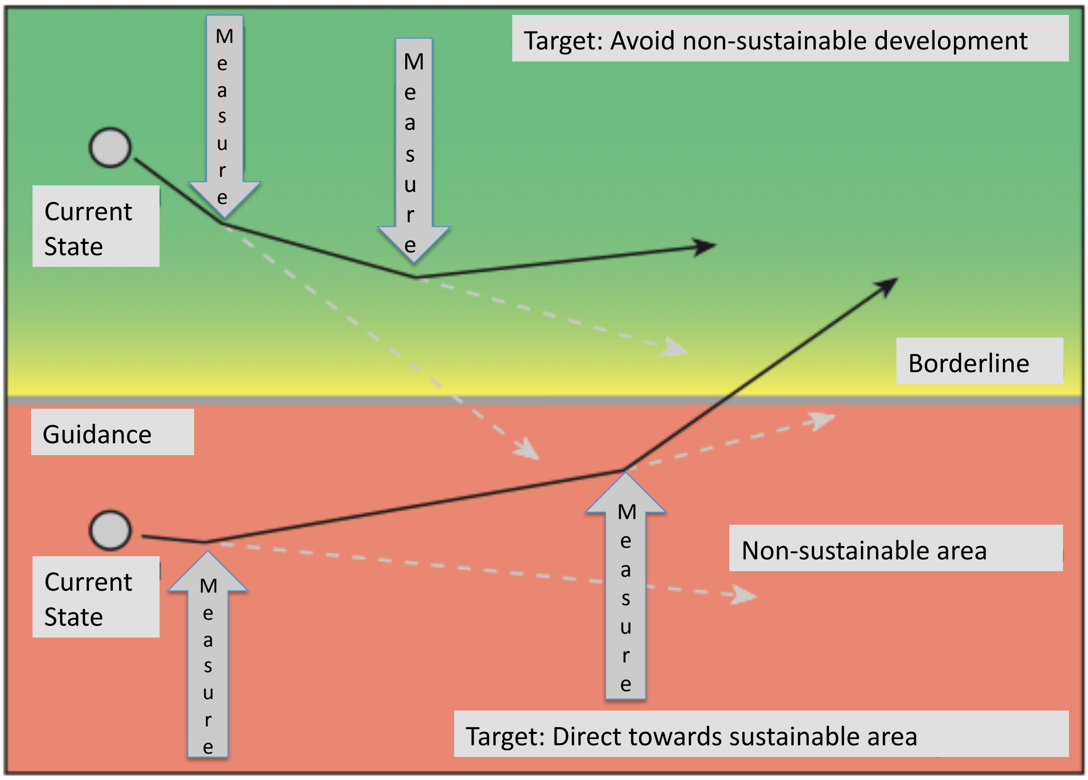

Figure 5 - Sustainable Transformation of Energy Systems (WBGU 2003, p.104)

The question arises here, which are the suitable measures to achieve the desired result. Besides providing a framework to guide the development, implementation mechanisms are needed.

2.2.5 Support Mechanisms

In the previous chapters criteria for a successful transformation were outlined and a potential pathway was portrayed. The literature indicates that actions at the regional level play an important role and are a potential way to promote sustainable energy systems. Recognizing this fact and considering the 100%-EER project as one master plan for the transformation of energy systems, the need for mechanisms, which facilitate the desired development, appears to be vital.

2.2.5.1 Policy Instruments

Numerous policies exist, facilitating the development of sustainable energy systems by providing incentives or setting restraints. For the implementation of sustainable energies, various financial instruments are in the works or already in practice, such as feed-in-tariffs, tradable certificates, environmental taxes (IPCC 2012, p.869). However, besides the purpose of this type of instruments, it is important to provide concrete support in regards to structuring and planning project. A potential instrument for the development of regional energy systems provides guidance to regional planners and includes information on essential variables.

2.2.5.2 Energy Concepts

Actors of the 100%-EER project argue that for a successful transformation profound and operational energy concepts are required (100%-EER 2010a, p.2). The term *Energy Concept* is used for multiple purposes, such as municipal planning, economic analysis and studies regarding the potential of energy (100%-EER 2010a, p.2). In principle, concepts are intended to support the accomplishment of energy targets and set the limitations for energy systems. They can be defined as a plan to pursue overall strategic targets and usually do not comprise detailed targets, measures and resource planning (100%-EER 2010a, p.3). Ideally, they cover the provision and the utilization of all energy forms (100%-EER 2010a, p.3). Thereby, they build the basis to develop a municipal or regional energy system and provide principal recommendations for action (100%-EER 2010a). Energy concepts are mostly applied in practice at the regional level, often in combination with guidelines.

In 2010, a study was conducted by the 100%-EER project group, which analyzed current energy concepts. The results showed that the structure of concepts constitutes three basic parts (100%-EER 2010a). In a first part, the local situation is typically analyzed and potentials are explored. This includes for example concrete information on the region’s energy consumption, GHG emissions, and its local potential for renewable energies. A second normative part contains a vision, targets, and in some cases potential scenarios. The third part includes strategies that point out fields of action and often consists of a catalogue of possible measures.

The study has shown, that on national level, the development of energy concepts is common practice and one of the most comprehensive instruments to pursue national targets (100%-EER 2010a, p.26). For regions in particular, the need to use a concept has been recognized, even though existing concepts are not standardized yet (100%-EER 2010a, p.26). It could be observed, that since the establishment of the *National Climate Initiative* in 2007, numerous concepts at the regional level have been designed. In order to achieve climate targets and to implement renewable energies in particular, energy concepts represent the prevailing instrument for regions (100%-EER 2010a, p.26). Nevertheless, the actors of the project argue that energy concepts represent a framework only and not a detailed planning instrument. The actual implementation of projects occurs locally by regional actors.

2.2.5.3 Formal Planning Concepts

The *Ministry of Transport, Building and Urban Development (BMVBS)* points out the role of regional planners as central actors in the region (BMVBS 2011, p.13). In this context it emphasizes the importance of informal concepts, in addition to formal regional planning. Formal planning concepts of the municipality solely are not suitable to take the required actions (BMVBS 2011).

2.2.5.4 Future Instruments

The *Sustainability Balanced Scorecard* (SBSC) originating from the *Balanced Scorecard (BSC)*, developed by *Kaplan* and *Norton* in the 1990s, is a strategic management instrument for organizations (Schaltegger and Dyllick 2002). It was designed to support the implementation of strategies and comprises of the four organizational perspectives *Finance*, *Customer*, *Processes*, and *Learning/Development* (Kaplan and Norton 2001). The transfer and implementation of the corporate strategy to the four perspectives of the instrument bridges the gap between strategic and operative planning and helps to achieve long-term strategic targets (Kaplan and Norton 2001, p. 65). The SBSC was developed within a series of research projects by the *Center for Sustainability Management* (CSM) of the *University of Lüneburg* and the *Institute of Economics and Ecology of the University of St.Gallen* (Schaltegger and Dyllick 2002). As a *strategic sustainability management instrument*, it integrates the three pillars of sustainability in order to improve the corporate performance within all three dimensions (Schaltegger and Dyllick 2002, p. 37). The basic concept of the instrument may be of use whenever implementing strategies and, as such, several examples exist where the BSC has been applied in practice beyond organizational level. Therefore, the instrument may be applicable to energy regions to provide support in areas where current instruments may lack so far.

At the regional level the instrument has been applied in two cases. Similarly to the intention of this study, the conventional BSC was used before for the purpose of developing 100%-Renewable-Energy-Regions (100%-EER) (Moser, Kucharczek and Hoppenbrock, 2009). In contrast to the instrument to be developed in this study, its focus and structure differed widely (See Appendix 1). A prevailing characteristic of its application was the focus on the analysis of the regional economical potential. With the objective to contribute to the regional economy, the development of economic targets and criteria dominated the instrument (Moser, Kucharczek and Hoppenbrock 2009, p.20). Corresponding with the typical characteristics of the conventional BSC, it solely targeted improved economic success by increased profits and reduced costs. The need for sustainable economic concepts was recognized, however, key figures that explicitly indicate environment or social performance were not listed. For the implementation of sustainable energy systems it is useful to integrate all three dimensions equally.

By implementing the three pillars of sustainability into the concept of the Balanced Scorecard (BSC), the instrument was further development to a Sustainability Balanced Scorecard (SBSC) (Figge, et al. 2001). The forms often differ due to varying formulating processes, however the common purpose is to overcome the shortcomings of conventional approaches to environmental and social management systems through a single and overreaching management tool. Conventional business instruments often consider economical factors only, whereas environmental and social targets are pursued in a parallel management system (Figge, et al. 2001, p.6 and p.55). It can be noted, that if those strategic relevant factors are not integrated and aligned to the corporate success as well, they cannot contribute to the economical dimension of sustainable development (Figge, et al. 2001, p.55). The second practical example demonstrates the application of a SBSC with its primary objective being the integration of sustainability (see Appendix 2). The *City of Graz* applied the advanced instrument to implement sustainability within various organizations within its region (Fresner, et al. 2006). By building a regional SBSC, including determinants for the regional development, a framework for the organizational implementation process of sustainability was provided. The project planner decided in this case to modify the perspectives within the SBSC to be more suitable for the purpose. Aligned with the overall target of the project to contribute to regional sustainable development, the top-perspective, within the SBSC was modified. Beside the *economic success* as the center of attention of the Finance perspectives *sustainable development* was the predominant target (Fresner, et al. 2006). The modified instrument enabled the region to successfully promote sustainable development within the regional network of private firms and organizations.

2.2.5.5 Identifying the Gap

It has become apparent that in theory support instruments can vary from financial support, providing a vision and a broad framework to detailed assistance for local planning (see Ch. 2.2.5.1 to 2.2.5.3). So far energy concepts are the predominant instrument, nevertheless, a common structure that is applied in practice to implement energy systems does not exist. In order to successfully facilitate a transformation at the local level, mechanisms have to support the accomplishment of energy targets and consider the principles of sustainability. It should be mentioned that different instruments do not have to be understood as contradictory, as they are rather intended to function complementary. Different mechanisms can also operate at different levels, for example different spatial dimensions (national, regional, district, building), and address different thematic dimensions (economy, technique, sociology, ecology) (100%-EER 2010a, p.2, George, Bonow and Hoppenbrock 2009, p.16).

There are two major factors for why it is worthwhile to explore further instruments. First is the support in the strategy implementation process. Literature has shown that overall strategies have been defined; nevertheless, the implementation of energy systems takes place at a regional level by local actors. Corresponding with the idea of the BSC, it is necessary to bridge the gap between strategic target planning and local planning and implementation. In contrast to only identifying fields of action as in the case of energy concepts, potential instrument may better support local processes by integrating influencing variables and aspects that are relevant for an energy region's success. Ideally, it would support the coordination of actors and provides a clear overview of the utility for and the expectations of citizens, corporations and the administration in the region. This may simplify the strategy implementation process and support the accomplishment of regional targets.

The second argument why further mechanisms should be explored is to strengthen the integration of sustainability into project planning effectively and in a well-structured manner. In the context of the transformation of energy systems, *Sustainability Management Instruments* are rather untested. Increasingly, organizations implement sustainability tools, meanwhile sustainability instruments can be of support for regions as well (Schaltegger and Dyllick 2002, p.1). When aiming for the development of sustainable energy systems at the regional level, an appropriable concept is one, which considers social, ecological and economical aspects equally. Approaches to implement more sustainable energy systems are in the works, but the contribution by corresponding instruments is limited. There may be still room to improve the effectiveness and up to now, the application of sustainability instruments in the context of regional energy is widely inexperienced.

3 Sustainable Regional Energy Systems

So far the criteria for a successful transformation towards sustainable energy systems have been outlined. It has also been illustrated that most decisions and activities regarding the implementation of renewable energies and the modification of energy systems takes place at the regional level. In consequence municipalities and local activity may play a significant role in the transformation process. Regarding the use of energy within regions, various forms of activities with different intentions and of versatile scope exist. The *European Union* implemented the large-scale demonstration project *ENEREG* (ENNEREG 2010), which is intended to pursue the *EU 202020*[7] targets through the development of model regions within various member countries. Within the German *E-Energy* project (BMWi/BMU 2012) *Smart Energy Regions* develop key technologies and business models for information and communication technology based energy systems. The *100%-Renewable-Energy-Regions (100%-EER)* project represents a network of regions and municipalities that pursue the overall target to supply themselves with 100% renewable energies. All types of projects mentioned above can be referred to as *Energy Regions*. They intend to facilitate the implementation of renewable energies and contribute to the development of sustainable energy systems at the regional level, but with varying research priorities. The focus of the present study is the 100%-EER project, which serves as a great example for implementing sustainable energy systems and adding economic value to the region.

The following outlines the sustainability aspects related to energy and subsequently explores the nexus of energy and regions. Analysis of the connection and the findings from research related to the 100%-EER project regarding numerous energy regions build the basis for identifying the exposure of regional energy systems to environmental and social aspects. Studying the environmental and social exposure of energy regions is essential to develop a SBSC for energy regions. With the intention to develop the sustainability instrument, to be used to implement sustainable regional energy systems, this chapter provides the foundation.

[7] Target of at least 20% reduction in greenhouse gas emissions, 20% increase in energy efficiency and 20% of energy from renewable energies by 2020 *ENNEREG - Regions paving the way for a Sustainable Energy Europe*, http://regions202020.eu/cms/ (accessed April 12, 2012).

3.1 Sustainable Energy

Results from the literature have shown that in order to overcome the challenges of conventional energy systems and to enable sustainable development, it is essential to initiate a transformation of energy systems (see Ch. 2.2.3). In this context, general requirements for a transformation of energy systems within the framework of sustainable development have already been outlined. Nevertheless, it appears advisable to look more in-depth into the sustainability dimensions in the field of energy in order to develop sustainable energy systems. In 2001, the *Enquete Commission on Sustainable Energy* of the *German Federal Parliament* pointed out that some segments of sustainable development could be identified where energy can play a particular role (Enquete-Kommission 2002). By studying the sustainability dimensions more in-depth, further information on the economical, social and ecological aspects related to energy will be obtained.

3.1.1 The Dimensions of Sustainability in the Field of Energy

Energy services are relevant to all three dimensions of sustainability and specific energy related aspects could be found in each of the dimensions of sustainability (Enquete-Kommission 2002). They require the utilization of environmental goods and resources. They provide the basis for the economic development and they impact the social dimension (Enquete-Kommission 2002). The Enquete Commission lays out the following aspects within the three dimensions of sustainability.

3.1.1.1 Ecological Dimension

Exploiting resources, converting them into energy, and finally utilizing the energy, cause tremendous environmental impacts. At the global, the regional, and the local level, the use of energy is a major cause for environmental degradation (Enquete-Kommission 2002, p.38). Globally, energy is the main source of Greenhouse Gas (GHG) emissions. And at the regional and the local level its use produces acid substances, volatile organic compounds or particles. The generation and use of energy can cause acidification and eutrophication of ecosystems, materials and plants. Moreover, it causes near-ground ozone and adverse effects to human health. Further environmental effects from the use of energy are the associated land use, th landscape changes, and the production of waste (Enquete-Kommission 2002, p. 38). It can be concluded that sustainable energy systems require a reduction of the environmental impact to a level that maintains ecosystems services (Enquete-Kommission 2002, Millennium Ecosystem Assessment 2005).

3.1.1.2 Social Dimension

The maintenance of ecosystem services correlates with the human well-being since provision, regulating, cultural service, as well as supporting services, affect the human well-being (Millennium Ecosystem Assessment 2005). Energy services are the foundations for the living conditions, economic productivity and the welfare of the society. Hence environmental effects and risks in energy use impact the social dimension (Enquete-Kommission 2002, p.39). In the global context, but also at the local level, equity issues, as well as distribution and participation problems regarding to energy become apparent (Enquete-Kommission 2002, p.39).

3.1.1.3 Economical Dimension

The cost level is an indicator for the scarcity of resources. High costs signal a high consumption of a resource. Low energy costs require the efficient use of a resource. The *Enquete Commission* states that, if external costs are internalized, energy costs are a suitable measurement for the consumption of scarce resources and indicate the relative sustainability of techniques and energy systems that provide energy services (Enquete-Kommission 2002, p.38).

3.1.1.4 Stability in Supply and Risks

Nowadays, the stability in energy supply concerns the resources that are used as well as the technological reliability of the energy systems. Used resources are mostly fossil resources concentrated on a few regions only. On a long-term this is an undesirable situation that requires adaptation. Possible measures are efficiency gains, storage, diversification, domestic resources and renewable energies (Enquete-

Kommission 2002, p.38). However, the plan to implement regional energy systems that are based on renewable energy brings new challenges regarding the stability of the energy supply. The availability of energy and the reliability of the grids are the future concerns associated with the development (see Ch. 2.2.3). A shift can also be observed regarding the risks to human health occurring from the provision of energy service. In contrast to nuclear power plants or other facilities that use fossil fuels, the risk profile of new energy systems may differ regarding frequency and scope.

3.1.2 Environmental Impacts from the Use of Renewable Energies

To accomplish the target of a transformation of the energy systems, technological alternatives and the application of innovative concepts are essential. The implementation of energy from renewable resources is a major component of future energy systems (IPCC 2012). Renewable resources can regenerate within a short period of time and typically, a sustainable use of the resource cannot deplete the source. The global energy potential is sufficient to supply the world's primary energy demand (IPCC 2012). However, due to the fact that resource are allocated unequally and local fluctuation occurs, the availability is not assured everywhere at all times (FVEE 2010a, p.17). Solar and wind energy, waterpower, biomass, geothermal and oceanic energy are examples for energies from renewable sources that are characterized by varying costs in correlation to the local availability and the conditions. The major challenge is seen in the improvement of the cost efficiency and in the integration of energy from renewable resources into present structures (FVEE 2010a).

Energy systems that are based on renewable energies allow the utilization of energy while resulting in a lower environmental impact in most cases (DLR, ifeu,Wuppertal Institut 2004). Many environmental effects, such as the use of finite resources and generation of GHG emissions, can be reduced. However, if the environmental effects of the different energy types are analyzed more in detail, it is noticeable that the environmental impact in some categories are higher than in comparison to conventional systems (DLR, ifeu,Wuppertal Institut 2004). The resource use, in particular from larger facilities, is the major obstacle for an environmental sound implementation of renewable energy systems (DLR, ifeu,Wuppertal Institut 2004, p.67). Life cycle assessments (LCA) for the different types of renewable energies have shown that in comparison to the conventional systems less GHG emissions are produced and less finite resource are consumed. In regard to the installation lower or equal amounts of materials are used. Solely the consumption of aluminum and steel for PV arrays exceeds the amount used for conventional energies (DLR, ifeu,Wuppertal Institut 2004, p.80). In regards to further environmental effects, such as eutrophication, acidification, and summer smog, the results of the LCA are ambiguous. The scope of the environmental impact depends on the applied technology, the energy carrier (biomass), the location and the chosen materials (DLR, ifeu,Wuppertal Institut 2004).

Besides GHG emissions, eutrophication, and resource use, environmental effects regarding renewable energies originate from the local and regional impact on the ecosystem. If a sustainable use of renewable energies is the target, a full exploitation of the theoretical potential of renewable resources is not possible, due to various limiting factors. In general, the potential of renewable resources, that is available and that can be used, requires to be technological feasible, economical profitable, environmentally sustainable, and obtain public acceptance (see Figure 6) (100%-EER 2008). The remaining potential can be used sustainably.

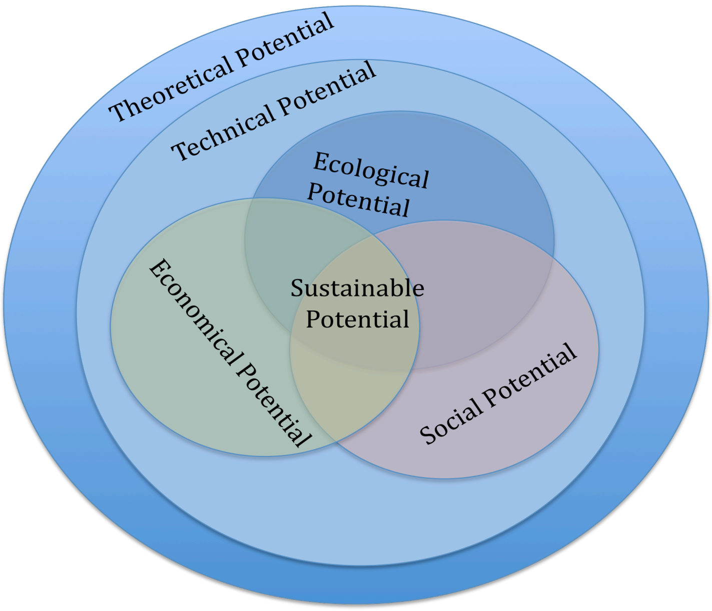

Figure 6 - Sustainable Potential of Renewable Resources (100%-EER 2008, p.5)

There are two concrete examples where the spatial development and environmental concerns are considered, wind energy and biomass energy. Figure 7 displays the potential of on-shore wind turbines. The potential is described in two German federal states, the first is the southern German state, Baden-Württemberg, and the second state, which borders the North Sea, is the federal state Niedersachsen. Designated areas for development and transportation, nature and landscape protection areas, special conservation areas, forests, biotopes, wildlife areas, breeding grounds, wetlands, and areas of visual sensitivity reduce the overall technological potential of wind resources. The remaining areas are grass land and agriculture areas that represent only 3,3% and 31% respectively of the theoretical potential (DLR, ifeu,Wuppertal Institut 2004).

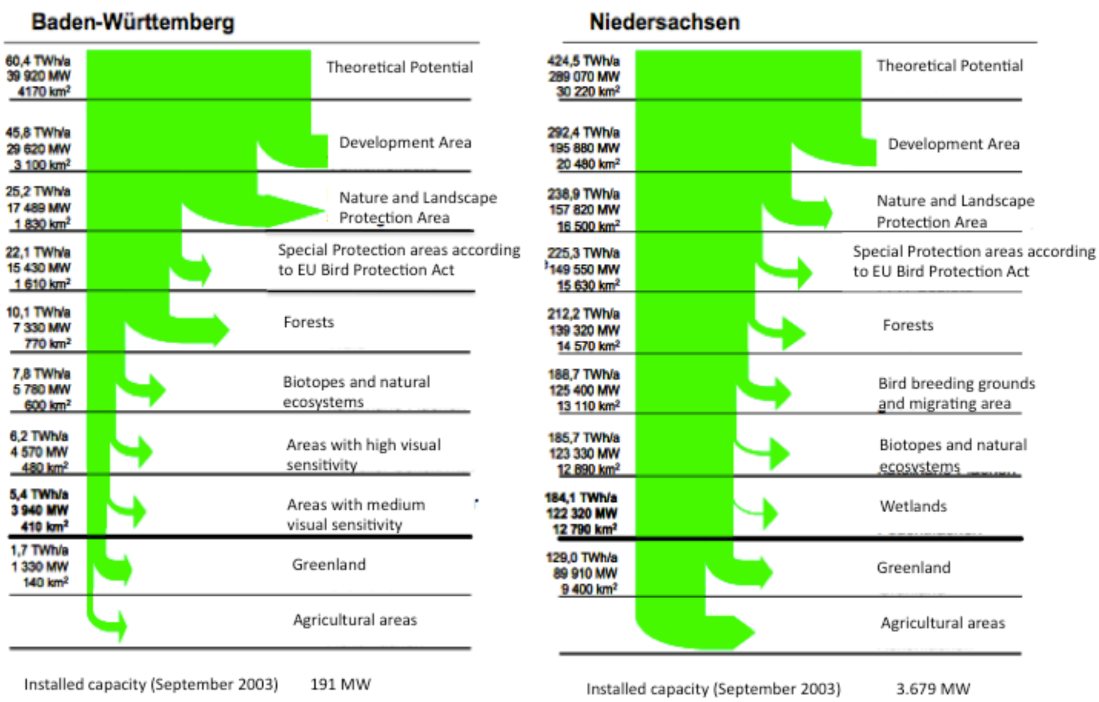

Figure 7 – Potential Areas for Wind Turbine Installations (DLR, ifeu,Wuppertal Institut 2004, p.127)

In regard to biomass resources, the potential varies according to the different types of energy carriers. In terms of organic residuals from industry and forestry, the technological potential almost equals the available amount. The potential of available areas to agriculture energy plants needs to consider nature conservation, water and soil protection issues (DLR, ifeu,Wuppertal Institut 2004).

It was noted that the potential for all renewable energies even under stringent nature conservation restrictions are enormous (FVEE 2010a, p.17). It was concluded that a considerable portion of the current energy demand could be supplied by renewable energy. For the heat energy and mobility sector especially, the potentials for efficiency improvements are great and would allow a reduction in the energy demand. Energy efficiency improvements support the extension of renewable energy. All in all, a 100% energy supply from renewable energy in Germany is feasible on a long-term even under stringent restrictions concerning the spatial aspects (DLR, ifeu,Wuppertal Institut 2004, p164)
A directional change from conventional systems to sustainable energy systems is limited by a number of determinants. However, some general practical elements can be part of a strategy to facilitate the transformation (Niederle 2008):

1. The energy demand should be orientated to the useable energy (room temperature of 20 degrees Celsius, light, transport item), not maximized energy generation
2. Planning and developing processes consider the effects of the energy use, in particular the intensity of the energy use (e.g. land utilization)
3. Efficient generation, transportation and utilization of energy
4. Optimizations in 1- 3 allow the provision of energy exclusively from diverse renewable resources

3.2 Regional Energy Systems

Regional power systems can vary from a system that is designed to feed power into the national grid due to its regional surplus to a system that receives electricity from the grid instead due to its deficit. It is also possible both cases occur due to the fact that surpluses and deficits arise and the region cannot balance fluctuations autonomously. In consequence some energy regions work towards a regional energy network. They enable a stable electricity supply across regions and avoid efficiency losses, which are a major criticism of regions that operate in autarky (George, Bonow and Hoppenbrock 2009, pp.29-30). While strengthening the region's economy is of high importance for a 100%-EER, the project group intends to work jointly with other regions to build regional networks rather than planning isolated solutions in order to maximize efficiency and success (100%-EER 2008a). The formation of energy region networks is also advisable due to the fact that municipalities often cannot provide sufficient energy for themselves while others generate a surplus. Although the energy demand of larger cities for example exceeds the energy potential of the region, surpluses are expected from other regions with large potentials. They often provide the structures to build on-shore or off-shore wind parks, solar parks, and water power facilities (100%-EER 2008).

3.2.1.1 Spatial Significance of Energy Types

The implementation of energy systems comprises of the different spatial levels with varying significance for each energy type. In general, it can be distinguished between the perspectives building, district or village, community, region, and national scope. Each of them offers different opportunities for the utilization of renewable energies (Moser, Kucharczek and Hoppenbrock 2009). Heat energy, though, is widely decentralized and actions take place at the spatial levels building, district, and at the municipality level (see Figure 8). Electricity is most significant on regional level with the tendency to affect the national level. Mobility model projects, that originate from urban areas mainly, reach from town level to a national scope.

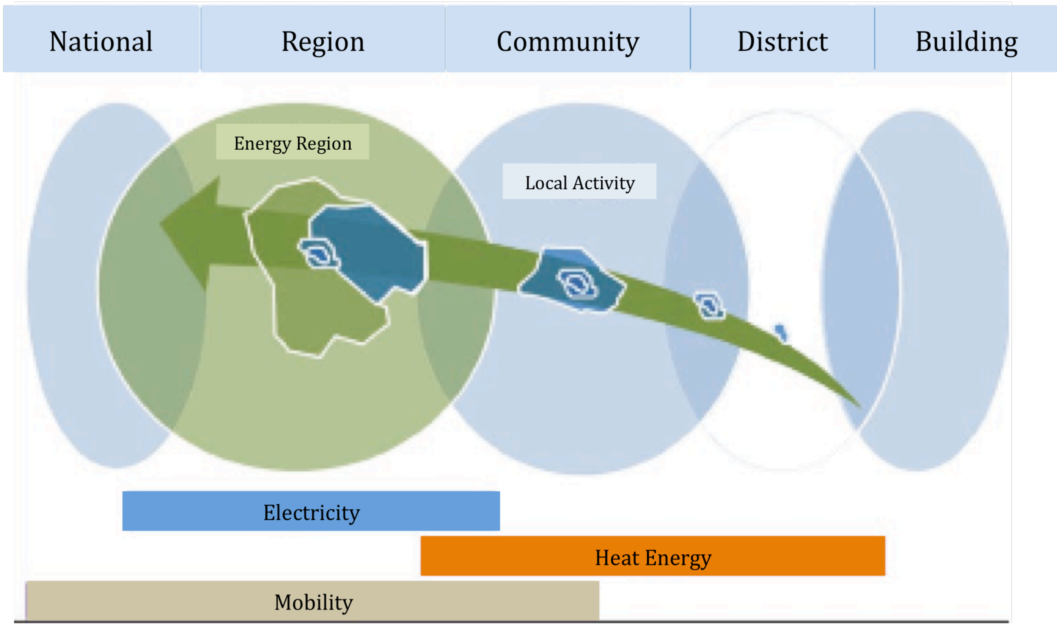

Figure 8 - Spatial Significance of Energy Types (Moser and Hoppenbrock, Modelle und gesellschaftliche prozesse für ein regionales energiesystem. 2008, p.11)

Out of the 52 energy regions that are defined as a 100%-EER and that took part of a written interview conducted by the 100%-EER project group, 42% merged with other regions. More than 40% of the 100%-EERs encompasses the scope of an administrative territory, and 17% represent communities (100%-EER 2009, p.22).

Due to the fact that action takes place on different levels, different spatial perspectives involve different actor groups in the process of implementing energy systems (Moser, Kucharczek and Hoppenbrock 2009). Successful concepts include all stakeholders, including citizens and businesses as part of the development (Lehmann, Niederle and Vollmer 2009). In the process of developing regional energy systems, municipal utilities are often perceived as a central actor due to their function as an embracing provider of energy services in the region (Lehmann, Niederle and Vollmer 2009). Besides national energy targets, the engagement in regard to the implementation of energy systems at the local level has also gained momentum in recent years, as regional decision-makers are believed to have a tight local affiliation and show a strong sense of regional identity (Moser, Kucharczek and Hoppenbrock 2009). Moreover, the regional financial capabilities for local investments into renewable energies are enormous. National wide, 26 billion Euros were invested in installations for renewable energies in Germany in 2010 (BMU 2011a).

3.2.1.2 Implementation of Renewable Energies and Strategic Key Components

For the implementation of renewable energies two basic concepts exist. They can be integrated into the existing supply system, such as electricity generation and distribution, heating and cooling systems, gas grids, and liquid gas distribution (see Figure 9). Renewable energy can be integrated in all sorts of electricity systems, reaching from large inter-connected continental scale to small stand-alone systems or even buildings. District heating systems allow the use of low-temperature energies, such as solar or geothermal and also biomass energies. Gas distribution systems can be used to inject biomethane or in future hydrogen, derived from renewable resources and synthetic natural gas (IPCC 2012, p.615).

Another approach that is pursued and that is very common in regard to renewable energy is the direct integration on-site for the end-user. In regard to transportation and vehicles within the end-user sector, liquid and gaseous biofuels are already in use. Renewable energies are also applied in buildings and households, where they can be integrated in new and existing structures. Agriculture, but also food and fiber processing industries often use biomass on-site to meet their own energy demand and often produce a surplus of fuel, heat or electricity. Thereby, renewable energies are integrated on-site and at the same time energy services are made available for the consumer (IPCC 2012, pp.615 - 616).

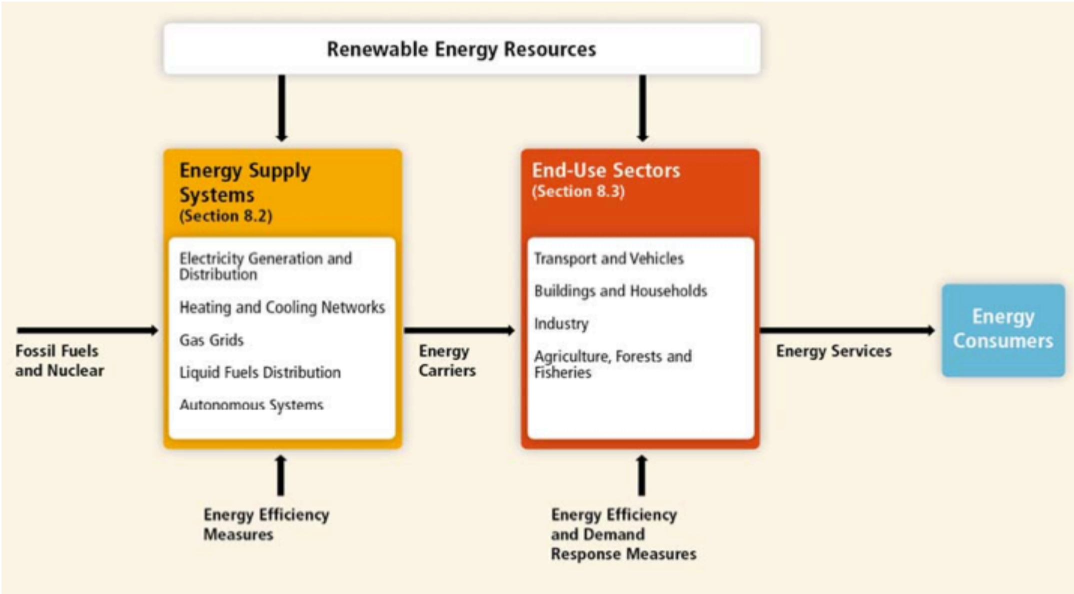

Figure 9 - Pathways for the integration of renewable energies (IPCC 2012, p.615)

With increasing integration of energies from renewable resources new challenges occur (IPCC 2012). Besides the different energy types that decide the scope of action, the characteristics of the energy type influences the scale of integration. Some energy types are more geographically distributed, while others, such as hydropower, are more centralized and constrained by the geographic location. New challenges for the integration also occur due to the variability of energies, which complicate the predictability. These factors contribute to additional system costs especially with the increasing share of renewable energies. The challenges for the integration of renewable energies, are contextual, as well as site specific, and require adjustments in current supply systems (IPCC 2012).

Energy efficiency measures can be applied within the existing supply system and also within the end-user sector (IPCC 2012). Potential energy efficiency gains are enormous and therefore, innovative concepts, which include the use of renewable resources and allow gains in energy efficiency, need to be developed. They should embrace measures that affect the demand side to increase the system's efficiency and the reduction of the consumption of energy (UBA 2009, Servatius, Scheidewind and Rohlfink 2012, Ethik-Kommission Sichere Energieversorgung 2011). The 100%-EER project group intends to make use of technological opportunities to enhance the energy efficiency, and moreover they aim to reduce the energy consumption through a behavioral change.

The effective functioning of sustainable regional energy systems, that allow efficiency gains and a reduction in the consumption, requires the participation of certain actors and also strategic key components for the system's technological development. For instance, the implementation of virtual control power plants, storages and demand-side-management (DSM) are essential parts in regard to the regional power supply (Lehmann, Niederle and Vollmer 2009). Virtual control power plants manage the fluctuating energy supply from renewable energies through the connection of decentralized energy generation and consumption units (Niehörster 2010). In combination with energy storages and load management, which allow more flexibility and assure a stable supply, they are important elements for the implementation. They enable the reliable functioning of energy systems and result in efficiency gains. Various actors are asked to participate, to jointly develop sustainable energy systems. Technological solutions that also involve telecommunication technologies and engineering, and financing concepts are required to not only develop renewable energies, but also to develop and implement system components (FVEE 2010a).

3.3 Energy and Regions

In general, a region is a complex geographic area of multi-dimensional interrelated structures. It is often based on territories, limited by political boundaries (Moser, Kucharczek and Hoppenbrock 2009). But besides political programs and planning control, it can also be defined by cultural and socio-economic conditions in the context of energy. Criteria for the boundary can be a commuting area, an infrastructure network, natural limitations, areas of usage, and geographic aspects of energy generation, such as agriculture, forestry, resources, waters, solar and wind conditions (BMVBS 2011). Thus, an energy region is not necessarily defined by the legal territory of the regional planner, but often by the scope of action of its stakeholders. Therefore regions have to be looked at more flexibility, depending on the regional conditions.

Energy plays an increasingly important role for regions with the progressive decentralization and implementation of renewable energy. It could be learnt from the literature that the implementation of sustainable energy is associated with a decentralization process. Decisions and activities increasingly take place at the regional level and bring with it structural changes. There are two main factors that support the implementation of sustainable energy systems at the regional level. First, regions can benefit from the development. The implementation of renewable energies and energy components evoke structural changes that can bring with it advantages. Imported resources and final energies are replaced by domestic sources, technologies and services, leading to regional supply chains (IÖW 2010).

Second, regions have been facing and experiencing structural changes many times in the past. In consequence they have implemented supporting structures and processes, and furthermore developed and applied instruments (Conrad 2007). Regions command a wide scope of strategic concepts within evolving legal frameworks and provide innovative applications of financial resources (Moser, Kucharczek and Hoppenbrock 2009). Hence, the existing conditions provide a suitable framework to facilitate the implementation of sustainable energy systems.

The following sections describe the effects on regions due to the increasing implementation of regional energy systems. Therefore, value creation processes and formal, as well as informal, development and planning processes are explored. Subsequently, their relation to a sustainable development of regions is illustrated.

3.3.1 Regional Supply Chains

Regions, which pursue the target to increase the intra- and inter-regional flow of materials and services, evoke local economic impulses and synergies (see Figure 10 and Figure 11). The effects are an increased value creation within the region and a strengthened independency from imports. In this context the important role of energy is apparent. Some regions strive for an expanded local energy supply, others even for energy autarky. Instead of exporting money in order to import energy, energy is increasingly provided and used decentralized. In consequence local value chains can be extended or closed (Müller, et al. 2011). A further effect is that the economical and technological control stays within the region (100%-EER 2012a). Local installations and all energy related services contribute to the structure of the regional economy (Rost 2009).

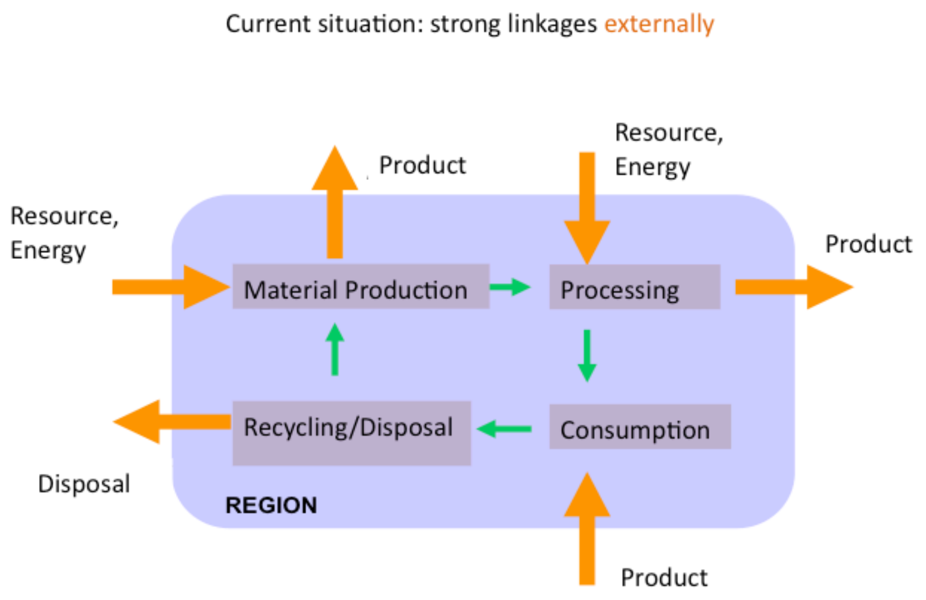

Figure 10 – Flow of Materials and Services: Current situation (Hahne 2008 adopted from TAURUS 1996)

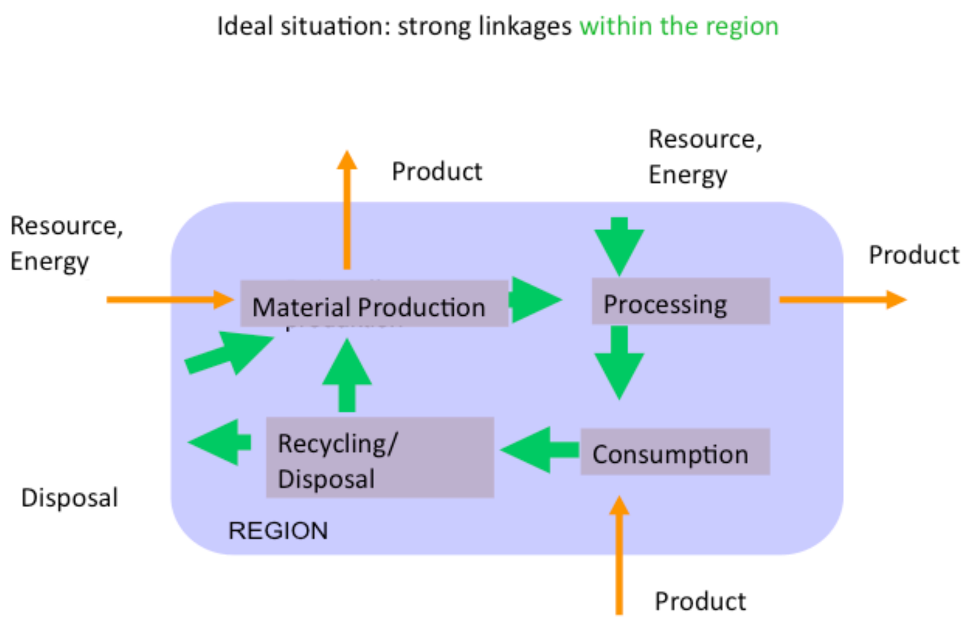

Figure 11 - Flow of Materials and Services: Ideal situation (Hahne 2008 adopted from TAURUS 1996)

Beyond local impulses, regions are not only affected by projects that originate from internal actors, such as regional initiatives or businesses; large energy providers have started to heavily invest into infrastructure projects and renewable energies in recent years. The investments concern regions to a far extend, as projects are implemented locally (Kemfert 2011).

External actors as well as internal actors contribute with their investment into the creation of regional value chains. The implementation of renewable energies and the process towards sustainable energy systems contribute to a change of the economic conditions in a region. The economic effects are (Conrad 2007):

- Increasing local investment,
- Development of jobs,
- Increasing tax revenue,
- Strengthening of the regional economy
- Reduction of energy imports and capital exports.

The creation of value within a municipality originates from corporate profits, tax payments (income and commercial tax) and the net income of employees (Hirschl, et al. 2010, pp.32-33). In general, it can be distinguished between direct, indirect and induced added value. The direct effects on the supply chain come from the operation of the plant. For municipalities it is decisive where businesses are located in order to obtain commercial taxes. Indirect effects originate from related suppliers and services. The structure of the network determines the regional supply chain mainly. Induced effects come from the generated money that is in return invested or spent within the region. The structure of financing and operating projects is especially decisive for a regional supply chain. Research projects have shown, that twice as much value is produced from an average 2-MW-Wind Power plant when it is 100% financed by regional actors in contrast to a supra-regional investor (BMVBS 2011, pp.26-27).

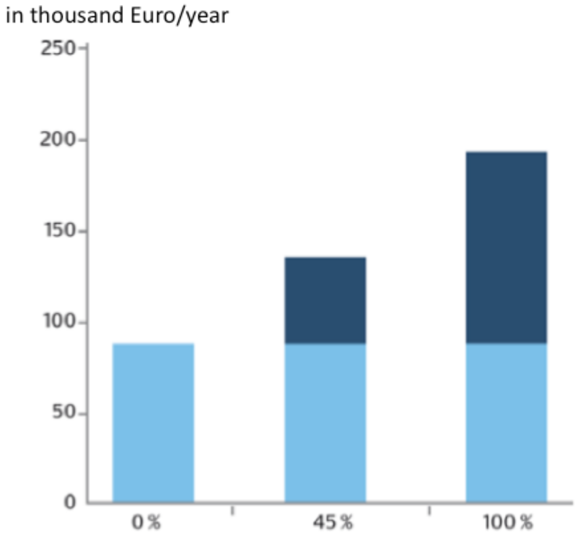

Figure 12 - Added Value of a 2-MW wind power plant in relation to the share of regional capital invested (BMVBS 2011, p.26)

However, to date, little information is available on the structure and processes of adding value to the region. The *Institute for Ecological Economy Research* recently published a study indicating that German municipalities generated 6.75 Billion Euro of added value from renewable energies in 2009, mostly from photovoltaic (36%) and wind energy (30%), followed by the utilization of biomass (24%). In total, 116.000 full-time positions were created from the effect of the municipal's direct added value, generating municipal tax revenue accounting for 610 M Euros (IÖW 2010, pp.11-17). When categorizing the value created from energy related investment into planning/installation, technical operation, business operation and trade, we can observe that the largest effects originate from the plant operation followed by investments (see Figure 13). Within the category planning/installation, photovoltaic accounts for the largest portion. While photovoltaic plays a minor role in technical operations, wind and biomass contribute the most to the value chain.

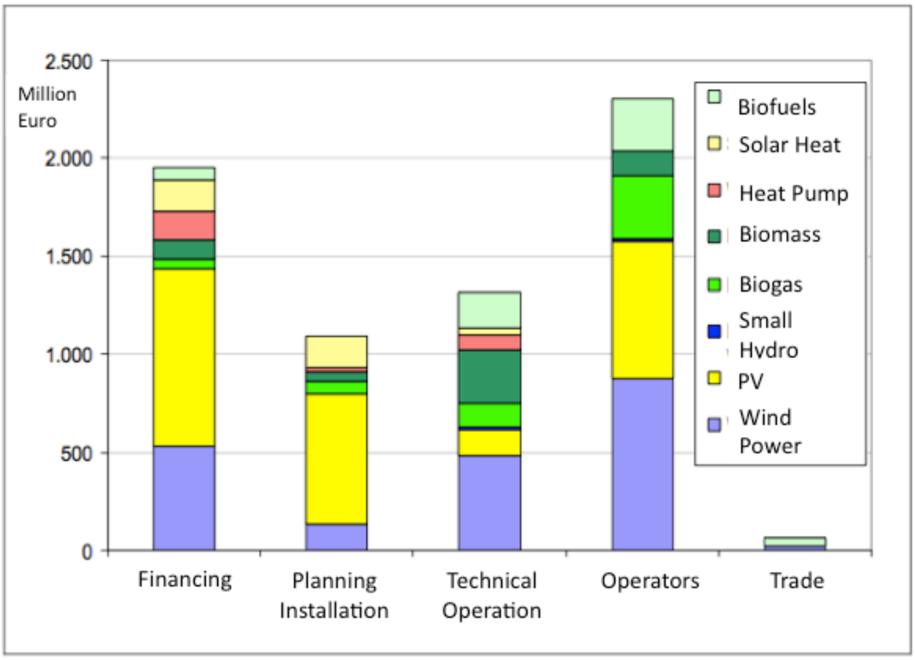

Figure 13 - Added value in 2009 in million Euros by value added step (IÖW 2010, p.210)

3.3.2 Formal Planning and Informal Concepts

Regions can profit from the implementation of renewable energies economically. They also provide a suitable basis for the development of sustainable energy systems and are often the driving force. Nonetheless, the increasing number of renewable energy installations and system modifications bring with it implications for formal region planning and moreover may influence the development of a region as a whole. National energy targets indicate that a further expansion of regional systems is planned and desired by some groups (100%-EER 2010a). The effects are increasing land use, competition in land usage, and impacts on the spatial development. They are of high relevance for spatial planning. Regional planners have to consider the interest of the regional economy including tourism, the settlement development, environmental concerns, and energy targets. Formal processes and instruments on municipal level are not capable to deal with the new challenges in all cases (BMVBS 2011, pp.2-4). In order to reach a balance between energy targets and the interests of project groups on one side and the public, the region's, and the private interests, as well as environmental concerns on the other, formal planning and informal concepts are required (BMVBS 2011, BBSR 2011). A starting point is to use regional energy concepts. From the legal perspective these informal instruments fall into the category of regional development concepts that are tied into the regional development act (BBSR 2011). Regional energy targets and the targets of the regional spatial planning often conflict and require the consideration of the interests of both. Formal planning in conjunction with informal concepts, allows for the production of scenarios for a structural spatial development and to lay out a land development plan for renewable energies (BMVBS 2011, p.18).

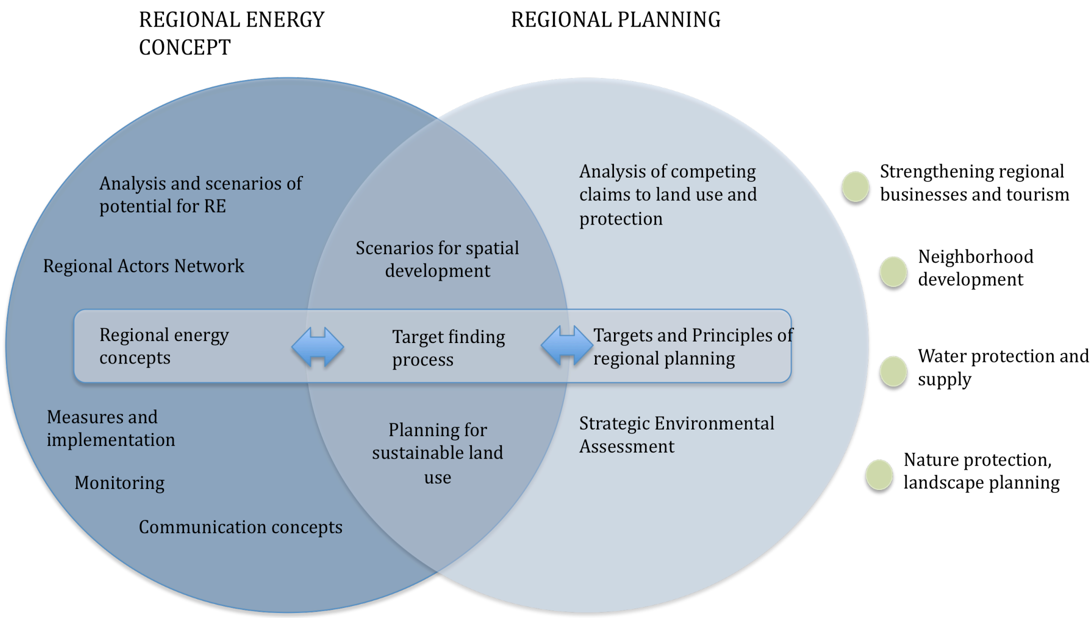

Figure 14 – Relationship between energy concepts and formal regional planning (BMVBS 2011, p.19)

The implementation of energy systems requires the active involvement of regional planners. A successful process of a sustainable implementation of regional energy systems requires the integrated application of informal and formal instruments.

3.3.3 Sustainable Regional Development

When economical targets and social interest are pursued, a region also has to consider ecological factors (Hauffe 2009). This implicates that social and economical claims to the region have to be in balance with its ecological function. Over the last decades, guiding principles of regional planning and its objectives have changed according to alternating conditions. Instruments of spatial planning were predominantly used for the purpose of strengthening regional economic structures in the 1970s. In contrast, in the 1980s, the focus of the development was on guiding principles such as ecological concerns, self-reliance and decentralization (Scholbach 1995). The concept of a *Sustainable Community Development* originated from two streams; first from the development of increasing self-reliance and *Endogenous Regional Development;* and second from the debate on a *Sustainable Development* (Peters and Sauerborn 1994).

For a sustainable regional development Peters et al. developed criteria in each sustainability dimension.

Ecological	Economical	Social
- Consideration of the carrying capacity of ecosystems - Energy conservation and use of renewable resources - Land use under consideration of ecosystem services - Conservation of biodiversity and the ecosystems soil, water, and air - Avoid or reduce mono culture - Environmental sound use of technology, low risk, and malfunction rate - Improvements in one region have no negative effects on other regions (waste or emissions)	- Fulfillment of the basic need, such as nutrition, cloth, housing, communication, culture, work, environment, mobility - Marketing stainable projects - Flow of information between enterprises, political administration, academia, research institutions and citizens to enable synergies and cooperation; target is to avoid market intervention, bureaucracy and anonymity of the market - Regional material flows and supply chains - Promotion of ecological products and production processes - Integration of various business segments	- Inter- and supra regional relationships based on cooperation and equity - Participation in the development of guiding principles and decisions - Transparency of trade and function chains - Decentralized responsibility of decisions and nearby relationships - Consideration of socio-cultural traditions

Table 2 - Outline of the Criteria Set on Sustainable Regional Development (U. Peters, et al. 1996, p. 67)

They build a framework for a region and support the development of targets for each sustainability dimension. The previous section has shown that in regard to the implementation of renewable energy, spatial planning plays an important role. To promote a sustainable regional development the *Federal Institute for Research on Building, Urban Affairs and Spatial Development*[8] *(BBSR)* defined a set of targets for sustainable spatial planning. In each sustainability dimension targets and target values were defined (BBSR 2011).

Targets	Indicators	Target Values
Economic Competitiveness		
Economic profitability	Added value and added value per capita	>75% of the Federal value
Innovation capacity	Engineers, chemists, physicians, mathematics per 1000 inhabitants	
Job qualification	Employees with higher education	
Conservation of the Natural Capital		
Reduction of land use	Land use development (ha/day)	Specific regional target value according to the 30 hectare target by 2020
Protection of biodiversity	Share of protection areas (%)	3% (national target 10%)
Avoidance of the utilization of Finite resources	Energy consumption per capita (MJ)	Max. average value of agglomeration areas
Reduction of material flow and resource use	Amount of waste per capita (kg)	
Improvement of water quality	Water quality grade II (%)	80% (overall target 100% of the surface water by 2015)
Social and Spatial Justice		
Improvement of level of income	Income per capita (Euro)	> 75% of the Federal value
Reduced level of financial assistance	Number of people that require social assistance (per 100 capita)	< 20% of national average
Improvement of level of employment	Number of employed people (per 100 capita)	> 90% of national average
Increased level of employment of women	Number of employed women (per 100 capita)	> 80% of national average
Improve provision of jobs	Number of unemployed people (per 100 capita)	< 25% of national average
Provision of living area	Living area per capita (square meter)	> 90% of average within the region
Improvement of fancial Situation of municipalities	Level of municipal debt	< 25% of national average

Table 3 - Target and Target Values of Sustainability Dimensions (BBSR 2011, p.3)

[8] Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR)

These overall targets illustrate the ambitions of a region that pursues the targets in accordance with sustainable community development. The targets of energy regions contribute to and widely correspond with the overall targets and intentions of any other region that pursues sustainable development. However, energy regions primarily pursue specific targets and strategies, which focus on the energy aspects.

3.4 100%-Renewable-Energy-Regions (100%-EER)

The previous chapter illustrated that the use of regional resources is of economic interest to a region. Nonetheless, projects have to consider ecological limitations and comply with public interests. Numerous regions have started to develop plans to build an energy supply with a high rate of renewable energies. Within the framework of the national wide 100%-EER project, 129 regions target a rate of 100% energy from renewable resources. So far 80 regions have already begun the implementation process and 49 have just determined the target to become a 100%-EER (100%-EER 2009).

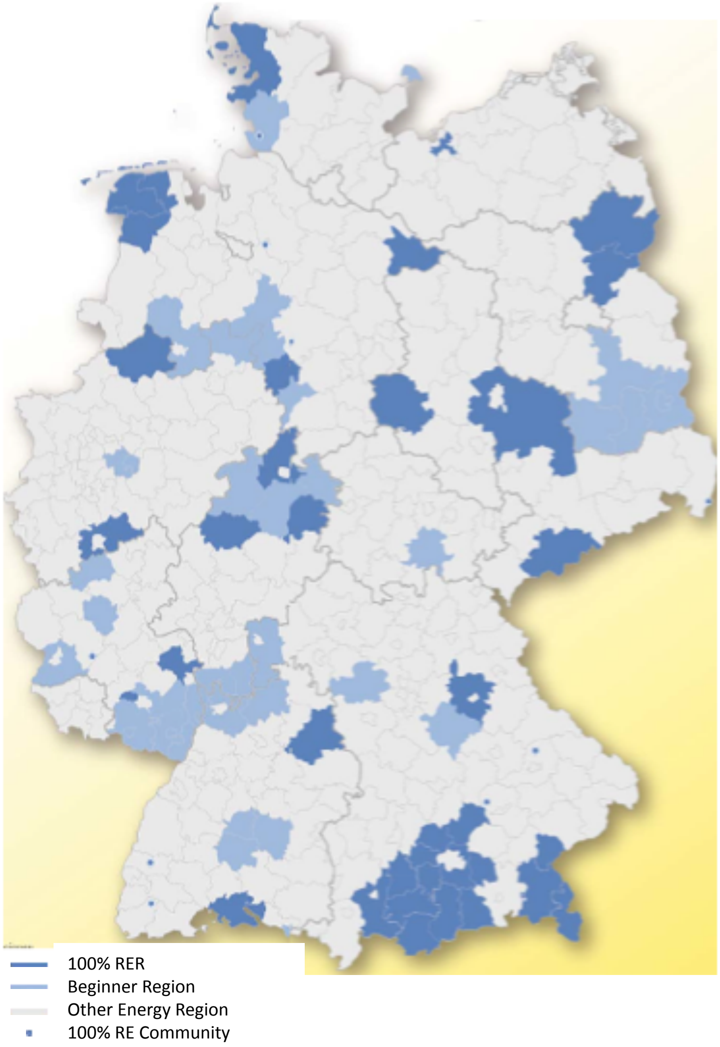

Figure 15 - Energy Regions in Germany (100%-EER 2009, p.61)

3.4.1 Targets and Current Status

In this chapter 100%-EER will be further analyzed to obtain a better understanding of the structure of energy regions and regional energy systems. The results of a written survey on 100%-EER from 2009 will provide the basis to learn about the intentions of energy regions, the implementation progress, and its actors.

Participating regions that aim at an energy supply from only renewable sources, mostly from local resources, do not intend to reach energy autarky, but to be part of a comprehensive network of decentralized energy systems. Their overall objectives comprise (100%-EER 2012a):

- Implementation of decentralized renewable energies
- Efficient use of resources
- Reduction of the energy consumption through behavioral change

Priority is given to a sustainable development of the energy regions, with the focus being on the efficient use of energetic and economic capabilities. In regard to social and economical aspects, they target the creation of regional supply chains (100%-EER 2012a).

Participating regions pursue different development steps. In general, it can be distinguished between action plans in the field of electricity, heat energy and mobility. Almost 67% of the regions that developed a regional target or resolution intend to provide more than 80% of their electric energy consumption by renewable energies. More than half of the regions intend to generate more than 80% of their consumed heat energy from renewable resources. Only one third pursue the plan to use renewable energies for at least 80% of their energy consumption in the field of mobility (100%-EER 2009, pp.30-31). It could be illustrated above that the development of the different energy forms depends on the spatial level, therefore it is not surprising that within the regions that wish to provide more than 80% of the energy from renewable energies, the development of renewable energies for mobility is not pursued at a community level (see Figure 8). In most cases communities and administrative districts only pursue electric energy or heat energy targets, not both (100%-EER 2009, p.30).

So far 83% of the actors have implemented model projects in their energy region and 63% of the regions determined the potentials for renewable energies. In 41% of the regions, capital from citizens has already been made available and 39% created a coordination center (100%-EER 2009, p.34). One third of the regions ascertained the regional energy consumption only, however 25% have already implemented the development of renewable energy plants in the municipal's development plan (100%-EER 2009, p.38).

Currently, 96% of the regions use photovoltaic, 85% solar heat and 85% bio energies (100%-EER 2009, p.37). The available biomass is used for biogas plants or bio-fuels and comes mainly from agriculture. Bio energy is also generated from forestry (pallets, wood chips, fire wood). Due to the geographic situation it is not possible for all regions to apply hydro energy. However, hydro and also geothermal energy are used in 59% and 52% of the regions (100%-EER 2009, p.37). Two third apply wind energy in their region.

It can be observed that most regions do not have the information available on the actual share of the specific energy on the total energy consumption. In particular in the field heat energy and mobility insufficient data is available. Thus, the regional energy mix cannot be determined. In regard to the future energy mix it is noticeable that across all energy types some regions neither use an energy types nor plan on using them in the future (100%-EER 2009, p.38). Geothermal is the type of energy the less commonly used by regions so far, but future plans for its implementation exist. The predominant energy forms that are currently used and are planned to further develop are still solar energy, biomass, and wind power (100%-EER 2009, p.37). Regions highlight the importance of bio and solar energies for the field of electricity as well as heat energy. This demonstrates that all of the regions plan to continue the development of bio energies. However, some regions will not further continue to implement wind power and solar energies (100%-EER 2009, p.39).

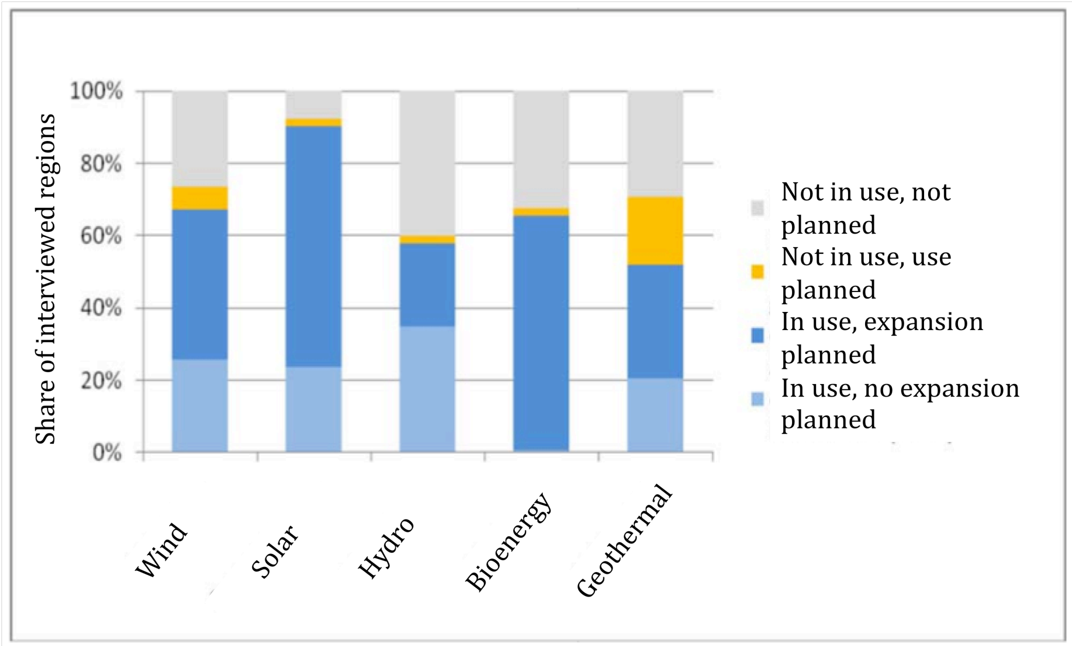

Figure 16 - Development of renewable energy within regions by energy type (100%-EER 2009, p. 39)

It should be remarked here that less than 50% of the regions did not declare their plans in regard to improvements in energy efficiency and energy conservations although they are part of the overall objective of 100%-EER.

3.4.2 Actors Groups and Major Obstacles

Besides the application of the specific energy types and the corresponding technological components, the involvement of stakeholders depend on the spatial level to a far extent. In general, actor groups can be divided into the private sector, initiative and societies, politics (majors and municipal administrators), and public administration. Out of the 52 regions that filled out the questionnaire the public administration group is the most represented with 38.5%. Political actors, mostly majors with almost 79%, are the second largest group, followed by the group initiatives and societies (100%-EER 2009, p.23). Only 13.5% of the actor groups come from the private sector that mostly operate within the scope of regional administrative territory. In contrast the group initiatives and societies act beyond the administrative districts within regional networks. Political actors usually solely act within their community (100%-EER 2009).

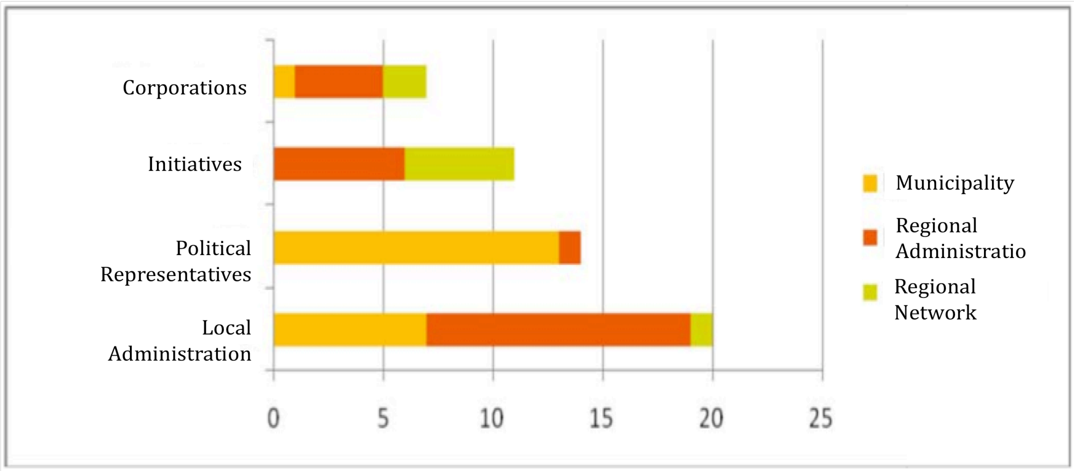

Figure 17 - Scope of action of by actor group (100%-EER 2009, p.23)

The results of the survey illustrate furthermore that initiatives and regional political institutions play an important role for the implementation of renewable energies, as they are the main initiators within regions. The main stimuli came from initiatives with 37%, followed by municipal council with 35%, enterprises with 28%, and citizens with 20% (100%-EER 2009, p.27). Across all actor groups the main driver for implementing renewable energy and a transformation of the regional energy system are economical motives. Climate protection targets are of high relevance as well. The implementation process is in most regions coordinated by a public administration, energy agencies or centers, and work circles (100%-EER 2009).

For the transformation of the regional energy system the following success factors were outlined (100%-EER 2009, p.47):

- Network of actors
- Promoters/multipliers
- Natural renewable energy potential
- Awareness
- Engagement of enterprises
- Municipal utilities
- Regional energy/gas grid
- Regional identity

Nearly all factors are rated as important or very important, only the success factors electricity/gas grid and municipal utilities were rated lower. Although some experts regard municipal utilities as an important criterion, interviewees rated them as the least important (Niederle 2008, p.103).

Most resolutions or target concepts could be accomplished through workshops, work circles, presentations and information sessions. This allowed the participation of a high number of stakeholders resulting in heightened acceptance. The major obstacles for regional actors are seen in the coordination and the approach to develop targets and in decision-making. Furthermore, the process is mainly hindered by the limitations of financial support. Subsequently, political differences, social concerns, as well as the availability of competences and knowledge are seen as further obstacles with almost equal importance. Although targets have not been defined in each region and many obstacles occur, most regional actors consider a firm resolution for a transformation process towards a 100%-EER as very important (100%-EER 2009, pp.26-28).

3.4.3 Summary of the Findings from 100%-EER Project Studies

A main achievement is that 60% of the regions developed a concept that constitutes the transformation of the regional energy system towards a supply with a 100%-renewable-energies. Nevertheless, regions target predominantly an electric energy supply from renewable resources, followed by the heat sector, whereas the mobility field is rather unattended. All in all, the approval of a resolution is seen as the basis, which may be also essential when applying the SBSC for an energy region. In this context it is important to remember that the political differences or different opinions are not the major obstacles, but the strategy, the coordination and the financing in the framework of developing concepts. Results have shown that in regard to the driving forces in the region and initiators for the development, public administrations and initiatives are prevailing. For the coordination of the energy transformation within the region, the public administration is the key actor. In consequence this may imply in regard to the SBSC that the public administration might be the main user for the instrument.

Most regions apply photovoltaic, solar heat, biomass from agriculture and forestry, and two thirds apply wind energy, however only 40% use recycling and waste materials in their region despite the fact that a high potential exists and that value can be added to the region. In contrast to the target to develop all energy types, recommended by the FVEE and the 100%-EER, many regions from the survey have not yet applied certain energies and are also not planning on implementing them in the future (FVEE 2010a, 100%-EER 2009, p.38).

Differing actor groups can accomplish broad agreements through the economic interests, which are the main motives across all groups. Problems, though, in the collaboration often occur, depending on the specific situation. If processes are initiated by the public administration or by businesses, the acceptance for a transformation of the energy system is rather high. Whereas, in the case that initiatives commence a transformation process, other actor groups can judge rather negatively the development.

4 The Sustainability Balanced Scorecard for Energy Regions

The BSC was initially intended to be used as a tool for the implementation process of corporate strategies (Kaplan and Norton 2001). In the case of regional energy, the overall strategic target is to establish energy systems, integrating renewable energy, to supply a region with renewable resources by 100%. In order to pursue this target and support local processes the scorecard was suggested as an appropriate planning instrument that also considers relevant environmental and social aspects. Its structure allows for the integration of non-monetary and soft factors, besides other economic variables, and the ability to align them to the economic success and with the strategic orientation (Kaplan and Norton 2001). The purpose of evolving the Balanced Scorecard (BSC) to a Sustainability Balanced Scorecard (SBSC) was the integration of sustainability aspects into the strategy implementation process. The previous chapter identified ecological, social and economical aspects that have to be reviewed in regard to energy systems at the regional level. The basic purpose of the instrument is to support the implementation of the overall strategy while considering relevant environmental and social aspects through cause-and-effect-relationships in each of the four perspectives: *Finance*, *Customer*, *Processes*, and *Development*.

In the following sections, a basic model of a *Sustainability Balanced Scorecard for Energy Regions* will be constructed to plan and implement energy systems within a region. In a first step, the suitability of the structure of a scorecard for this purpose is reviewed and the need for modifications is explored. The second part focuses on the integration of the environmental and social exposure of an energy region.

4.1 The Balanced Scorecard as a Strategic Management Instrument

Within the four perspectives, concrete objectives, indicators, detailed targets, and initiatives can be derived from the vision and overall strategic target (Kaplan and Norton 1997). The instrument can be used to measure the performance and moreover to serve as a communication, coordination, and control instrument for the successful implementation of a strategy (Kaplan and Norton 2001, p. 24, pp. 34-35, p. 262). The transfer to the four perspectives of the instrument bridges the gap between strategic and operative planning and helps to achieve long-term strategic targets (Kaplan and Norton 2001, p. 65).

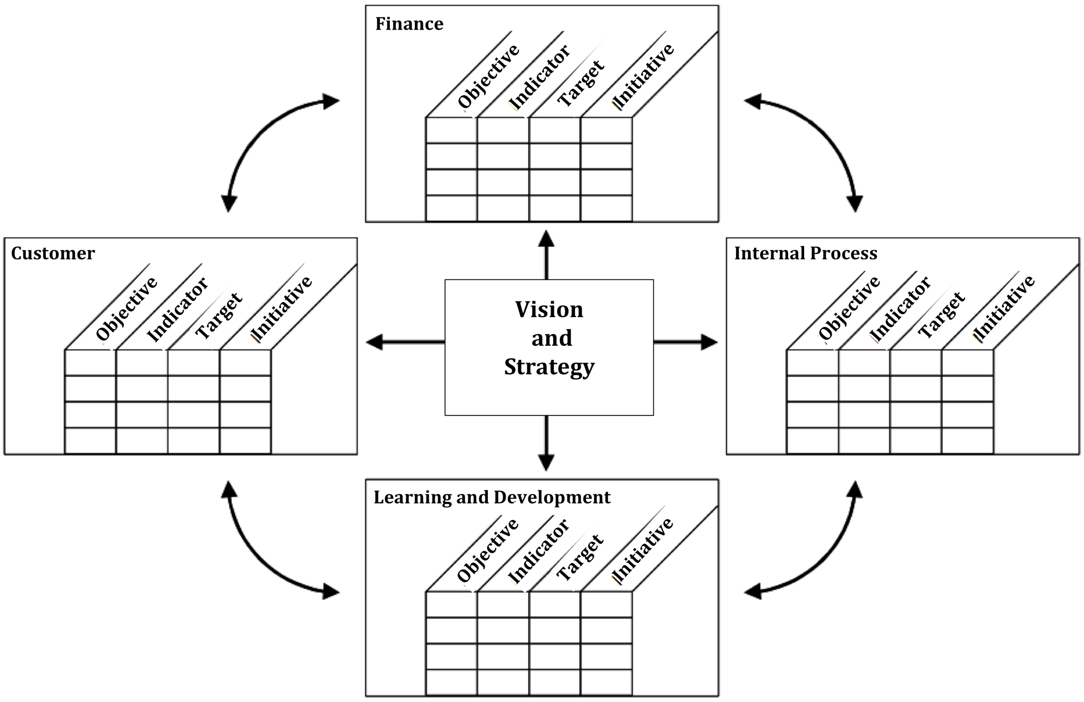

Figure 18 - Balanced Scorecard (Kaplan and Norton 1997, p.9)

Meanwhile, the enhanced Sustainability Balanced Scorecard integrates all environmental and social aspects that are relevant for the economic success (Schaltegger and Dyllick 2002). A starting point for developing the SBSC is the definition of a strategy. Strategic targets need to be outlined precisely and the definition of economic success within the context has to be determined. In a second step, the applicability of the instrument to the purpose of planning and implementing regional energy systems has to be reviewed for each perspective of the SBSC.

4.1.1 Strategic Targets and Economic Success

The overall strategic target of an energy region, such as the 100%-Renewable-Energy-Regions, is to supply the region fully by energy from renewable resources on a long-term. Energy systems must be established that allow sustainable provision of energy services. As a major premise, this implies the efficient use of the energetic capabilities, a reduction of the energy consumption, and at the same time cost-efficient systems.

Long-term economical success in community development can be measured by the value added to the region (see Ch. 3.3.1). As it was illustrated in Table 2 (see p.56-57), it is a major economic target of a region to increase the regional flow of goods and services, and to build and complete local supply chains. For an energy region investing local money into regional energy projects is crucial as they evoke the maximal added value (compare Figure 12, p.53).

Energy systems that enable the provision of cost-efficient energy services correlate with the level of economic and social welfare, which can be regarded as an indicator for the economic success of a region (see Ch. 3.1.1.2). Stabile energy prices are defined as a further success criterion, as they are the basis for the regional economy and ultimately the welfare of the society (see Ch. 3.1.1.2). While this is a rather abstract definition of the economic success suitable for a universal model, indicators and target values of more detailed economic targets suggested by the BBVS for a concrete practical case can be found in Table 3 (see chapter 3.3, p.58).

4.1.2 Suitability of the Structure of the Conventional Balanced Scorecard

In the context of energy systems at the regional level a few modifications to the structure of the SBC are required in order to assure its functionality in the context of energy regions. Typically, the Finance Perspective includes the core aspects *profits*, *costs*, and *assets* to formulate lagging indicators (Kaplan and Norton 1997). Since the economic targets in regard to regional energy rather originate from the economic interests of a region than an energy system, the indicators for economic success will be derived from the concerns of an energy region. The indicators for economic success are the *Value Added to the Region*, the *Local Investment* and the *Stability of Energy Prices*.

In order to formulate the indicators for the *Customer Perspective* it has to be clarified first who the customers of an energy region are. As it is the intention to provide energy services to everyone, each consumer of energy from the regional energy systems can be considered a customer. This definition includes individuals, businesses and industry, as well as public organizations. However, not all energy is generated within the same region due to the fact that regional networks exist, allowing energy exchange to balance fluctuations or insufficient resource availability. For the strategic planning of a region, consumers from neighboring regions that use the energy of the particular region are also considered customers. This is of primary relevance in regard to the electricity supply and the field of mobility, but may also be applicable in the case of heat energy. In the customer perspective the conventional scorecard focuses typically on the *market share*, *customer satisfaction*, and *profitability* (Kaplan and Norton 1997). In regard to energy regions, the core aspect here is the *Share of Customers* that purchase energy from regional energy systems.

The *Internal Process* perspective can be at least separated into three categories. First, the *Development and Innovation Processes* and Second in *the Operation Processes*. Here, the major focus areas are the development of a *product* or a *service* and the *manufacturing process* of a product or the *provision of a service*. In the case of energy regions this perspective concerns the actual process of providing energy services. Hence it comprises of the first phase of the *Development of an Energy System* and in the second the process of *Generating Energy*. Thus, this third perspective within the scorecard is the part where the actual development and implementation of regional energy systems takes place. This perspective is connected with the Customer perspective through cause-effect-relationships. The targets of the perspective provide the basis to accomplish the targets for the Customer perspective, which in return contribute to the next perspective. Thereby, the targets and the aspects of each perspective align with the economic targets in the Finance perspective and the overall strategy. Here the realization of sustainable energy systems can be accomplished while pursuing a strategy-orientated development in coherence with the targets of the other perspectives. All strategic relevant environmental and social aspects that focus on the system design can be incorporated at this point.

The focus of the fourth perspective, Learning and Development, is the regional actor groups. They are the workforces for regional energy systems; thus, coordinating actors and building networks are decisive within the learning and development perspective.

In contrast to the BSC, a non-market perspective can extend the SBSC in order to integrate factors that affect the implementation of the overall strategy. All environmental and social aspects that are not influential through market mechanisms and that are not of economic nature, but that are relevant for the economic success, can be integrated in the non-market perspective. For example GHG emissions from energy plants that do not fall under the European Union Emission Trading Scheme can be a decisive criteria for the success of a strategy but at the same time are not covered through market mechanisms. However, it has to be determined in each case if there is an actual non-market factor with strategic relevance or if it is a hygiene factor that does not need greater attention and that only minimal requirements have to be ensured (Schaltegger and Dyllick 2002). Due to the fact that all aspects function at least indirectly through market mechanisms, e.g. settle development in communities and visual sensitivity that affect prices for land, a non-market perspective will not be included in the scorecard model.

4.2 Integrating Sustainability Aspects in Strategy Implementation

In chapter 4.1.1 the strategic targets were determined for a typical region that attempts to implement regional energy systems. Moreover the economic intentions were described. In theory, the second step in the development of a SBSC is to identify environmental and social aspects of a business unit. In this chapter the environmental and social aspects are described as those that play a role in developing regional energy systems. Out of all the identified aspects, only the ones that are relevant for the achievement of the strategic targets and contribute to the economic success will be included in the instrument. Their strategic relevance will be reviewed in each perspective of the SBSC in the following.

4.2.1 Environmental and Social Exposure of Regional Energy Systems

In chapter 3.1, the principal environmental and social aspects in the case of energy have already been identified. Moreover the aspects, stability in energy supply and risk related to energy were addressed. However, the specific characteristics of energy at a regional level have to be taken into consideration. When talking about energy, aspects of the *environmental dimension* can be categorized into:

- Atmospheric greenhouse gases
- Resource use
- Local emissions
- Land use

Regional energy systems are exposed to all of them above, however in regard to the SBSC not each aspect is of strategic relevance. Most vivid are the energy related *GHG emissions*. Various energy projects are the results of taking action on climate change, and as illustrated above, regional energy systems are considered a great opportunity to reduce national GHG emissions. In fact, they are the second most named reason why regions apply regional energy systems (100%-EER 2009, p.46). However, when talking about the implementation of a sustainable energy system at the regional level that comprise only renewable energies with relatively low amounts of GHG emissions, regional energy systems are less exposed to GHG emissions.

The analysis of the ecological impact from renewable energies has shown that the *resource consumption* of different energy types varies according to the used materials, locations and further factors. It has also been recognized that in some cases the use of finite resources can be higher than for conventional technologies. With growing resource prices the use of resources gains increasing economic relevance. In consequence, photovoltaic, in particular, with the highest resource use, is affected and therefore experiences higher rates within the German Feed-in-Tariff program (UBA 2012). In regard to the environmental or social exposure of a regional energy system, the use of finite resources is economically relevant and potentially essential for the economic success, as it plays an important role for developing cost efficient energy systems in the Internal Processes perspective. Regional energy systems are exposed to the use of a finite resource to some extend although renewable energies are applied.

Local emissions in the form of waste, noise, and air pollution, which cause adverse effects on the ecosystem and also cause health concerns, directly impact the region (see Ch. 3.1.1 and 3.1.2). An energy region is highly exposed to those environmental aspects, as the region can suffer effects, such as acidification, eutrophication, biodiversity losses, and also adversely effects on the human well-being. The selection of the suitable technologies but also zoning and sitting processes are an important measure here.

Similarly, regions are highly exposed to *land use* issues. Besides environmental concerns, further aspects have to be taken into account. On the one hand, land consumption from energy facilities and also farming of energy plants can affect the ecosystem and on the other hand, land use competition occurs within the region due to the different interests for available land. As illustrated in chapter 3.3.2, regions require the collaboration between formal planning and informal energy concepts to consider all regional interests, such as settlement development, tourism, local businesses and industries, environmental protection, landscape conservation, preservation of historic sites, and also energy targets. The application of suitable energy technologies and the selection of the location are essential. They determine land use practices and the physical as well as virtual interferences.

Within the *social dimension* a number of aspects exists that energy systems within a region are exposed to. They are usually closely interrelated with economic and environmental aspects of an energy region. For instance an energy region exposed to the health concerns that arise from the energy generation and distribution. The local emissions mentioned above can cause negative effects on the health of local citizens. Interferences caused by regional systems are an important aspect regarding the social exposure of regions.

Land use patterns influence the ecosystem and as mentioned above, conflict with the regional interest groups. The settlement development is competing with the development plans of an energy region with potential adverse effects for citizens (see Ch. 3.3.2). Increasing property prices and adverse effects from operations of the plants are the result. Thus the region's energy systems are exposed to the land development plans of a region.

In regard to the social dimension, the aspects of security in supply, accessibility to energies, and price stability play a major role. For the regional economy and ultimately the society a secure energy supply, stable prices are essential and at the same time, the stability of a system is a basic requirement for the welfare of a society (see Ch. 3.1.1). The last requirement is the access for each individual to energy. The intention is here to provide increasing access to most common forms of renewable energies. When developing sustainable energy systems, these prerequisites have to be considered.

Public acceptance for regional energy is essential in the implementation phase and also when gaining new customers. Most of the aspects described above are essential to gain public acceptance. Environmental effects, energy prices, health concerns, spatial planning as well as the design of the energy system and the business model are factors that involve the public. The participation of affected individuals in project planning, operations, and as investors, allow for financial and technological control to some extent. In consequence, conflicts can be avoided, the acceptance for energy projects can be increased, and new customers of regional energy can be attracted.

4.2.2 Strategic Relevance of the Identified Environmental and Social Aspects

In a top-down process the relevance of the identified environmental and social aspect is reviewed for each perspective of the SBSC. In the graph below all aspects are listed and their relevance for the economic success and the overall strategy is depicted for the specific perspective.

<table>
<tr><td colspan="2"></td><td>Environment</td><td>Social</td></tr>
<tr><td colspan="2" rowspan="3">Sustainability Aspects of Regional Energy Systems</td><td>Atmospheric concentration of greenhouse gases from energy related emissions</td><td>Health concerns arise from the use of regional energies</td></tr>
<tr><td>Use of finite resources for construction</td><td>Creation of value from regional energy systems contribute to social welfare</td></tr>
<tr><td>Impact on local ecosystems:
<u>Local emissions:</u>
- air pollutants
- waste materials
- noise
<u>Land use:</u>
- Land consumption
- Competitive land use
- Visual Sensitivity</td><td>Implementation of local energy systems affect public acceptance
- Settlement development
- Security in Supply
- Accessibility to Energies Price Stability
(Stakeholders Participation allows technical and financial control through involvement in projects and operations as well as investors)</td></tr>
<tr><td colspan="2"></td><td colspan="2">Strategic Relevance of Environmental and Social Aspects</td></tr>
<tr><td rowspan="4">SBSC Perspectives</td><td>Finance</td><td></td><td></td></tr>
<tr><td>Customer Customers of an Energy Region</td><td>Land use issues apparent in this perspective. Energy projects interfere with other regional interests and affect the public acceptance. Addressed in Internal Process Perspective (high relevance)</td><td>Public acceptance and price stability are key in this perspective (high relevance)</td></tr>
<tr><td>Internal Processes System Develop-ment and Energy Provisioning</td><td>Growing resource prices of finite resources affect Internal Process Perspective economically (moderate relevance)
Minimizing local emissions allow a reduced environmental impact, a premise that affects the customer perspective (high relevance)</td><td>Public acceptance requires the mitigation of negative health effect. (high relevance). Besides energy system's impacts on the ecosystem, the avoidance of a negative influence on the settlement development is of strategic relevance (moderate to high relevance)</td></tr>
<tr><td>Learning and Development Actor Groups of an Energy Region</td><td>The development of an energy system that is designed to produce a minimized impact on the ecosystem begins in the learning and development perspective through the integration of all stakeholders and required experts groups</td><td>Public acceptance, security in supply, accessibility to energies, price stability are essential for the accomplishment of the strategic targets. Key is the financial and technological control through the stakeholder participation (strategic relevance within all perspectives)</td></tr>
</table>

Table 4 - Review of the strategic relevance of environmental and social aspects (Author's own illustration)

The economic success of regions was characterized by the value added to a region, investing in local energy systems, and stabile energy prices. These are the objectives of the Finance perspective and any contribution to that can be considered economically relevant. Aspects identified in the environmental and social dimension mostly make only an indirect impact on the Finance perspective and in consequence the overall target. The relevance of the environmental and social aspects becomes apparent through the cause-effect-relationship chains between the four perspectives. Their contribution to the economic success is rather determined in the Customer, Internal Process, and Learning and Development perspective, and affects the finance perspective indirectly. The aspects affect the Customer, Internal Process, and Learning/Development perspectives in so far directly, as they are integrated here in the form of *lagging* and *leading indicators*.

In the Customer perspective *land use* issues are highly relevant. Relevance for the economic success occurs due to the fact that environmental concerns emerge and development plans of the energy projects may interfere with other regional interests. They might compromise the settlement development, industries or other interest groups of the region. Public acceptance is vital for the project implementation and customer acquisition. Disturbances of the ecosystem that are caused by land use practices as well have to be addressed in the Internal Process perspective where the implementation of energy installations is the focus. In regard to the strategic relevance, it can be said that land use issues relate to the environmental and social dimension, and affect both, the Customer and the Internal Process perspective within the SBSC. Therefore related lagging and leading indicators should be integrated in the two perspectives.

Local emissions are highly relevant to the Internal Process perspective. The development of an energy system that targets at minimizing adverse environmental effects and impacts on human health can be conceptualized here. Resulting negative effects impact the customer perspective and ultimately influence the economic success. In the Learning and Development perspective, where expert groups and affected groups interact, the basis for managing local emissions is provided.

With growing fossil resource prices, the resource use is increasingly relevant for the Internal Process perspective. The need for fossil resources in energy installations while prices are increasing may negatively impact the economic success. When targeting at project cost-efficiency, the price level of resources needs to be factored in.

Atmospheric emissions do not directly relate to any of the perspectives of the SBSC. Nevertheless, climate change mitigation was recognized as the second most named motive for the development of renewable energies, thus one could assume that the reduction of GHG emissions might be influential regarding public acceptance.

Within the social dimension accomplishing public acceptance for energy projects is most relevant. This concerns primarily the Customer perspective. On one side environmental aspects affect the public acceptance. The exposure of energy systems to health effects becomes apparent in the Customer perspective. Public acceptance that is influenced by health effects, caused by the potential energy systems, need to be addressed already during the project planning and the implementation phase in the Internal Process perspective. On the other side the acceptance is influenced by conflicts with the visual sensitivity or other irritations related spatial planning. Nonetheless, acceptance is also influenced by the security in energy supply, the accessibility to energy, and the price stability. These factors have to be addressed in the Learning and Development perspective. Control or involvement in the project planning through stakeholder participation may play an important role here. Stakeholder participation begins in the Learning and Development perspective but is of strategic relevance within all perspectives. Accomplishing an energy supply within a region of 100% energy from renewable resources requires the collaboration of all stakeholders.

4.2.3 Conceptual Structure

In the following the lagging and leading indicators of each of the four perspectives are described. They all are aligned with the overall strategic target to supply the region by 100% renewable energy. Indicators of the Finance perspective are derived from the information on the economic success of regions that were discussed in chapter 3.3.1 and 3.3.3. The strategic relevant environmental and social aspects from chapter 4.2.2 are integrated in the Customer, Internal Process, and Learning and Development perspective in form of indicators. Further aspects that were gained from the information in chapter 3, and that appear to be of strategic relevance, are also elements of the SBSC in form of indicators.

4.2.3.1 Finance Perspective (Economic Sustainability)

Profitability, productivity, and cost efficiency are the core aspects of the finance perspective in the conventional BSC. Taking into account these aspects, the following economic targets for the finance perspective can be defined.

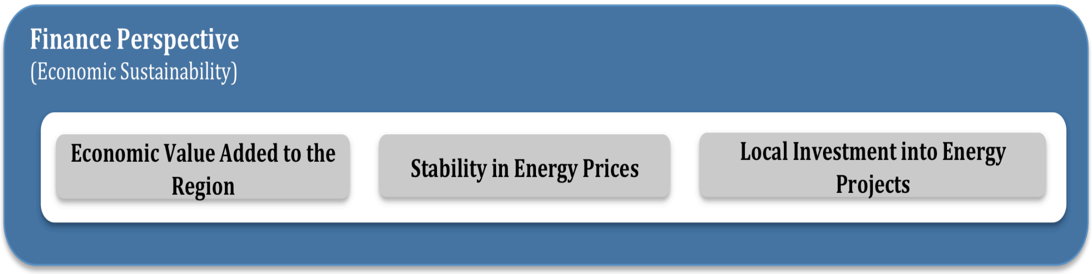

Figure 19 - SBSC for Energy Regions: Finance Perspective (Author's own illustration based on Kaplan and Norton 1997, p.9 and Hahn and Wagner 2001, p.14)

It was mentioned in chapter 3.3.1 that it is the main goal of economical sustainability in regard to energy to enable low energy prices while internalizing external costs. The avoidance and internalization of externalities in particular is addressed in the third perspective, Internal Processes, where the focus is on planning regional energy systems and the operations for energy provision. In order to provide economic efficiency as well as social welfare, *stable energy prices* are an important target. It goes along with the national target to provide energy at affordable prices while social costs are included.

As illustrated in chapter 3.3, ideally, regions pursue sustainable community development to build regional supply chains and to *create regional value*. The effects are the creation of jobs and economic stimuli to the regional economy. It could be demonstrated that the effect of creating added value to the region can be strengthened by the utilization of local capital for regional energy projects instead of external capital. Besides these economic benefits, the participation of stakeholders in energy projects through *local investment* grants the financial control and ultimately the technological influence (see Ch. 4.2.2.3).

As mentioned above, the economic success for an energy region that develops and implements sustainable energy systems is characterized by the three targets within the finance perspective. The nexus between the environmental and social aspects on one side and the economic success on the other is apparent due to the cause-effect-relationships. This provides the possibility to identify and measure the relevance of certain aspects that contribute to the economic success.

4.2.3.2 Customer Perspective

The concept of the BSC is intended to illustrate the essential factors in each perspective that contribute to the economic success and eventually to the overall target. In this second perspective, which focuses on the customer, a target that is defined is supposed to lead to the economic success in the finance perspective. As it is also the case in the Internal Process and Learning and Development perspective, lagging indicators are generated and leading indicators are identified that allow for the measurement of success and enable the accomplishment of the target within the perspective. Here the relevance of environmental and social aspects becomes apparent and the cause-and-effect-relationships can be portrayed.

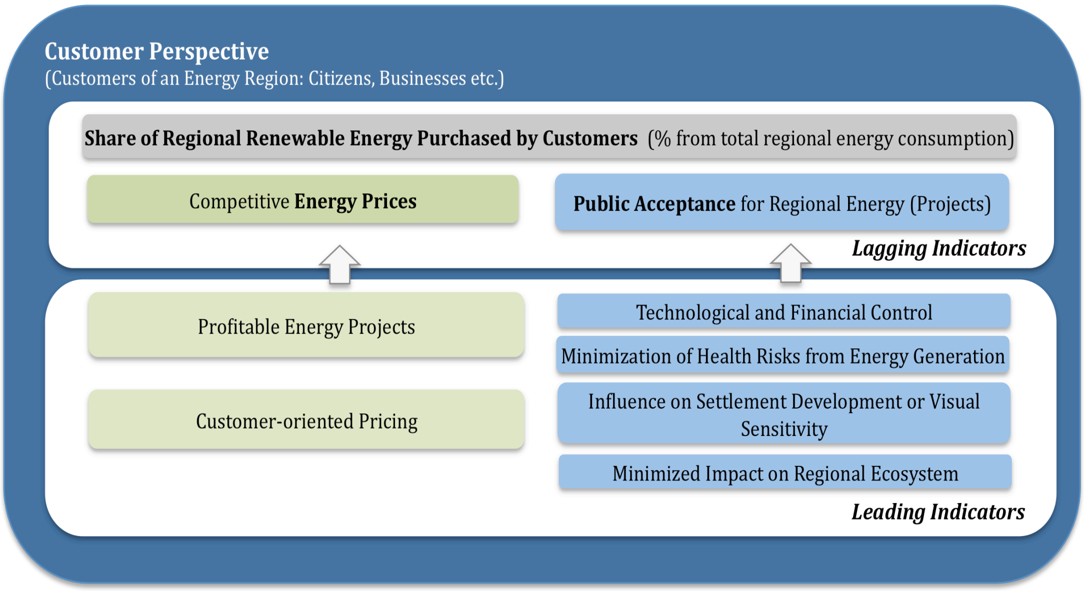

Figure 20 - SBSC for Energy Regions: Customer Perspective (Author's own illustration based on Kaplan and Norton 1997, p.9 and Hahn and Wagner 2001, p.14)

The conventional core aspects within the Customer perspective are *market share* and customer related targets, such as customer satisfaction and reliability. A customer in the case of energy regions is everyone who receives energy from the regional energy system in whatever form of energy: electricity, heat or mobility related. The target in this perspective in the case of regional energy is to increase the market share of consumers that purchase energy from the region energy systems. In accordance with the 100%-renewable-energy-target the following indicators in order to accomplish the targets are identified in the Customer perspective.

The first lagging indicator, in order to gain customers, is *competitive energy prices*. In accordance with the national targets, this is also a premise for regional energy systems. It contributes to the economic target of stable energy prices and can be achieved through the leading indicators profitability of energy projects. A premise for reaching customer is suitable pricing models. This in return, requires investment into cost-efficient technologies and energetic efficient projects. This challenges the design of regional energy systems that is addressed in the Internal Process perspective

The second lagging indicator that supports gains in customers is *public acceptance*. As it was outlined earlier, this term comprises various claims, interests and concerns of the stakeholders when regional energy systems are developed. Only if a certain level of public acceptance is accomplished, can the realization of projects be feasible and citizens, businesses, and local industries purchase energy from region's energy systems. We could learn from the previous chapter that the level of acceptance often correlates with the regional actors. Thus, acceptance is easier to achieve if projects are initiated by municipal utilities or administration than by regional initiatives.

Nonetheless, besides the actor and initiator groups, further influencing variables exists that determine the public acceptance. Economic success can only be achieved when public acceptance is present, and the relevance of the environmental aspects in this context becomes apparent here. Local emissions from the regional systems that create health concerns are the major obstacle in the implementation phase of a project. Similarly, adverse effects on the settlement development or interferences in the appearance of the landscape are barriers for project planners. A leading indicator is the collaboration between the responsible of the formal planning process and the energy project planners. Siting processes and the selection of suitable energy technologies can be improved. As the findings from the 100%-EER project have shown, energy regions require a municipal resolution and an energy program with energy targets as a basis. This allows the enhanced coordination and better cooperation. Strong coordination and cooperation provide the basis to effectively considering environmental and health concerns, as well as individual interests. However, many regions are not yet progressed to that stage, nor do they know the energy consumption of the region. Moreover, some have not yet determined the regional energetic potentials. In consequence, these factors inhibit the development of energy targets. Besides the avoidance of adverse health effects from noise, air pollution or waste, a better coordination would also allow an improved landscape and nature protection.

Nevertheless, an enhanced planning process that may result in more public acceptance can be achieved through the greater participation of stakeholders. If stakeholders function as project planners or perhaps later on as operators, they gain some form of technological control over the organization of the project. Through the involvement of stakeholders the development and implementation can be improved since various interest groups are represented and can be influential. A further factor that may contribute to more public acceptance and allows further beneficial effects is the financial participation. If stakeholders of the planning and implementing process participate financially at the same time, they have a say in the pricing and are the benefiters of the gained revenue. Furthermore, local capital is invested in regional projects, which affects the maximum added value for the region.

4.2.3.3 Internal Process Perspective

Competitive energy prices and public acceptance are key factors for the economic success. These two targets bring certain requirements to the regional energy systems that have to be met in the Internal Process perspective. The main targets of this perspective that intends to support the targets of the Customer perspective are project cost-efficiency and the minimization of the potential for conflicts.

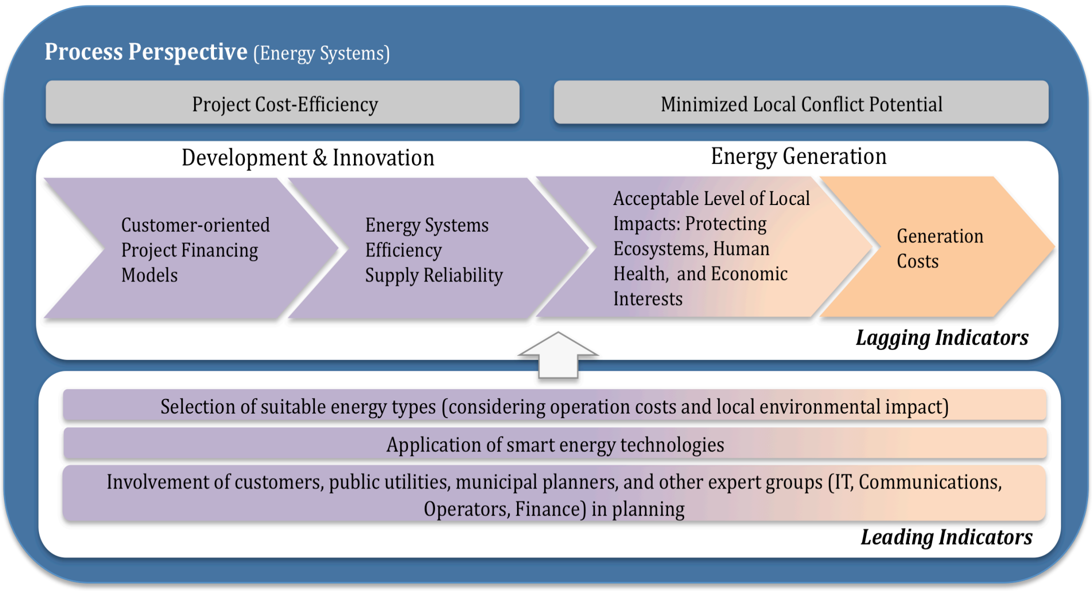

Figure 21 - SBSC for Energy Regions: Internal Process Perspective (Author's own illustration based on Kaplan and Norton 1997, p.9 and Hahn and Wagner 2001, p.14)

In a first step the focus is on the development of regional energy systems and in a second on the provision of energy services. However, the content of these two steps and the implications to the generation of leading indicators are overlapping. The main lagging indicator is the energy system's *cost-efficiency*. The design lays out the basis for the associated costs for energy generation. In regard to renewable energies, generation costs are less exposed to resource prices once they are generating energy. By contrast the variables in cost planning are rather in the implementation of installations. First, the selection of the energy technology in regard to the costs is of importance, and second, a major cost variable is the design of the overall system. The combination of energies, network structures, storage capacities, and smart energy technologies allow efficiency gains. Improved resource and cost efficiency are the results that contribute to profitability and environmental sustainability.

The design of the system also decides about *potential conflicts* from local impacts. However, associated issues are of broader magnitude and have to be addressed already in the Learning and Development perspective, where the stakeholder collaboration and basic regional planning is the focus. The Internal Process perspective primarily concerns technological alternatives during project planning. In order to reach the targets of reducing the environmental impact and avoid health risks, the involvement of interest groups is required, and furthermore experts are essential when conceptualizing regional systems. Besides experts, such as local utilities, IT, communications, operators, and finance, that are required in regard to establishing efficient and reliable systems, individuals, private and municipal project planners are essential. In a joint effort they can contribute to minimize the environmental impact and costs through efficiency gains from optimized project planning, facility installations and the application of appropriate system components.

The establishment of efficient energy systems and associated energy generation cost are two lagging indicators contributing to the targets in the Internal Process perspective. Furthermore, the design of the project-financing model is influencing the profitability of a project as well. Financial participation can be indicative of success. The shareholder, who ideally is a customer as well, participates in the pricing process and profits from the revenue. At the same time, as a customer, competitive pricing is of interest as well. This also results in induced economic effects. In contrast, supraregional investors are less desirable, as less value is added to the region. Participation may not only contribute to the price attractiveness and regional added value, it may also facilitate the implementation process.

4.2.3.4 Learning and Development Perspective

The overall target of the Learning and Development perspective is the *effective collaboration* of the different interest and expert groups. Activities within this perspective lay out the basis to accomplish efficient energy systems that enable cost-efficiency and a reduced environmental impact. It could be learnt from chapter 3.3 and 3.4 that there are some basic requirements that concern the development of an energy region. One is the joint consideration of formal and informal planning. Land use issues can be avoided if spatial planning concepts consider energy targets. Thus, competitive land use or competing economic interest can be addressed, and ecologic impacts minimized. A lagging indicator is the accomplishment of regional energy targets and ideally a municipal resolution on the region's future development.

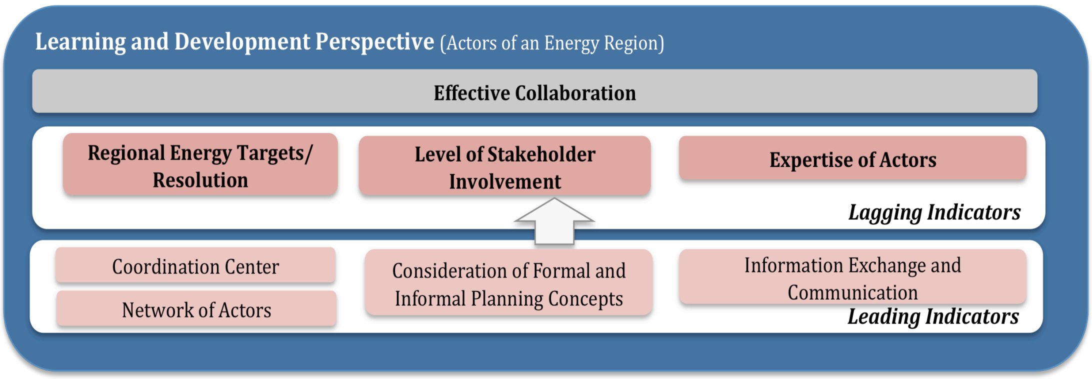

Figure 22 - SBSC for Energy Regions: Learning and Development Perspective (Author's own illustration based on Kaplan and Norton 1997, p.9 and Hahn and Wagner 2001, p.14

The region's commitment to the 100% renewable energy target, a high level of stakeholder involvement and a wide scope of expertise are the lagging indicators of this perspective. The participation of various experts in the development supports a design of a sustainable energy system. A network of experts allows for a maximum of efficiency and environmental sound planning. An effective network of actors, a center that coordinates actors, and the exchange and communication of information between actors are the leading indicators for a successful collaboration.

In the Learning and Development perspective, environmental and social aspects can be integrated already from the beginning, resulting in increased consideration in other perspectives. Therefore, taking into account environmental and social aspects at all stages of a project. As mentioned earlier, the foundation for most regions are determining energy targets and to pass a resolution, which supports joint project planning.

4.2.3.5 Overview of the Sustainability Balanced Scorecard of Energy Regions

Although the SBSC is formulated in a top-down process, the structure can be regarded more flexible due to the fact that each scorecard needs to be modified for its specific purpose. *Kaplan* and *Norton* put emphasis on the fact that the structure needs to be oriented by the particular corporate strategy (Kaplan and Norton 1997, p.33). The instrument explains the tie points and the causal-and-effect-relationship between the perspectives. It illustrates how lagging and leading indicators are interconnected and affect one another.

It was determined as the overall strategic target for a region to accomplish an energy supply from 100% renewable energies. The SBSC describes aspects for the four perspectives that contribute to this target. Environmental and social aspects are integrated that are relevant to accomplish the overall target. The Finance perspective contains the potential economic targets that energy regions typically pursue when intending to be supplied by 100% by renewable energies. The region's economic interests are to add regional value, to facilitate stable energy prices and to promote local investment. The Customer perspective focuses on the target to increase the market share of energy from the regional energy systems. Thus, it contributes to the economic targets and directly supports the accomplishment of the overall target. The accomplishment of the overall target requires cost-efficiency of potential energy systems. Furthermore, conflicts between regional interest groups that hinder the implementation have to be avoided. The Internal Process perspective targets a design of regional energy systems that enables cost-efficiency and minimizes conflicts between regional interest groups. Affords to optimize the collaboration of actors and all sorts of stakeholders furthermore facilitate the accomplishment of the overall target. Leading indicators within each of the four perspectives point out aspects to be considered in regard to the objectives. Lagging indicators signify the status that needs to be achieved

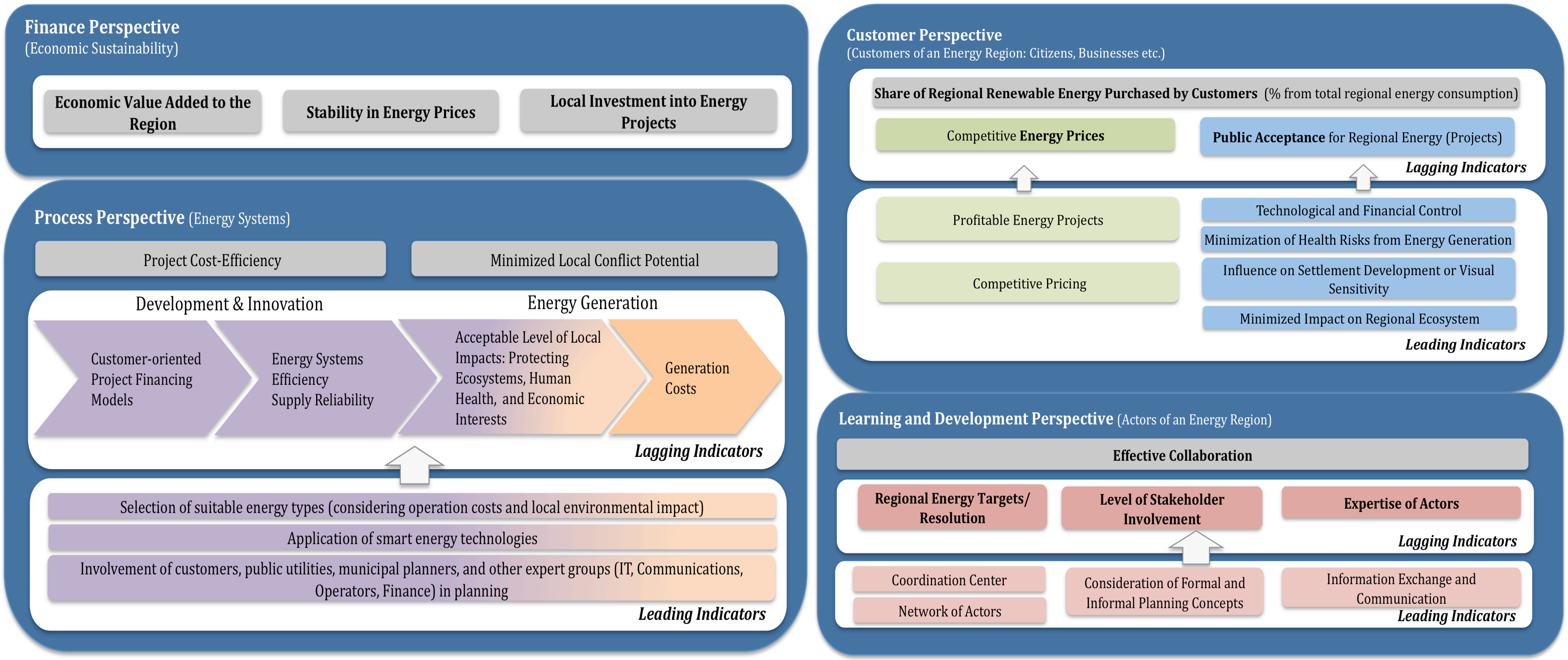

Figure 23 - Sustainability Balanced Scorecard for Energy Regions (Author's own illustration based on Kaplan and Norton 1997, p.9 and Hahn and Wagner 2001, p.14)

5 Discussion

Increasing resource prices and instability in energy supply challenge the viability of our energy systems. Simultaneously, environmental degradation, and climate change are the results of conventional systems. The transformation of energy systems relies on local projects that are in the works and often point the way ahead. A paradigm shift can be induced through energy projects that rely on a new system architecture and that consider ecological limitations and public acceptance. In the past, energy concepts were predominantly used for planning and implementing projects at local levels. In an attempt to better integrate environmental and social targets in a structured manner, a SBSC for energy regions was developed. Furthermore, it was the intention to bridge the gap between strategic targets planning and local planning and implementation processes.

Three concrete objectives were defined to be pursued in the development of the SBSC for Energy Regions. First, it was the intention to facilitate the sustainable provision and the use of energy. The aim was to integrate sustainability aspects throughout the development of the scorecard. The major advantage of the concept of the scorecard is that only strategic relevant aspects are included, thus only essential aspects for the success are considered. Environmental and social aspects are considered within all perspectives of the SBSC, however, the focus is on the Internal Process perspective, where the design of energy systems is the focus. Significant contribution to facilitate provision and use of energy comes from the learning and development perspective. The regional planning processes, which include stakeholder involvement and defining regional targets, is emphasized here and provides a basis. These two perspectives might be seen as most relevant and suitable for planning and implementing sustainable regional energy systems overall. The internal process perspective can be seen as the heart of the SBSC that includes the most relevant variables to successfully implement sustainable energy systems. On the downside, the environmental and social aspects that have no direct relevance for the success, for instance the GHG emissions from operations, are disregarded.

The second objective was to enable the user of the instrument to define and pursue targets typical for energy regions. It was the assumption that all energy regions pursue the overall target to accomplish an energy supply of 100% from renewable resource. Following this overall strategy, targets were defined for each perspective. Numerous targets of the SBSC correspond with targets representative for sustainable community development (see Table 2, p.56). However, they were tailored to an energy region. The author did not intend to exclude the possibility to add further targets, but to emphasize essential key factors to be used as aiming points when planning sustainable regional energy systems. Thus, the suggested targets are intended to be used universally across regions as they are significant landmarks for the development of 100%-EER and provide direction to a potential instrument user. The identified targets may support the local planning processes in a region or even a single project.

Exemplary target values were outlined in chapter 3.3.3, which provide a basis for measuring the success of an energy region within the three sustainability dimensions. They allow for the comparability between regions and to the national status. Integrating these target values in the SBSC in a next step also provides the opportunity for a more standardized concept.

In order to measure the effectiveness of the developed instrument in regard to its contribution to the accomplishment of regional targets, it has to be applied in a series of real cases. Nevertheless, from a theoretic point of view, the SBSC's strength seems to be the integration of variables that, if considered, have a positive effect on the region's success. Within the four perspectives, only relevant aspects are analyzed. In this process, the structure of the BSC also supports the identification of aspects from four different perspectives. This may help to learn more about the utility for certain actor groups and the expectations to them, which was considered as desired above. The disadvantage is that at the same time this also limits the scope of consideration to only these perspectives, nevertheless, if desired, they can be adjusted. The scorecard is an instrument with the ability to provide planning orientation and considers aspects that are relevant to success, however, it does not support detailed planning.

The third objective for the development of the instrument is to provide a common conception to coordinate stakeholder participation and project planning. This primarily comprises the Learning and Development perspective that addresses regional planning processes and actor groups. In terms of the chronological order of a project, the Learning and Development perspective is the first step in the process, as it is desirable for an energy region to define targets and to pass an official resolution. In a second step, regional stakeholders can be gathered, actor networks can be built, and experts involved. Creating cause-effect-relationships allows for the identification of the relevance regarding the economic success. A major strength of the scorecard is that the importance of some aspects is portrayed, which otherwise might be neglected due the missing distinction of the relationships. The importance of stakeholder involvement, which is emphasized within the 100-EER project (see Ch. 3.4), can be visualized within the scorecard.

A general advantage of the structure of the instrument, which indicates cause-effect-relationships, is that the overall product, the SBSC for energy regions, does not only indicate what to do, but also why to do it. Instead of solely providing guiding targets, the user of the instrument is able to relate the targets to the resulting effects. This contributes to a better understanding by all stakeholders and enhances the practicability of the instrument.

Practicability of the instrument is generally a major aspiration to support the strategy implementation process. In this context, it was also intended to provide a clear overview of the utility for and the expectations from citizens, corporations and the administration in the region. In regard to the ease of the instrument it can be said that, despite its complexity it is fairly easy to understand. Regarding its application, however, modifications to the region or project may be required, which is not surprising as *Kaplan* and *Norton* already pointed out the need for adjustments to the specific requirements of a business unit (see Ch. 1.2.). In this context the integration of the suggested target values may also be appropriate if needed.

The SBSC, potentially used by regional planners, is a holistic approach that concerns the planning of energy regions in a whole and not from the perspective of a particular audience only. Citizens, corporations and administrations can make use of it and identify the potential. It allows all types of groups to better understand their role, resulting in a better understanding of what are expected contributions of each actor and what are their benefits.

When developing a regional energy system with the target to fully supply a region with renewable energy the scorecard can be used as a planning instrument. It still requires adjustments to the local needs, and modifications based on the outcomes from practical projects, information from local networks, and research. It can be considered as an appropriable instrument that supports the accomplishment of defined objectives and beyond. Its contribution to accomplish strategic targets may also provide additional benefits in comparison to other instruments. The major advantages are the cause-effect-relationships, the integration of all economic relevant environmental and social aspects, and the characteristic of demonstrating the importance of stakeholder participation, which traditionally is not a part of an instrument. Detailed planning, however, finds less attention. Also, the energy conservation aspect experiences less attention within the fours perspective of the scorecard although it was identified as a major target of an energy region.

The SBSC for energy regions was closely structured in accordance to the original BSC. In contrast to the case where the SBSC was applied beyond corporate level, to the City of Graz, only minor modifications were implemented. The perspective's titles of the SBSC for energy regions have not been changed and the perspective's targets were adopted from the conventional targets suggested by *Kaplan* and *Norton* and modified to an energy region. In comparison to the other case, where a conventional BSC was applied in the case of energy regions, the development of an SBSC strengthens the consideration of sustainability aspects in the planning and implementation process in a region. In this former scorecard, the extension of renewable energy was simply considered as developing sustainable energy systems. Using the SBSC for energy regions enables studying the environmental and social aspects more in-depth and highlighting their relevance for the success.

6 Conclusion and Future Implications

Some characteristics of the developed SBSC for Energy Regions are very supportive when planning and implementing regional energy systems. The instrument provides decisive targets within each perspective and contributes to accomplishing regional targets through illustrating crucial landmarks. A further positive factor is the possibility to modify its structure to a practical case. This flexibility increases the effectiveness of the instrument as it provides a foundation including a broader framework that can be added by further aspects. The applicability of the instrument though has to be tested in a practical case. This study focused on the suitability of the structure of the instrument including the content of the four perspectives.

The structure the SBSC allows for the successful integration of most sustainability aspects into the instrument. Thus, it effectively enables the consideration of sustainability in the planning and implementation process. The advantage of considering strategic relevant aspects is at the same time the drawback, as from a perspective of contributing to sustainable development, it is negative that certain aspects are disregarded in the process of identifying the strategic relevance of environmental and social aspects. The founding idea of strengthening the integration of sustainability into a corporation's strategy by aligning them to the economic success also excludes some aspects that are not relevant. This is a main disadvantage of the concept of the BSC itself, which may need to be addressed in future, when applying the SBSC for energy regions.

The SBSC is an instrument that provides support to regional planners and is intended to contribute to the transformation of energy systems by providing guidance in local planning and implementation. Additional research and information gained from practical projects should be further included in the four perspectives of the SBSC. This would improve its effectiveness and complement relevant aspects in order to update the instrument, a prerequisite in this dynamic field and environment of change.

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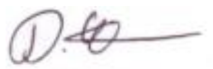
Declaration

Hiermit versichere ich, dass ich diese Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe. Außerdem versichere ich, dass ich die allgemeinen Prinzipien wissenschaftlicher Arbeit und Veröffentlichungen, wie sie in den Leitlinien guter wissenschaftlicher Praxis der Carl von Ossietzky Universität Oldenburg festgelegt sind, befolgt habe.

Unterschrift



Appendices

Appendix 1 - Prototype Balanced Scorecard for Regional Energy Supply

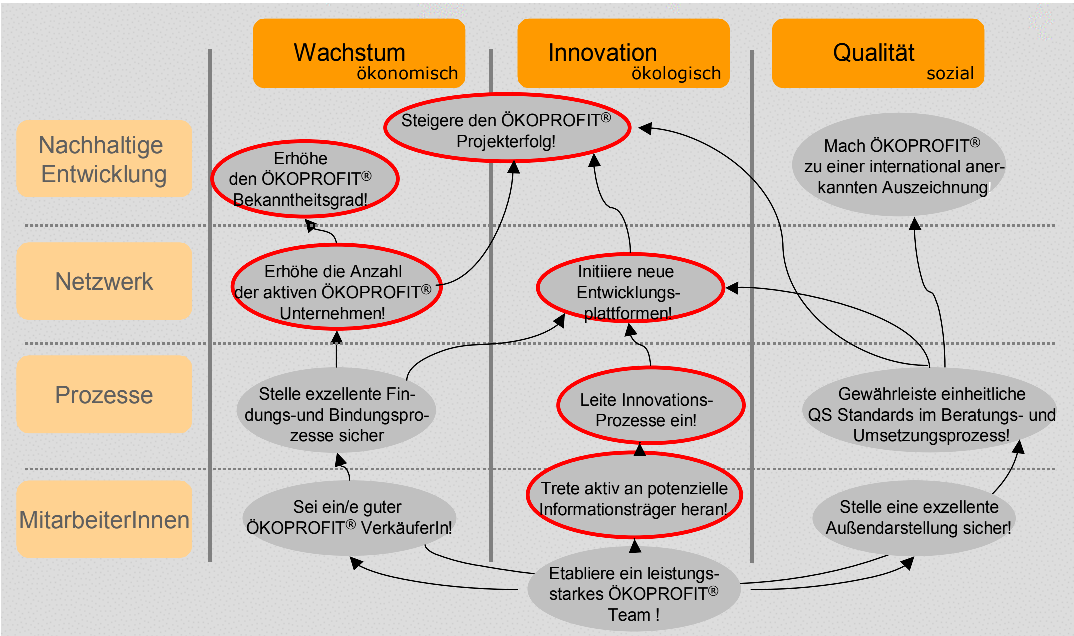
Übergeordnete Vision

„Unsere Region will durch den Einsatz erneuerbarer Energien und von Energieeffizienz zukunftsorientiert, nachhaltig und wettbewerbsfähig aufgestellt sein".

Perspektiven der Balanced-Score-Card (BSC)	**Vision und Übersetzung der BSC auf die regionale Zielperspektive**	**Kriterien**	**Mögliche Kennzahlen / Kategorien f. Kennzahlen**
Finanzperspektive *(Erträge und Kosten)*	**Die Praxis erweist die REV als das kostengünstigere Modell** Regionen sind primär an nachhaltig ökonomischen Erfolgsmodellen interessiert Regionen sollten ihre Kompetenz durch ein zukunftsweisende und -fähige regionale Energieversorgung schärfen und so auch ihr Human- und Gesellschaftskapital weiter-entwickeln.	• Auswirkungen auf die regionale Einkommensentwicklung (spezifische Ertrags- und Renditeparameter) • Umfang des regional eingesetzten Kapitals, Investitionen und Reinvestitionen • Externe Unternehmensnutzen bzw. -kosten: Umwelt-Energie- und Sozialkosten bzw. Gewinne, Logistik, Arbeitsplatzauswirkung	• Durchschnittliche Ausgaben der Unternehmen, privaten sowie öfflichen Haushalte für Energieprodukte und Dienstleistungen in Euro im Verhältnis zum jeweiligen Gesamtvolumen von Einkommen bzw. Budget sowie den jeweils anfallenden Gesamtkosten (möglichst räumlich aufgeschlüsselt in kommunale Ebene, Landkreis, regionale Ebene) (Bemerkung: um die Bedeutsamkeit und Gesamtamtaufwendungen beurteilen zu können) • Umsätze und Gewinne der regionalen Unternehmen durch Produkte und Dienstleistungen für erneuerbare Energien oder Energieeffizienz • Anzahl der Arbeitsplätze in regionalen Unternehmen durch Produkte und Dienstleistungen für erneuerbare Energien oder Energieeffizienz • Anteil an Bürgerkapital an kleinen und mittleren Unternehmen (KMU) oder Genossenschaften der Region für Produkte und Dienstleistungen im Bereich erneuerbare Energien und Energieeffizienz • Anteil von Bürgerkapital an Projekten zu erneuerbaren Energien und Energieeffizienz • etc
Markt- und Kundenperspektive *(Zufriedenheit der Kunden, Kunden-anbindung)*	**In der Praxis erweist sich die REV als die Lebensqualität der Menschen erhöhend** Regionen sind primär an Unternehmen, Lösungen und Produktionsbereichen interessiert, die sich (in der Summe ihrer Wirkungen) positiv auf die Lebensqualität der Menschen auswirken **Es geht um einen vertrauensvollen Verbraucherbezug**	• Akzeptanz, Verständlichkeit- + Einbezogenheit (sbj.L) Vorteils-, Bequemlichkeits-, und Serviceauswirkungen (sbjL) • Servqual-Kriterien / GAP-Modell (sbjL), • (Trend-) Auswirkung auf die Menschen der Region: Gesundheit, Soziales, Arbeit (besser-schlechter) (oL), • Produktionsbedingungen und deren Auswirkungen auf die Menschen, Beschäftigten, Region (oL) Sozialer und ökologischer Fortschritt (oL)	• Anteil der ortsansässigen Kunden mit Nachfrage nach Produkten und Dienstleistungen regionaler Unternehmen für erneuerbare Energien oder Energieeffizienz im Verhältnis zur Nachfrage bei überregionalen Anbietern bzw. zur Gesamtnachfrage • Anzahl der regionalen Lieferanten in der Wertschöpfungskette von regionalen Unternehmen im Bereich erneuerbare Energien oder Energieeffizienz • Ergebnisse regelmäßiger Kunden-Zufriedenheitsanalysemessungen • Häufigkeit und Länge der Transportwege in der Liefer- bzw. Wertschöpfungskette im Bereich erneuerbare Energien oder Energieeffizienz • Abgestimmtes Beschwerde bzw. Verbesserungswesen (Anzahl der Vorschläge / Verbesserungen) • Häufigkeit und Länge der Transportwege zum Endkunden für Produzenten und Dienstleister im Bereich erneuerbare Energien und Energieeffizienz • etc
Wachstums- und Potentialanalyse *(Einschätzung vergleichbar Portfolio, Voraussetzungen)*	**Die REV bedingt die Entwicklung von neuen Technologien, Verfahren und Wertschöpfungsketten** *„Durch die Förderung erneuerbarer Energien und Energieeffizienz sollen sowohl Wachstum, Produktivität und Nachhaltigkeit für die Wirtschaft erhöht werden."* Regionen sind primär an Unternehmen interessiert, welche Verfahren und Lösungen der Spitzentechnologie verwenden (best-practices)	• Zukunftsfähigkeit der Technik und Verfahren • Wissenschaftliche Bewertung, Patente und Einzigartigkeit.(USP), • Differenzierungsfähigkeit Wirkgrade: energetisch, sozial • Konvergenz-, Vernetzungs- und Integrationsfähigkeit	• Anzahl der Innovationen von regionalen Unternehmen durch Produkte und Dienstleistungen für erneuerbare Energien oder Energieeffizienz • Entwicklung der Umsätze und Gewinne der regionalen Unternehmen durch Produkte und Dienstleistungen für erneuerbare Energien oder Energieeffizienz • Anzahl der jährlich neu gewonnen Arbeitsplätze in regionalen Unternehmen für Produkte und Dienstleistungen erneuerbarer Energien oder Energieeffizienz • Anzahl der regionalen Unternehmen für erneuerbare Energien oder Energieeffizienz mit Existenz seit fünf Jahren, 10 Jahren, 15 Jahren etc. (Beständigkeit der wirtschaftlichen Tätigkeit von Unternehmen in der Region) • Anzahl und Größenordnung der Unternehmen der regionalen Unternehmen für erneuerbare Energien oder Energieeffizienz und ihre Zunahme an Mitarbeitern • Zuzug von Neubürgern in in die Region durch spezielle Angebote im Bereich erneuerbare Energien und Energieeffizienz bspw. über die kommunale Bauleitplanung • etc
Prozess- und Strukurperspektive *(Variablen des Prozess-managements)*	**Die Umsetzung einer REV bedeutet einen wertvollen Beitrag auf die Standortqualität** *„Regional verortete und verantwortlich wirtschaftende Unternehmen sollen mit den Bürgern bzw. Kunden über die Herstellung und Verwendung erneuerbarer Energien und Energieeffizienz neue stabile Märkte und Wirtschafträume mit Kompetenz und Know-how als lernende Region und dadurch möglichen kontinuierlichen Entwicklungs- bzw.*	• Kriterien die einen Vergleich mit anderen / angrenzenden Regionen zulassen (z.B: Infrastrukturangebote) • Attraktivität des Standortes für z.B. Wirtschaftsunternehmen aber auch die Bevölkerung, spezielle Gruppen (Alter, Geschlecht, Familien, Migranten/Internationaliät etc.), • Kriterien welche die Wettbewerbsfähigkeit einer Region / regionalen Lösung ausdrücken (z.B. Projektdurchführungskompetenzen,	• Anzahl der Anfragen/Interessensbekundungen regionaler Unternehmen für erneuerbare Energien oder Energieeffizienz zur Standortansiedlung • Anzahl der Schulungen zur Ausbildung benötigten Personals im Bereich erneuerbare Energien oder Energieeffizienz • Anzahl und Intensität gemeinsamer Initiativen zur Förderung erneuerbarer Energien und Energieeffizienz • etc
	Verbesserungsprozess für die Stabilität der Lebens- und Standortqualität in der Region schaffen." Regionen sind primär an der Ansiedlung von Lösungspartnern interessiert, welche die Standortqualität erhöhen d.h. die Ansiedlung von Wirtschaftsunternehmen und definierten Bevölkerungsgruppen ermöglichen. Hierfür entwickeln die Regionen geeignete Infrastrukturen und Kompetenzen (z.B. Management- und Projektdurchführungs-kompetenzen).	Gründerzentren, • Managementerfahrung) • Nachhaltigkeits- (Sustainable) und Umweltberücksichtigung • Demokratie- und Gesellschaftsentwicklung • Vernetzungsbereitschaft und –fähigkeit	

Source: George, Bonow and Hoppenbrock 2009, p.20

Appendix 2 - Strategic Targets of the SBSC for the Ökoprofit Network in the City of Graz



Source: Fresner, et al. 2006, p.40