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Towards CO_2eq-neutral Cities: A participatory approach using Backcasting and Transition Management

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Content Overview

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Summary

The need for global climate change mitigation has sparked climate protection activism on the city-scale in Germany. As one of the main sources for CO_2-emissions, cities are of particular importance in the context of climate change. Due to the high population density of cities, which results in a highly centralised energy consumption in addition to limited available space for renewable energy, cities face a particularly difficult challenge to achieving emission reductions. Financially supported by the German government, an increasing number of municipalities are developing climate protection concepts. Several climate protection concepts for cities in northern Germany were compared, in order to identify the general practice and methodological approaches used on the city-scale.

After reviewing the climate protection concepts previously developed for cities in northern Germany, it was found that a standard methodological approach was lacking. Among the reviewed climate protection concepts, goal orientated approaches were rarely applied. Although most cities had defined CO_2-emission reduction targets, in less than half of the cases were the respective city's CO_2-emission reduction targets achieved when the defined measures were implemented. Furthermore, the setting of long-term goals, in order to attain highly ambitious reduction targets, was lacking among the concepts. None of the reviewed cities had set a CO_2-emission reduction target beyond the year 2030. Based on these findings, a novel methodology for climate protection on the city-scale was developed.

According to the Intergovernmental Panel on Climate Change (IPCC), industrialised countries, such as Germany, must reduce their CO_2-emissions by 80 to 95 % by the year 2050, to avoid the most severe consequences of global climate change. The achievement of such high reduction goals requires that, where possible, CO_2-emissions are even further decreased to compensate for areas where high CO_2-emission reductions are very unlikely from today's perspective. The term CO_2eq will be used in this thesis to indicate that in addition to CO_2 all other greenhouse gases regulated within the Kyoto-Protocol Annex A are considered. Thus, the developed methodol-

ogy was tailored to the specific requirements of cities with highly ambitious CO_2eq-emission reduction targets, such as 100 % CO_2eq-emission reduction, also termed "CO_2eq-neutrality".

The novel methodology incorporates the goal-orientated backcasting approach for the development of climate protection measures. A desired CO_2eq-emission reduction target, for example CO_2eq-neutrality by the year 2050, is set and then climate protection measures are defined for achieving this goal. For a long-lasting climate protection process on the city-scale, policies for a transition towards a CO_2eq-neutral city must be established and maintained, in the long-term. Therefore, transition management, an approach that focuses on the implementation of transforming systems over a time period of one to two generations, was included in the developed methodology.

The use of backcasting and transition management, in tandem, was identified as a promising concept. Further research was needed on how the two approaches may be combined and further advanced to achieve optimal results in the context of climate protection on the city-scale. For example, one short-coming of backcasting is that it lacks a management strategy. When backcasting is incorporated into the transition management process, it adopts the relevant management and implementation strategies, thus re-enforcing it. The transition management process is improved by the use of backcasting for the development of climate protection scenarios, due to the goal-orientated approach for scenario development regarding climate protection measures.

The achievement of ambitious CO_2eq-emission reduction targets largely depends on the acceptance and willingness of stakeholders and the public to contribute to these aims. Top down approaches "forcing" solutions onto the stakeholders and the public are not considered the right means to achieve the necessary transition to long-lasting sustainable development. Participation is seen as a key factor to achieve changes. Furthermore, mitigation of climate change depends entirely on human decisions (behavioural, as well as investment decisions). The reasons and possible influences for human behaviour and decision making are analysed in the field of human psychology. Relevant contributions include the development of intervention instruments to encourage climate friendly behaviour, the development of strategies for encouraging individuals or companies to make decisions based on social interests, the development of communication networks such as informal networks for promoting climate protection, and the provision of insight into the importance of stakeholder participation.

Combining backcasting, transition management, and insights from psychology, a thorough methodology for the development of climate protection concepts and the establishment of a climate protection process on the city-scale was developed. An overview of the main steps of the newly developed methodology for cities is presented in Figure 0.1, followed by a concise description of the individual steps.

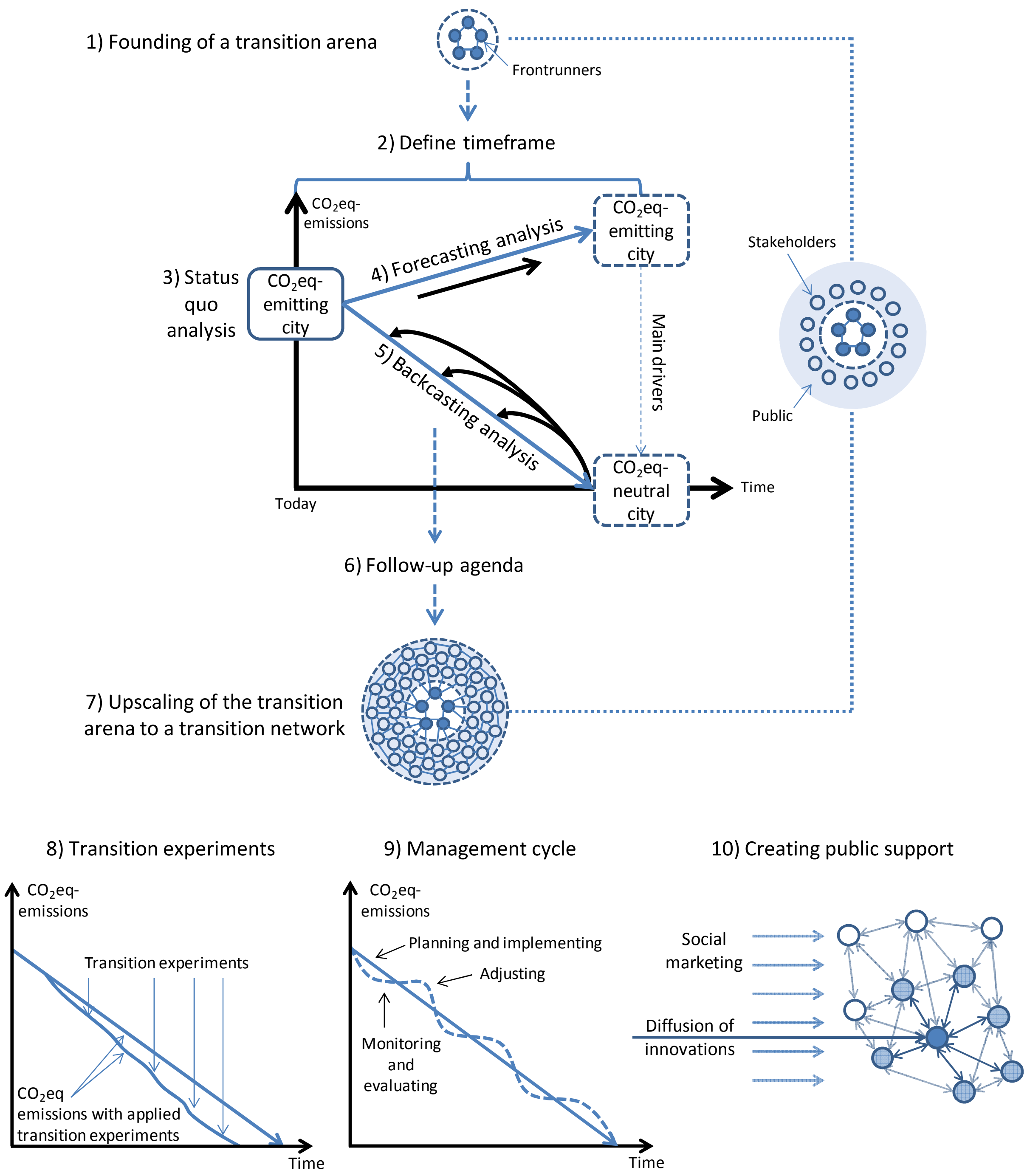


Figure 0.1: *New methodology for cities which aim to obtain CO_2eq-neutrality*

Step 1: Founding of a transition arena To start and establish the process of climate protection on the city-scale, a "transition arena" (a group of locally rooted stakeholders) is founded. The transition arena promotes the idea of local climate protection by using their existing networks and stimulating the formation of new coalitions. The transition arena is responsible for ensuring the long-term continuation of the transition towards a CO_2eq-neutral city.

Step 2: Define timeframe The second step is to define the timeframe for achieving the goal of a CO_2eq-neutral city. The target year is determined by the transition arena in a participatory way. Taking the particularities and specific challenges associated with different city sectors and branches into account, an ambitious target is set that still allows all sectors of a city to achieve the goal.

Step 3: Status Quo analysis After defining the timeframe, a status quo analysis is performed. The status quo analysis is used to quantify energy demand and CO_2eq-emissions within the city borders. The status quo analysis also includes the identification and involvement of relevant stakeholders in the city. The status quo analysis is a crucial step, as it lays the foundation of the forecasting and backcasting analyses.

Step 4: Forecasting analysis A forecasting analysis is performed to determine how energy demand and CO_2eq-emissions of a city will develop over time, if current trends continue. Therefore, the main drivers of energy demand and CO_2eq-emissions are identified, and their future development is determined. Analysing the future development of drivers and the resulting development of energy demand and CO_2eq-emissions prevents over- or underestimating the necessary amount of climate protection measures to take. The analysed development of drivers is integrated into the backcasting analysis.

Step 5: Backcasting analysis Based on the results of the status quo and forecasting analyses, a backcasting analysis is performed. In this step, climate protection measures are determined for achieving of a CO_2eq-neutral city. The knowledge and the experience of local stakeholders and the public is used to develop a climate protection concept with the best possible specific solutions for the city in question. Together with the stakeholders, a scenario is constructed that identifies and quantifies climate protection measures. The backcasting scenario contains the information about when, what and to which extent climate protection measures should be applied to achieve a CO_2eq-neutral city.

Step 6: Follow-up agenda The step "follow-up agenda" is included to increase the chance of implementation of the developed climate protection measures. The follow-up agenda contains objectives, projects, and responsibilities for planned activities to achieve a CO_2eq-neutral city. These are the climate protection measures that have been agreed upon during the backcasting analysis. The agenda is also used to identify barriers for the transition to achieving a CO_2eq-neutral city and to develop suitable strategies to reduce these barriers. The follow-up agenda also includes an implementation strategy.

Step 7: Upscaling of the transition arena to a transition network In this step, the transition arena is upscaled to increase the number of people committed to the climate protection process on the city-scale. By following the presented steps of the novel methodology, the process of upscaling the transition arena is already partly achieved. In the process of founding the transition arena, performing the status quo, and forecasting and backcasting analyses, more people become involved in and committed to the process over time. The upscaling of the transition arena to a transition network is a continuous process.

Step 8: Transition experiments A climate protection process has to have the flexibility to respond to new developments, therefore the step "transition experiments" is included in the novel methodology. Transition experiments are normally high risk, expensive, and time consuming projects, but when successful, contribute greatly to reducing CO_2eq-emissions. First, possible transition experiments are identified and then prioritised for testing. The tested transition experiments are evaluated and the decision is made about whether or not the transition experiments should be upscaled to a widely applied technology.

Step 9: Management cycle The climate protection process needs to be monitored and controlled on a regular basis. The management cycle includes the phases of planning, implementing, monitoring, evaluating, and adjusting. Every year of the implementation phase, the question is raised as to whether the intermediate goals have been fulfilled. If this is the case, the process continues as planned, to achieve a CO_2eq-neutral city. If the goals were not fulfilled, adjustments to the climate protection process and the defined climate protection measures are necessary.

Step 10: Creating public support The focus of the participatory approach is on motivating local stakeholders and raising awareness of the general public. Successful stakeholder involvement is dependent on strong public support. Using the theories of diffusion of innovations and social marketing, effective tools for the communication and distribution of behavioural changes are applied.

The presented methodology for the participatory development of climate protection concepts for cities with the aim of obtaining CO_2eq-neutrality using backcasting, transition management, and psychology was successfully applied in a case study. The city of Flensburg, Germany was chosen for testing the developed methodology. The main objective of the case study was to test the novel methodology and to gain in-depth insights into the participatory concept development for cities with highly ambitious long-term emission reduction targets. A summary of the case study is provided below.

The transition arena in Flensburg, titled Klimapakt Flensburg, was founded by nine local institutions, companies, and organisations in December 2008. The ambitious aim of the transition arena was to reduce the CO_2eq-emissions for the city of Flensburg by 30 % by the year 2020, and to obtain CO_2eq-neutrality by the year 2050.

In 2009, over a time period of ten months, a status quo analysis and forecasting analysis were performed. The development of the total CO_2eq-emissions of Flensburg from 1990 to 2006 was quantified in the status quo analysis. In the year 2006, Flensburg emitted more than one million tons of CO_2eq into the atmosphere. The forecasting analysis showed that a continuation of given trends is insufficient to achieve significant CO_2eq-emission reductions. Introducing the forecasting scenario provided a strong starting point for illustrating, on a scientific level, the need for the implementation of a climate protection concept for the city of Flensburg.

During the backcasting analysis 16 workshops were conducted, to develop over 100 climate protection measures for the city of Flensburg, for achieving their target of CO_2eq-neutrality. More than 200 people, including representatives from over 50 local companies, organisations, and institutions attended the workshops. It was found that a high degree of participation of stakeholders and the public is advantageous for the development of a city-specific climate protection concept. The stakeholders and the public are those ultimately responsible for the implementation of the developed climate protection measures, and their specific knowledge of the city helped to establish a climate protection process tailored to Flensburg's particular characteristics.

Including transition management into the novel methodology helped to set up a long lasting process for a city aimed at achieving CO_2eq-neutrality. The foundation of a local transition arena, and the upscaling of the transition arena to a transition network fit very well into the general process. In the Flensburg case study, the necessary structures for a transition towards a CO_2eq-neutral city were established in less than three years. Applying insights from psychology helped to facilitate the process of local climate protection. Being aware of psychological aspects and utilising them was found to increase the chance for the successful application of the novel methodology. A solid participatory basis for climate protection was established in the city of Flensburg, and from today's perspective, the ground-work has been laid for Flensburg to successfully achieve the goal of CO_2eq-neutrality by the year 2050.

The novel methodology and its application in the case study showed that the setting of long-term goals, partnered with highly ambitious reduction targets for a city, is possible and widely supported by local stakeholders and the public. The case study of Flensburg showed that the use of goal-orientated approaches in the development of climate protection concepts is a suitable approach and can have a positive influence on today's general practices. Other cities should be encouraged to follow in the same direction.

As a last remark, the application of the novel methodology to the city of Flensburg benefited from a political framework that financially supported the development of climate protection concepts for cities during a time period of one year. Developing and applying the novel methodology, it was found however, that setting up the necessary structures to generate a self-contained climate protection process on the city-scale requires more time than one year. The first two years of establishing a climate protection process on the city-scale were entirely funded by the Klimapakt Flensburg. To ensure a self-contained long-lasting climate protection process on the city scale, an extension of the funded project time from one to at least two years is recommended.

1 Introduction

Since the publication of the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2007b), there is little question that an anthropogenic global climate change is occurring. Since the beginning of the Industrial Revolution 250 years ago, humans have been contributing to a significant increase in green house gas concentration in the atmosphere through the use of fossil fuels. The concentration values of the most important greenhouse gas, carbon dioxide (CO_2), are far exceeding the natural range of the last 650,000 years (IPCC 2007a, p. 5). Already today, the manifold effects are noticeable. The sea level rose an average of three millimetres per year in the last two decades because of thermal expansion of the sea water and a global melting of ice (IPCC 2007a, p. 2). If the climate warming continues and the Greenland ice shield melts completely, it is predicted that the sea level will rise by seven meters in the next few hundred years (IPCC 2007c, p. 17).

The fact that CO_2 emissions into the atmosphere has an effect on the climate is not a new finding. Already in 1896, the Swedish scientist Arrhenius published a paper (Arrhenius 1896) quantifying the effect of carbon dioxide on the earth's surface temperature. In a later publication he pointed out that burning of fossil fuels can cause an increase in global temperatures. The fact that it took more than one hundred years for people to become aware of climate change, points out one of the main problems associated with this phenomenon: there is a time gap of generations between emitting green house gases and the resulting effect on the climate (IPCC 2001, p. 20). The delayed impact raises the question of intergenerational justice and sustainability. According to the IPCC, it is necessary to reduce the CO_2-emissions in developed countries by 80 to 95 % by the year 2050, in order to limit a severe rise in average global temperatures (IPCC 2007d, p. 776).

Cities are of particular importance in the context of climate change. Due to the high population density of cities, which results in highly centralised energy consumption in addition to limited available space for renewable energy, cities face a particularly difficult challenge in achieving emission reductions. In 2008, for the first time in human history, more than half of the global population was living in urban areas (UNFPA 2008, p. 90). In more developed, industrialised nations, the percentage of people living in cities is even greater than 75 % (UNFPA 2008, p. 90). Even though every country has its own definition of the term city, cities may be characterised as a concentration of people and companies with a certain level of infrastructure, and a dependence on external resources such as food or energy (Satterthwaite 2011, p. 1763). For the purposes of this thesis, in congruence with United Nations Population Division (2010), cities are defined according to the criteria used by each individual country.

Given the high population and density of people living in cities, they are one of the main sources for global CO_2-emissions. An advantage of city living is that a higher population density is found to reduce per capita energy consumption (Newman and Kenworthy 1999; Dodman 2009). The advantage is compensated by the disadvantage that cities are a "concentration of economic and industrial activities in the area" (UN-Habitat 2011, p.33) which increases the specific CO_2-emissions per m^2. The contribution of CO_2-emissions from cities to the global CO_2-concentration in the atmosphere largely depends on the calculation method. UN-Habitat (2011, p. 33) differentiates between production and consumption based analyses. Most emissions in cities are not caused by the production of goods, but rather by the activities of the urban population. UN-Habitat (2011) calculated that following a production based approach, 40 to 70 % of global green house gas emissions result from cities. Taking a consumption based approach, the value is between 60 to 70 %. Other studies even estimate the share of cities in total CO_2-emissions at almost 80 % (Larsen and Gunnarsson-Östling 2009, p. 260).

Cities are not only major contributors to global climate change, but they themselves are also largely impacted by the effects of climate change. There are a variety of studies in which the research is focused on global warming and the vulnerability of urban areas. An analyses of 64 case studies conducted by Lankao and Tribbia (2009) identified the six most important climate change related threats for cities: heat waves, storm surge, sea level rise, drought, changes in temperature, and air pollution. McGranahan et al. (2007) assessed the risk of sea level rise for coastal zones. Thirteen percent of the world's urban population is living in areas less than ten meters above sea level (McGranahan et al. 2007, p.17). This number is predicted to increase in the future.

The presented numbers are leading to the conclusion that cities are a responsible player in global climate change, and it is in their own interest to play a major part in reducing CO_2-emissions. The IPCC's reduction goal of 80 to 95 % of the total CO_2-emissions by the year 2050 for developed countries should be adopted by every single city of the Annex I countries. In the last years, an increasing number of municipalities are committing to CO_2-emission reductions, and joining networks related to energy efficiency improvements or the use of renewable energy sources. European examples are the European Covenant of Mayors (over 2,800 member cities) or the Climate Alliance (1,600 member cities). The achievement of a 80 to 95 % CO_2-emission reduction target requires a long-term sustainable strategy for cities. National and international policies are now directing their attention towards processes with the participation of different stakeholders and the public (Reed 2008, p. 2417). The German government has recognised the particular importance of the participatory development of sustainable strategies to reducing CO_2-emissions on a city-scale. Since 2008, the development of climate protection concepts for German municipalities has been financially supported by the German government. More than 1,000 concepts had already been funded by 2011.

In the next section sustainability, in particular as it pertains to cities, is addressed, and the use of this term is defined in the context of this thesis. This is followed by the development of a redefined approach to CO_2-neutrality for cities. For determining the common practice of climate protection on the city-scale, existing concepts for northern German cities are reviewed, and the applied methodological approaches compared. Having been developed based on the results from this comparison, the hypothesis of this thesis will then be stated and the relevant research questions listed.

1.1 Definition of sustainability in the context of cities

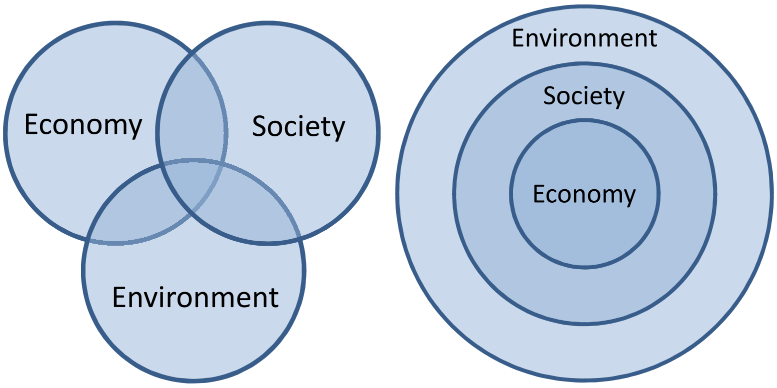
In Germany, the term sustainability was first used in the year 1713 by the forest ranger Hans Carl von Calowitz (Deutscher Bundestag 2004, p. 1). During the beginnings of the Industrial Revolution, he understood that the increasing wood demand would inevitably lead to a depletion of forests. His view of sustainability was based only on resource economics. It took over 250 years until more holistic approaches of sustainability were formed. In 1966, Nobel Laureate Sir Macfarlane Burnet, an Australian virologist, described the importance of sustainability when he advised that “the resources of the earth must be maintained for the use and enjoyment of future generations in a measure not less than we now enjoy” (Blutstein 2003, p. 339). Twenty years later, in the widely known Brundtland Report from the United Nations World Commission on Environment and Development (WCED), sustainability is defined as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland report 1987, p. 51). Even though they are often used interchangeably, a differentiation between “sustainability” and “sustainable development” is made. Following the definition of Moles et al. sustainability “is an aspirational future situation” whereas sustainable development is “the process by which we move from the present status quo towards this future situation” (Moles et al. 2008, p. 145).

With rising awareness of the importance of sustainability, the number of definitions steadily increased (Glavic and Lukman 2007, p. 1875). By the year 1992, already more than 70 different definitions for “sustainable development” had been created (Kirkby et al. 1995, p. 371). Throughout the majority of definitions for sustainability, the three aspects of economy, environment, and society are considered (Lozano 2008, p. 1838). Depending on the different concepts, the relationship between the three aspects differs.

A visualisation of the two most common approaches is provided in Figure 1.1 on page 12. In Figure 1.1 a) the three aspects of a sustainable development (economy, society and environment) are symbolised by three overlapping circles, where each circle is equal in size. The area in which all three circles overlap represents sustainable development. The three aspects of sustainable development are fully integrated (Lozano 2008, p. 1839). Areas, in which only two of the three circles overlap, are considered to be a partial integration of sustainable development. In this visualisation, the economic, social and environmental aspects are equally important. As Elkington (2002) states “sustainable development involves the simultaneous pursuit of economic prosperity, environmental quality, and social equity”. In contrast to Figure 1.1 a), where the three aspects of sustainable development are converging but separate systems, Figure 1.1 b) depicts the three aspects of sustainable development as interconnected and interdependent systems. The economy and society are both constrained by the environmental limitations and have to work within its limits. A functioning environment is understood as a necessity to sustain social and economical activities. The ecological economist, Herman Daly, in particular, argued for this approach (Daly 1992; Costanza and Daly 1992; Daly 1996). Daly (2007, p. 14) defined three rules for a sustainable development:

1. “Limit use of all resources to rates that ultimately result in levels of waste that can be absorbed by the ecosystem.
2. Exploit renewable resources at rates that do not exceed the ability of the ecosystem to regenerate the resources.
3. Deplete nonrenewable resources at rates that, as far as possible, do not exceed the rate of development of renewable substitutes.”

The definition of sustainable development from Daly will be used throughout this thesis in accordance with Figure 1.1 b). For the achievement of a sustainable development cities have to function within the renewable capacity of the environment. In Europe, “nowadays cities are



(a) Venn diagram (b) Embedding diagram

Figure 1.1: *Comparison of two approaches to sustainable development*

seen as motors for [...] sustainable development" (e.g. Rotmans et al.). The idea by Forman (1995, p. 435), "think globally, act locally and plan regionally" further emphasises today's sentiment regarding the importance of cities in the context of sustainability. Like many systems under research for sustainability, cities are extremely complex systems with interactions on a multitude of levels and scales (Zellner et al. 2008, p. 474). This includes the complex web of human social, cultural, and institutional processes (Rotmans et al. 2000, p. 266), the impact of human activities on the natural environment (Chan and Huang 2004, p. 134), and the constant interaction with their geographical surroundings (Ravetz 2000, p.38). Therefore, in addition to acting locally, climate change mitigation should also be addressed on the national, international, and global scale.

In the context of sustainability on the city-scale, applying a holistic approach towards achieving sustainability is key. A holistic approach includes all city sectors in the process, rather than the focus being on just one or two city sectors. Due to the complexity of a city, a holistic integrated systems approach should be used to achieve sustainable development (Rotmans et al. 2000, p. 266) (Zellner et al. 2008, p. 474) (Chan and Huang 2004, p. 134). In addition to the holistic approach, where all city sectors are included, the integrated system approach emphasises the relationship between the different sectors. By including the sectors in an integrated way, it is ensured that measures in one sector are not negatively affecting climate protection efforts in another.

The term sustainability, when applied to cities, encompasses the three main aspects of sustainability, which are the ecological, economic, and social aspects, while being aware that the economy and society are subsets of the environment. Cities are understood as dynamic systems and the achievement of their sustainability needs to coincide with continuous changes. A holistic approach should be applied to achieve sustainability on the city-scale, taking all city-sectors into account.

1.2 Definition of CO_2-neutrality

The CO_2-reduction target of 80 to 95 % by 2050 includes all possible sources for CO_2-emissions. In addition to energy related emissions, there are, e.g. emissions from land use changes, process related emissions in the chemical industry, emissions from agriculture due to the use of fertilizers, and emissions induced by the effects of global warming itself. For these, as well as the energy related emissions in some cases, such as national and international flight transport, economically feasible solutions are not in sight. Therefore, other areas will have to reduce their CO_2-emissions even further than 80 to 95 %, to compensate for the previously mentioned CO_2-emission sources. Thus the goal of a CO_2-emissions reduction of 100 % was chosen for cities in this dissertation. Instead of using the terms of a 100 % emissions reduction target, the term CO_2-neutrality is introduced and clarified in the context of cities. In the following sections, an overview of different CO_2-emissions accountings (gross and net emissions, direct and indirect emissions) and a refined approach to CO_2-neutrality for cities is provided.

1.2.1 Carbon dioxide

Anthropogenic climate change is the result of a variety of climate-related greenhouse gases emitted into the atmosphere. The most important greenhouse gas is carbon dioxide CO_2 (IPCC 2007e, p. 2). With an anthropogenic radiative forcing of 1.66 W/m^2, the contribution of CO_2 to global climate change is 3.5 times higher than the contribution of the second most important greenhouse gas, which is methane CH_4 (IPCC 2007e, p. 4). Especially in industrialised countries, CO_2-emissions are the main contributor to climate change. In 2008, 87 % of Germany's contribution to climate change was due to CO_2-emissions (Umweltbundesamt 2010). As the most important greenhouse gas, carbon dioxide serves as a reference value for the global warming potential of other greenhouse gases. In this dissertation, all greenhouse gases regulated within the Kyoto-Protocol Annex A (p. 19) are taken into account:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)

From this point forward, the term CO_2eq will be used to indicate that all greenhouse gases regulated within the Kyoto-Protocol Annex A are considered.

1.2.2 Net and gross emissions

In this subsection, a differentiation between net and gross emissions is made. This discernment will be necessary for the complete understanding of proceeding discussions on different concepts for obtaining CO_2eq-neutrality. Gross emissions are emissions released at the emission source while net emissions are equal to the change of the CO_2eq-concentration in the atmosphere when the entire carbon cycle is taken into account. A depiction of this difference can be found in Figure 1.2 on page 15. In the example provided, a power plant with a fossil fuel (coal) and renewable energy source (wood) is depicted. The gross emissions in this case are those which are released directly from the power plant into the atmosphere. Both fuel types, coal and wood, have gross emissions. The net emissions are determined by the used fuel source. In the case of wood, the CO_2eq taken from the atmosphere during the lifetime of the tree (and stored as biomass) is deducted from the gross emission value. This value is equal to the net emissions, and in this case would be zero. In the case of coal, there has been no recent reduction in the CO_2eq-concentration in the earth's atmosphere, as it was formed millions of years ago and thus the net emissions are equal to the gross emissions.

A CO_2eq-neutral fuel source represents an "ideal" fuel source where the extraction of the fuel source and relative CO_2eq-emissions can be balanced out over a short period of time by regeneration. The regeneration of that fuel needs to occur quickly in order to have no long-lasting consequences on today's atmospheric CO_2eq-concentrations. In the case of wood, the relatively short regeneration period of wood's source, e.g. for most trees 10 - 150 years, allows for tree re-planting and subsequent re-growth to compensate for those which are cut-down for fuel. In the coal-case and with other fossil fuels, the regeneration period is many millions of years, and thus CO_2eq-emissions used in the combustion process cannot be balanced by "coal replanting". Therefore, wood is considered to be a renewable fuel source with zero net emissions, whereas coal is considered to be a non-renewable fuel source with positive net emissions.

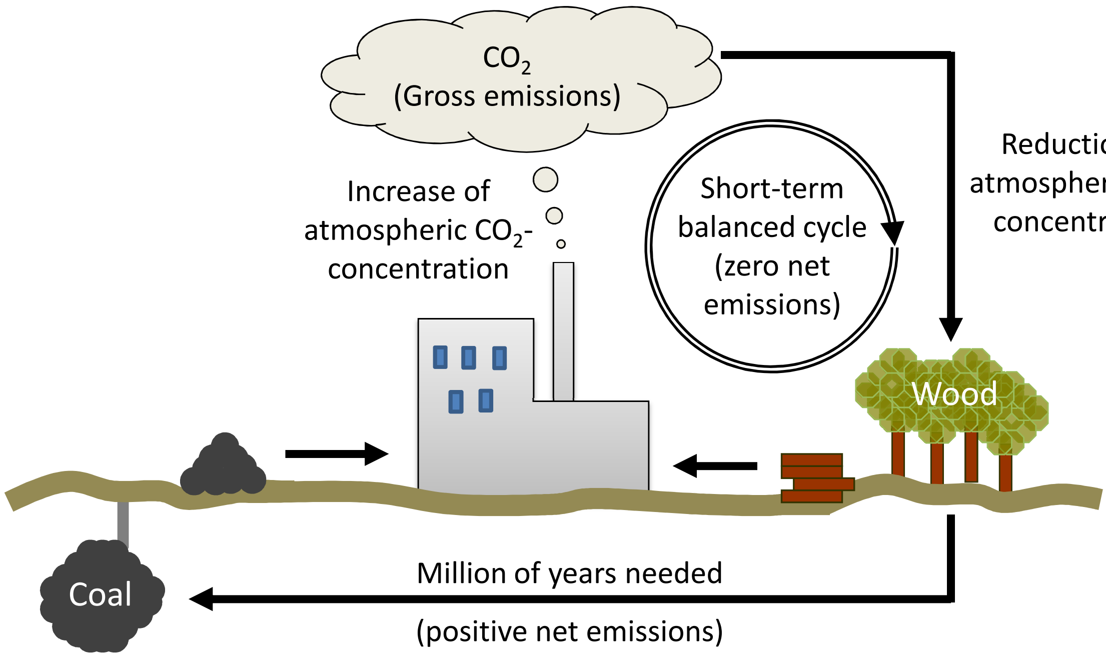


Figure 1.2: *Net and gross emissions*

Thus, net emissions determine whether additional CO_2eq is released into the atmosphere, and therefore contributes to the effects of global climate change. In this dissertation, net CO_2eq-emissions are used unless otherwise indicated.

1.2.3 Direct and indirect emissions

In addition to net and gross emissions, direct and indirect emissions are distinguished. The differentiation between direct and indirect emissions is mostly found in literature pertaining to carbon footprints (i.e. Wiedmann and Minx (2007), Grubb and Ellis (2007)). Carbon footprints are a well-known and widely used method used for calculating the impacts of cities and nations on the climate or environment (Satterthwaite 2011, p.1766). Wiedmann and Minx (2007, p. 4) define direct emissions as emissions that are internal and on-site; the emissions can be directly controlled by the owner. Indirect emissions are off-site or external emissions that are released in the up- or downstream of a product (Wiedmann and Minx 2007, p. 4). They cannot be directly influenced by the owner of a product. For instance, the direct emissions of a car are determined by the used amount of petrol. The indirect emissions are the emissions that are connected to the production process of a car.

Whereas carbon footprints might focus on any product, service, or consumption activity (Wiedmann and Minx 2007, p. 7), the emphasis of this thesis is placed on the supply and demand of energy. Direct and indirect emissions of energy usage are defined according to Fritsche and Rausch (2008). The immediate emitted emissions for the usage of fuels are defined as direct emissions. They are mainly determined by the carbon content of the fuel. Indirect emissions are emissions released by the provision of fuels. They are determined by the processes and energy intensity of the upstream process-chains (production, processing, and transport of the fuel). A visualisation of direct and indirect emissions can be found in Figure 1.3. It shows the direct, indirect, and total CO_2eq-emissions of a coal fired power plant. The indirect emissions are emissions from the use of fossil fuels in the upstream process-chain. The direct emissions are released into the atmosphere when the coal is burnt at the power plant. The total CO_2eq-emissions are the sum of the indirect and direct CO_2eq-emissions.

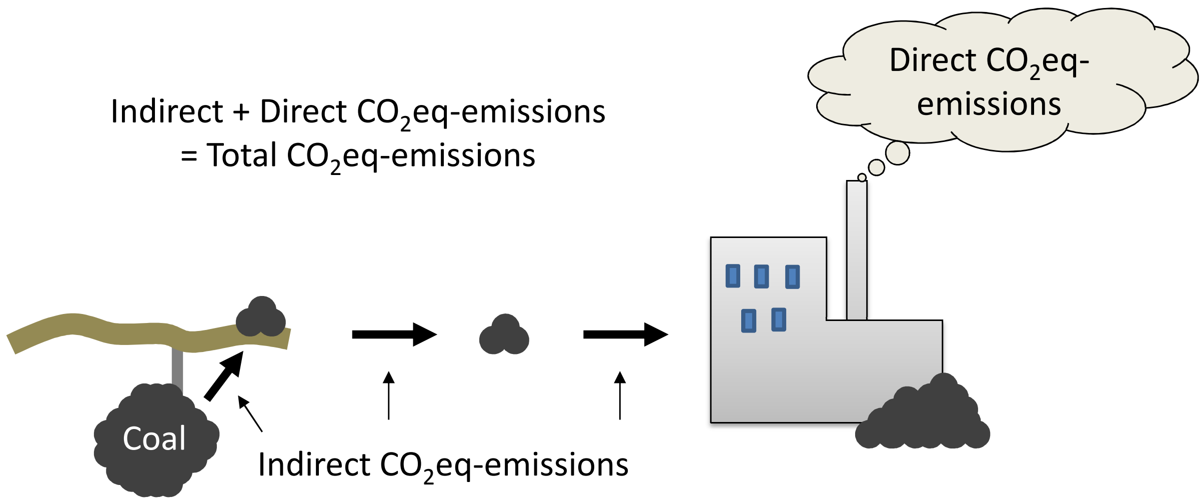


Figure 1.3: *Direct and indirect emissions of a coal fired power plant*

The direct as well as the indirect emissions are contributing to the effects of global climate change. Therefore, in this dissertation, the total net CO_2eq-emissions are used unless otherwise indicated.

1.2.4 A refined approach to CO_2eq-neutrality for cities

For achieving a CO_2eq-neutral state, or otherwise termed, “CO_2eq-neutrality”, the following three approaches most commonly found in the current literature are:

- Inducing a “climate-compatible” amount of greenhouse gases (<2 t CO_2eq p.P./a)

- Reduction and offsetting of residual CO_2eq-emissions
- Reduction of direct local greenhouse gas emissions by 100 %

The first approach, inducing a "climate-compatible" amount of greenhouse gases, assumes that there is an amount of greenhouse gases that can be emitted into the atmosphere within the limits of the ecosystem. Authors normally refer to the emission reduction targets from the IPCC of 80 to 95 % for industrialised countries, or less than two tons of CO_2eq per capita and year worldwide. Even before the publication of the Fourth Assessment Report from the IPCC, similar targets were defined (Kok et al. 2002, S. 1). In the book "Global Warming and Social Innovation: the Challenge of a Climate Neutral Society" Kok et al. (2002) defined a climate neutral society as one "that minimizes its negative impact on the climate system and its contribution to climate change" (Kok et al. 2002, S. 1).

The second approach consists of three steps allowing offsetting of CO_2eq-emissions:

1. Calculating climate-damaging emissions
2. Reduction of emissions where possible
3. Offsetting of residual emissions

The Department of Energy and Climate Change (2009, p. 5) emphasis that calculating CO_2eq-emissions and offsetting them without a previous reduction is not considered to be CO_2eq-neutral. Offsetting of residual emissions can always only be the last option (WWF 2008, p. 4). Possible options for offsetting certified emission reductions are provided within the scope of the Kyoto-protocol (emission trading, clean development mechanism and joint implementation).

The third approach for achieving "CO_2eq-neutrality" also consists of three steps. This approach assumes a reduction of greenhouse gas emissions by 100 %, by applying the following steps:

1. Reducing energy consumption
2. Increasing energy efficiency
3. Substituting all residual fossil fuels by renewable energies

Following the third approach, CO_2eq-neutrality equals zero net CO_2eq-emissions. Offsetting of residual emissions is not considered. The third approach is focused on the reduction of energy demand, and aims to substitute all residual fuels instead of offsetting emissions, thus directly reducing the local CO_2eq-emissions by 100 %.

The approach with the highest total CO_2eq-emission reduction is applied in this thesis for the term CO_2eq-neutrality. Therefore, the third approach is applied and was furthered to include a differentiation between direct and indirect emissions. The steps involved in this furthered approach for obtaining CO_2eq-neutrality on the city-scale are listed below:

1. Reduction of direct emissions from citizens and companies in the city by 100 % by:
   1.1. Reducing energy consumption
   1.2. Increasing energy efficiency
   1.3. Substituting all residual fossil fuels by renewable energies
2. Avoiding of indirect emissions to the greatest possible extent
3. Influencing external parameters in a proactive manner to minimise indirect emissions

1.3 Review of city climate protection concepts

In this section, climate protection concepts for cities in northern Germany are compared in order to identify the general practice and methodological approaches that are commonly used. In turn, this will enable the development of regional climate protection concepts at the city-scale. A comparison of the different approaches most commonly used for developing climate protection concepts is made, and strengths and weaknesses of the varying approaches are pointed out.

A set of criteria were defined for narrowing down which climate protection concepts should be compared. Only concepts which met certain defined criteria and occurred in the desired region were considered. The two main criteria included (1) the geographic scale and (2) the size of the city based on its population. In the following paragraphs, these criteria are defined for the scope of the comparison.

Climate protection concepts developed for northern Germany may be characterised by the geographic scale for which the concept was developed. Both city-scale and regional-scale climate protection concepts exist for northern Germany. For concepts developed on the city-scale, the scope of the project ends at the city border. For climate protection concepts developed on the regional scale, a region of protection is defined which may include area outside of the city borders, and often includes both urban and rural areas. Methods for achieving high CO_2eq-emission reduction targets in rural areas face challenges which differ significantly from those of cities. In Germany, much attention has already been paid to developing concepts for rural areas. For example, most areas that are already 100 % renewable in Germany are either very small communities with less than 10,000 people, or are regions with low population densities (more detailed information to be found on www.100-ee.de). The integration of renewable energy technologies for the purpose of reducing CO_2eq-emissions, such as the installation of wind power plants or the growing of energy crops, in most cases, is not feasible in urban areas. Cities require their own set of unique solutions for CO_2eq-emission reduction. For example, the reduction of energy demand is often the main focus for concepts developed on the city-scale. The scope of this dissertation focuses on climate mitigation and solutions specific to cities. Therefore, only climate protection concepts which were elaborated on the city-scale were chosen for this comparison.

The comparison was further refined to only include those climate protection concepts from cities with a certain population size. Northern Germany consists of the five federal states: Schleswig-Holstein, Niedersachsen, Mecklenburg-Vorpommern, Hamburg, and Bremen. The structure and culture of smaller cities creates different dynamics compared to larger cities. This leads to cities of different sizes requiring different methodological approaches to, for example, account for smaller or larger involvement of stakeholders, which may include the public, companies, organisations, and the city government. Climate protection concepts for cities with a population size greater than 50,000 and less than 250,000 citizens were chosen for this comparison. The climate protection concepts for those cities which did not meet this criteria were not used in the comparison, with one exception, which is detailed in the next paragraph.

Fifteen cities were identified in northern Germany which fulfilled the pre-defined criteria by the end of August 2012. In addition, one exception was made with the city of Elmshorn. Elmshorn has a population of 48,924, only slightly below the defined threshold, and was included in the comparison. Thus a total of sixteen climate protection concepts were included into the comparison. Interestingly, of the thirty cities in northern Germany with the pre-defined population size, only the mentioned 16 had climate protection concepts. This finding demonstrates both the current awareness of the importance of climate protection concepts on the city-scale, and the potential for the development of city-scale climate protection concepts in the future in northern Germany. The sixteen cities included in the comparison are listed in Table 1.1 on page 20 with the publication date of the climate protection concept.

After identifying the cities for the comparison, each city's climate protection concept was reviewed in detail based on a defined set of questions. These included: (1) whether the climate protection concept was developed in a participatory way and if so, the method used and how many and which stakeholders were involved in the process; (2) whether the climate protection concept focuses on specific city sectors or if an integrated approach is used; (3) whether a status

Table 1.1: *Cities in northern Germany with a city-focussed climate protection concept and a population size between 50,000 and 250,000 citizens by the end of August 2012.*

City	City size (year 2010)	Published
Braunschweig	248,867	Nov 10
Kiel	239,526	May 08
Lübeck	210,232	Sep 10
Rostock	202,735	October 05
Osnabrück	164,119	Apr 08
Oldenburg	162,173	Apr 11
Wolfsburg	121,451	May 09
Göttingen	121,060	June 10
Norderstedt	71,992	Nov 09
Celle	70,242	Nov 11
Hameln	57,771	June 10
Stralsund	57,670	October 10
Greifswald	54,610	June 10
Langenhagen	52,582	Sep 10
Emden	51,616	Sep 10
Elmshorn	48,924	February 11

quo analysis was performed or not and what methodological approaches were applied and (4) what city reduction goals were set and what reduction values were calculated in the climate protection concepts. These questions for comparison are further detailed and addressed in the sections to follow.

In the following the reviewed climate protection concepts are listed. In addition to the long-version of the climate protection concepts the reviewed short-versions and appendixes are listed as well.

- Braunschweig: Geo-Net Umweltconsulting GmbH (2010), Lübben (2010);
- Kiel: Stadtverwaltung Kiel (2008), UTEC, Ingenieurbüro für Entwicklung und Anwendung umweltfreundlicher Technik GmbH (2003);
- Lübeck: URS Deutschland GmbH (2010);
- Rostock: Hansestadt Rostock (2005), Hansestadt Rostock (2010);
- Osnabrück: Wagner et al. (2008a), Wagner et al. (2008b), Winterkemper and Timmermann (2010);
- Oldenburg: Schäfer-Breede et al. (2011a), Schäfer-Breede et al. (2011b), Schäfer-Breede et al. (2011c), Amt für Umweltschutz und Bauordnung Oldenburg (2012);
- Wolfsburg: Stadt Wolfsburg Umweltamt (2009), Steuerkreis der Wolfsburger Agenda 21 (2009), Umweltamt der Stadt Wolfsburg (2005);

- Göttingen: Beratungsbüros 4K (2010a), Beratungsbüros 4K (2010b);
- Norderstedt: Lindner and Schmidt (2009);
- Celle: Projektgruppe Klimaschutz Celle (2011);
- Hameln: Wilde and Tegtmeier (2010);
- Stralsund: Ahlhaus et al. (2010);
- Greifswald: Hamacher and Bartelt (2010b), Hamacher and Bartelt (2010a);
- Langenhagen: Sahling et al. (2010b), Sahling et al. (2010a);
- Emden: Rieck et al. (2010);
- Elmshorn: Rieck et al. (2011)

1.3.1 Application of participatory concept development

This section addresses the question of whether the climate protection concept was developed in a participatory way and if so, the method used and how many and which stakeholders were involved in the process. Participation requires that people, aside from those from the organisation developing the concept, politicians and the city administration are involved in the development of the concept. A climate protection concept is considered to be developed in a participatory way only if external persons are involved in the developmental process.

Stakeholder involvement is a crucial part of the backcasting analysis. Stakeholder involvement is seen as a key-factor to achieve changes (Quist 2009, S. 5). In the literature (e.g Street 1997, p. 142) traditional approaches where decision making is based only on expert opinions is not seen as up-to-date any-more. Also top-down approaches in general “forcing” solutions onto the stakeholders and the public are not the right means to achieve the necessary transition to a sustainable development (Loorbach 2008, S. 17). Opening up science to the stakeholders and the public can, according to Haughton and Hunter (1994), only be beneficial, because they are an important source of knowledge and help to develop suitable and location-specific solutions. Furthermore the achievement of high emission reductions largely depends on the acceptance and willingness of the different stakeholders to contribute to these aims (Vermeulen and Kok 2002, p. 41). The participation will also increase the understanding and awareness of the stakeholders and the public for the challenges ahead (Barton and Bruder 1995). Quist (2007a, p. 48) and de Kerkhof (2004, p. 26-27) identified four major arguments for stakeholder involvement in decision-making:

1. “Increased legitimacy of the decision, as more stakeholders have been involved

2. Increased accountability, as the stakeholders involved have become co-responsible for the decision and related activities and action plans
3. Increased richness of the process, due to the input a wider range of viewpoints, interests, information and expertise about the topic under consideration."(de Kerkhof 2004, p. 26-27)
4. Stakeholders are "needed and indispensable for putting solutions into practice" (Quist 2007a, p. 48)

In Table 1.2 on page 23 the cities included in the comparison are listed in order of city size. Here it is shown that eleven of the 16 cities compared have developed their climate protection concepts in a participatory way. Only five of the 16 concepts did not include stakeholder involvement. Out of those five climate protection concepts, three were developed by the city administration and it was claimed that participation was a cost factor. From the eleven participatory developed climate protection concepts, nine were developed by external offices, consultants or institutions. Four out the five concepts that did not use a participatory approach were developed in the year 2009 or earlier. The finding that eleven out of 16 cities developed their climate protection concept in a participatory way reflects the findings from Reed (2008, p. 2417-2427) that participation is today, becoming the norm.

The majority of climate protection concepts reviewed were provided online and were available in one or more of the following formats: as an executive summary, a long-version and/or as a presentation. Two of the 16 concepts were not made easily available to the public. Instead the respective city administration had to be contacted for a version to be provided by e-mail.

Table 1.3 on page 23 provides an overview of the number of different stakeholders that were involved and what type of involvement was used. The amount of involvement varies greatly; from, for example, only ten people to more than 160 people for the development of climate protection measures. The number of people involved is already a good indicator for the participatory concept development but involvement is not only about quantity but also about quality. For this purpose Table 1.3 does not only provide information about the number of people involved but also includes information about the number of different stakeholders that are included in the process. From all of the climate protection concepts reviewed, the highest number of companies involved was 60 in the city of Göttingen.

Table 1.3 also provides information about the type of involvement of stakeholders. Five concepts used working groups. Working groups are a group of people that meet at least one time to discuss a given topic. Three of the concepts used workshops. In contrast to working groups

Table 1.2: *Participatory concept development for climate protection concepts of northern German cities*

City	Participatory concept development	Concept development
Braunschweig	yes	external
Kiel	no	city administration
Lübeck	yes	city administration
Rostock	no	city administration
Osnabrück	no	external
Oldenburg	yes	external
Wolfsburg	no	city administration
Göttingen	yes	external
Norderstedt	yes	external
Celle	yes	city administration and external
Hameln	yes	city administration
Stralsund	yes	external
Greifswald	yes	external
Langenhagen	yes	external
Emden	no	external
Elmshorn	yes	external

workshops are planned and carried out by a specific person. Expert interviews were carried out for three of the concepts. Climate councils were used for three of the concepts. Thus, a variety of different participatory techniques were used for the participatory development of climate protection concepts in this region.

Table 1.3: *Type and extent of participatory climate protection concept development*

City	People involved	Stakeholders involved	Participation type
Braunschweig	n.a.	n.a.	n.a.
Lübeck	10	7	Climate council and interviews with decision makers
Oldenburg	110	n.a.	Think-Tank, Expert-Telephone-Interviews and 2 workshops
Göttingen	69	60	5 working groups
Norderstedt	27	11	Expert-interviews and workshops
Celle	100	n.a.	Climate council and 4 working groups
Hameln	50	n.a.	5 working groups
Stralsund	30	25	3 working groups
Greifswald	160+x	7	3 citizen forums, citizens discussion groups, climate council
Langenhagen	n.a.	9	3 working groups
Elmshorn	42	42	One Workshops

1.3.2 Concept focus (integrated vs. specific sector focussed)

This section addresses the question whether the climate protection concept focuses on specific city sectors or if an integrated approach is used. Depending on the extent of the concept, climate protection concepts may focus specifically on particular sectors. For example a climate protection concept may be developed to only address the transport sector or the possible areas of influence of the city administration. Climate protection concepts may also follow an integrated approach, in which all sectors of a city are taken into account. Integrated climate protection concepts for cities follow a holistic approach which utilises synergies between different sectors. Climate protection concepts that only focus on one particular sector may ignore possible consequences for other sectors. A reduction of emissions in one sector could, for example, lead to higher emissions in another sector.

Table 1.4 lists the focus points of the different concepts for the individual cities. From the 16 climate protection concepts compared, seven cities had developed climate protection concepts that were specific-sector focussed. Concept focuses ranged from those addressing solely the city administration to those addressing one or more city sectors. Nine of the climate protection concepts addressed all sectors of the city.

Table 1.4: *Focus of the measures developed in the climate protection concepts*

City	Focus of measures
Braunschweig	All sectors
Kiel	City administration
Lübeck	All sectors
Rostock	Ideas for all sectors. Focus mainly limited to city administration influence.
Osnabrück	City administration
Oldenburg	All sectors
Wolfsburg	City administration
Göttingen	All sectors
Norderstedt	Focus on buildings
Celle	All sectors
Hameln	Main focus on energy, energy utility, transport, administration, minor focus on industry and commercial.
Stralsund	All sectors
Greifswald	Transport and Energy
Langenhagen	All sectors
Emden	All sectors
Elmshorn	All sectors

1.3.3 Comparison of methodological approaches

This section addresses the question whether the following was performed or not in the climate protection concepts compared: (1) status quo analysis; (2) foercasting analysis; (3) backcasting analysis and (4) development of an implementation strategy. The results of the comparison are shown in Table 1.5 on page 26.

Conducting a status quo analysis represents a preliminary step for the development of climate protection measures and is an essential foundation for a climate protection concept. With a status quo analysis the energy demand and CO_2eq-emissions of a city are determined. Without a status quo analysis, only qualitative recommendations can be made. The importance of a status quo analysis is confirmed by the finding from the reviewed climate protection concepts that all sixteen climate protection concepts included a thorough status quo analysis.

The second question was whether a forecasting analysis with the development of a forecasting scenario was performed. A forecasting scenario, or as it is otherwise termed, a reference scenario, shows the development of energy demand and CO_2eq-emissions over time for the case that no additional climate protection measures are implemented. A forecasting scenario may also be performed to identify the main drivers of energy demand and CO_2eq-emissions of the future development. For example a city could be in the situation that due to an increasing population size, the energy demand and subsequently, the energy-related CO_2eq-emissions, may increase significantly in the future. From the 16 climate protection concepts compared, four cities had developed a forecasting scenario (see Table 1.5).

The third question was whether backcasting was used for developing a climate protection scenario or not. In contrast to the forecasting scenario, backcasting is a goal-orientated approach used for scenario development (a detailed overview of the backcasting approach is provided in Section 2.3 on page 45). A desired CO_2eq-emission reduction target is determined and then climate protection measures defined on how to achieve the CO_2eq-emission reduction target. Backcasting is most suitable for long-term goal-orientated scenario development. From the 16 reviewed climate protection concepts, only one had employed backcasting. The other concepts used either forecasting (continuation of given trends), results from other cities', or performed their own calculations.

After the development of climate protection measures, it is important that the climate protection process continues and that these measures are implemented. The development of an implementation strategy for a climate protection concept may help to increase the level of later implementation of climate protection measures. Therefore, the question was addressed in the comparison, whether an implementation strategy was developed or not. From the 16 reviewed climate protection concepts half of the concepts had developed an implementation strategy. From the eight concepts that had developed and included an implementation strategy into their concept, six had been financially supported by the Federal Ministry of Environment. Climate protection concepts funded by the Federal Ministry of Environment have to fulfil certain criteria, which influence the way the concepts are developed.

Table 1.5: *Methodological approach used for the development of the climate protection concepts*

City	Backcasting	Implementation strategy	Forecasting	BMU-Funded
Braunschweig	no	yes	no	yes
Kiel	no	no	no	no
Lübeck	no	yes	no	no
Rostock	no	no	no	no
Osnabrück	no	no	no	no
Oldenburg	no	yes	yes	yes
Wolfsburg	no	no	no	no
Göttingen	no	yes	no	yes
Norderstedt	no	yes	no	yes
Celle	no	no	no	no
Hameln	no	no	no	yes
Stralsund	no	yes	no	no
Greifswald	yes	no	yes	yes
Langenhagen	no	no	no	yes
Emden	no	yes	yes	yes
Elmshorn	no	yes	yes	yes

1.3.4 Emission reduction goals of the city and the climate protection concept

This section compares the cities in terms of their reduction goals and the calculated reduction values in the climate protection concepts. The results are shown in Table 1.6 on page 27.

The reduction target years for the cities compared range from 2015 to 2030, with the majority of targets being set at 2020. Five out of the 16 compared cities (Rostock, Elmshorn, Stralsund, Hameln, Emden) are members of the Climate Alliance of European Cities, sharing the same CO_2eq-emission reduction goals. Climate Alliance member cities have committed to the goal to reduce their total CO_2eq-emissions by 10 % every five years. Two cities had climate protection concepts developed without setting a CO_2eq-reduction goal.

The comparison shows that only in seven cases the city's CO_2eq-emission reduction targets are actually achieved when implementing the climate protection measures defined in the climate protection concepts. In the two cases for which no targets were set, also no overall calculations on the reduction potentials through the implementation of climate protection measures were provided. In two additional cases no detailed calculations on the reduction potentials were made, even though CO_2eq-emission reduction goals existed for both cities. In five of the cities compared the calculated reduction values provided in the concept were lower than the city reduction goals.

Table 1.6: *Cities emission reduction goals and the calculated reduction values in the climate protection concepts*

City	Target year	City reduction goal	Calculated reduction in concept
Kiel	2020	40%	none
Lübeck	2015	10%	10%
Rostock	2020	10%/5a	10%/5a
Norderstedt	2030	50%	50%
Elmshorn	2020	10%/5a	4%/5a
Stralsund	2030	50%	50%
Greifswald	2020	14%	14%
Braunschweig	no	no	no overall number given!
Osnabrück	no	no	no overall number given!
Oldenburg	2020	40%	17.50%
Wolfsburg	2020	20%	20%
Göttingen	2020	40%	39%
Celle	2020	40%	no detailed calculation of potentials
Hameln	2020	24%	29%
Langenhagen	2020	40%	25%
Emden	2020	24%	17%

1.3.5 Conclusion of the review

In conclusion, the analysed climate protection concepts for northern German cities (population: 50,000 to 250,000), provided useful information regarding climate protection concepts already developed in this region.

The finding that approximately 50 % of the cities, which met the population size criteria, had climate protection concepts, demonstrates both the current awareness of the importance of climate protection concepts on the city-scale and the potential that still exists for the development of these programs.

Based on the results from the comparison, the inclusion of participatory approaches into climate protection concepts appears to be becoming the norm, however the amount of stakeholder involvement and the applied participatory techniques vary greatly between the concepts. These results demonstrate a need for a standard approach, aiming at the inclusion of participation into city-scale climate protection concepts.

The comparison further showed that a standard methodological approach for climate protection concept development is lacking. The majority of compared climate protection concepts, for example, did not perform a forecasting analysis. In addition, promising goal-orientated methodological approaches, such as backcasting, were only applied in one case. These findings demonstrate the need for a modern, unified approach for the development of climate protection concepts.

The setting of long-term goals, partnered with highly ambitious reduction targets, was lacking among the concepts compared. To achieve sustainable development, climate change mitigation should be planned, not only over the short- and mid-term, but also over the long-term, so that highly ambitious reduction targets can be reached (e.g. 80 to 95 % emission reductions by the year 2050 as published by the IPCC).

The comparison showed that only half of the climate protection concepts had developed an implementation strategy. An implementation strategy increases the chance of maintaining climate protection measures, and helps to ensure an ongoing climate protection process. This gap points out the need for a holistic methodology that incorporates implementation strategies as a standard in the development of climate protection concepts.

Finally, the comparison showed that the use of goal-orientated approaches in the development of climate protection concepts was rarely applied. In less than half of the cases, the city's CO_2eq-emission reduction targets would actually have been achieved when implementing the climate protection measures defined in the climate protection concepts. This finding points out the need for a new, goal-orientated approach for the development of climate protection concepts on the city-scale.

1.4 Derivation of research questions

To minimize the serious consequences of climate change, goal-directed actions are required. Besides national and international agreements, local solutions need to be developed to address this global problem. Only on a local-scale are all stakeholders readily available and can necessary activities be successfully coordinated to develop a consistent climate protection concept.

Understanding the global need for climate change mitigation, cities in Germany have started the process of climate protection on the city-scale. Financially supported by the German government, an increasing number of municipalities are developing climate protection concepts for cities. However, after analysing the climate protection concepts developed for cities in northern Germany, it was found that a standard methodological approach for climate protection concept development is lacking. Goal-orientated approaches in the development of climate protection concepts were only applied in one case. Also, only half of the climate protection concepts for the cities had developed an implementation strategy. In general, the setting of long-term goals partnered with highly ambitious reduction targets was lacking.

In order to achieve highly ambitious CO_2eq-emission reduction targets, a long-term sustainable strategy for cities is required. Through integrating approaches like backcasting and transition management, as well as insights from psychology, a unified methodology to establish and maintain a climate protection process on the city-scale can be developed.

In the following the hypothesis of this thesis is presented:

Hypothesis By integrating backcasting, transition management, and psychological aspects, it is possible to develop a holistic method for the participatory development of climate protection concepts for cities that allows for the achievement of highly ambitious CO_2eq-emission reduction targets, such as CO_2eq-neutrality.

For addressing the different aspects of the hypothesis, a variety of research questions were derived. Answering the defined research questions will allow the development of a systematic answer to the hypothesis. In the following, the research questions are listed:

1. Can the two approaches of backcasting and transition management be used together in a holistic way for climate protection on a city-scale, and do they complement each other? *This research question is addressed in Chapter Two, Four, and Five.*

2. How can backcasting and transition management be used to set up a highly ambitious participatory climate protection process on a city-scale? *This research question is addressed in Chapter Two and Chapter Four.*

3. How can insights from psychology be used to facilitate the process of climate protection on a city-scale, and to establish and maintain a long-lasting process? *This research question is addressed in Chapter Three and Chapter Four.*

4. How can the developed methodology be applied in practice? *This research question is addressed in Chapter Five.*

5. Is it possible, with the use of the developed methodology, to establish structures in the city that will carry on the climate protection process and can the establishment of structures be accomplished in a short period of time? *This research question is addressed in Chapter Four and Chapter Five.*

6. What lessons can be learnt from the exemplary application of the methodology for other cities and where is further research needed? *This research question is addressed in Chapter Six.*

In order to answer the first research question, Chapter Two begins with the introduction of the field of future studies. Scenarios are a cornerstone for the development of climate protection concepts. The benefits of participatory approaches in this context are discussed, and participatory backcasting is introduced. Afterwards, the theory of transition management is introduced. The main focus of transition management is not on scenario building, but rather on how a long-term transition in society can be achieved. Transition management delivers valuable insights for the organisation of a long-term changeover to a CO_2eq-neutral city. Chapter Two concludes with a comparison of backcasting and transition management. The comparison of the two approaches in the context of climate change for cities addresses the first research question. Furthermore Chapter Two provides the basic knowledge to answer the second research question.

In Chapter Three, an introduction to psychology is provided. It is shown how psychology supplies crucial input to facilitate the initiation of a climate protection process and its continuation, as well as maintenance over time. The inclusion of this chapter is based on the idea that climate protection cannot only be reduced to technical solutions. With the introduction of background information on human behaviour and applicable theories, Chapter Three answers the third research question.

In Chapter Four, a novel methodology is developed for the creation of climate protection concepts for cities. This is based on the combined approaches of backcasting, transition management, and psychology. Individual steps for this novel methodology are outlined in this chapter. With the development of a new concept, Chapter Four delivers the necessary information to answer the second and third research questions.

In Chapter Five the newly developed approach is presented in a case study, where the approach was applied to the city of Flensburg, Germany. The approach was tested over a time period of two and a half years. Research questions four and five are addressed here.

The final chapter, Chapter Six, presents a discussion of the important results of the thesis and the conclusions. A critical assessment of the work is presented here and further recommended research directions are indicated. Research question six is answered in this chapter.

2 Forecasting, backcasting and transition management

To identify possible approaches for the participatory development of a climate protection concept, a literature review was performed. The two most promising approaches identified, backcasting and transition management, will be presented in this chapter and discussed in the context of CO_2eq-neutrality on the city-scale. The promise that these two approaches hold for the field of climate protection development is reflected in the arguments provided in this chapter. The two approaches of backcasting and transition management will be compared, suggesting how the two approaches may be combined, and relative directions of future research will be pointed out. In the following section the field of future studies will be introduced and different types of scenario development strategies will be detailed for the development of climate protection concepts.

2.1 Introduction to future studies

The field of future studies is an interesting field of study because future development is always uncertain. To actively think about the future is not a new concept. It is deeply rooted in western traditions (Börjeson et al. 2006, p. 6). In his book Cornish (1977, p. 51-57) provides an overview of various utopia's and prophecies that existed over time, leading back as far as Plato's Republic where an ideal future society is depicted. In addition to the development of new ideas, future predictions in natural systems have also been made (Börjeson et al. 2006, p. 6). Almost 2,000 years ago the Ptolemaic system of astronomy allowed accurate predictions for the movement of any star over a long time period (Makridakis et al. 1998, p. 2). Nowadays, the practice of forecasting is used in all different fields, ranging from the well-known daily weather forecast to very specialised economic forecasts (Clements and Henry 1998, p. 7).

Vision and scenarios are the foundation of future studies. An overview of scenario typologies was developed by Börjeson et al. (2006, p. 6). In his 2006 paper "Towards a user's guide to scenarios - a report on scenario types and scenario techniques" from the Department of Urban studies, Royal Institute of Technology, Stockholm, detailed perceptions of future studies and existing scenario typologies are presented. Börjeson et al. (2006, p. 6) points out two main approaches of looking at the future in the context of scenario development; the active and passive approaches. The active approach is when companies or individuals use scenarios to look at future developments to identify where it might be possible to alter the development. The passive approach is when companies and individuals accept the development as inevitable, and therefore use the scenarios to prepare to react to the future developments.

In support of an active approach, Cornish (1977) argues that the future is shaped by human decisions and that future studies are helpful to study upcoming possibilities. Furthering the argument for an active approach, Dreborg (1996, p. 826) adds that future studies are an important instrument for forming an opinion and a view about the future. Following these arguments, the future is not seen as something static, but rather as a dynamic development that can actively be shaped.

Different approaches for conducting future studies have been developed over time. The aim of the following sections is to contribute to the general understanding of future studies and to indicate which methodological approaches are useful for scenario development with the focus on climate protection concepts.

2.1.1 Vision

Two terms commonly used in the field of future studies are "vision" and "scenario". In general, a vision describes a desired end-state, whereas a scenario describes a future development. The literature provides different more concrete definitions of what a vision is. Johnson et al. (2008) define a vision as "a desired state for organising the future". However, Wilson (1992) argues that this definition of a vision is oversimplified and is lacking information about realistic possible future developments. Boaventura and Fischmann (2008, p. 598) state that it is necessary to first analyse, for example, the market environment and conditions before deciding on a specific strategy. In agreement with other authors (e.g. Ashley and Hall (1985), Godet et al. (2001), Schoemaker (2002)) two basic components are set for a vision. The first is the "future configuration desired for the organisation" and the second is "a future environment where this configuration can be successful" (Boaventura and Fischmann 2008, p. 598). Even though the viewpoint of the listed authors comes from an entrepreneurial background, the definition of a vision is also applicable to cities. Similar to companies, cities are faced with strong external influences. Only when factors such as future population development and economic growth are taken into account, realistic visions for cities can be developed. Based on research performed by Boaventura and Fischmann (2008, p. 598) the concept of a vision depicted in Figure 2.1 is used in this dissertation.

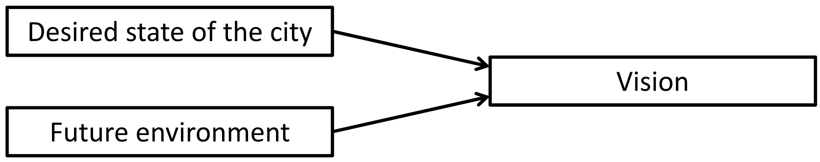


Figure 2.1: *Concept of vision for cities (adopted from Boaventura and Fischmann (2008, p. 598))*

To summarise, a vision for a city defines how a city and its surrounding environment should be in the future. Additionally, the vision should have well defined, long-term and concrete goals. The term vision does not encompass how the vision can be achieved. Therefore, in this dissertation, a vision is considered to be a method of goal-setting, which is inspiring, but also realistic. Furthermore a vision should be capable of being long-lived.

2.1.2 Scenarios

Scenarios, next to visions, are the most basic concept in the field of future studies (Börjeson et al. 2006, p. 7). According to Mannermaa (1991) scenarios are used to research the future based on the unpredictability of future developments. Alternative futures are described by scenarios by using different assumptions for future developments. Varying assumptions of future developments allows for the analysis of the effects of possible uncertain future developments. Scenarios represent a promising way of dealing with uncertainties for future developments (Gausemeier et al. (1998, p. 113), Dortmans and Eiffe (2004, p. 1050), Bood and Postma (1997, p. 635)).

In the literature two different views of scenarios can be identified. Scenarios are either described as possible future states or as the development to future states (Börjeson et al. 2006, p. 7). In the literature from the 1970s and 1980s (e.g. MacNulty (1977), Brauers and Weber (1988)) a scenario was viewed as a possible future state and not as a development. In the current literature, the term scenario describes possible end states in the future in combination with consistent intermediate steps for future development (Boaventura and Fischmann 2008, p. 599). In this dissertation the modern view of the term is applied.

Although the time dimension of a scenario historically has been defined differently, most authors of today agree that scenarios, essentially, are mental models, which provide information about the future (e.g. van der Heijden (1996), Chermack (2005), Boaventura and Fischmann (2008)). The construction of different alternative futures helps to "overcome limitations on thinking" (Boaventura and Fischmann 2008, p. 599). Scenarios can be used to analyse the effects of alternative developments. Bood and Postma (1997, p. 635) identified six major functions of scenarios:

1. Evaluation and selection of strategies
2. Integration of various kinds of future-oriented data
3. Exploration of the future and identification of future possibilities
4. Making stakeholders aware of environmental uncertainties
5. Stretching of stakeholders' mental models
6. Triggering and accelerating processes of organisational learning

The above functions underline the aim that scenarios are not meant to foresee the future, but rather are meant to broaden the knowledge and to gain a better understanding of possible future problems (Dortmans and Eiffe 2004, p. 1050). Because of the impossibility to foresee the future, the quality of a scenario or the likeliness of certain predicted developments to come true is very difficult to assess in advance (Dortmans and Eiffe 2004, p. 1049). Scenarios need to be understood, not as an accurate description of the future, but rather as a way to learn about the possible influence of different factors over the development period. The foundation of scenario planning is therefore a "complex network of influence-factors" (Gausemeier et al. 1998, p. 114) which includes a framework of specified assumptions (Bunn and Salo 1993, p. 292). In the literature the term "influence-factor" is used interchangeably with the terms "driving forces" (Schwartz 1991) and "causal factors" (Porter 1998). In this dissertation, the term "driving factors" will be used. Driving factors may be classified into three categories. Following the approach from Porter (1998) or Wack (1985) driving factors are either constant, predetermined or uncertain. The classification of the driving factors is an important step in the development of scenarios (Bood and Postma 1997, p. 634). Constant driving factors are those factors which do not change over time. Predetermined driving factors are those factors which are determined prior to the scenario development, and may or may not change over time depending on how they are defined. Uncertain driving factors are those factors that are variable. Therefore, it is the uncertain driving factors, which determine different scenario outcomes. Using a set of driving factors for scenario development is crucial for identifying possible future problems and for developing suitable solutions.

Once the scenarios have been developed they are used to analyse future developments and help decision makers to better understand the possible future results of their decisions (Bood and Postma 1997, p. 635). Scenarios provide the necessary information to make strategic decisions for the future (Dortmans and Eiffe 2004, p. 1050).

In summary, scenarios are describing possible future end states with consistent intermediate steps for future development. By using and varying a defined set of driving factors, possible future developments can be identified. Analysing possible future developments allows for the development of strategic decisions for the future, ultimately benefiting the society in the context of climate change.

2.1.2.1 Historical development of scenario

In comparison to the general field of future studies, which extends back almost 2,000 years, scenario analysis represents a relatively new field of research. The origins of scenario analysis are in warfare. For example the United States federal government used scenario analyses in the 1950s to analyse how nuclear wars might start (Martino 1983). One decade later scenario analyses were used by companies as a reaction to their traditional prediction methods becoming less accurate (Geurs and van Wee 2004, p. 48). New approaches were needed to make plans for "unpredictable" events and developments. One of the first and most prominent examples of the successful use of scenario analysis in business was by Shell Oil. In the 1970s, preceding the oil crises in 1973, Shell Oil analysed the consequences that an oil shortage would have on consumers and how countries would react to it using different scenarios (Geurs and van Wee 2004, p. 48). As a consequence, Shell Oil was better prepared to contend with the effects of the oil crisis of 1973 than most other oil companies (Geurs and van Wee 2004, p. 48). In addition to this, Shell Oil also extended the time horizon of their scenario analyses considerably. This allowed Shell's management, for example, to analyse the effects on the natural gas price of the fall of the Soviet Union (Miller and Waller 2003, p. 94).

Since the first use of scenario analyses the number of applied examples has increased at a rapid pace. An overview of the 100 most important examples documented in the literature can be found in Varum and Melo (2010, p. 357). In general, it can be seen that over time the purpose and methodology of scenarios changed from purely predicting the future to exploring alternative futures (Sondeijker 2009, p. 51). Sondeijker (2009, p. 47-49) distinguishes three different generations of scenarios. The first generation scenarios where based on an extrapolation of given trends in combination with analysed relationships of different driving factors from the past (e.g. Shell Oil). During the first oil crisis in 1973 it became clear that this approach was not able to prepare companies for major unexpected changes (Godet 1987). Therefore the second generation scenarios shifted from the extrapolation of given trends to exploratory and prospective approaches which were supposed to foresee possible changes or at least to be able to analyse their effects and adapt their own strategy (Berkhout et al. 2002).

The first and second generation of scenarios focused mainly on economic developments and were seen as a tool for the strategic planning of companies. With raising awareness towards sustainable development, a third generation of scenarios were developed after the Brundtland report (1987) and the Earth Summit in 1992 (Sondeijker 2009, p. 49). The third generation of scenarios included the idea that structural and societal changes are required to achieve sustainability (Sondeijker 2009, p. 49). Focusing only on economic aspects was not enough, environmental and social aspects had to be included in the scenario on all levels and in a systematic way (Raskin et al. 2003). In this third generation of scenario development, scenarios are expected to be comprehensive, developed in a participatory way and acknowledging uncertainties about the future development while taking into account that certain effects of climate change are irreversible (Raskin et al. 2003). For climate protection concepts on a city-scale, the third generation of scenarios is most applicable due to its focus on sustainability.

2.1.2.2 Scenario typologies

The described history of scenario development with the three distinguished generations of scenarios already points out that scenarios can be applied to many different situations and circumstances. Over the years a large variety of future studies have been developed (Börjeson et al. 2006, p. 10) to fulfil new specific tasks. Based on methodologies developed by previous authors, Börjeson et al. (2006) developed a new methodology for the classification of the different scenarios into three main categories, each consisting of two further scenario types. The new classification is widely accepted in the current literature (e.g. Kowalski et al. (2009, p. 1064), Höjer et al. (2008, p. 1059)). The three categories define scenarios by their function and the goal the user aims to fulfil. Is the aim to create a probable, a possible or a preferable view of the future (Börjeson et al. 2006, p. 14)? After answering this question the scenario category is further specified by two scenario types in each category. In the following paragraphs the different scenario categories with their scenario types will be described according to the classification from Börjeson et al. (2006). The different scenario typologies are depicted in Figure 2.2 on page 39.

The first scenario category is “predictive scenarios”. The aim of the scenario is to give an impression of what the future will probably look like or how likely certain events are. Börjeson et al. (2006, p. 4-5,15) emphasises that these scenarios assume a certain steady development and are largely based on historical data. These scenarios help stakeholders to develop a strategy on how to react or adapt to likely events in the future. According to Börjeson et al. (2006, p. 4-5) the two predictive scenario types are “Forecasts” and “What-If” scenarios. The purpose of a forecast is to develop a scenario assuming a continuation of current trends. A set of specified driving factors are applied. What-if scenarios are used to find out about the consequences of major forthcoming events (internal, external or both) on determined factors (Börjeson et al. 2006, p. 16).

The second scenario category is “explorative scenarios”. Their purpose is to identify possible developments independently from individuals beliefs on how the future could unfold (Börjeson et al. 2006, p. 4-5). Different scenarios are developed illustrating a range of, not necessarily likely, but possible events (Börjeson et al. 2006, p. 18). The explorative scenario category is further distinguished into external and strategic scenarios (Börjeson et al. 2006, p. 4-5). The focus of external scenarios is on the development of external factors and their influence on the stakeholders. Their purpose is the development of strategies that can withstand most external developments (Börjeson et al. 2006, p. 19). Similar to external scenarios, strategic scenarios also take external influences into account. However, their focus lies on analysing consequences of different internal strategic decisions (Börjeson et al. 2006, p. 20).

The third scenario category is called “normative scenarios”. They start out with a defined target for the future and then see how this target might be reached (Börjeson et al. 2006, p. 4-5). Börjeson et al. (2006) divides this scenario category into preserving and transforming scenarios. Preserving scenarios are used when a given target is likely to be fulfilled with the structure of the system in place. Therefore it is not a question if the aim is likely to be achieved but how it can be achieved in the most efficient way (Börjeson et al. 2006, p. 20-21). However, when the system in place renders the achievement of the target impossible, the use of transforming scenarios become necessary (Börjeson et al. 2006, p. 20-21). One example of the use of transforming scenarios is backcasting. The backcasting approach assumes that marginal adjustment of the system in place, even in the long run, will not be sufficient, but that a trend break is necessary (Börjeson et al. 2006, p. 21). The set goal is a highly prioritised target (Börjeson et al. 2006, p. 21), which might be, for example, the achievement of highly ambitious CO_2eq-emission reduction targets to avoid the serious consequences of global climate change. Backcasting will be explained in detail in Section 2.3 on page 45.

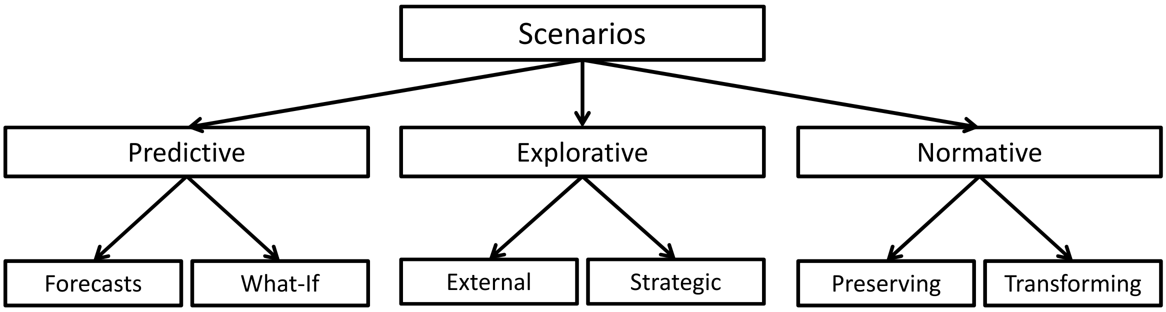


Figure 2.2: *Scenario typology (modified from Börjeson et al. 2006, p. 14)*

Two scenario categories are most feasible for cities with the aim of obtaining CO_2eq-neutrality: the predictive and the normative scenarios. Predictive scenarios help to understand the development of cities with a continuation of given trends and may show the need of climate protection measures. With the use of normative scenarios, research can be performed on how to achieve the set target of a CO_2eq-neutral city. With a set target for a city, the use of explorative scenarios is the least suitable scenario category. From the predictive scenarios, the forecast is preferable to the What-if analyses. The aim should be to see how the CO_2eq-emissions will develop in the future following current trends and not to investigate the influences of a forthcoming event. With the normative scenarios it is argued that for cities to achieve CO_2eq-neutrality, a stepwise adjustment of current development is not sufficient, but instead, a major change is needed. Therefore a transforming scenario should be applied in this case. Following these arguments, the scenario typologies forecasting and backcasting are used in this dissertation and are explained in more detail in Section 2.2 on page 41 and Section 2.3 on page 45.

2.1.2.3 Generating techniques for scenarios

One of the main steps in scenario development is to decide on the generating technique used for scenario development. The term “generating techniques” describes the way ideas or knowledge can be collected from experts or stakeholders (Börjeson et al. 2006, p. 25). The three main techniques utilise surveys, Delphi-methods and workshops. The literature distinguishes between internal and external scenario project work (Börjeson et al. 2006, p. 28). Internal scenario work is carried out internally by the researcher without incorporating external points of view. In contrast to internal scenario work, external scenario work explicitly asks for the involvement of stakeholders in the process of scenario development. In the following the three main generating techniques for scenarios will be explained.

Surveys are used to collect opinions of stakeholders on a specific topic in a systematic way (Börjeson et al. 2006, p. 26). Depending on the survey number, the expected percent return, number of questions and degree of detail, surveys can be conducted by means of interview, telephone or written questionnaire. In the context of climate protection concepts, surveys are mainly used for the purpose of gathering information on the intentions of the stakeholders or on their expectations for the future relative to climate change mitigation (Börjeson et al. 2006, p. 26).

In the Delphi-method interviews or surveys are used to gather knowledge about possible future developments from experts incorporating at least one feedback round to harmonise the results. According to Woudenberg (1991, p. 132) it was developed by Kaplan et al. (1950) in the 1950s to increase the accuracy of prediction by using group interaction. Delphi studies serve a dual purpose: they collect experts' opinions and also harmonise them. The Delphi study recognises that the more people are involved, the better a forecast will be. When only one person is asked the person could be biased or misinformed. Normally Delphi studies have a strong focus on technologies and technological breakthroughs (Börjeson et al. 2006, p. 26). The experts are normally asked questions by a central coordinator. Delphi studies have been carried out to forecast possible future developments, years of technological breakthroughs and the probability of certain technological developments (Börjeson et al. 2006, p. 26).

Workshops are commonly used for the purpose of scenario development, especially for qualitative topics where it is important to understand the underlying structure of the system under research (Börjeson et al. 2006, p. 25). For the development of climate protection concepts in Northern Germany, only three out of the 16 climate protection concepts had used workshops. Five had used working groups. In working groups, as well as workshops, a group of people, e.g. the stakeholders, meet to develop ideas and solutions for addressing the problem at hand. The main difference between a working group and a workshop is that workshops are moderated and coordinated by a moderator who leads through the entire event. In contrast, a working group is a group of people that meet without a central moderator or coordinator.

The field of future studies utilises a specific type of workshop termed "scenario workshops". In this type of workshops, groups of stakeholders meet to develop visions or proposals of possible future development (Street 1997, p. 145). Scenario workshops can be understood as workshops with the special focus on scenario building. When using backcasting for the scenario development, the moderation of the workshop should be performed by a person that knows how to engage the participants in both the development of short- and long-term solutions. In the case of climate protection concepts, the use of scenario workshops is viewed as a cornerstone.

Analysing the different ways of generating techniques for scenarios, workshops represent the most promising technique for involving stakeholders and the public into scenario development. Workshops allow for the discussion of local climate protection measures in a participatory way. Workshops in contrast to surveys or the Delphi-method maintain the ideals of the participatory approach by promoting the direct exchange of knowledge between stakeholders. Surveys and the Delphi-method lack the possibility for stakeholders to work together to form ideas, discuss measures and work through problems. Having the different stakeholders work together on solutions facilitates the process of developing an integrated climate protection concept and setting up networks. It is recommended that when a high degree of participation and interaction between the stakeholders is needed, that workshops are used as the generating technique for the climate protection scenario.

2.2 Forecasting

As previously described, forecasting belongs to the category of predictive scenarios. Its aim is to describe the most likely future development along a given set of internal and / or external drivers (Bagheri and Hjorth 2007, p. 86). A forecasting scenario serves as a reference result for the future development (Börjeson et al. 2006, p. 16). According to Geurs and van Wee (2004, p. 48) forecasting is used in policy making when the setting of a goal is not possible or controversial. The scenario planning depends almost entirely on causality (Bagheri and Hjorth 2007, p. 86) and the analysis of previous trends. Therefore the forecasting results are likely to be incremental and a reflection of current developments into the future (Geurs and van Wee 2004, p. 48). As a result of the way forecasts are created and the increasing uncertainty about future developments over time, they are best suited for short-term predictions (Börjeson et al. 2006, p. 16) or times of steady development.

Forecasting was popular in the 1950s and 1960s when steady economic growth in industrialised countries allowed for accurate predictions of future developments (Höjer et al. 2008, p. 1959). The availability of more efficient computers that were able to process more factors and to analyse past trends in more detail helped to increase the accuracy of forecasts (Huss 1988, p. 377). However, forecasts did not allow for the consideration of qualitative information, the prediction of turning points (Huss 1988, p. 377) or the inclusion of unlikely events. These disadvantages become clear during the 1970s. The unforeseen oil crises and fast developments in society made most forecasts of little use (Höjer et al. 2008, p. 1959). While short-term forecast maintained popularity (Banister and Hickman 2006, p. 2) long-term forecasts are often incorrect and thus less frequently used (Berkhout et al. 2002). Sondeijker (2009, p. 47) states that long-term forecasts tend to over- or underestimate future developments because of too many unpredictable factors. The "rather mechanistic view of systems" (Kowalski et al. 2009, p. 1064) in forecasts called for new methodologies that are able to deal with "highly complex, long-term sustainability problems" (Banister and Hickman 2006, p. 2), which is not possible with forecasting techniques. With forecasts largely being based on extrapolating existing trends they are not able to produce creative solutions for the future (Banister and Hickman 2006, p. 2). Long-term forecasts are seen by some researchers (cp. Robinson 1990, p. 821) as scenarios that only display their embedded assumptions, and subsequently do not reveal new insights into the future.

The development of forecasting methodologies has appeared to have reached its limits (Huss 1988, p. 378). However, even though forecasting does not allow for a clear and accurate picture of the future, forecasting is still considered a useful tool in climate protection concept development. The aim, in this context, of long-term forecasting is not necessarily to create the most accurate picture of the future (Huss 1988, p. 378), but rather to be used as an important step to develop strategies to actively change current conditions (Huss 1988, p. 378). Forecasts should be seen as a communication medium (Huss 1988, p. 378), for the visualization of what would happen, for example, if we were not to implement further measures to protect the climate. Therefore, a long-term forecast not only serves as a communication medium but also as a mode of motivation to change the forecasted development. Performing a long-term forecast also helps to identify important driving factors on future energy demand and CO_2eq-emissions and to identify, analyse and monitor given trends and their possible future development (Huss 1988, p. 378). Therefore, a forecasting scenario can also serve as a reference scenario for the future development (Börjeson et al. 2006, p. 16).

In the context of cities and CO_2eq-neutrality, a forecast scenario helps to identify the main drivers of CO_2eq-emissions, and determines how CO_2eq-emissions will develop over time when current trends are continued. A forecast scenario can be understood as a business-as-usual scenario, with the main purpose being to analyse the future with the assumption of a continuation of given trends.

2.2.1 Driving factors of energy demand and CO_2-emissions for cities

This section provides a general overview of different drivers of energy demand and CO_2eq-emissions for cities. In the publication, "Climate Change and Cities: The Making of a Climate Friendly Future" from Dhakal (2008, p. 177), the author analysed the main drivers for cities.

Depending on the academic and professional backgrounds of the people developing a city-scale climate protection concept, project perspective and foci may differ. According to Dhakal (2008, p. 177) different foci of system analysts, economists and social scientists can be distinguished. System analysts tend to focus on the various energy sectors of a city, such as household, industrial, commercial and transport sector (cp.Section 4.3.1 on page 118). In contrast economists link CO_2eq-emissions to factors such as the average income, the elasticity of certain goods or the economic growth. Social scientists relate green house gas emissions to broader effects that are deeply rooted in society, including behavioural aspects. Following the arguments from Dhakal (2008, p. 178) to gain the most accurate understanding of the driving factors, a combination of the different multi-disciplinarily perspectives is necessary. Drivers for energy demand and CO_2eq-emissions will be distinguished between urban development, economic development, infrastructure and technology, urban form and function, behavioural and societal factors, globalisation, institutional and political factors as well as natural factors. In the following those drivers relevant to scenario development for a city will be introduced. For example natural factors (e.g. latitude, altitude, coastal or inland location) will not be taken into account for scenario development, because they are beyond the city's influence.

Urban development is one of the major drivers of energy consumption and CO_2eq-emissions of a city (Dhakal 2008, p. 178). Depending on the population size, the composition and the distribution of population energy demand and CO_2eq-emissions vary. Dhakal (2008, p. 178) argues that population size in combination with other factors can be a direct measure of CO_2eq-emissions for a city. These other factors are for example the average living space per capita and the household size. Various previous studies have found a correlation between household size and energy consumption. Smaller households with one or two persons consume significantly more energy per person than households with, for example, four or five people. Following the studies from Dhakal (2008, p. 178) there is no imperial data that shows a significant correlation between the income of individual households and their energy consumption. Also the exact impact of different demographic population pyramids on energy consumptions is largely unknown. This also applies to the energy consumption of households with different age structures. The development of the population size and its related factors should be taken into account for the scenario development.

The general infrastructure and the urban form and function of a city has an effect on the CO_2eq-emissions as well. According to Dhakal (2008, p. 180) the city size, density, shape and distribution of its functions influence the energy demand. This becomes obvious, for example, in the transport sector. A more compact urban settlement allows for better and more cost efficient public transport. The same applies to the distribution of heat in district heat networks. Newman and Kenworthy (1999) found a direct correlation between city density and the energy demand. Segregated land use and urban sprawl were found to increase the specific energy demand while an urban form that allows for efficient public transport and “walkable” cities reduces energy demand and therefore CO_2eq-emissions (Newman and Kenworthy 1999). For the forecasting analysis it is recommended to assume that the general infrastructure and the urban form and function of the city remains the same. During the backcasting analysis climate protection measures may be developed that have an influence on these factors.

In addition to urban development, the economic development of a city plays a major role in the energy demand and CO_2eq-emissions. There is a direct link between economic growth and CO_2eq-emissions (Kok et al. 2002, p. 7). For most cities under research economic growth was found to be the most influential factor influencing CO_2eq-emissions (Dhakal 2008, p. 179) (Lankao 2007, p. 161). Dhakal (2008, p. 179) specified this finding further by distinguishing between the different economic structural components of a city. For example, it was found that economic growth of the industry sector and economic growth of the commercial sector have a different influence on the quantity of energy demand and CO_2eq-emissions. Since the commercial sector is less focused on producing goods and more focused on providing services they are less energy and CO_2eq-intensive. The higher the share of services is, the weaker the proportional linkage to the development of CO_2eq-emissions. The ratio between economic growth and CO_2eq-emissions differs from city to city, and thus must be researched for the city in question. The idea of limiting economic growth for climate protection can be found in the literature (e.g. Hopkins 2008) but has gained little political support. One reason is that economic growth, to some extent, is necessary for reducing poverty in developing countries (Moe 2012, p. 3) and decreases unemployment in developed countries. The economic development should be taken into account separately for the commercial and industry sectors for the scenario development.

Autonomous technological development is also a driving factor of energy demand and CO_2eq-emissions. Autonomous development in this case is defined as the technological advancement happening without political incentives. These developments are market driven. Examples include the insulation of buildings, the efficiency of electrical appliances and the fuel consumption of private cars. Quantitative data on autonomous technological development for city sectors is seldom. If no data on the autonomous technological development is available it is recommended to work with the overall historical development of energy demand and CO_2eq-emissions. Following this approach the autonomous technological development will not be quantified, but still included into the scenario development with the total development.

While technological developments influence energy demand and CO_2eq-emissions, humans are ultimately responsible for the operation and the planning of these systems. Therefore, behavioural and societal factors must be taken into account. Following Dhakal (2008, S. 181) behavioural aspects may include changes in daily routines like switching off lights when not in the room. It also includes aspects like choosing cars with small engines or actively living close to one's work place to avoid long commutes. For the forecasting analysis behavioural and societal factors stay constant. During the backcasting analysis climate protection measures may be developed that lead to behavioural and social changes.

Also political factors influence energy demand and CO_2eq-emissions. Political decisions in a city, on a regional, national or international level can have large implications on energy consumption and CO_2eq-emissions. For example, in Europe the Emission Trading Scheme reduces emissions, while the phase out of light bulbs favouring energy efficient lighting solutions reduces the energy demand. Thus, institutional and political factors need to be considered when analysing the driving factors for cities (Dhakal 2008, S. 181). For the forecast analysis only political aspects are considered that are either already in place or their future implementation is fixed by law.

The aforementioned drivers affect both individually and in combination the energy demand and CO_2eq-emissions for each individual city. Drivers which are constant for the city and those which change over time must be determined prior to conducting the forecasting analysis.

2.3 Backcasting

As described in the scenario typology, backcasting belongs to the category of normative scenarios. In contrast to forecasting, a backcasting scenario describes how the most desired future can be achieved. In the field of sustainability, the continuation of current trends may not be the most desirable future (e.g. in the reduction of green-house gas emissions) (Robinson 2003, p. 842). Among future studies, backcasting is not only viewed as an approach, but as an attitude towards uncertainties (Dreborg 1996, p. 822-824) (Höjer and Mattsson 2000, p. 629). Instead of focusing on the likeliness of a future development, the aim of backcasting is to explore alternative futures with a problem-driven approach (Robinson 2003, p. 843-845). This way of exploring new directions, such as the transition to a CO_2eq-neutral city, will be explained in more detail in this section.

In contrast to the preserving normative scenarios backcasting is explicitly a transforming normative scenario (Quist 2007a, p. 236-237). It is assumed that an optimization of the given system is not enough to fulfil the targets but that a major change is needed. These changes or transitions can normally not be achieved on the short-term. End-points for the desired future are usually chosen for a time-period of one or two generations (25-50 years) into the future (Robinson 2003, p. 842). Thus backcasting is a methodology for developing scenarios with a long-term goal. In contrast to forecasting, which predicts the future by a continuation of given trends, backcasting begins with the defining of a desired future (cp. Figure 2.3 and Figure 2.4). Following this step, it is analysed how the targets can be achieved by looking back from this defined future and identifying the intermediate steps (Quist 2007a, p. 11).

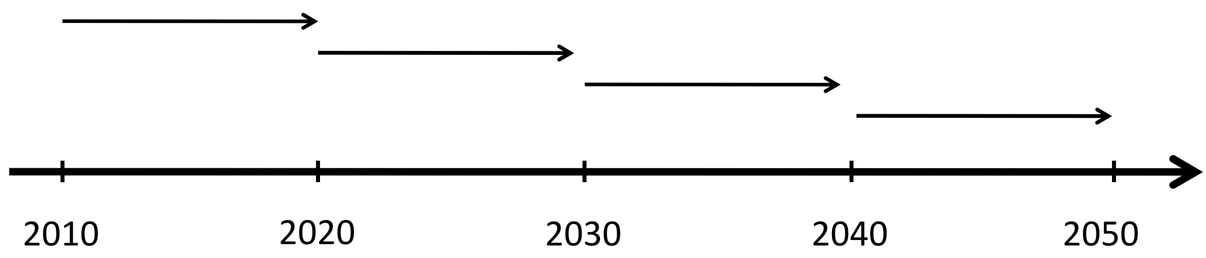


Figure 2.3: *Forecasting*

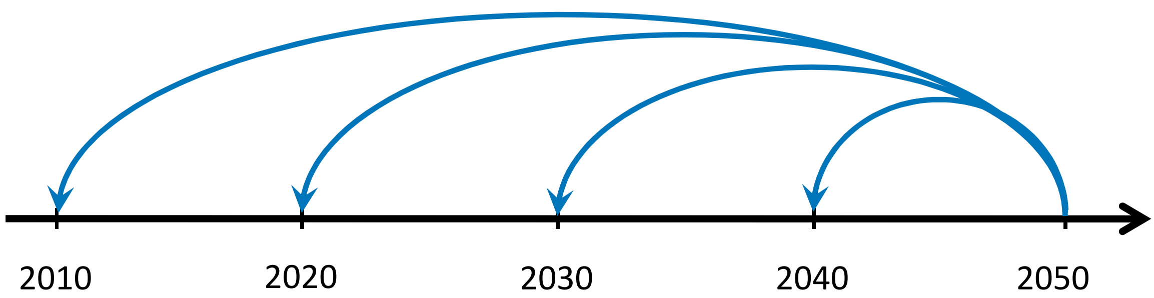


Figure 2.4: *Backcasting*

In his doctoral thesis Quist (2007a, p. 30) analysed different backcasting studies and defined the six main aims of backcasting analyses:

- Generation of future visions and analysing these;
- Putting visions and options on the agenda of relevant arenas;

- Developing a follow-up agenda with activities for various groups of stakeholders in line with the envisioned desirable future;
- Participation of a wide range of stakeholders;
- Awareness and learning among the stakeholders involved with respect to the future vision, the consequences, the agenda and the views and perspectives of others;
- Realising follow-up and stakeholder cooperation.

Dreborg (1996, p. 814) argues that backcasting is ideal for cases where long-term complex problems are deeply rooted in society or in cases where externalities cannot be satisfactorily solved by the markets and which can only be solved by major changes. Following the arguments from Höjer and Mattsson (2000, p. 628-629) backcasting is mostly relevant when longer-term forecasts show that targets will not be met. Dreborg (1996, p. 816) list five characteristics that favour backcasting:

- “when the problem to be studied is complex, affecting many sectors and levels of society;
- when there is a need for major change, i.e. when marginal changes within the prevailing order will not be sufficient;
- when dominant trends are part of the problem, these trends are often the cornerstones of forecasts;
- when the problem to a great extent is a matter of externalities, which the market cannot treat satisfactorily;
- when the time horizon is long enough to allow considerable scope for deliberate choice. ” (Dreborg 1996, p. 816)

The question of sustainability or more precisely, of a CO_2eq-neutral city, clearly fits into this pattern. Therefore, backcasting is a promising approach for the development of climate protection concepts for cities with ambitious CO_2eq-reduction targets.

2.3.1 Development of backcasting from first to second generation

Backcasting was first used by Lovins (1976) as a planning tool for electricity demand and supply. Backcasting was later applied to the field of sustainable development (Quist 2007a, p. 18) coinciding with the growing importance of sustainable development in the 1980s when the Brundtland report (1987) was first published. Coinciding with the growing demand for sustainable solutions, participatory approaches also became more important.

The growing importance of participation during this time was reflected by the further development of backcasting. Since the 1990s a shift from traditional backcasting towards participatory backcasting occurred. One of the first and most important steps of backcasting is to define a desired future. Robinson (2003, p. 844) raises the question, whose desirable future is expressed in backcasting scenarios? Here it is widely agreed upon that stakeholder involvement is crucial, not only because their stakes are affected, but also because they have the context-specific knowledge and the resources to realize a vision or scenario (Quist 2009, p. 2) (Vermeulen and Kok 2002, p. 41). Quist (2009, p. 1) found that the participation of stakeholders shows a strong link with the extent of spin-off and follow-up in backcasting experiments. Participation is seen as a key factor when developing sustainable solutions and therefore was integrated into backcasting.

Recently the term "second generation backcasting" can be found in the literature, which was developed and popularized by Robinson (2003). In his paper from 2003 he argues for a second generation of backcasting, "where the desired future is not determined in advance of the analysis" (Robinson 2003, p. 839). Determining the desired future, which is achieved with the stakeholders, is seen as a part of the backcasting process. Second generation backcasting differs from first generation backcasting in that it does not impose the normative conditions in advance (Robinson 2003, p. 854). In first generation backcasting experiments, the emphasis was on defining the desired future and then analysing how it can be achieved (Robinson 2003, p. 848-849). In second generation backcasting, instead, the focus lies on the choice of pathways to achieve given aims. Therefore, the specific characteristics of the end-point do not need to be known in advance (Robinson 2003, p. 848-849). The end-point is seen as a product of the process. In a learning and discovery process with the different stakeholders the end-point is shaped over time. This is especially important when stakeholders from a variety of fields with different interests and field-specific goals are participating. Due to discussions of possible pathways and an emerging learning-process from the different point of views of the stakeholders, the set of future conditions is formed.

Second generation backcasting is also characterised by a shift in the modelling of scenarios. In the traditional approach, a model was developed from a group of experts and the results were presented. Bagheri and Hjorth (2007, p. 87) argues that to achieve a learning process all stakeholders should be involved in the process of modelling. It helps the stakeholders to better understand the consequences of certain actions and the interactions between them. By seeing the outcomes of their choices the stakeholders might change their original ideas for a desirable future (Robinson 2003, p. 848-849). The focus of second generation backcasting therefore lies on social learning and the involvement of both experts and non-experts (Quist and Vergragt 2006, p. 1033).

The development of backcasting is depicted in Figure 2.5. It shows the development steps of the first generation backcasting towards the second generation backcasting. Both generations of backcasting are being used today.

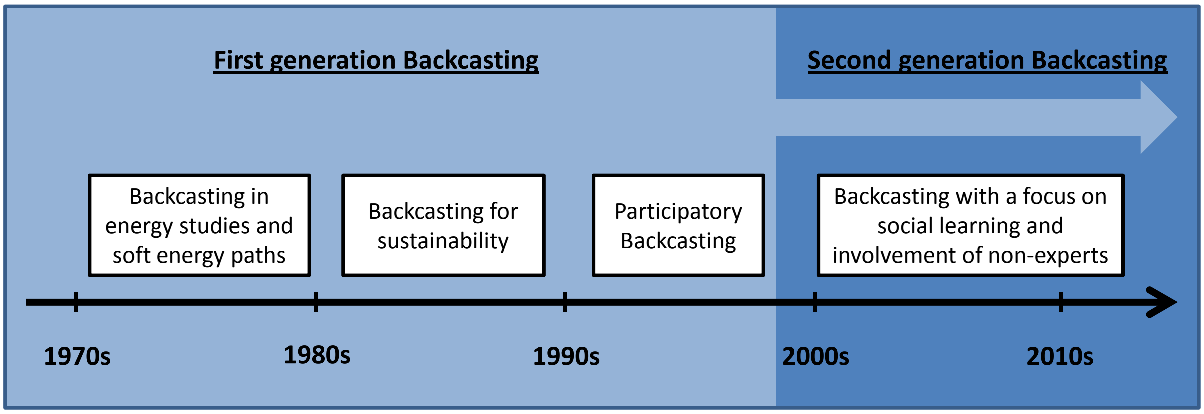


Figure 2.5: *Development of the backcasting approach from the first generation to the second generation of backcasting*

2.3.2 Backcasting methodology and steps

Since the origin of backcasting in the 1970s a variety of methodologies were developed. Quist (2007a) analysed the development of backcasting over time and distinguished several varieties of backcasting by analysing and comparing four different backcasting approaches including their frameworks. The four backcasting approaches were all applied in practice (Sustainability Backcasting approach by Robinson, The Natural Step (TNS), Sustainable Technology Development (STD), Sustainable Households (SusHouse); a detailed project description can be found in Quist (2007a, p. 24-28), an overview in table form can be found in Herrmann 2010). Besides the sustainable backcasting approach by Robinson (1990) the analysed backcasting approaches applied participatory methods. The approaches contained between four and seven methodological steps. Quist (2007a, p. 232) compared the individual steps and developed a generalised approach for backcasting, consisting of five steps:

1. Strategic problem orientation
2. Development of future vision
3. Backcasting analysis
4. Elaboration of future alternative and definition of follow-up agenda
5. Embedding of results and agenda and stimulation of follow-up

The five step backcasting approach from Quist (2007a) is understood as the basic methodology for backcasting experiments and will be applied in this dissertation. As a transforming, normative approach it is suitable for scenario development for cities with the goal of obtaining CO_2eq-neutrality. and will be applied.

2.4 Transition management

Forecasting as well as backcasting are approaches for scenario development. When working in a participatory way on a city-scale, where climate protection measures are implemented by individual decision makers, only scenario development is not enough. Climate protection requires also a strategy to establish and maintain a climate protection process to ensure that the objectives for emission reduction are achieved. One approach that is focusing on the implementation of transforming systems is transition management, which will be presented in the following section.

In the last decade, it has been discussed if an incremental change along existing technological development paths (Kern 2006, p. 4) is enough to achieve ambitious CO_2eq-reduction targets. The long-term character of climate change is one of the key aspects to consider when working on solutions for a sustainable world (Kok et al. 2002, p. 1). Until now long-term issues are not institutionalised in policy and government processes (Loorbach 2010, p. 169). Too much focus lies on the political election cycles, so that the planning horizon becomes limited to short- or mid-term intervals (Loorbach 2010, p. 169). However, the problems of climate change can only be solved when considering the long-term. Different authors suggest that the development and introduction of new ways of thinking and overcoming existing structures on all levels of the society will be necessary to achieve transition to sustainability (Loorbach 2007, p. 11) (Loorbach 2010, p. 162) (Kern 2006, p. 4). New approaches are necessary to address the current issues of sustainability and to achieve a transition.

In the last decade evolutionary approaches like “strategic niche management”, “time strategies” or “transition management” were widely discussed in the literature. Nill and Kemp (2009, p. 668) argue that evolutionary approaches provide the foundation for sustainable policy innovations which are necessary to achieve fundamental changes. The achievement of a sustainable future depends on the development and application of structured and flexible approaches (Loorbach 2007, p. 11). A detailed comparison of the three mentioned evolutionary approaches was performed by Nill and Kemp (2009). The main characteristic of evolutionary approaches is that the future development is seen explicitly as a dynamic process. It is flexible to new technologies and events. Evolutionary approaches are characterised by an ongoing process of learning and improvement making.

The complexity and depth of integration of the problems in society calls for a new approach that is able to address short-term goals as well as the upcoming long-term challenges for a sustainable development (Loorbach 2007, p. 11). The consideration of short-term as well as long-term goals closes the gap between incremental and radical changes (Stephens and Graham 2009, p. 5). The combination of incremental short-term goals combined with a long-term perspective is a valuable potential (Stephens and Graham 2009, p. 5) for a sustainable development. According to Loorbach (2007) the balance between a structured strategy and flexibility, between management and self organisation and between theory and practice needs to be achieved. Transition management tries to fulfil these requirements. It is a new approach, which first arose in the year 2000 and is still being further developed. The goal of transition management is to achieve sustainability through a directed influence of society (Loorbach 2007, p. 12). It is an evolutionary approach that uses ongoing dynamics to achieve a long-term change in society by establishing incremental steps. As typical for evolutionary approaches, a sustainable development is achieved over time in a process of continuous learning and a trial-and-error approach (Loorbach 2007, p. 12).

2.4.1 Definition of transition

Following the most commonly used definition in the literature (Rotmans et al. (2001, p. 15), Kemp and Loorbach (2003, p. 8), van der Brugge (2009, p. 18)) a transition describes a fundamental change in society over a time-span of one to two generations (25-50 years). The concept of transition, which was introduced by Rotmans et al. (2001, p. 15), has its origin in the field of biology, in the specific field of population development. Davis (1945) and Notestein (1945) shaped the term “Demographic transition model” in 1945. The model describes the population development of a country when changing from an pre-industrial society to an industrialised nation (Caldwell 1976; Kirk 1996). The model states, that with an increasing degree of industrialisation in the beginning the population number increases due to a decreasing death rate and a constant birth rate. Over time the birth rate adapts to the death rate and after an initial population growth the population will reach a constant level. Kirk (1996) states that the demographic transition is one of the best documented phenomenon in society. The universal phenomenon that a stable system due to internal and external influences undergoes a change and reaches, after an adaptation phase, a stable system again, was included into the transition management theory.

In detail, a transition is extremely heterogeneous (Rotmans et al. 2001, p. 15). Nevertheless, when simplified, it can be described by three main characteristics (van der Brugge 2009, p. 18). The first characteristic is the time span. It is argued that to achieve a transition, a time span of one to two generations is necessary. Therefore, a transition is classified as long-term. The second characteristic is that a transition contains major changes in technology, economy, ecology, social-cultural, political and institutional developments with complex interactions between them (van der Brugge 2009, p. 18) (Kemp and Loorbach 2003, p. 8). The third and last characteristic is, that a transition takes place on different levels of society which are also in close interaction (van der Brugge 2009, p. 18) (Kemp and Loorbach 2003, p. 8). A transition is a fundamental and structural change in all levels of society, e.g. dominant culture, structure and procedure (van der Brugge 2009, p. 17).

2.4.2 Differentiation between transition and optimisation

Following van der Brugge (2009, p. 17) a transition, which is characterised by fundamental changes, differs from an optimisation, which is characterised by small, incremental changes. The difference is depicted in Figure 2.6 on page 53. It can be seen that an optimisation from a holistic perspective can be the better solution in the beginning. A transition, however, requires that existing paths are left and the experimental testing and comparison of different alternatives is undertaken. Due to the circumstance that experiments are not necessary successful, an optimisation can be the more efficient way to reduce emissions in the beginning. For instance, Mulder (2007, p. 253) argues that in the industry sector the focus lies on the optimisation of processes. An achievement of sustainability, however, cannot be reached by optimising fossil fuel powered technology (Mulder 2007, p. 258). It requires a fundamental shift. Thus investments in optimisation can be lost capital for stakeholders. In addition invested capital influences future investment decisions (Kemp and Loorbach 2006, p. 126). Therefore, the combination of short-term goals and long-term aims should be a necessity.

Transitions with innovations have an additional disadvantage in the beginning of the process because of compatibility issues. The major advantage of compatibility is that the existing structure can be used. The more actors that agree on one technology, the more interesting it is for other actors to join in. A compatibility-network is created. This ultimately creates a barrier for new technologies that are not compatible. Thus possibilities for actors supporting new technologies

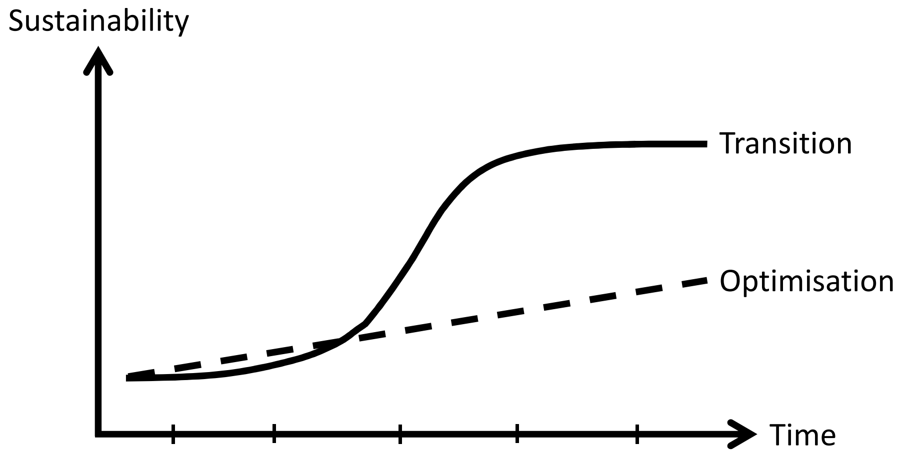


Figure 2.6: *Visualisation of the difference between optimisation and transition (modified from van der Brugge 2009, p. 17)*

are limited. van der Brugge (2009, p. 87) argues that one way for incompatible innovations to develop is through niches. Niches provide a protected environment where innovations can be developed independently from the market.

Transforming approaches like backcasting or transition management should be used when the achievement of long-term targets is more important than short-term efficiency (Börjeson et al. 2006, p. 22). If the achievement of short-term aims is the main focus point optimisation scenarios should be used instead (Börjeson et al. 2006, p. 22). In both cases compatibility is a key factor for an easier achievement of the goals.

2.4.3 Historical development of transition management

Transition management was developed in the Netherlands. The term was first used in the fourth national environmental plan in 2001 and integrated into the national policy (Loorbach 2008, p. 2) (Kern 2006, p. 1). With the development of the fourth national environmental plan, it was claimed that for the achievement of a sustainable development a change was necessary. The current problems in the area of agriculture, transport, natural resources and energy could not be solved by the established traditional environmental policy (Kern 2006, p. 1). This was the starting point for the transition management approach. Jan Rotmans and Rene Kemp developed transition management combining a variety of study fields in one holistic interdisciplinary approach.

The needs for transition management are outlined in the points below (Loorbach 2008, S. 6,7) (Kemp and Loorbach 2003, p. 7):

- ”To deal with uncertainties, through the use of scenarios
- To keep open options and deal with fragmented policies:
  - to stimulate knowledge and technological change
  - to pursue innovation and incremental improvements
  - to take a multi-domain view with attention to all relevant actors
- To have a long-term orientation and to use this for short-term policies
- To pay attention to the international aspects of change processes and find solutions at the right scale
- A set of specific tasks for the government, namely to stimulate, mediate, engage in brokering services, create the right conditions, enforce its laws and engage in steering”

Up until now transition management was applied in different fields and sectors. Stephens and Graham (2009, p. 2) distinguishes two categories for transition management. The first is the descriptive historical analysis of already finished transitions. The second is the prescriptive analysis that focuses on present or future transitions. Due to the historical analysis important knowledge regarding the structure and course of action of the process was gained. Studied examples are, for instance, the electricity (Verbong and Geels 2007) and water (van der Brugge 2009) sector in the Netherlands, the worldwide transport sector (transition from horse to automobile (Geels and Schot 2007) or from sailing boats to steam vessels (Geels 2002) and the hygienic transition with the introduction of sewage system and treatments plants (Geels 2006). Nowadays transition management is used in such areas as infrastructure and higher education (Truffer and Stürmer 2009). Transition management has been used at both the regional (e.g. Scholz and Stauffacher (2007)) and local levels (e.g. Vergragt and Brown (2010)).

2.4.4 Core aspects of transition management

Kemp and Loorbach (2003, p. 13) define transition management as a mathematical equation: “transition management = existing policies + long term vision + vertical and horizontal coordination of policies + portfolio-management + process management”. This short and concise mathematical illustration is a good description of the core elements of the transition management approach.

Transition management uses incremental steps when establishing a transition. This is useful for getting those people and companies involved used to the transition process. Additionally, working in incremental steps, prevents a rapid change, resulting in a smoother transition process. Transition management makes use of the existing policies and possibilities of the current system to achieve a fundamental change (Rotmans et al. 2001, p. 24). It uses the existing system and its existing dynamics instead of forcing a transition (Rotmans et al. 2001, p. 24) (Kemp and Loorbach 2003, p. 11). Due to the structural incremental changes resistance from the society is kept to a minimum level (Rotmans et al. 2001, p. 25). Additionally transition management is characterised by being a flexible process, where companies and individuals involved do not follow a strict blue-print, but rather have the flexibility to adapt during each step of the process so that the best results are achieved. These two characteristics ultimately lead to a transition from one state to another with the least amount of resistance.

Transition management focuses less on single events but rather on the general requirements for a change. The approach aims at initiating a sustainable development and creating a shift from the current to the future system. It is therefore applicable on a city-scale, where individual aspects are not the main focus, but rather the general requirements for a sustainable city as a whole.

Even though transitions are highly individual complex processes there are uniform patterns, mechanisms and dynamics that can be identified in each transition project. Hence Loorbach (2008, p. 5 ff.) analysed and compared a variety of transition projects. The similarities from the compared Transition Projects resulted in the defining of the core aspects of transition management. In the following list the main aspects and terms of transition management are summarised (for a more detailed description see Loorbach (2008, p. 13-15)):

Dynamics of the system Knowledge of the system and its processes is a requirement for effective management. This may include analyses of the interaction of ongoing developments on and between all levels.

Long term thinking Long-term thinking (25 - 50 years) for shaping short-term policies. Analysing the interactions of short and long-term goals is unavoidable.

Flexible and adjustable objectives Flexible objectives allows a better adjustment to internal and external changes of a complex system.

Creating space for niches A niche is a protected space where innovations can develop independently from the market and its dominant structure.

Focus on frontrunners Frontrunners are creative persons, strategists and visionaries. They are active at many different levels and bring forward the transition.

Guided variation and selection Instead of selecting innovations early-on, options should be kept open. This allows one to gain knowledge about the advantages and disadvantages of different innovations before making any decisions. Experiments can help to reduce uncertainties.

Radical changes in incremental steps Necessary fundamental changes that are needed for a transition are not immediately performed. This would cause avoidable resistance in the current, mostly incompatible system. Incremental steps allow the system to adopt gradually to new circumstances. Bringing the necessary fundamental changes in line with incremental steps is one of the core aspects of transition management.

Learning-by-doing, doing-by-learning and social learning The aim is to change the perspective of actors. Learning-by-doing is the development of theoretical knowledge and the testing of these in practice. Doing-by-learning is the usage of practical learned knowledge to test a theory. Social learning stimulates the development of visions, paths and experiments.

Anticipation and adaptation Anticipation of future trends and development by taking weak signs and small changes into account. This is "a key element of a pro-active, long term strategy such as transition management" (Loorbach 2008, p. 14). A transition should be accompanied by an adaptation strategy. An adjustment should already be performed while a system is developing in an undesirable direction and not just afterwards.

2.4.5 Phases of a transition

The transition management theory assumes that a transition can be described in a simplified way by an s-curve. The s-curve is one of the most fundamental curves in the field of natural adaptation processes (cp. demographic transition model), learning processes respectively technology development and the implementation of innovations on the market. Developments following an s-curve, start slow in the beginning and then grow continuously until the development reaches a maximum and slows down again (van der Brugge 2009, p. 19). The flat parts of the curve are dynamic equilibriums, e.g. a steady population number.

An s-curve can be divided into different time sections (van der Brugge 2009, p. 23) (Rotmans et al. 2001, p. 17) (Kemp and Loorbach 2003, p. 8). The time sections are defined using the multi-phase concept. Disagreement exists regarding the exact division and the titles of the sections. Rotmans et al. (2001), Loorbach (2007), Kemp and Loorbach (2003), Stephens and Graham (2009) name them as "pre-development, take-off, breakthrough and stabilisation phase". However, in this thesis the division from Wiek et al. (2006, p. 742) will be used, which views the take-off not as an individual phase, but rather as a transition point to the acceleration phase. The main advantage of the division from Wiek et al. (2006) is the inclusion of milestones to define the transition phases. The beginning of each phase is marked by a milestone, which allows a clear distinction of the individual transition phases. An illustration of the different transition sections from Wiek et al. (2006, p. 742) can be seen in Figure 2.7 on page 58.

Transition and transition management for organizational and societal systems (adapted from Rotmans et al. [5]). Key components of transitions are phases, milestones and system states (axes). As illustrated by the arrows above the real and the ideal transition curves, transition management initiates and supports transition processes, starting from incentives and iteratively passing through different management phases.

Figure 2.7 shows a simplified transition. Depending on the system the form of the s-curve varies in speed, the amount of change and the timeframe of the transition (Rotmans et al. 2001, p. 18) (Kemp and Loorbach 2006, p. 106). The characteristics of such a heterogeneous development cannot be determined in advance. Therefore, it is not the aim of the multi-phase concept to predict the shape of the transition. Instead the multi-phase concept helps to determine the advancement of the system under study (Loorbach 2008, p. 17) (van der Brugge 2009, p. 24). In addition, the multi-phase concept allows a transition with a time span of one to two generations to be divided into shorter, more manageable time sections (van der Brugge 2009, p. 24).

The first phase of a transition is called the “pre-development” or “pre-transitional” phase. Structural changes occur very slowly and the system stays in a dynamic equilibrium (Rotmans et al. 2001, p. 17). The slow development in the beginning is the ideal situation in transition management. The transition is based on the existing dynamics and uses those to realise the transition to a new system (Rotmans et al. 2001, p. 25). Changes are not forced, which minimises the fear and resistance of actors and the public for a fundamental change.

The second phase is the acceleration phase. The acceleration phase is the start of the transition and is associated with rapid progress (Wiek et al. 2006, p. 742). Innovations and new ideas are introduced and become more competitive, resulting in a rapid adaption of the innovation or idea, thus resulting in a dramatic change of the system (van der Brugge 2009, p. 24) (Rotmans et al. 2001, p. 17). The change starts to be noticeable and is the consequence of structural changes in the social, economic, ecological and institutional areas of the system under research (Rotmans et al. 2001, p. 17) (van der Brugge 2009, p. 24).

Finally the process moves into the stabilisation phase (Rotmans et al. 2001, p. 17). In this part of the transition the speed of change is decreasing and a new dynamic equilibrium will be achieved (van der Brugge 2009, p. 24). The transition to the new system is complete and the "post-transitional-phase" is reached. Thus, transition management does not answer the question how long the dynamic equilibrium will exist. Van der Brugge (2009, p. 24) argues that transitions themselves are a dynamic cyclic process and that after one transition the next one could follow immediately.

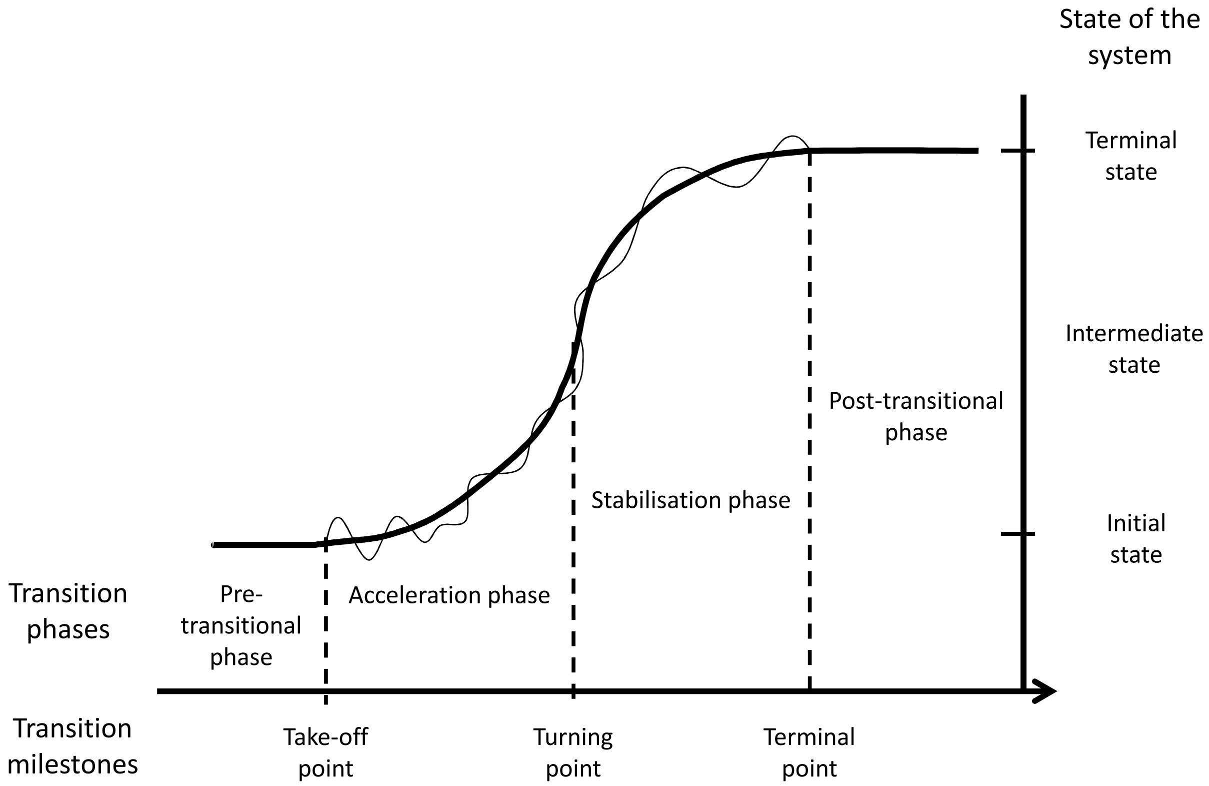


Figure 2.7: *Transition and transition management (modified from Wiek et al. 2006, p. 742)*

Figure 2.7 shows, in addition to the idealised s-curve, a possible more realistic shape of the curve (thin line). Transition management researches agree that a transition does not follow an s-shaped development exactly, but that it has highs and lows (van der Brugge 2009, p. 25) (Wiek et al. 2006, p. 742) (Rotmans et al. 2001, p. 17). A transition should be seen more as a cascade in which innovations are breaking through on different levels at different speeds (Kemp and Loorbach 2006, p. 107). The s-curve is a metaphor for the change from one dynamic equilibrium to the next by transitioning through a certain developmental phase (van der Brugge 2009, p. 19). One of the main aspects of a transition is that in contrast to an optimisation, it is not a linear process (van der Brugge 2009, p. 24); stable periods are followed by unstable ones, with fast intermittent changes.

Van der Brugge (2009, p. 27) argues that in addition to the idealised s-curve of a transition, further development paths of a system are possible. A generalised figure of different paths is shown in Figure 2.8. Three additional curves are depicted where a successful transition does not occur. In the situation of a "lock in" initial innovations influence the existing system only slightly. Consequently, necessary innovations for a transition are not prevalent (for further information about lock-ins see: Foxon (2007), Perkins (2003, p. 1), Rip and Kemp (1998), Arentsen et al. (2002), Unruh (2000)). In the situation of a "backlash" innovations are initially taking off, but they fail to become established and a new equilibrium is not achieved. The system under research returns to the old equilibrium. The last curve describes the situation of a "break down" of a system. During a "break down" the current system is destabilised but the introduced technology or measure fails, resulting in a system that is less sustainable than before.

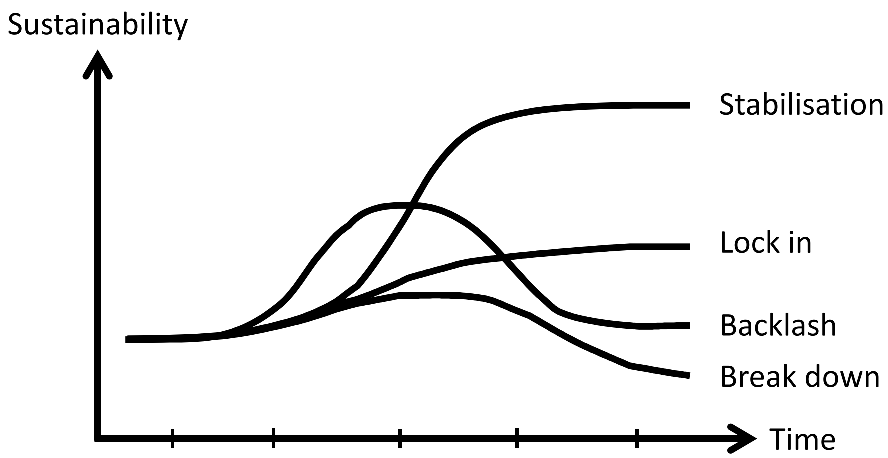


Figure 2.8: *Possible pathways of a system change (modified from van der Brugge 2009, p. 28)*

2.4.6 Transition management steps

Following Rotmans et al. (2001, p. 22-24) the methodology for transition management originally contained five steps. These included (1) problem definition and transition objectives, (2) transition visions, (3) transition paths and interim objectives, (4) evaluating and learning and (5) creation of public support. Kemp and Loorbach (2003, p. 13-16) further detailed this approach. The five step approach of Rotmans et al. (2001) is described below, and incorporates the additions from Kemp and Loorbach (2003). The additions are included within the original five steps, and not as separate steps, as suggested by Kemp and Loorbach (2003), for the purpose of simplicity.

2.4.6.1 Problem definition and transition objectives

To achieve sustainability an unstructured problem needs to be solved through collective efforts. A mutually understood definition of the present problem should be developed (Kemp and Loorbach 2003, p. 13) to create awareness of the existing problem. Once the problem is defined objectives are determined. Following Rotmans et al. (2001, p. 22,23) the objectives should be motivating and should include multiple perspectives and may be quantitative as well as qualitative. Transition management as an evolutionary approach allows for the objectives to be further developed or adapted to upcoming events over time (Rotmans et al. 2001, p. 23).

2.4.6.2 Transition visions

The initial step of setting transition objectives provides the fundamental basis for developing transition visions (Kemp and Loorbach 2003, p. 14). The visions must be appealing, creative and be supported by a number of actors (Rotmans et al. 2001, p. 23) (Kemp and Loorbach 2003, p. 13). Inspiring visions help to mobilise actors, as long as they remain realistic regarding possible innovations and are not promising false hopes (Rotmans et al. 2001, p. 23) (Kemp and Loorbach 2003, p. 14).

Instead of creating only one vision, Rotmans et al. (2001, p. 23) argue that a variety of visions should be developed. Through experiments conducted later on in the transition management process, the most promising visions should be determined. By developing a variety of visions, transition management differs from traditional approaches, which try to determine a single, concrete way for achieving set objectives (Rotmans et al. 2001, p. 23) (Kemp and Loorbach 2003, p. 14).

2.4.6.3 Transition paths and interim objectives

Achieving the set visions is described using transition paths with defined interim objectives. Different paths are possible to achieve a particular vision. Following the arguments from Nill and Kemp (2009, p. 673) and Kemp and Loorbach (2006, p. 126) allowing different paths to achieve a vision in combination with transition experiments guarantees that a "lock in" will be avoided.

Transition paths should include uncertainties, barriers and necessary changes for implementation including transition experiments (Kemp and Loorbach 2003, p. 15). The vision in combination with the transition paths and experiments creates the transition agenda (Kemp and Loorbach 2003, p. 15). In the beginning of the transition process, the competition between different transition paths and technologies is limited, because a broad portfolio was chosen to keep different options open. Competition between transition paths will continue to increase, especially once financial decisions need to be made, such as the investment of money into particular experiments. This ultimately leads to a narrowing-down of possible transition paths (Nill and Kemp 2009, p. 675).

2.4.6.4 Evaluating and learning

In transition management the evaluating and learning process is continual. Progress and achievements are analysed and through an evaluation of applied measures a learning process takes place (Rotmans et al. 2001, p. 24) (Kemp and Loorbach 2003, p. 15). When reaching an interim objective the evolved actors in the transition process determine the achievement of the aims. When certain goals are not achieved the causes should be understood, analysed and learned from. Following Rotmans et al. (2001, p. 24) typical questions for evaluation are: Is the transition process dominated by certain actors?; Are there enough secure commitments?; Should additional actors be included in the process?; Was new knowledge gained?; What can we learn from those for the future?

2.4.6.5 Creating public support

A continuous task is the creation and maintenance of public support (Kemp and Loorbach 2003, p. 16) (Rotmans et al. 2001, p. 24). This is especially important in the beginning of the process, when a fast achievement of results is unlikely (Kemp and Loorbach 2003, p. 16). A loss of public support could lead to a failure of the transition and the old system being retained. A good way to maintain public support in the beginning is through the integration of participatory decision making and involvement of society in the determination of goals (Kemp and Loorbach 2003, p. 16) (Rotmans et al. 2001, p. 24,30). Applying a top-down and bottom-up approach utilises the advantages of the heterogeneity of society. It supports the use of niches and allows a collective learning process (Rotmans et al. 2001, p. 24).

2.4.7 Implementation of transition management

One of the biggest challenges of transition management is to implement the comprehensive and complex transition to a manageable management system without losing too much of the complexity and underlying dynamics (Loorbach 2010, p. 168). Operational instruments need to be defined that allow an active involvement in transitions (Stephens and Graham 2009, p. 2).

Loorbach (2008, p. 15) portrays transition management as a cyclic process on different development levels. He distinguishes strategic, tactical, operative and reflexive levels to influence a transition (Loorbach 2010, p. 172-175) which will be described in detail in the following sections. The fragmentation enables the development of suitable instruments for the different situations, such as the application of transition management on the city-scale for climate protection.

2.4.7.1 Strategic Level: Transition arena and vision

In the beginning of a transition process a transition arena is founded. The transition arena is a small network of frontrunners with different backgrounds (Loorbach 2010, p. 173) (Kemp and Loorbach 2003, p. 16) (Kemp and Loorbach 2006, p. 111). The number of actors should be between 10 and 15 and should be chosen by their competence and interests (Loorbach 2010, p. 173,174). The transition arena benefits from the heterogeneous knowledge base created by the involvement of various actors, in particular from the actors' different perception of problems. The variety of different professional, educational and social backgrounds in the transition arena promotes the discussion of different problem solutions (Loorbach 2010, p. 173) and helps the actors to see the problem from a different perspective. The transition arena should be independent from traditional policy networks in order to avoid a domination of established interests (Kern 2006, p. 5). The transition arena should support the creation of new coalitions, relationships and networks as well as promote the development of new ways of thinking (Loorbach 2008, p. 16).

The members of the transition arena do not need to be experts. They can also be networkers or opinion leaders. Most importantly they need to be willing to invest time and energy into the transition process (Loorbach 2010, p. 174). The composition of the transition arena will most likely change over time with new members joining and old members leaving (Loorbach 2010, p. 174).

The transition arena defines long-term objectives and according to the objectives develops visions. Visions are an important instrument to achieve new insights and knowledge about possible future developments (Loorbach 2010, p. 175). In transition management visions are not seen as blueprints but will change over time and adapt to new circumstances.

2.4.7.2 Tactical Level: Transition agenda

Building on the developed vision, a mutual transition agenda is developed (Loorbach 2010, p. 175) (Kemp and Loorbach 2003, p. 16). A transition agenda contains a number of objectives, projects and instruments to achieve the objectives (Loorbach 2010, p. 175). Therefore, responsibilities for planned activities and projects are being fixed (Loorbach 2010, p. 175). With a timeframe of five to fifteen years the tactical level is considered mid-term (Loorbach 2010, p. 171).

The transition agenda should be rooted into the different networks, organisations and institutions (Loorbach 2010, p. 175). The transition agenda serves as an orientation for the ongoing transition process on a global as well as individual scale. One aim of the transition agenda is the further distribution of transition networks, which originate from the transition arena. On the tactical level, also structural barriers (e.g. regulations, economic framework, consumer behaviour, infrastructure or certain technologies) for a transition are identified (Loorbach 2010, p. 175). During the development of a transition agenda the interests of organisations and individuals become more clear and are influencing future strategies (Loorbach 2010, p. 176). During this time companies and organisations should be involved who are willing to participate for the long-term (Loorbach 2010, p. 176). The participants need to have a certain amount of authority in their respective companies and enough insight to see where their company's participation in the transition process is possible (Loorbach 2010, p. 176) (Kemp and Loorbach 2006, p. 112).

2.4.7.3 Operative Level: Experiments

The operative level includes all short-term (zero to five years) innovative activities and experiments (Loorbach 2008, p. 15); the so called transition experiments. Transition experiments are likely to be high risk projects, but when successful they can largely contribute to a transition (Loorbach 2010, p. 176). New transition experiments are derived from the transition vision and agenda. Alternatively transition experiments can also be seen in combination with already existing innovative experiments (Loorbach 2010, p. 176), as long as they both are working towards fulfilling the transition vision. When an experiment is successful it can be repeated on all different levels and further extended (Loorbach 2010, p. 176).

Transition experiments are normally both costly and time consuming. Therefore, existing infrastructure should be used, where possible, and the results of implementation of measures continuously controlled (Loorbach 2010, p. 176). Improving already existing technologies has a lower risk than developing a "breakthrough technology" (Mulder 2007, p. 258). In the operative phase the focus of transition management lies on the creation of a portfolio of experiments. A certain diversity of completed experiments is important as long as they help the transition (Loorbach 2010, p. 176). The more extensive the portfolio of experiments and technologies, the less likely a lock-in in a certain technological development path will occur (Kemp and Loorbach 2003, p. 11). The portfolio of experiments should complement and strengthen each other, help with the transition to sustainability, work on large scale, and have a significant result (Loorbach 2010, p. 176).

2.4.7.4 Reflexive Level: Monitoring and evaluating

On the reflexive level existing policies and ongoing social changes are analysed in order to monitor and evaluate the transition process (Loorbach 2010, p. 170). The monitoring and evaluating needs to become an integrated part of the management process and include the other three levels (strategic, tactical and operative levels) (Loorbach 2010, p. 171). Continuous control is an essential part of the evaluation and learning process of a transition (Loorbach 2010, p. 177) (Taanman 2008).

Loorbach (2010, p. 177) distinguishes between the control of the transition process and the control of transition management. Controlling the transition process is the investigating of physical and social changes of the system as well as the development of innovations (Loorbach 2010, p. 177). The controlling of transition management contains different aspects. First the network activities, responsibilities, activities and projects of the different actors are verified (Loorbach 2010, p. 177). Second the transition agenda is checked concerning the planned activities, objectives, projects and instruments (Loorbach 2010, p. 177). Following this, the transition experiments are checked concerning the gained knowledge and ongoing learning process (Loorbach 2010, p. 177). Finally the transition process needs to be controlled concerning the progress, the barriers and points that need to be improved (Loorbach 2010, p. 177).

The integration of continuous monitoring and evaluation on every level of the transition management process helps to start and maintain the process of social learning, which evolves due to the cooperation of the different actors (Loorbach 2010, p. 177).

2.4.7.5 Transition management cycle

The previously presented levels of the transition are combined in a transition management cycle. Loorbach (2008, p. 15) divides the cycle into four parts. First the problem is structured and a transition arena is developed and organised (strategic level). Second coalitions and transition agendas are developed (tactical level). Third the developing transition network is mobilised and projects as well as transition experiments are executed (operational level). Fourth the transition experiments are analysed and evaluated and the learning process is started (reflexive level). Based on the gained knowledge from analysing and evaluating the projects and transition experiments, visions, agenda and coalitions are adapted. In reality there is no clear timely sequence of the different steps of the transition management cycle (Loorbach 2010, p. 171). Figure 2.9 shows a visualisation of a transition management cycle.

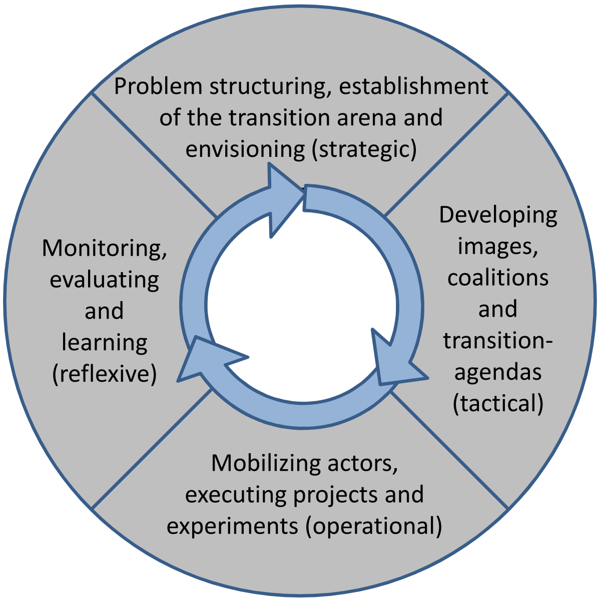


Figure 2.9: *Transition management cycle (modified from Loorbach 2008, p. 16)*

2.4.8 Transition Scenario

Since the beginning of its development, transition management has been continuously further developed and extended by new tools. It has been pointed out that the process of scenario development needs to be further developed (Sondeijker 2009). Sondeijker (2009) devoted her thesis to this topic and extended the transition management theory by transition scenarios. She argues that existing approaches of future studies are not sufficient enough to describe a transition process (Sondeijker 2009, p. 17). Different authors (Quist 2007b; Van Asselt et al. 2005; Bruggink 2005) have already previously tried to create an approach for transition scenarios but were unsuccessful. The concept developed by Sondeijker (2009) for transition scenarios, named TRANSCE, represents a new way of creating scenarios in a complementary way to the transition vision. It is intended to bridge the existing gap between transition management and future studies.

Sondeijker (2009, p. 25 ff) argues that existing scenario approaches are not suitable to describe the fundamental changes needed for a transition. They are mainly focused on content. Sondeijker (2009, p. 56) points out that in addition to the content the process needs to be taken into account. Also including fundamental institutional changes is hardly possible in traditional scenarios. The strategic activities of actors, education and coalitions are rarely presented. Sondeijker (2009) defines a transition scenario as "participatory explorations of possible long-term development trajectories that incorporate a structural systems change towards a desired, sustainable future state of the system." Sondeijker (2009, p. 62)

In agreement with the transition management theory Sondeijker (2009, p. 72) argues for the creation of more than one scenario to be able to deal better with uncertainties. A lock-in in a certain technological development path becomes less likely when options are kept open.

Sondeijker (2009) defined a seven step approach for a transition scenario. According to Sondeijker (2009, p. 21), the main disadvantage of TRANSCE is that it is not necessarily meant to create plausible or realistic scenarios but rather serves for exploration purposes. Furthermore it is a very detailed approach. For instance a transition scenario should contain the effects of developments of the structure, culture and daily life from an end-user perspective including changes on all levels. A good intermediate step from the TRANSCE approach that will be taken into account in this thesis is the definition of possible upcoming challenges for a transition. It is a preparation for the implementation of measures. Furthermore it helps to identify aspects of the future system that should not be in place anymore for a sustainable development.

As previously mentioned different authors (Quist 2007b; Van Asselt et al. 2005; Bruggink 2005; Sondeijker 2009) have tried to create an approach for transition scenarios. The complexity of transitions complicates the development of a manageable approach. Further research is needed to develop a more manageable approach for the development of transition scenarios. Instead of including the TRANSCE approach it is argued that a combination of transition management and the backcasting approach is more suitable for developing climate protection concepts at the city level.

2.4.9 Summary

Transition management represents a fairly new approach for achieving transitions towards sustainability, which continues to develop. Wiek et al. (2006, p. 741) state that so far transition management has been rarely applied to mid-sized, complex systems like regions or cities. Transition management was developed in the Netherlands and has mainly been applied there to areas such as infrastructure, higher education and the development of environmental policies. Additionally one instance of transition management application was in Belgium (Loorbach 2010, p. 179). Loorbach (2010, p. 179) points out that applying the approach to different countries is a major challenge for the future. Both questions (use for cities and in Germany) will be researched in combination with backcasting in this thesis. The following list summarises the steps and implementation of transition management as described in the previous sections. In addition to the summarised steps and the implementation of transition management, the transition management cycle applies.

Steps:

- Problem definition and transition objectives
- Transition visions
- Transition paths and interim objectives
- Evaluating and learning (development rounds)
- Creating public support

Implementation:

- Strategic Level: Transition arena
  - Small group of frontrunners with different backgrounds
  - Focusing on certain transition problems

  - Developing of transition visions
- Tactical Level: Transition agenda
  - Upscaling of the transition arena to a transition network
  - Creating transition scenarios and transition paths
  - Concretization of objectives, responsibilities, investments and strategies
- Operational Level: Transition experiments
  - Experiments that fit into a transition path
  - Projects with a high level of risk
  - Learning process
  - Upscaling from micro to meso-scale when successful
- Reflexive Level: Monitoring and evaluation

Transition management as an evolutionary approach, partly stemming from the field of innovation studies, has a strong focus on innovation. The strong innovative focus results in an emphasis on transition experiments on the operational level of the transition management implementation. In transition management theory, it is argued, that a transition requires leaving existing paths and undertaking experimental testing and comparison of different alternatives (Loorbach 2010). For the application of transition management to climate change mitigation on a city-scale, this point of view must be broadened. Purely focusing on transition experiments during the operational implementation phase of transition management would be a methodological short-coming for the development of climate protection concepts on the city-scale. In addition to testing, evaluating and implementing transition experiments, climate protection requires the reduction of energy demand and CO_2eq-emissions also by applying non-innovative climate protection measures. Most of the technology for achieving highly ambitious CO_2eq-emission reduction targets is already available. Therefore, the strong focus on transition experiments has to be broadened to also include non-innovative climate protection measures. Furthermore, climate change mitigation depends entirely on human decisions and their willingness to implement climate protection measures. The operational phase has to account for the mobilisation and integration of more stakeholders in the local climate protection process. For the development of a methodology for climate protection on the city-scale, transition experiments, non-innovative climate protection measures, and the participation of stakeholders will be included in the operational phase.

2.5 Transition management and backcasting for CO_2eq-neutral cities

The question whether transition management or backcasting are suitable approaches to address the challenges of obtaining the achievement of a CO_2eq-neutral city is discussed in this section by using a defined set of criteria. According to the introduced methodologies in the previous chapters suitable approaches need to be able to fulfil the following requirements:

1. Ensuring a sustainable development
2. Using a normative approach
3. Integration of long-term and short-term aspects
4. Using an integrated approach dealing with a high level of complexity
5. Participation of stakeholders and the public
6. Flexibility of the approach
7. Promotion of follow-up

The first requirement to address is the question whether backcasting and transition management are approaches suitable to achieve a sustainable development. The definitions of the terms sustainability and a sustainable development were provided in the Chapter 1 (Section 1.1 on page 10). An adaptation of these terms was performed to make them applicable for cities. Sustainability for cities was defined using holistic and precautionary principles while taking into account a participative integrated system approach. To be suitable for the newly developed methodology, transition management and backcasting need to fulfil the criteria set by the holistic and precautionary principles of sustainable development. Transition management as well as the newer generations of backcasting explicitly include sustainability in their methodology and have been applied in the context of sustainability (Loorbach 2007, S. 11) (Quist 2007a, S. 18). Following the holistic approach of sustainability, economic, environmental and social aspects are considered on the short-, mid- and long-terms (Lozano 2008, p. 1840). Transition management as well as backcasting are both feasible to take economic, environmental and social aspects into account for the transition to a more sustainable development. This is especially the case for transition management, which was primary designed to not only include economic and environmental aspects but to also explicitly include social aspects. As Loorbach (2007, S. 12) states, the goal of transition management is to achieve sustainability through a directed influence of society. In conclusion, both approaches do fulfil the requirements for a sustainable development.

The second requirement to be addressed is whether backcasting and transition management can be used to work towards a pre-set target. Both approaches need to allow for the inclusion of normative assumptions. For the achievement of sustainability it is in general assumed that major changes are necessary. A continuation of given trends is most likely not enough to achieve ambitious emission reduction targets. Using normative approaches first a desired target is defined. Second it is researched how the desired target can be achieved (Börjeson et al. 2006, p. 4-5). Depending on the desired target transformations of systems can be analysed using normative approaches. Transition management as well as backcasting have both been designed as normative approaches and therefore fulfil this requirement.

The third requirement addresses whether the approaches can integrate long-term and short-term aspects. For a climate protection concept with long-term emission reduction targets, short-, mid- and long-term aspects must be considered. The long-term target indicates the pathway for emission reduction. It is a first indicator of how much every year or decade the emissions have to be reduced on average. Another argument is that cities with their over time grown structure and specific challenges need considerable time to accommodate major changes. The building stock, the energy supply structure, the city layout, etc. cannot be changed on a short- or mid-term scale. For a city to achieve sustainability a long-term development is necessary. The long-term target should be broken down to short- and mid-term targets. Smaller time frames are better manageable than longer time frames. Working on short-term aspects for climate protection helps to define concrete climate protection measures for the near future. People seem to envision short- and mid-term climate protection measures better than long-term measures. Taking short-term aspects into consideration is also important to promote a more sustainable process. Only when climate protection measures are working on the short-term an implementation is likely. This is especially true for businesses and companies. A climate protection concept that demands too much in the beginning might fail and not be able to continue. Therefore, the approaches applied need to be able to combine short-, mid- and long-term aspects. Transition management as well as backcasting are combining long-term goals with short- and mid-term objectives (Loorbach 2007, S. 11) (Robinson 2003, S. 842) and therefore fulfil these criteria.

As a fourth requirement both backcasting and transition management need to be able to handle a high level of complexity in an integrated way. Cities are a highly complex system with interactions on many levels. These interactions can be on an intra-sector and inter-sector level. This means that some climate protection measures, for example, those for the transport sector, will have effects not only on the transport sector but could also affect the energy demand and emissions in other sectors. The interactions in a city need to be understood when developing a climate protection concept in an integrated holistic way. The interactions do not only include technical relations, but also the interactions between different stakeholders and their individual interests. To achieve a CO_2eq-neutral city all sectors (e.g. the commercial, industry, household, transport and financial sectors) need to be taken into account. The high level of complexity is not only due to the complex interactions between sectors, stakeholders and their individual interests. The future task of achieving a sustainable development with the target of CO_2eq-neutrality for a city is a very complex task, which includes uncertainties of the future development that need to be addressed. These uncertainties are both social and technical in nature. The degree of involvement and commitment of stakeholders and the public to the local climate protection process is an example of an social uncertainty. The achievement of the main target heavily relies on individual human decisions and the availability and economic feasibility of renewable resources that ultimately will allow for CO_2eq-emission reduction. The availability of technical solutions to reduce the energy demand and substitute fossil energies is a technical uncertainty. Transition management was explicitly developed as a new approach to address highly complex and deeply integrated problems in society for the achievement of a sustainable development (Loorbach 2007, p. 11). Therefore, transition management fulfils the fourth requirement to be able handle a high level of complexity in an integrated way. The same accounts for backcasting. As already presented in Section 2.3 on page 45 Dreborg (1996, p. 814) argues that backcasting is ideal for cases where long-term complex problems are deeply rooted in society. Especially “when the problem to be studied is complex, affecting many sectors and levels of society” (Dreborg 1996, p. 816). Therefore, both approaches are able to deal with a high level of complexity in an integrated way.

The fifth requirement for backcasting and transition management is to be suitable approaches for participation of stakeholders and the public. The involvement of stakeholders and the public is a key factor for sustainable development on the local scale. This is not only because the stakes of the citizens are affected, but also because they are a valuable source of knowledge and will be the ones who ultimately implement the climate protection measures (Quist 2009, S. 2). Since the 1970s, backcasting has seen a shift from being expert-focused to including a broad participation of the public. Transition management is also focused on participation and includes a well-structured network-methodology on how to achieve participation.

The sixth requirement is the flexibility of the approach. The development of a climate protection concept always depends on the year of the development and the available technology and assumptions about future developments. Therefore, current climate protection concepts are meant to focus the energy and investments in a sustainable direction until new knowledge is gained or new unforeseen developments happen which might facilitate the process. A continuous learning process is important to keep the future development flexible to new happenings. Learning is also necessary for the participators to achieve a better understanding of the challenges and possible solutions. Since the second generation of backcasting was developed, social learning has been included into the approach (Bagheri and Hjorth 2007, p. 84). Transition management as a newly developed approach included social learning and a management cycle right from the beginning. Therefore, both approaches are considered to be flexible.

To increase the chance of later implementation of climate protection measures follow-up should be promoted. Therefore, a suitable approach needs to include a concept of how to enable follow-up. As already described in previous sections, the transition management and backcasting approaches both include the promotion of follow-up.

In conclusion, transition management and backcasting both fulfil the basic requirements for being suitable to address the challenges of a new methodology for a CO_2eq-neutral city. In the following sections it is discussed how the two approaches need to be advanced in order to develop a holistic and unified methodology for the obtaining of CO_2eq-neutrality on the city-scale. The adaptation will be explained in detail in the sections to follow.

2.6 Comparison of backcasting and transition management

After explaining backcasting and transition management this section serves the purpose to compare the two approaches. The most important points are summarised and the specific focus of the approaches are shown. As shown in Figure 2.2 on page 39 three different scenario typologies exist. These are the predictive, explorative and normative scenarios. Backcasting as well as transition management belong to the normative scenario category. Both are explicitly transforming approaches. The main aspects of both approaches were already explained in this chapter. In the following subsection the differences between the two normative transforming approaches backcasting and transition management will be explained.

2.6.1 Existing comparisons between backcasting and transition management

While literature and case studies for backcasting are available from a variety of different authors, transition management as a new study field is still developing and, therefore, few comparisons of the two approaches currently exist (Quist and Vergragt 2006, p. 1028). The need for further research is pointed out by various authors (Quist (2007a, p. 236-237), Nill and Kemp (2009, p. 678), Rotmans et al. (2001, p. 23-24)).

Backcasting and transition management are seen as related approaches, where the similarities outweigh the differences (Quist 2007a, p. 22, 236-237). As being explicit normative, both approaches assume marginal changes of current trends as not being sufficient to achieve the goals (Börjeson et al. 2006, p. 21). Instead trend breaks are necessary (Börjeson et al. 2006, p. 21). Both approaches are looking at a time-span of one to two generations like most transforming scenarios. This is due to the circumstance that in order for the future to change considerably, a certain time-span is seen as a requirement (Robinson 1990, p. 824). Therefore, both approaches combine the element of long-term thinking for making short-term decisions. Breaking down a complex long-term problem into mid-term and short-term small sub-problems creates a well structured and consistently thought-through process (Kemp and Loorbach 2003, p. 21). In doing this, an abstract long-term image of the future is transferred into a manageable set of short- and mid-term goals.

Differences between the two approaches have been pointed out by Rotmans (2006, p. 57). Due to the monitoring and evaluation included into transition management, this approach is considered to be an evolutionary approach, which uses and combines both Forecasting and backcasting to a certain extent. Thus transition management explicitly includes a management strategy. The main differences are certainly the strong focus of transition management on policy processes and that different options are kept open by developing and maintaining a number of visions (Quist 2007a, p. 22). In contrast to backcasting, transition management is also supposed to be applicable to any complex societal problem (Rotmans et al. 2001).

2.6.2 Single or multiple visions

As pointed out in the previous section and acknowledged by different authors, transition management explicitly includes the development of more than one scenario. In the backcasting approach it is not defined whether one or more scenarios should be developed. Therefore, throughout the history of backcasting applications can be found using one (e.g. Novel Protein Foods, Multiple Sustainable Land-use) or more scenarios (e.g. Sustainable Household Nutrition).

Rotmans et al. (2001, p. 23) argue that for transition management, a variety of visions should be developed. The main reason for this is that options are supposed to be kept open, until a clear decision can be made for one technology or the other (Kemp and Loorbach 2003, p. 11). Transition management is a highly flexible approach because not only are different visions developed, but also different paths are seen as possible to achieve a certain vision. It multiplies the number of visions and future possibilities. The decision of which way to go is made alongside the development process. The most promising technology and vision are determined by Transition experiments. Following the arguments from Nill and Kemp (2009, p. 673) and Kemp and Loorbach (2006, p. 126) the use of multiple visions helps to avoid a lock-in in a certain technological development path.

A different mentality exists for backcasting. It is acknowledged in this approach that it is unlikely that the envisioned future in the backcasting experiment matches with the real development on the long-term (Quist 2007a, p. 67). It is argued, however, that in the field of sustainability, the main aim is not to predict the most likely development. It is more important that the developed vision "has led or contributed to a system innovation towards sustainability" (Quist 2007a, p. 67). "It can even be of crucial importance that adaptations and adjustments are made due to knowledge breakthroughs or emerging external developments" (Quist 2007a, p. 67). In comparison to transition management, the flexibility is not necessarily achieved by creating multiple visions, but rather by adjusting a single vision over time to new happenings and newly gained knowledge.

To answer the question whether a single or multiple vision approach should be applied Quist (2007a) analysed previous backcasting experiments. He found that backcasting experiments with only one vision lead to a significant higher degree of follow-up and spin-off than backcasting experiments with multiple vision approaches (Quist 2007a, p. 209). It did not make a difference if multiple visions were developed in the first stage of a backcasting experiment as long as the final outcome was one single vision. Due to the circumstance that there is evidence from analysed backcasting experiments that single visions should be developed (Quist 2007a, p. 236), and because of transition management as a new approach with no experience for stating the benefits of a multiple vision approach, it is argued that forming a flexible single vision is the best approach.

2.6.3 Experiments

Transition management belongs to the group of evolutionary approaches. It follows a step-by-step methodology where experiments play a major role in determining the future developments. Experiments researched on a small-scale have the advantage that costs are kept low in the trial and error process (Kemp and Loorbach 2006, p. 119). Furthermore, performing experiments allows a flexible change of ongoing developments and the usage of newly-gained knowledge in future experiments (Kemp and Loorbach 2006, p. 119). Nill and Kemp (2009, p. 678) add that a portfolio of experiments not only increases flexibility, but also decreases the chance of a lock-in in certain development paths. To conclude, experiments are an essential part of the transition management process.

In contrast to transition management, backcasting still lacks a conceptual framework of the process from the backcasting study to the follow-up and spin-off (Quist 2007a, p. 226). "The process that connects the two phases has not been conceptualised" states Quist (2007a, p. 226). Using experiments can be one promising way to bring these two phases closer together.

Additionally, when developing a single vision, flexibility to new technologies and new knowledge is heightened. This flexibility is considered to be a key factor for later implementation of measures. In a highly complex field, such as sustainable development, unstructured problems need to be solved. Easy solutions are rare and so the outcome is most likely unclear when only one technological pathway is followed. Therefore, following the transition management approach, it is argued that experiments should play an important role for achieving sustainability. This is especially true on the city-scale. Every city has its own structure and individual characteristics that need to be considered and researched by using experiments to gain insight into what solutions for climate protection work and what do not.

2.6.4 Management process of a transition

In transition management it is argued that a transition needs a certain degree of influence to develop in the desired sustainable direction. This is achieved by explicitly including monitoring and controlling methods as well as a management cycle into the implementation process of transition management. In transition management, with its focus on policy development, it is often assumed that a centralised management is achieved by the government or a government organisation (e.g. Quist (2007a, p. 230), Rotmans et al. (2001, p. 25)). This is not necessarily always the case, especially on the city level. It could also be achieved by the Transition Arena or other organised groups of actors involved in the transition process.

Backcasting assumes that a strong vision provides guidance and orientation in a decentralised way. Backcasting does not explicitly include monitoring and controlling or a management cycle in the implementation process. A unified management strategy for the implementation does not exist (Quist 2007a, p. 237-238).

This thesis follows the theory that a centralised coordination of the transition process is crucial for actually achieving a transition towards sustainability. Only when a process can be established supported by committed and responsible individuals and organisations, can a long-lasting transition to a CO_2eq-neutral city be achieved.

2.6.5 Formation of networks

The creation of networks and coalitions represents a crucial element of transition management (Loorbach 2008, p. 16). Loorbach (2008, p. 16) states that one of the main characteristics of transition management is a social movement through coalitions, relationships and networks created around the transition arena. Over time the growing networks are increasing the pressure on the political and economic framework to ensure a long-term transition process (Loorbach 2008, p. 16). Therefore, the formation of networks is a crucial step in transition management. The strategies and the methodology for the formation of networks in transition management were described in detail in Section 2.4.7 on page 62.

Even though the shift from traditional backcasting to participatory backcasting was an important step and goes hand in hand with ongoing national and international policy developments (cp. Section 2.3.1 on 47), backcasting itself does not include a sound methodology on network formation or diffusion of the vision. Quist (2007a, p. 226-227) points out in his doctoral thesis how backcasting did and continuously benefits from including network approaches like the industrial network perspective from Håkansson (1989, 1987). The formation of networks is not rooted in the backcasting approach and future research is called for in this respect (Quist 2007a, p. 226-227).

Transition management as a new approach benefits from including the knowledge of network theory in a holistic way. The methodology from transition management will be used for the formation of networks and the diffusion of the vision.

2.6.6 Methodological steps

After comparing individual aspects of backcasting and transition management the methodological steps will be compared. This section will not describe the individual steps in detail, but rather will focus on the comparison of the two approaches. In the following list the steps from backcasting and transition management are shown as a reminder.

- Backcasting steps:
  1. Strategic problem orientation
  2. Development of future vision
  3. Backcasting analysis
  4. Elaboration of future alternative and definition of follow-up agenda
  5. Embedding of results and agenda and stimulation of follow-up
- Transition management steps:
  1. Problem definition and Transition objectives
  2. Transition visions
  3. Transition paths and interim objectives
  4. Evaluating and learning (development rounds)
  5. Creating public support

The first steps in backcasting and transition management are quite similar. Both backcasting and transition management start with the problem orientation respectively the problem definition. Also the second step of both approaches is almost the same. In backcasting it is the “development of future vision" whereas in transition management it is called “Transition visions". Therefore, both focus on the vision development in their second step. A difference though is that transition management focuses not only on one vision, but explicitly asks for the creation of more than one vision to avoid lock-ins. The question if a single or multitude of visions should be developed was discussed in detail in Section 2.6.2 on page 73. It is argued that the use of only one vision is superior because it provides a stronger guidance with an increased chance for follow-up.

The third step in backcasting is the “backcasting analysis". During the backcasting analysis a scenario on how to achieve the given goal is developed. This again, is very similar to the third step in transition management which is the determination of “Transition paths and interim objectives". In addition backcasting explicitly includes the steps “Elaboration of future alternative and definition of follow-up agenda" and “Embedding of results and agenda and stimulation of follow-up".

Additional to the backcasting approach transition management adds the elements of evaluating and learning as well as actively creating public support. Including evaluating and learning in the process follows the general idea of transition management that a transition needs to be flexible and managed to a certain extent. In development rounds existing and new technologies are evaluated and the advantages and disadvantages identified to make better decisions about future implementation.

The step of creating public support is seen as a continuous task in transition management. Creating public support is implied in participatory backcasting and could also be included into the follow-up agenda. However, it is not mentioned explicitly in backcasting as an additional step or a crucial part of the generalised backcasting approach.

In addition to the general transition management steps, a comparison of the transition management implementation process to the backcasting approach helps to further understand the similarities and the differences. The transition management steps were further detailed by Loorbach (2010, S. 168). Four levels for the implementation of a transition management process were determined. These are the strategic, tactical, operational and reflexive levels. For each level a detailed procedure is given. Figure 2.10 on page 79 shows the levels for the implementation of transition management and compares them to the backcasting approach. White text indicates that the step is part of both backcasting and transition management. These are the "focus on certain transition problems", "developing of transition visions", "Creating transition scenarios and transition paths", "Concretisation of objectives, responsibilities, investments and strategies". The step "focus on certain transition problems" is included into the backcasting steps as strategic problem orientation. The step "developing of transition visions" is called in backcasting "development of future vision". The step "Creating transition scenarios and transition paths" is part of the backcasting analysis in the backcasting approach. "Concretisation of objectives, responsibilities, investments and strategies" is done in backcasting in the last two steps which are "Elaboration of future alternative and definition of follow-up agenda" and "Embedding of results and agenda and stimulation of follow-up". Black text in the Figure 2.10 indicates that the step is an additional aspect or a more detailed approach in comparison to backcasting.

A major difference between the two approaches is that transition management includes the formation of a Transition Arena and the upscaling of the Transition Arena to Transition Networks as two steps of its approach. Therefore, it explicitly includes a network-strategy. These steps are not included in the backcasting approach. The same applies to the operational and reflexive level of the implementation of transition management with their specific focus on implementation and evaluation of the process.

- Strategic: Transition Arena
  - Small group of frontrunners with different backgrounds
  - Focusing on certain transition problems
  - Developing of transition visions
- Tactical: Transition Agenda
  - Upscaling of the transition arena to a transition network
  - Creating transition scenarios and transition paths
  - Concretization of objectives, responsibilities, investments and strategies
- Operational: Transition Experiments
  - Experiments that fit into a transition path
  - Projects with a high level of risk
  - Learning process
  - Upscaling from micro to meso level when successful
- Reflexive: Monitoring and evaluation

Figure 2.10: *Comparison of backcasting and transition management. Steps written in white are common to both approaches while black text indicates that it is an additional step or a more detailed approach to backcasting.*

2.6.7 Transition management and backcasting in tandem

Transition management is an approach used for managing a transition until the transition goal is reached. Backcasting may be employed in the first stages of transition management for scenario development (Quist 2007a, p. 238). The vast benefits of the two approaches have been discussed in detail in the previous sections of this chapter. The answer to the following research question remains: Can the two approaches of backcasting and transition management be used together in a holistic way for climate protection on a city-scale, and do they complement each other?

Contention exists between authors about whether backcasting is already a part of transition management or not. Backcasting sometimes is seen as an integrated part of transition management, but no detailed information on the application of backcasting is provided. For example, Rotmans et al. (2001, p. 23-24) refer to backcasting as a part of the transition management approach, however a simplistic form of backcasting is used and no explanation of how the backcasting experiment should be carried out is provided.

Backcasting and transition management complement each other, strengthening the argument that the two approaches should be used in tandem, or combined in some way. For example, a short-coming of backcasting is that it lacks a management strategy (Quist 2007a, p. 238). When backcasting is incorporated into the transition management process, it adopts the relevant management and implementation strategies, thus re-enforcing it. The transition management process would benefit from the use systematic use of backcasting for the development of climate protection scenarios due to the goal-orientated approach for scenario development respectively climate protection measures.

Transition management and backcasting present promising approaches for the development of climate protection concepts, however further development of both approaches is needed. The use of both approaches in tandem is a promising concept, however, a detailed description of how the two may be combined to achieve optimal results in the context of climate protection scenario development has yet to be achieved.

One aim of this doctoral thesis is to combine the approaches of transition management and backcasting into a combined holistic approach. The novel approach, detailed in Chapter 4 is applied to a climate protection concept developed for a mid-sized German city in Chapter 5. The application of the two approaches on a city scale will answer the previously mentioned research question.

3 Contribution of Psychology

The mitigation of climate change depends entirely on human decisions. This includes behavioural decisions and also investment decisions. The reasons and possible influences for human behaviour and decision making are analysed in the field of human psychology. Human decisions are influenced by human psychology in many aspects. In this chapter the contribution of psychology to the achievement of highly ambitious climate protection targets is discussed. The focus of this chapter is on discussing psychological strategies for their use in the development of an effective methodology for a city-scale climate protection concept.

3.1 Introduction to environmental psychology

Following Prose (2010) economic instruments are a key factor for successful climate protection. According to the rational choice theory people are driven to maximise their benefit (Unternehmensführung 1997, p. 66). For example, household residents should take all economic measures to reduce their energy costs and maximise their income (Prose et al. 2000). Therefore, people should adapt to energy efficient technologies as soon as it pays off financially (Prose et al. 2000). Different authors in the research field of Energy Efficiency Measures and Behaviour Change showed however, that human beings are not necessarily acting according to the rational choice theory (Stern 2011, p. 303).

The difference between the assumed cost minimisation on the long-term following the rational choice theory to the actual behaviour is called the energy efficiency gap (Jaffe and Stavins 1994). It was not only found that an energy efficiency gap exists but that the difference is quite large, when looking at the CO_2eq-reduction potentials (Stern 2011, p. 304) (Creyts et al. 2007).

The difference between the rational choice and the actual behaviour can be partly explained by the “theory of bounded rationality” from Simon (1972). The theory of bounded rationality explains the discrepancy between the expected human behaviour from the rational choice theory and the observed behaviour of humans in daily life (Simon et al. 2008, p. 3). According to Simon (1972, p. 163-164) this is due to incomplete information of alternatives, the complexity of determining the most economic option, or other environmental aspects that create barriers for the individual to determine the best option from known alternatives and the available time-frame to make a decision. The theory of bounded rationality helps to explain human decisions for energy conservation or climate protection. Human reasoning cannot be understood in a purely rational-economic way. The theory of bounded rationality is considered for the development of the methodological approach used in this thesis in Chapter 4 where psychological aspects were considered in addition to the classical rational economic view.

3.1.1 Historic development of environmental psychology

Environmental psychology is a sub-discipline of psychology, which was developed in the 1960s (Swim et al. 2009, p. 23). It was recognised that the physical environment has an influence on human behaviour, which had been mainly ignored up to that point (Gifford 2007, p. 200). Starting in the 1980s environmental psychologists began to work on matters of environmental awareness and environmental action (Fischer 2002, p. 2). This development was, according to Gifford (2007, p. 200), probably driven by the early work of Greenpeace and the publication of the Brundtland report (1987). For the development of environmental psychology it was a big step. Psychologists started to research environmental problems on a large-scale (Swim et al. 2009, p. 23). They were researching possible solutions for “resource dilemmas, traffic problems, urban blight, and crimes against nature” (Gifford 2007, p. 200). Some had even started working on solving the problem of global warming from an environmental psychology perspective (Gifford 2007, p. 200).

In his article on environmental psychology and sustainable development Gifford (2007) explains the development of environmental psychology. He also provides reasons why psychology has not been applied to the field of climate change mitigation so far. One of the main reasons is that environmental psychologists focus too often on individuals rather than taking an holistic system approach (Gifford 2008, p. 274). Furthermore psychologists normally work in an academic environment, whereas climate change measures should be developed and tested in real life (Gifford 2008, p. 274). Only a few authors like van den Berg et al. (2007) have applied environmental psychology on a city-scale. Van den Berg et al. (2007) analysed how cities can be “greened” and how this process can positivity effect human health. A combined approach incorporating environmental psychology, cities and green house gas emission reduction has not yet been developed. Including environmental psychology into the development of a concept for cities with the aim of obtaining CO_2eq-neutrality is a multi-disciplinary approach, which will essentially help to expand both fields of study.

3.1.2 Contribution of psychology to a sustainable development

Following the arguments from Prose and Homburg (1997) already today technical solutions are available to reduce CO_2eq-emissions dramatically. Even financially competitive solutions are often not implemented (McKenzie-Mohr 2002, p. 545), which is referred to by Prose and Homburg (1997) as an implementation gap. Homburg and Prose (1997) draw the conclusion from their experience from working in the field of environmental psychology that including psycho-social aspects is a key factor besides technical solutions, for a successful implementation of climate protection measures.

Psychologists have contributed to the development of intervention instruments to encourage climate friendly behaviour and to gain a better understanding as to why or why not individuals responds to certain intervention instruments (Swim et al. 2011, p. 244). Psychologists help to "design and test systems that make certain environmental choices more noticeable (e.g., energy-use feedback) or attractive or that make environmentally beneficial actions more convenient, combining economic and non-economic inducements to action in highly effective ways" (Swim et al. 2011, p. 243).

In agreement with Swim et al. (2011, p. 243) climate change is an issue of resource depletion where people's behaviour may be described by the theory of Hardin (1968) "tragedy of the commons". Individuals tend to maximize their own short-term benefit even though it is unsustainable over the long-term, resulting in the depletion of resources and a social loss for all. Climate change mitigation requires collective action. Psychological tools can aid in the development of strategies for encouraging individuals or companies to make decisions based on social interests versus making decisions based on one's own self-interests (Swim et al. 2011, p. 2443).

The field of psychology can contribute to the mitigation of climate change by using relevant theories and tools to develop information and communication methods like informal networks that promote climate protection on the individual-scale (Swim et al. 2011, p. 243). The application of psychology for the mitigation of climate change is not limited to the individual-scale, but can also be applied to organisations. For example, theories and tools from psychology can be used to achieve the target of reducing a company or organisation's CO_2eq-emissions (Swim et al. 2011, p. 2443). Implementing and remediating the principles of sustainability in an organisation's daily business is seen as a key challenge in this dissertation.

Including psychological aspects into climate change mitigation also allows for better-defined arguments why participation of the public is a key factor when working on solutions to reduce CO_2eq-emissions. According to Homburg and Prose (1997) the success of climate protection on a city-scale depends almost entirely on the extent of implementation of climate protection measures. The decision for implementation is made on an individual or business-level. Either way, it depends on human decisions which are always to a certain extent objective. Psychology can deliver useful insights about how and with what criteria decisions are made by an individual, group or organisation (Homburg and Prose 1997). In addition to the insight into decision criteria, psychology is also useful for setting-up participation in the most suitable way. Depending on the stage of the concept, be it either the development or the implementation phase, different methodologies should be used for including the public and local businesses into the process.

Including psychology can help climate change mitigation firstly by promoting a better understanding of individual and organisational behaviour in the content of climate change and by developing effective intervention instruments to promote climate-friendly behaviour. Therefore, including psychology into the development of a climate protection process is more than just understanding behaviour. It is about using the psychological knowledge to design the most effective and sustainable solutions for climate change mitigation.

3.1.3 Not feeling the risk

As described by Kruse (1995, p. 85) humans are not sensitive to a variety of environmental changes that are happening at a slow rate and remaining under a noticeable threshold. In other words, they are unable to detect environmental change or processes that are occurring over centuries, like global climate change. Global climate change is a phenomenon that lies below this detectable threshold. Humans cannot directly experience the effects of higher CO_2eq-concentrations and the induced climate change, and thus do not actively notice it. Another aspect complicating the detection of climate change is the discrepancy between the cause and the effects of climate change both in time and space. There is a time gap of generations between emitting green house gases and the resulting effect on the climate like global temperature rise and sea level increase (IPCC 2001, p. 20). Special discrepancy of emitted CO_2eq-emissions and the consequences are noticeable today. For example most CO_2eq is emitted by industrialised countries, however the effects are being dealt with in, for example, the small island nation of the Maldives or the Arctic, where the effects of sea level rise and ice melt, respectively, are imminent.

Following the same arguments Swim et al. (2009, p. 27) concludes that humans only experience climate change due to the presentation of the phenomenon by a variety of communication pathways. Communication pathways might include the form of education in schools, TV documentaries or news reports, information on the internet or information shared via human interactions. All methods of communicating the effects of climate change present the disadvantage that they can only be in abstract-form and leave room for personal interpretation. Moser and Dilling (2011, p. 163) point out the importance of communication and the need for proper illustration and explanation in order to accurately convey the effects of climate change. This is important in terms of climate change policy development because people will only be willing to act and promote climate friendly policies when they have gained an understanding of climate change and its effects (Swim et al. 2009, p. 27).

The circumstance of "not feeling the risk" has different psychological implications. Not being able to directly experience the consequences of one's own actions creates room for doubt whether the connection between CO_2eq-emissions and global climate change really exists (Kruse 1995, p. 86). The more severe the limitations or restrictions for humans for climate change mitigation are, the stronger their doubts are of whether climate change is true or not (Kruse 1995, p. 86). An example of a severe restriction for an individual might be a limitation of allowable annual flights. An example within a business context might be restrictions or additional financial investments, e.g. in green appliances or technologies. The implications of "not feeling the risk" need to be considered when developing solutions for the mitigation of climate change in a participatory setting.

3.2 Overview of psychology theories relevant for climate protection concepts

In this section an overview of psychology theories will be provided which are relevant for developing a climate protection concept. Some of the theories were developed to be applied to individual-behaviours, however examples of how these theories might be applied to social groups (e.g. in a company or business) are also provided, keeping in mind the focus of this dissertation which is to promote climate protection measures on a business or organisation-scale. The psychological theories for individuals can be used to promote climate protection on both the individual and organisation-scale.

In the following section the view of psychology will be broadened and social marketing included. Communication and diffusion processes will also be explained. The combination of the psychology theories introduced in the first section along with the broadened-view of psychology discussed in the next section will provide a good foundation for developing a standard methodology for climate protection concepts.

According to Fischer (2002, p. 3) environmental friendly behaviour of individuals is driven by knowledge, values, norms, incentives and feedback. Feedback helps to reflect the individual's own actions. In the following the theory of norm activation theory, theory of planned behaviour, determinants of action, intrinsic and extrinsic motivation, antecedent and consequent interventions will be explained.

3.2.1 Norm activation theory

The norm activation theory and the planned behaviour theory, which will be explained in the next section, are both widely used to explain environmental behaviour. They are both used to identify and understand behaviour and behavioural changes. The norm activation theory was developed by Schwartz (1977). It was first developed to explain the normative influences on altruism behaviour. According to the norm activation theory two norms are influencing human behaviour: The social norm of the environment and the internal personal norm. It is these norms that define the personal norms of a person (Fischer 2002, p. 3). An important aspect of the norm activation theory is that behavioural change is not only based on internal beliefs, but also on the norms of the surrounding environment.

Although the norm activation theory was developed to explain the influence of norms on altruism, it can also be applied to environmental related behaviour (Homburg and Matthies 1998). Homburg and Matthies (1998) argue that environmental related behaviour can also be understood as an altruistic behaviour. According to Gigli (2008, p. 8) the norm activation theory postulates that only under certain conditions the internal personal norm will be activated. First, it is necessary that an individual is aware of the problem, for example the problem of climate change. Second, the individual needs to know about possibilities of action. In the case of climate change, possibilities of action might be the different climate protection measures. This is important because only when a person knows about possibilities for climate change mitigation, are they willing to bear personal responsibility. Third, the internal personal norm will lead to actions when the personal consequences are perceived as not severe in a negative sense (Gigli 2008, p. 8). In consequence climate protection measures are more likely to be accepted and applied when there are only small limitations or restriction to the individual.

In summary, according to the norm activation theory climate change behaviour is influenced by internal and external norms. The internal norm will lead to measures for climate change mitigation when climate change is perceived as a problem, solutions are at hand, and the consequences are acceptable for the person. These psychological aspects need to be considered when developing a climate protection concept in a participatory way as well as during the implementation phase of climate protection measures. The norm activation theory is depicted in Figure 3.1. The grey boxes indicate the norms influencing the final behaviour of individuals. Light blue boxes indicate the influencing factors on the norms. Dark blue boxes show the thought-chain that is influencing the internal personal norm.

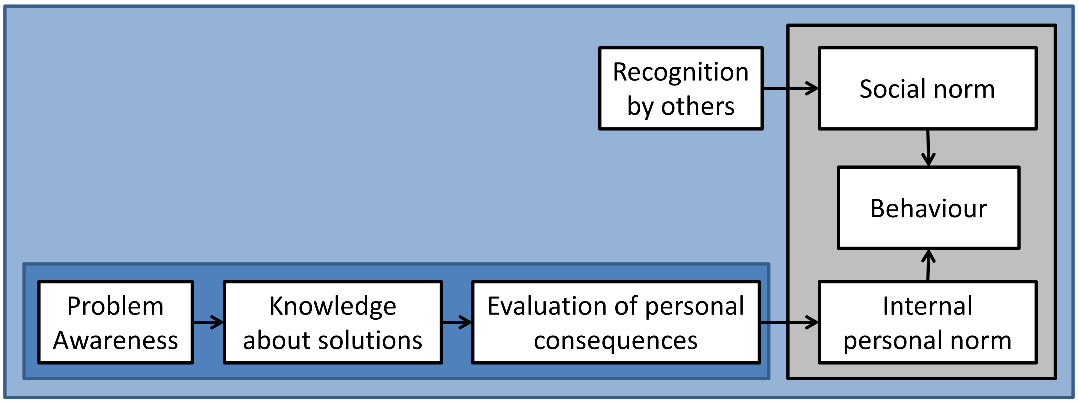


Figure 3.1: *Norm activation theory*

3.2.2 Theory of planned behaviour

The theory of planned behaviour was developed by Ajzen (1991). This theory explains people's reasonings for their actions in the context of attitudes. First, an action is determined by the intention of doing something, or the conscious decision to act. The positive or negative attitude towards a climate protection measure can be determined using the expectancy-value theory. The expectancy-value theory was created by Fishbein and Ajzen (1975). The theory states that humans assign a value to their beliefs. The theory also assumes that humans have a certain expectation which is based on their values and beliefs. The expectation can be understood as the perceived probability that the objectives will be achieved. Fishbein and Ajzen (1975) defined that the motivation or the attitude is the product of the expectations times the value. This means that a high value can compensate low expectations and the other way around, as long as both values are not zero (Schuler and Brandstätter 1995, p. 72). In the context of climate change this means that individuals will also implement climate protection measures when they value climate change mitigation highly, even though the expectation that these measures will make a significant change is low.

The second aspect of the theory of planned behaviour is the subjective norm, which influences the behaviour of the individual (Gigli 2008, p. 9). It includes the perceived social pressure to act in a certain way. For example, when people are climate conscious they expect others to be climate conscious. As will be further described in the following section, the external environment plays an important role for individual decisions. If people expect others to react in a positive way to their efforts to protect the climate, than they are more likely to perform climate protection measures.

The last aspect of the theory of planned behaviour is the perceived behaviour control (Fischer 2002, p. 3). It indicates how easy or difficult the action is for the individual. The level of difficulty is subjective. Therefore, climate protection measures need to incorporate individual hindrances. Climate protection needs to be understood on an individual decision basis.

The main aspects of the theory of planned behaviour are depicted in Figure 3.2 on page 89. The original figure from Ajzen (1991) (grey background) was extended by the expectancy-value theory (dark blue background), the recognition by others and hindrances. Combining the different theories and aspects provides a holistic picture on how behaviour can be influenced or changed. The general principles should be kept in mind when developing a climate protection concept together with different stakeholders. In this dissertation it is assumed that these principles are uniform and can be applied on both the individual and organisational scale.

3.2.3 Determinants of action

Utilizing the insights from the norm activation theory and the theory of planned behaviour, determinants for an action were identified. Prose et al. (1996) and Hennicke et al. (1997) distinguish three major steps for actions in the field of climate protection: (1) the development of a willingness to act, (2) the decision to act and (3) the action of acting.

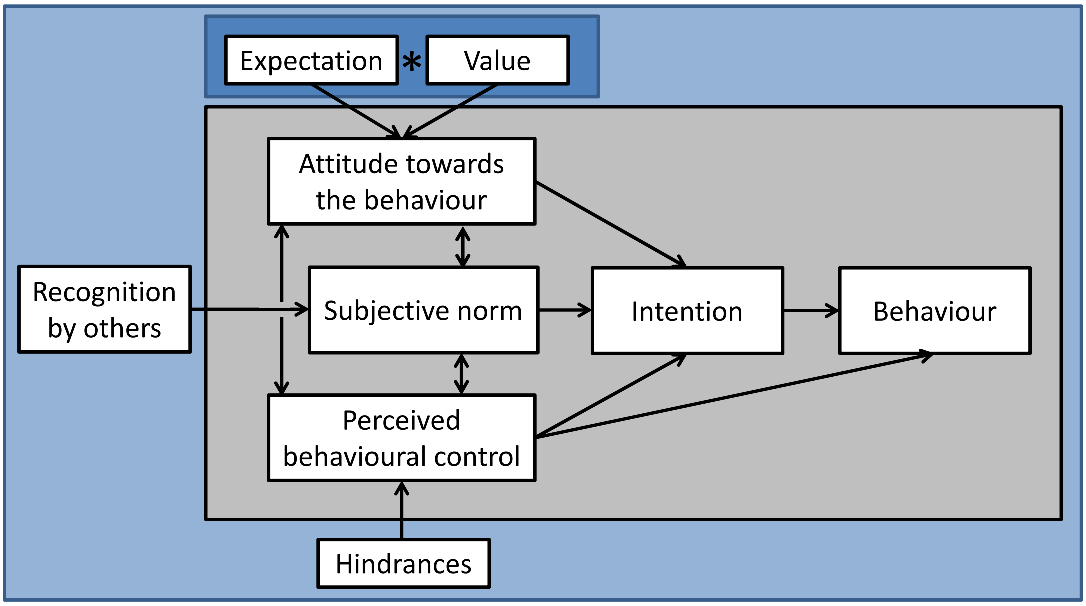


Figure 3.2: *Theory of planned behaviour modified to include the major influencing factors (inner grey area according to Ajzen (1991))*

According to Prose et al. (1996) six criteria are used for promoting the willingness to act for climate change mitigation.

(1) The first criterion is the value of climate protection. Individuals are more likely to act when they understand climate change as a personal relevant issue, have knowledge about the cause of climate change and possible solutions.

(2) The second criterion is to see climate change as a community task. Climate protection measures can only be successful when, not only one individual, but everyone is participating.

(3) The third criterion is reward. For example an individual is willing to implement climate protection measures because they hope to benefit in some way. Saving ones energy might be a financial benefit, for example. An individual could have social benefits which lead back to the previously discussed social norms, e.g. doing something because of the potential benefit of achieving a higher reputation among colleagues.

(4) The fourth criterion is the social norm (introduced in Section 3.2.1 and Section 3.2.2). When the social environment of an individual has a climate friendly attitude then the individual is surrounded by this social norm, which increases the chance of the individual also to be climate friendly.

(5) The fifth criterion, self-efficiency, takes into account the perceived chance to realise measures. For example, an individual is more likely to implement a climate protection measure when they perceive it as a feasible task, then if they perceive it as something difficult to achieve. In general the perceived chance increases the more often the task or measure is performed by an individual.

(6) The last criterion, previous experience and gained knowledge, helps to promote further climate protection measures. This is the case when climate protection measures have been applied successfully and the gained knowledge during the implementation helps to promote further measures of that kind.

The second major step in the field of climate protection is the decision to act (Prose et al. 1996) (Hennicke et al. 1997). Following Hennicke et al. (1997, p. 21) the decision to act is not only based on financial criteria as it is claimed by the rational choice theory. The already introduced "theory of bounded rationality" from (Simon 1972) explains why even economic climate protection measures are not necessarily always already implemented. It also shows that decisions are not necessarily objective but may often be subjective. The expectancy-value theory allows for a value insight into how the decision to act is formed (Hennicke et al. 1997, p. 21).

The third major step in the field of climate protection is the action of acting (Prose et al. 1996) (Hennicke et al. 1997). After the decision is made that a climate protection measure should be implemented the last step is the actual realisation of the measure. When there is a high willingness to act, implementation is more likely. Once the decision is made project details need to be fixed, e.g. time of implementation, finance, responsibilities etc.

According to Prose et al. (1993) the implementation of climate protection measures is the highest when it is seen as a personal issue by individuals or organizations. However this is difficult to achieve due to the complex characteristics characterizing the global phenomena of climate change, as discussed in Section 3.1.3 "Not feeling the risk". It is essential that people are willing to invest in the implementation of climate protection measures for a climate protection concept to be successful. Therefore, the success depends on the psychological aspects discussed so far such as how humans can be made aware of climate change and identify with the problem. Prose et al. (1993) points out that climate protection concepts can deliver solutions on how to reduce CO_2eq-emissions. However, without the awareness of humans and their drive to act in favour of climate protection implementation, the success of the concept is unlikely. Consequently, methodologies need to be developed and applied that take these psychological aspects into account.

3.2.4 Intrinsic and extrinsic motivation

In addition to the previously introduced behavioural theories there is the "motivation or self-determination theory". This theory was first developed by Harlow (1953) and later on extended by White (1959). They found that behaviour cannot only be based on rational considerations. People also act according to their intrinsic or extrinsic motivation.

Intrinsic motivation is defined as "engagement in an activity for its own sake" (Vansteenkiste et al. 2006, p. 20). These are tasks that are enjoyable or interesting to the specific person (Ryan and Deci 2000, p. 55). Extrinsic motivation on the other hand means that a task is done to achieve something that is independent from the task itself (deCharms 1968). White (1959) found in his studies that also animals would engage in activities just for the interest or curiosity, but not an external reason, like a reward. The most important finding is, that the performance and willingness to act largely depends on the kind of motivation (Ryan and Deci 2000, p. 55). It was found that intrinsic or more autonomous extrinsic motivation resulted in higher engagement and performance (Miserandino 1996).

Ryan and Deci (2000, p. 60) point out that intrinsic motivational aspects are important, but that most activities are performed for extrinsic reasons. Therefore, knowing how to motivate individuals in those cases must be understood. The main aspect for motivating individuals is to promote the internalization of values and environmental friendly behaviour. According to Nuttin (1973) the theory of self-determination also explains why people are engaging in an activity more likely when they perceive themself as one of the initiators. This is another reason to follow a participatory approach when developing a climate protection concept. When people are actively engaged in the process of concept development and have their ideas included, they will be more likely to identify with the concept. According to Vansteenkiste et al. (2006, p. 21) identification refers to people valuing an activity and understanding it as their own. This perspective of self-determination leads back to the behavioural theory that people need to see the personal relevance of an activity in order to engage in it. For the development of a climate protection concept this behavioural phenomenon should be kept in mind. Climate protection needs to be introduced in a way, were people find it personally relevant.

Ryan and Deci (2000, p. 56) state that the degree of intrinsic motivation varies depending on the individual and the task. Therefore, it is important to assign the right task to the right people.

Baumeister and Leary (1995, p. 497) analysed in their paper "Desire for Interpersonal Attachments as a Fundamental Human Motivation" the importance of relatedness for the motivation. It showed that bonds between individuals, like family, friends, working colleagues etc. can lead to greater motivation in people. This comes from a human's innate desire to feel related to others (Vansteenkiste et al. 2006, p. 21). Oftentimes beliefs, values or behaviours from other individuals can be adapted as one's own. In the case of climate protection concept development, these drivers of human motivation are important, and underlies the importance of climate protection networks, like the transition arena. These drivers of human motivation also present an argument as to why, for example, workshops may be more useful for climate protection development than individual separate interviews.

To summarize, climate protection friendly behaviour is most successful and sustainable when it is an internal process, instead of being externally forced. Therefore, climate protection concepts should aim to achieve the highest possible degree of people doing climate protection for intrinsic reasons.

3.2.5 Antecedent and consequent interventions

In applied psychology interventions are widely used to achieve changes in behaviour. Interventions are defined as any kind of measure or action that is done purposely to achieve a change. Two types of interventions may be distinguished. These are the antecedent and consequent interventions. Antecedent interventions are those which are taking place before an action, whereas consequent interventions are interventions which take place after an action (Hennicke et al. 1997, p. 16).

Antecedent interventions have been found to be generally more effective than consequent interventions in the context of behaviour change (Prose 1994). Examples of antecedent interventions are self-commitment, demonstration and goal-setting. Whereas consequent interventions, for example, may include feedback, rewards or punishment. Dwyer et al. (1993, p. 275) analysed 54 studies and found that the antecedent measures, commitment, demonstration and goal setting, were most suitable for promoting environmental friendly behaviour. Antecedent interventions were also found to be longer-lasting and therefore more sustainable (Hennicke et al. 1997, p. 16). Consequent interventions were found to be effective during the time of the experiment (Dwyer et al. 1993, p. 275), but had hardly any positive influence afterwards (Hennicke et al. 1997, p. 16).

The most effective antecedent interventions include commitment, demonstration and goal setting (Dwyer et al. 1993, p. 275) (Hennicke et al. 1997, p. 16). In the following the three strategies will be explained, and in so doing will enhance the psychological ground-work for the development of climate protection concepts.

The antecedent intervention, commitment, is a verbal or written agreement to carry out or achieve a specific objective. In the case of climate protection, this could be, for example, a company or an individual's commitment to highly ambitious CO_2eq-emission reductions. According to Kaufmann-Hayoz et al. (2001, p. 46-47) the term commitment in this context also includes collaborative agreements. Collaborative agreements are used often in the private sector to reduce energy demand or emissions when it is not regulated by public policy. According to (Prose 1994), Swim et al. (2011, p. 248) and McKenzie-Mohr (1999, p. 3) small commitments in the beginning can lead to stronger commitments with higher reductions at the end. They attribute this to the foot-in-door effect. Katzev and Johnson (1983) found in his study that people that were asked to achieve a moderate task first were significantly more likely to also achieve more ambitious targets later on. This is called the foot-in-door effect. McKenzie-Mohr (1999, p. 3) provides two main reasons why the foot-in-door effect is effective. First, people that commit to a small task adjust the way they perceive themself. Second, people have a strong desire to be seen as consistent in their behaviour and decisions. When performing a status quo analysis, for example, where information is gathered from the stakeholders in the beginning of the development of a climate protection concept, this first contact and commitment to data delivery sets a foundation for the development and prioritization of climate protection measures and increases the chance of later commitment and participation in the development of climate protection measures.

Another type of antecedent intervention, demonstration of measures, has been found to be significantly more effective than the pure presentation of information (Ester and Winett 1981). During workshops and different events, the demonstration of green technology and behaviour can therefore help the adoption of climate protection measures. For climate protection measures to be applied on a local level, climate protection needs to be brought from a scientific level to a level that can be experienced.

A third antecedent intervention is goal setting theory. Goal setting theory is mainly used on motivational aspects in work settings, but may also be applied to other fields according to Locke and Latham (2002, p. 714). Goal setting theory is one of the best researched and most robust theories in psychology (Locke et al. 1981, p. 125) (Latham and Locke 1991, p. 214). The main finding of the theory is that performance and goal difficulty are directly related to one another (Latham and Locke 1991, p. 214). Setting high goals leads to a higher performance than setting easy goals (Locke 1968, p. 157). It was also found that setting concrete goals results in higher performance than setting vague goals like “do your best” (Latham and Locke 1991, p. 215) (Locke 1968, p. 157) or setting no goals (Locke et al. 1981, p. 125).

In addition to setting specific challenging goals, goal setting can only be successful if people have the ability and knowledge about how to fulfil a certain task (Locke et al. 1981, p. 125) (Locke 1968, p. 184). Furthermore, it was found that goal setting in combination with frequent feedback on the task-performance to show the progress in relation to the goal increased the performance in comparison to a situation where no feedback is given (Locke et al. 1981, p. 125,127) (Hampton 1973, p. 83). This finding is attributed to the fact that people who do not know how they are doing have no way to adjust their effort or are even able to tell how much they need to perform in general to achieve the goal (Locke and Latham 2002, p. 708). In conclusion goal setting with frequent feedback is more effective than just setting goals. Only feedback that leads to the setting of specific difficult goals for the individual increases their performance (Latham and Locke 1991, p. 225). Therefore, it is important to set goals and include a form of feedback when developing and implementing a climate protection concept.

For goal setting to be most effective goal acceptance and commitment to goals is crucial (Locke and Latham 2002, p. 707). Those involved need to accept the goals as their own or as their intention (Locke 1968, p. 184). Research indicates that goal commitment is most relevant when difficult goals are set (Klein et al. 1999, p. 893). The relationship between goal commitment and goal difficulty in relation to the task performance is depicted in Figure 3.3 on page 95.

Locke and Latham (2002, p. 707) emphasize two aspects that promote goal commitment. First, the goal and the results that are expected when working towards the goal need to be of value to the individual. Second, the individual must believe that they can achieve the goal. As seen in Figure 3.3 goal commitment is crucial for the achievement of highly ambitious targets. In the goal setting literature, different ways of achieving higher goal commitment were analysed. Hollenbeck et al. (1989, p. 18) found that the commitment to difficult goals was higher when it was a public commitment instead of a private one. This also applies to group commitments (McKenzie-Mohr 1999, p. 3). Goal commitment was also found to be higher when leaders were “communicating an inspiring vision and behaving supportively” (Locke and Latham 2002, p. 707). In conclusion setting highly ambitious targets, making the targets public and obtaining

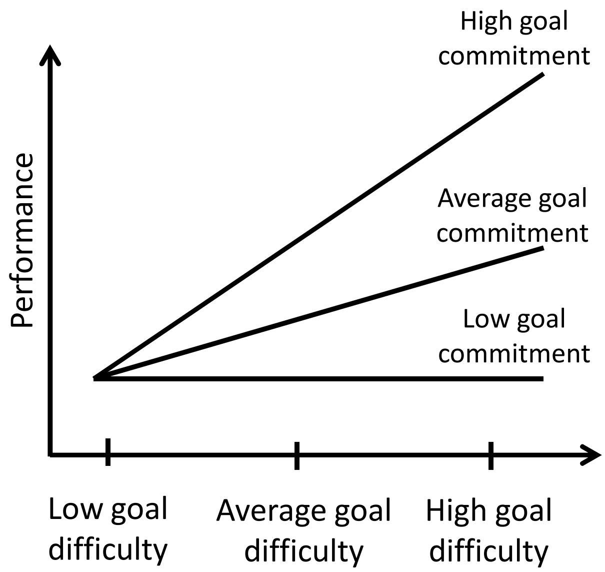


Figure 3.3: *Relation between goal commitment and goal difficulty to task performance (modified from Klein et al. (1999, p. 886)*

support of those targets from local leaders are strategies that will help ensure goal commitment, and therefore a successful project.

Interestingly it was found that goal setting works independently if the goals were set in a participatory way or if they were assigned (Latham and Locke 1979, p. 73). The main importance for the process is that a goal is set. In the context of climate protection, emission reduction goals can be set by individuals or small groups of frontrunners. Agreeing on a reduction goal therefore does not need to be part of the participatory concept development but, rather, can be assigned earlier in the concept development. It needs to be ensured, however, that the goal is realistic and people will be able to identify with it. When setting the goal in the beginning of the climate protection process common goals increase the cooperation of different groups. While group-specific goals can cause the opposite (Hampton 1973, p. 84). Therefore, climate protection goals should be set as a main target, but should not define individual separate goals.

Backcasting makes use of the findings from the goal setting theory by first defining the goal and then working towards it. This is the opposite to Forecasting where no goal is set in the beginning (see Section 2.2 and Section 2.3 for a more detailed explanation of these two terms). In terms of participatory concept development, goal setting can provide valuable information about how to set up specific steps. For example workshops can be designed in a way were the attendees try to achieve a specific, challenging but realistic goal. Also the implementation phase with its Monitoring and Controlling steps enables the necessary direct feedback to increase motivation according to the goal setting theory, increasing the likelihood that the goal will be reached.

3.3 Communication and diffusion of climate protection

The achievement of highly ambitious CO_2eq-emission reductions largely depends on the participation of as many individuals as possible in the process. The field of psychology can contribute knowledge on how to design processes to successfully attract, involve and engage large numbers of people in the process. Communication and diffusion instruments are used for this purpose. These instruments differ from the classical policy instruments which are the "command and control instruments, economic instruments, service and infrastructure instruments and collaborative agreements" (Kaufmann-Hayoz et al. 2001, pp. 33). Classical policy instruments require the support of public authorities (Kaufmann-Hayoz et al. 2001, p. 91). In contrast, communication and diffusion instruments can be used independently from city authorities in a "bottom-up approach". In transition management, the transition arena should be independent from the dominant structure in place. This is the main argument why communication and diffusion instruments are, in contrast to the others, a better option for developing a methodology for the transition to a sustainable city.

Communication and diffusion instruments include two aspects. The communication part targets the planned behaviour by using knowledge that the individual might have, their targets or behavioural routines (Mosler et al. 2001, p. 123). The diffusion instrument may be defined as the carrier of the communication message. Its objective is the highest possible penetration of the target group (Mosler et al. 2001, p. 123). Using communication and diffusion instruments for a climate change process in a society helps to identify the most effective ways to involve more and more people in the process. In particular, diffusion studies are useful tools for gaining an understanding of how environmental behaviour can reach a stage where it becomes self-spreading in a society (Fischer 2002, p. 3).

Most of what is known in the field of diffusion studies was gained by analysing innovation processes. In agreement with Prose et al. (1993, p. 2), climate protection can also be understood as in innovation, with a focus not only on technical and economic aspects but also on social and ecological aspects. Different studies were carried out, for example by Mosler et al. (2001, p. 126), to analyse the diffusion of behaviour changes in a city. One of the projects analysed how a voluntary car speed reduction in a city neighbourhood can be achieved by using different diffusion instruments. It was found that the diffusion of behaviour was most successful when people were approached in person (Mosler et al. 2001, p. 137). The finding that the diffusion of behaviour changes is more efficient than the use of mass-media is further supported in the literature (e.g. Lee and Schumann (2002, p. 1), Moser and Dilling (2011, p. 168)). The same applies to, not only behaviour changes, but also for the diffusion of innovations (Rogers 2003).

It needs to be stated, however, that other communication and diffusion instruments exist. An overview of communication and diffusion instruments is provided in the following subsection.

3.3.1 Communication and diffusion instruments and target groups

The objective of communication instruments is to influence "the actors' internal conditions of action" (Kaufmann-Hayoz et al. 2001, p. 48). This includes their personal preferences, their economic choices, their knowledge and their routines. A communication instrument is therefore a tool that helps to address the individual determinants of actions without focusing on individuals. The goal of communication instruments is explicitly not to affect single individuals (Kaufmann-Hayoz et al. 2001, pp. 48) but rather to achieve a high penetration of the target group. This is achieved by using diffusion instruments. Including communication and diffusion instruments into the novel methodology to be developed (see Chapter 4) creates a direct link between psychological aspects and high stakeholder involvement, both vital in the climate protection process.

There are two types of communication instruments: (1) instruments with a direct request of adopting certain behaviours or goals and (2) and those which do not have a direct request (Kaufmann-Hayoz et al. 2001, p. 69). Examples of communication instruments with a direct request include any form of persuading or appeals (Kaufmann-Hayoz et al. 2001, p. 41). This includes persuading of options, facts or behaviour. Also promoting self-commitment is a communication instrument with a direct request (Kaufmann-Hayoz et al. 2001, p. 41). Prose (1994) sees the direct request instrument of persuasion, or any kind of social interaction or influence that promotes climate friendly behaviour in others, as a social cornerstone for climate protection. Examples of communication without a direct request include the presentation of information, like facts and options, or giving good practice examples of certain technologies or behaviour (Kaufmann-Hayoz et al. 2001, p. 41). In addition providing feedback is seen as an instrument without a direct request.

Diffusion instruments are used to achieve a high penetration of a target group. In general there are two kinds of diffusion instruments. Diffusion can be achieved by using direct personal contact or by using mass media (Rogers 2003, p. 205). Direct personal contact has the advantage that it is a two-way exchange of information and that it is more likely to persuade a person to change their behaviour (Rogers 2003, p. 205). In contrast mass media has the advantage of reaching a large number of people quickly, therefore rapidly spreading information (Rogers 2003, p. 205). A disadvantage of personal contact is that it is time consuming. Mass media has the disadvantage of loss of spread, or the phenomenon when you reach a large number of people through a marketing effort but the actual number of people that remembered and processed the information is few (Kaufmann-Hayoz et al. 2001, p. 79). The findings from Rogers are shown in Figure 3.4. On the mid- and long-term both diffusion instruments should achieve a stage of self-diffusion (Kaufmann-Hayoz et al. 2001, pp. 48). The idea of diffusion is also incorporated into transition management, even though it is not explicitly stated. Transition management makes use of a network strategy including the use of personal networks, which are a form of diffusion.

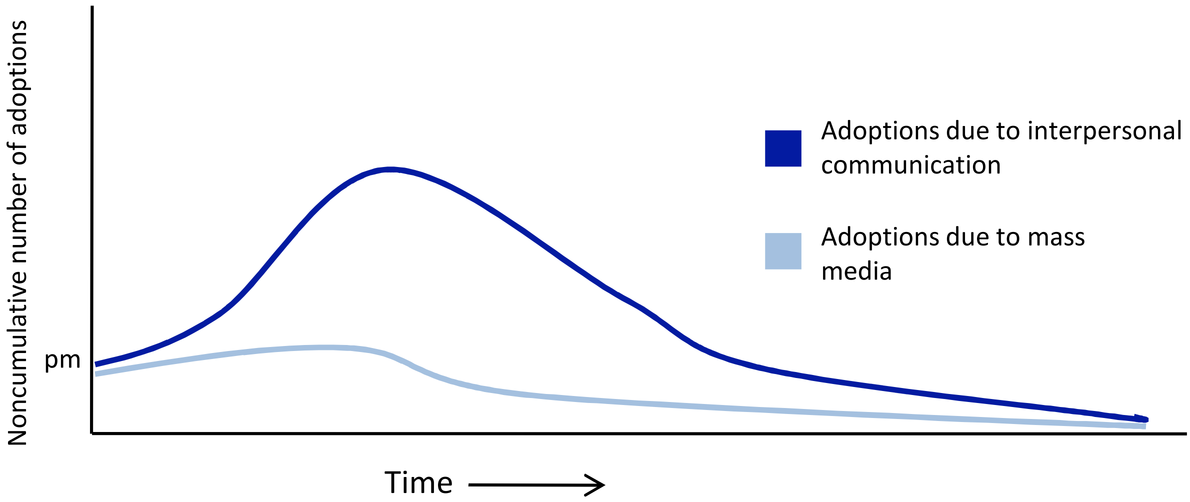


Figure 3.4: *Comparison of the diffusion of innovations due to interpersonal communication and mass media (Rogers 2003, p. 210)*

The direction in which actions are diffused by interpersonal communication in a group or society needs to be taken into account when applying communication and diffusion instruments. For a successful diffusion it is not necessary to involve the entire population at once. In general changes are only adapted by a certain percentage of people in the beginning. This presents the question who and how to involve the different stakeholders in a city in the most efficient way. To achieve highly ambitions reduction targets everyone needs to participate in protecting the climate. Therefore, different groups of people need to become involved in the climate protection process over time.

In Figure 3.5 different types of people, characterised by their adaptation to innovations and their frequency distribution in society are shown. This theory may also be applied to the adoption of climate protection measures on a city scale. According to Rogers (2003, p. 280) people may be classified by their personal characteristics in respect to the adaptation of new technologies and concepts. Stakeholders may also be distinguished by these classifications which include: innovators, early adopters, early majority, late majority and laggards (Rogers 2003, p. 280).

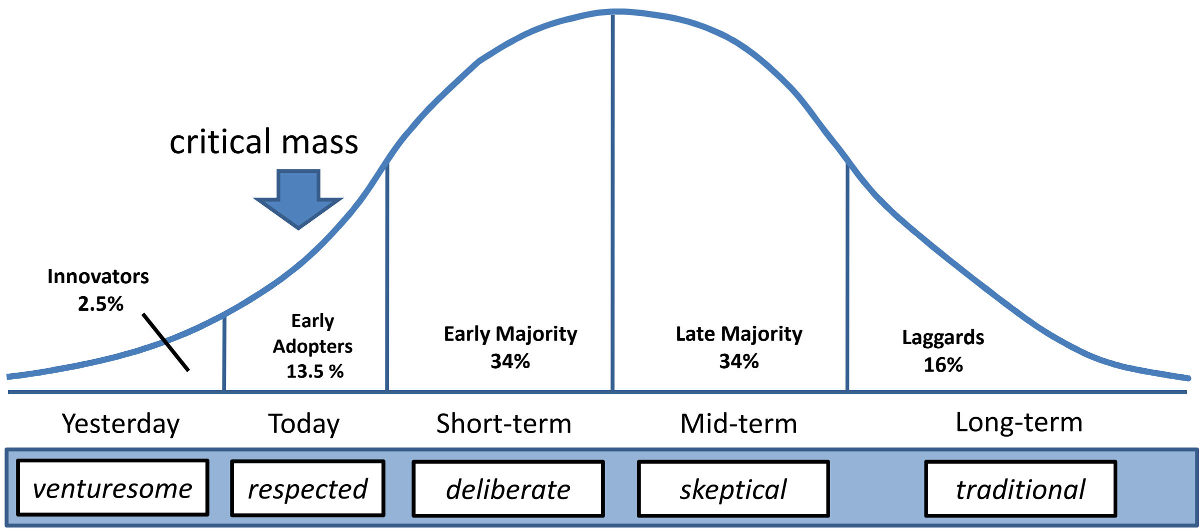


Figure 3.5: *Characterisation and frequency distribution of different types of people in society according to their adaptation to innovations (Rogers 2003, p. 280, adapted and modified)*

Innovators are venturesome people that are easily willed to try and to follow new developments. They like to experience new concepts or technologies and are willing to deal with major disadvantages that come with the early stage of a product development. The disadvantage is that they are willing to try almost everything. Therefore, innovators cannot necessarily be considered a role model for the rest of the society. Innovators typically make up about 2.5 % of the population. In the context of achieving highly ambitious emission reduction targets, innovators should certainly be part of the process, however, they are not a group that warrants a high focus in the early stages of the diffusion of the concept. With their innovative mind these people are likely to join the process themselves, without focusing special attention to attract them.

Early adopters are open to new developments but also have a reflective attitude towards new developments. Early adopters are generally respected and deeply rooted in society. They are opinion leaders and role models. They are using their networks to diffuse innovations. If the development is useful they will largely influence the opinions of the early majority. The early adopters are the most important group when it comes to the diffusion of innovations or concepts. They represent approximately 13.5 % of the total population and can be considered together with the innovators, to make up the critical mass required for innovations to take off. Therefore, it is crucial to focus most of the energy towards including the early adopters into the diffusion of an innovation or concept (Rogers 2003, p. 283).

The early majority can be considered as deliberate in that they are willing to adopt new developments when they can follow role models that have successfully adopted new technologies or concepts already. They are very likely to become involved when they can see the advantages of the new development. The early majority account for 34 % of the population. The early majority should be targeted after the early adopters have been integrated into the process. (Rogers 2003, p. 283-284).

A main focus on early adopters is emphasised. If early adopters are involved successfully, they will become the stepping-stone to convincing the early majority to adopt the concept. In total 50 % of the population will be involved when those two groups plus the innovators are involved. (Rogers 2003, p. 281)

The late majority, known for being sceptical to new developments, follow once the initial 50 % of the population are involved. They should be included in the process with special attention on the mid-term. (Rogers 2003, p. 284)

The last group of people to adopt an innovation or concept are the laggards, and make up the remainder of the population (16 %). They are characterised as being highly traditional and will only adopt an innovation if everyone else has already adopted it. Therefore, special attention should only be paid to them at the end of the implementation process. Including them in the beginning of the implementation process will be counter-productive and could de-motivate the other groups. (Rogers 2003, p. 284-285)

Through the communication and interactions between the different adopter groups, experiences with innovations are passed further into the groups who are less willing to adopt. Rogers (2003) states that with the concept of diffusion of innovations only a critical mass of individuals needs to be convinced and involved in the process in the beginning to achieve a continuous diffusion. The critical mass can be achieved most efficiently by focusing on the early adopters. This is visualised in Figure 3.6 on page 101. The early adopters play a key role in society and therefore in the climate protection process.

The transition arena and the evolving transition network can use the described “communication and diffusion instruments to put pressure on public authorities or on private companies” (Kaufmann-Hayoz et al. 2001, pp. 48) to support the process. Changes can be brought about more quickly using communication and diffusion instruments than with using classic policy instruments (Kaufmann-Hayoz et al. 2001, pp. 48).

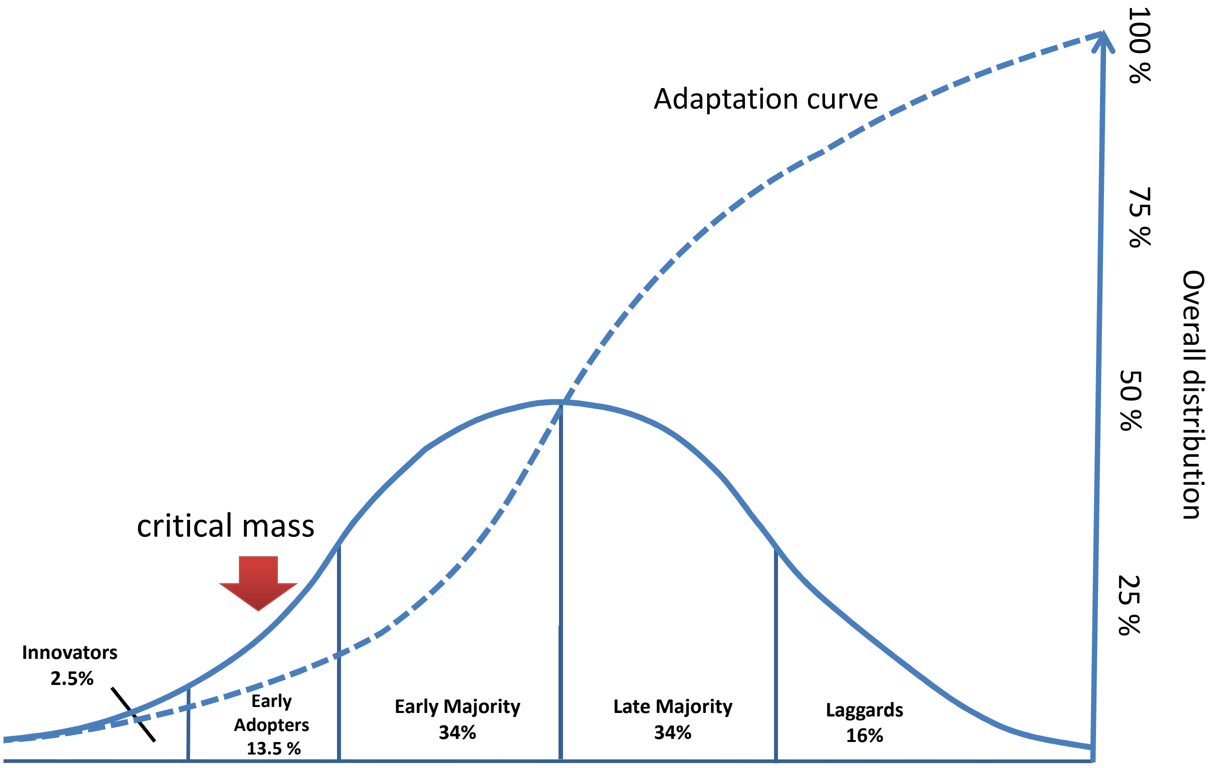


Figure 3.6: *Achievement of a critical mass by focusing on the early adopters (Rogers 2003, adapted and modified)*

3.3.2 Social marketing

In the previous section it was already stated, that communication and diffusion instruments can be used for climate protection purposes. In this context, their goal is to promote climate friendly behaviour. Social marketing was also developed with these same goals in mind. Social marketing uses methods from commercial marketing, in particular those focussed on behaviour change, for non-commercial purposes (Brohmann et al. 2002, p. 13). The concept of social marketing stems back to 1971. In this year the term was first used and defined by the authors Kotler and Zaltman (1971) in their article “Social Marketing: An Approach to Planned Social Change”. They defined the term social marketing as “the design, implementation, and control of programs calculated to influence the acceptability of social ideas and involving considerations of product planning, pricing, communication, distribution, and marketing research” (Kotler and Zaltman 1971, p. 5).

The definition of social marketing has evolved further over the years. In his article “Social marketing: Its definition and domain” Andreasen (1994) analysed the origins of social marketing, how it evolved, how it is used and argued for an adjusted definition of social marketing. The definition that will also be used in this thesis is: "Social marketing is the adaptation of commercial marketing technologies to programs designed to influence the voluntary behaviour of target audiences to improve their personal welfare and that of the society of which they are a part." (Andreasen 1994, p. 110). This definition in contrast to the original definition from Kotler and Zaltman (1971) explicitly includes the influence of behaviour and the improvement of general welfare. Following the definition from Andreasen (1994) it becomes clear that the main purpose of social marketing is to achieve behaviour change. Social marketing is more than just providing information (Andreasen 1994, p. 110).

One of the main differences between commercial marketing and social marketing is the "product" to be sold. With commercial marketing these products are either goods or services. While social marketing is used to sell behaviours (Kotler et al. 2002, p. 20). As a result, social marketing does not benefit stakeholders but the welfare of individuals, groups or society as a whole (Kotler et al. 2002, p. 20). So far social marketing has been "used to improve public health, prevent injuries, protect the environment, and increase involvement in the community" (Kotler et al. 2002, p. 20). Over the last few years social marketing has also been used for climate protection at the community level to achieve sustainable behavioural changes (Brohmann et al. 2002, p. 14).

Social marketing takes into account the belief that certain behaviours cannot be explained from an individual perspective. To achieve behavioural changes also the social environment including norms and interactions with family, friends and colleges need to be considered (Brohmann et al. 2002, p. 13). Therefore, social marketing does not primarily target individuals, but rather groups or communities (Brohmann et al. 2002, p. 13). Social marketing, in contrast to social advertising, does not only use mass media for communication, but also uses other communication instruments as well as diffusion instruments (Kotler and Zaltman 1971, p. 6). According to Kotler and Zaltman (1971, p. 6) "The message is passed on and discussed in more familiar surroundings to increase its memorability, penetration, and action consequences."

The process framework of social marketing is shown in Figure 3.7 on page 103. It is adapted from Kotler and Zaltman (1971, p. 10). External and internal aspects are also shown. The process can be divided into an external and an internal influence part. The external part consists of the surrounding environment, with its economic, political, technological, cultural and competitive developments and the target market. Competition, for example, might be another organisation targeting the same target group for the same purpose. Depending on the situation a primary, secondary, tertiary and miscellaneous target market can be defined. The external aspects are marked with a blue background in Figure 3.7. The internal aspects have a grey background. The internal aspects consist of a change agency, planning variables and channels for distribution.

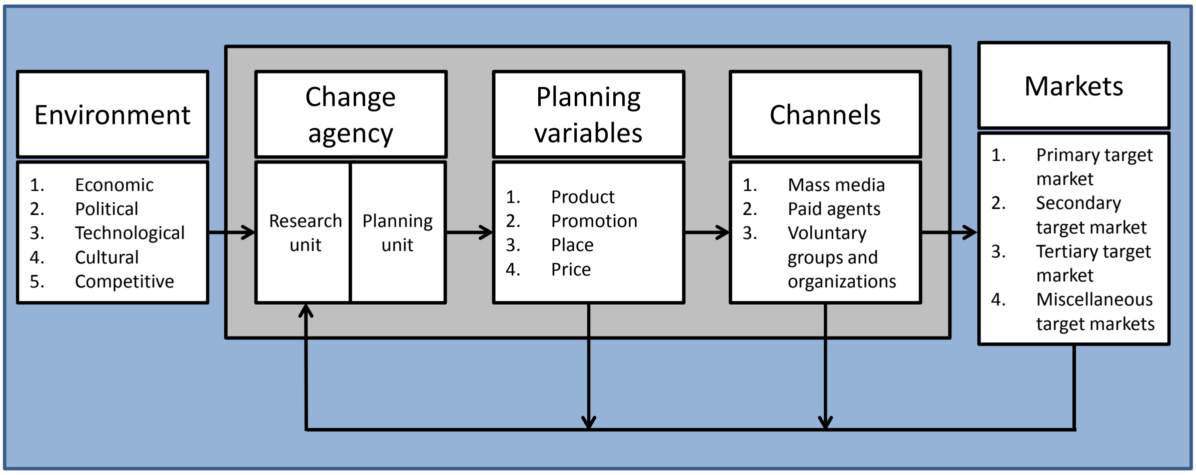


Figure 3.7: *Social marketing planning system (adapted from Kotler and Zaltman 1971, p. 10)*

In social marketing the change agency has two main tasks, research and planning. In the research unit, developments in the environment are collected and analysed. Certain external changes can be advantageous or disadvantageous for the product and need to be considered in the process. Furthermore the research unit collects information and feedback from the other steps of social marketing. This allows a form of monitoring and controlling of the overall process. The feedback should be used to analyse the effectiveness of past programs (Kotler and Zaltman 1971, p. 10) and help to increase the effectiveness of future programs.

The planning unit of the change agency uses planning variables to define their product. According to Kotler and Zaltman (1971, p. 7-9) the four P's of marketing management should be integrated into the process. These are product, promotion, place and price. Defining a product for a social issue can be a difficult task. For climate protection a product could be the investment in efficient appliances, cars or buildings or green technologies. Without a defined product it will be a challenge to direct the target group in the desired direction. The promotion of the product is the communication-persuasion strategy (Kotler and Zaltman 1971, p. 7). Promotion uses all forms of advertising, including mass media, personal selling, publicity and sales promotion (Kotler and Zaltman 1971, p. 7). Places are defined as any location or outlet that allows an individual to turn their motivation into action, e.g. implementing climate protection measure (Kotler and Zaltman 1971, p. 8). People need to be provided with information what exactly they can do and how and where to get it. For example making households aware of places where they can go to sign up and receive the service of an energy check for their household. Price includes financial cost, e.g. investment costs, energy cost or opportunity costs and psychic costs (Kotler and Zaltman 1971, p. 9). The price therefore can be understood as what people are willing to do or pay to achieve the desired change. It does not need to be able to be measured in monetary terms.

After defining the planning variables, the change agency uses different channels to reach the target markets. These might be mass media, paid agents or voluntary groups and organisations. Therefore, different communication and diffusion instruments are used. Depending on the goal the change agency can use different programs to address different markets. For climate protection many different kinds of differentiations depending on the goals can be made. The primary market, for example, might be the private household sector, the secondary market, the commercial sector and the tertiary market, the industry sector.

Kotler and Zaltman (1971, p. 12) emphasize that using social marketing does not guarantee that the defined goals will be achieved. There are too many external factors that can influence the outcome and in some cases the price that needs to be paid for a change could be too high. Social marketing should be seen as "a bridging mechanism which links the behavioural scientist's knowledge of human behaviour with the socially useful implementation of what that knowledge allows" (Kotler and Zaltman 1971, p. 12). Using social marketing knowledge for climate protection purposes allows the designing of an effective process of addressing social issues from a marketing perspective. With this knowledge readily at hand, there is no reason why social marketing should not be used.

3.3.3 Community based social marketing

Based on social marketing, an approach to community based social marketing was developed by McKenzie-Mohr (McKenzie-Mohr 2002). He argues that ambitious environmental goals can only be achieved with high levels of public participation (McKenzie-Mohr 2002, p. 544). It is crucial to understand how people and companies can be involved as effectively as possible in order to achieve the desired goals. Psychology can deliver useful information on how to design effective processes for encouraging and changing the behaviour of people. McKenzie-Mohr used community based social marketing to allow for psychology findings to be available to program planners at the local level.

McKenzie-Mohr (1999, p. 1) argues that too many initiatives attempt to change behaviour using mass-media communication techniques and large scale information campaigns to inform the public. Aronson and Gonzales (1990) and Yates and Aronson (1983) found that education and spreading information using mass-media, although effective in raising awareness for environmental problems, is not likely to actually change behaviour (e.g. the level of education and knowledge about environmental concerns was found to have little or no impact on the behaviour of people (Geller 1981, Geller et al. 1983, Finger 1994, Bickman 1972). Furthermore McKenzie-Mohr (2002, p. 545) states that too many programs are pointing out the finical advantages for individuals. In agreement with Hennicke et al. (1997, p. 21) the decision to act is not solely based on financial criteria. Other criteria like the social and internal norm are influencing the behaviour and therefore the individual decision. Referring to the findings from Costanzo et al. (1986) mass-media campaigns are often not efficient because the difficulty to change behaviour is largely underestimated, which is an additional reason why to include psychology into the climate protection process.

Community based social marketing offers an alternative to information campaigns by using the insight of psychology to create effective tools for the communication and distribution of behavioural changes. Community based social marketing makes use of the circumstance that "behavioural change is most effectively achieved through initiatives delivered at the community level which focus on removing barriers to an activity while simultaneously enhancing the activities benefits" (McKenzie-Mohr 1999, p. 1).

Following McKenzie-Mohr (2011, p. 8-10) community based social marketing consist of five steps:

1. Selecting behaviour
2. Identifying barriers and benefits
3. Developing strategies
4. Piloting
5. Broad-scale implementation and evaluation

Pin-pointing the behaviour that should be changed is the first step in community based social marketing McKenzie-Mohr (2011, p. 8). Instead of marketing general targets like the reduction of CO_2eq-emissions or the reduction in energy use the specific desired behaviour change needs to be addressed. For example, targeting a behaviour change from motorised individual traffic to the use of green modes of transport, like walking, biking, taking the bus. This is also the case in social marketing were it is emphasised that a clear product or message needs to be developed for successful marketing. Without the initial selection of a specific behaviour, it is a challenge to develop good marketing. McKenzie-Mohr (2011, p. 12) recommends to first identify which sector (e.g. industry, commercial, household, transport) makes the most sense to target. For the chosen sector, the area which uses the most energy must be identified. For the household sector the area with the highest energy demand would be the heating. This prioritisation requires that a status quo analysis has already been done. After defining the target the necessary behavioural change can be defined. For reducing energy demand for private transport this could be promoting the use of green modes of transport like using a bike or the bus system, or promoting the investment into energy efficient cars or regular car-maintenance.

The second step of community based social marketing is to identify the barriers that prevent people from changing their behaviour or implementing a certain climate protection measure (McKenzie-Mohr 2011, p. 9). Along with identifying the barriers, the benefits of climate friendly behaviour including investments have to be analysed (McKenzie-Mohr 2011, p. 9). Barriers and benefits can be analysed by reviewing the literature or by observations and survey research (McKenzie-Mohr 2011, p. 9). This also includes interviews. Once the barriers and benefits are identified, social marketing can be tailored exactly to these factors. Identifying barriers and benefits increases the effectiveness of the marketing. The identification of barriers and benefits to an activity is one of the main differences between community based social marketing and social marketing.

The third step of community based social marketing is the development of effective strategies to change behaviour (McKenzie-Mohr 2011, p. 10). Community based social marketing makes use of social science research were effective tools for behaviour change have been developed and tested. Many of these strategies have been described previously like gaining commitment or goal setting. A speciality of community based social marketing in comparison to social marketing is that the focus is on the community level. McKenzie-Mohr (2011, p. 10) points out that especially at the community level, direct personal contact is a crucial element. This is supported by findings in social and psychology research which show that behaviour changes are most likely "in response to direct appeals from others" (McKenzie-Mohr 2011, p. 10).

The fourth step is piloting the strategy. This means that the developed strategy is tested first on a very limited number of people before applying it on the community scale. Piloting the strategy and adjusting it to the response makes the marketing more efficient (McKenzie-Mohr 2011, p. 10). Piloting also makes sense from an economic perspective. Before spending a lot of money on marketing, it can first be tested with a limited budget if the desired behaviour change is achieved or if another approach should be tested.

The last step of the community based social marketing is the implementation and evaluation of the marketing (McKenzie-Mohr 2011, p. 10). The evaluation of the marketing will be crucial to identify if a behaviour change was achieved and if not why. It allows for the adjustment of the marketing strategy, and thus allows for the marketing strategy to become more effective over time.

In Figure 3.8 community based social marketing and social marketing are compared and contrasted. The light blue background on the top indicates the community based social marketing, while the grey on the bottom indicates the steps from the social marketing. The dark blue areas are indicating common steps or possibilities for an integration of the two approaches. Both follow a similar direction by defining different steps and looking at certain points more or less in detail. Social marketing starts with analysing the external environment and its possible effects on the marketing. This is not an explicit part of community based social marketing. In social marketing the change agency is divided into a research and a planning unit. It is not explicitly stated, but the change agency could perform the first two steps of the community based social marketing, which are the selection of the behaviour which should be changed and identifying barriers and benefits of the behaviours that are to be promoted. The step of community based social marketing "Developing Strategies" is included in social marketing as the two steps "Planning variables" and "Channels". Therefore, social marketing is more concrete with these steps and the underlying possibilities to design the marketing process. Addressing the market community based social marketing in contrast to social marketing is doing a beta test of the designed strategy before implementing it on the large scale. At the end both approaches are doing an evaluation of the marketing. The main difference is that social marketing feeds back information to the change agency in every stage of the process, while community based social marketing has for each individual step a feedback loop. It first perfects each individual step before the next one is carried out.

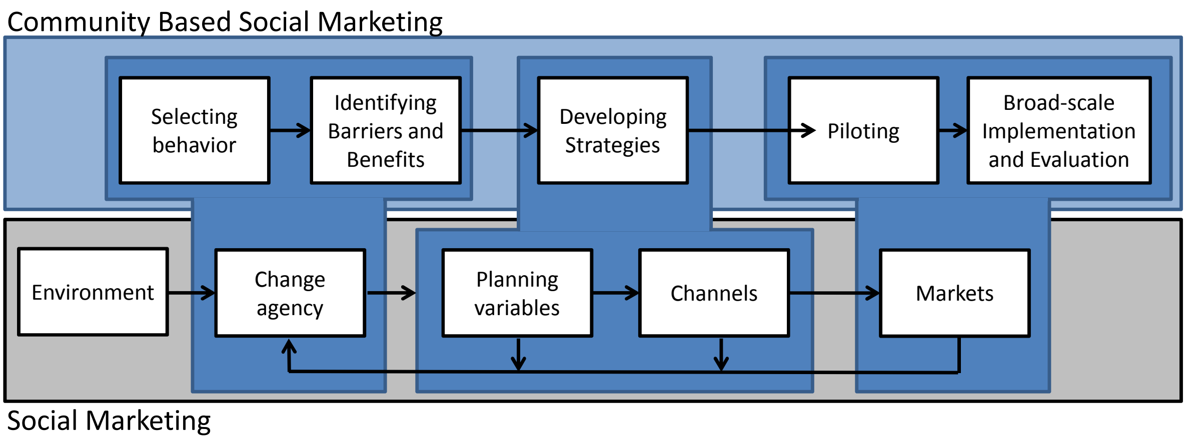


Figure 3.8: *Comparing and contrasting community based social marketing with social marketing*

3.4 Conclusion

A number of psychological theories and approaches may be used for the development of an effective methodology for a city-scale climate protection concept.

In the field of behavioural psychology, which lays the groundwork for theories in environmental psychology as it relates to psychology in sustainable development, researchers are moving away from classical approaches like the “rational economic model”. Instead a more holistic approach is now accepted for understanding human behaviour, explained by the “theory of bounded rationality”.

The field of environmental psychology is still in its infancy. Psychology as it has been applied to sustainable development in the context of climate change, has only become popular in the last 10-20 years. Relevant contributions include the development of intervention instruments to encourage climate friendly behaviour, the development of strategies for encouraging individuals or companies to make decisions based on social interests, the development of communication networks like informal networks for promoting climate protection, and the providing of insight into the importance of stakeholder participation. A combined approach incorporating environmental psychology, cities and green house gas emissions, for example, has not yet been developed.

Spatial and temporal time-lags between emitting CO_2eq and the relative effects on the climate are one of the main challenges associated with committing people to the problem of climate change. This characteristic of climate change makes this phenomenon and its effects nearly impossible to identify in ones everyday life, resulting in difficulties associated with getting people to act or motivating people with respect to this issue.

The challenge stated above makes it essential when developing a climate protection concept, to implement psychological tools for drawing people’s attention to the issues of climate change and understanding what drives people to make changes or to act. “Norm activation theory” addresses human behaviour and willingness to change when confronted with a decision to act and points out the relative importance of problem awareness, knowledge about solutions and recognition by others and the internal personal norm. “The theory of planned behaviour” highlights the importance of people’s values and beliefs, social pressure and how easy or difficult an action is for driving behavioural change. “The determinants of action” are addressing an individual or groups willingness to act, additionally points out the importance of reward, the perceived chance to realize measures, previous experience and gained knowledge.

Understanding what key factors are important for motivating people to act is important when developing a climate protection concept. “The theory of intrinsic and extrinsic motivation” highlights the importance of targeting people’s intrinsic motivation by promoting the internalization of values and environmental friendly behaviour and assigning the right task to the right people. The antecedent intervention of goal setting is an effective technique for motivating people. “The goal setting theory” points out the importance of value of the goal to the individual and the individual’s belief of whether or not the goal is attainable for effective goal acceptance and commitment.

Achieving highly ambitious CO_2eq-emission reductions largely depends on the participation of as many individuals as possible in the process, making the communication and diffusion of information vital for climate protection concept development. Communication and diffusion instruments may be used for this purpose, where a high penetration of the target group is the goal. Although mass media is the most popular means of sending a message out in mass, findings show that personal contact has a much higher success rate in the spreading of information. More recently, social- and community based social marketing have been used to spread social ideas. The latter, most applicable to the city-scale, highlights the importance of selecting a behaviour to be changed, identifying barriers and benefits, developing strategies, piloting and broad-scale implementation and evaluation when trying to successfully spread social ideas, such as those related to climate protection, at the community level.

In conclusion, theories and ideas from the field of psychology can be used to increase the effectiveness of changing people’s behaviour, increasing the willingness of people to act and to remain motivated when confronted with choices and challenges pertaining to climate change. Additionally psychology may be used to increase the effectiveness of the spreading of information through communication and diffusion methods, and may also be applied to social marketing strategies, including those on the community, or city scale. The psychological theories and approaches discussed in this chapter will provide a basis for the development of a novel methodology for reducing CO_2eq-emissions in a German city in the case study presented in Chapter 5 of this dissertation.

4 A novel methodology for cities

After the introduction and discussion of suitable approaches for the development of climate protection concepts with highly ambitious long-term targets in Chapters 1 to 3, a novel methodology, developed based on the theory introduced, will be presented in this chapter. The novel methodology presented here combines backcasting and transition management to create a holistic approach for the development of ambitious city-scale climate protection concepts with the particular goal of achieving CO_2eq-neutrality. Insights from psychology (as introduced in Chapter 3) have been incorporated in order to ensure the creation of a participatory long-lasting sustainable process.

In Chapter 1 climate protection concepts already developed for cities in northern Germany were reviewed. This review provided a basis of understanding of the approaches and methods currently applied to climate protection concepts for this region. From the review, the following main trends were identified: (1) most climate protection concepts included a participatory approach; (2) approaches and methodologies applied differed greatly between concepts; (3) only one out of 16 concepts reviewed applied the promising approach of backcasting to their concept development; (4) only seven from the 16 concepts reviewed successfully achieved a set of CO_2eq-emission reduction targets with their measures developed; (5) only 50 % of climate protection concepts reviewed included an implementation strategy.

The aim of this chapter is to introduce a novel methodology developed which incorporates the promising approaches of backcasting and transition management as well as addresses the gaps of other regional climate protection concepts pointed out in the paragraph above. The novel methodology is city-focused and therefore addresses the specific challenges that cities face in obtaining CO_2eq-neutrality. The developed new approach will not only advance research in backcasting and transition management, but will also show how both concepts may be used together and how they may be applied for climate protection on the city-scale.

The novel methodology is depicted in Figure 4.1. In the following paragraphs a brief description of the methodology based on Figure 4.1 is provided. In the sections to follow each individual step is described.

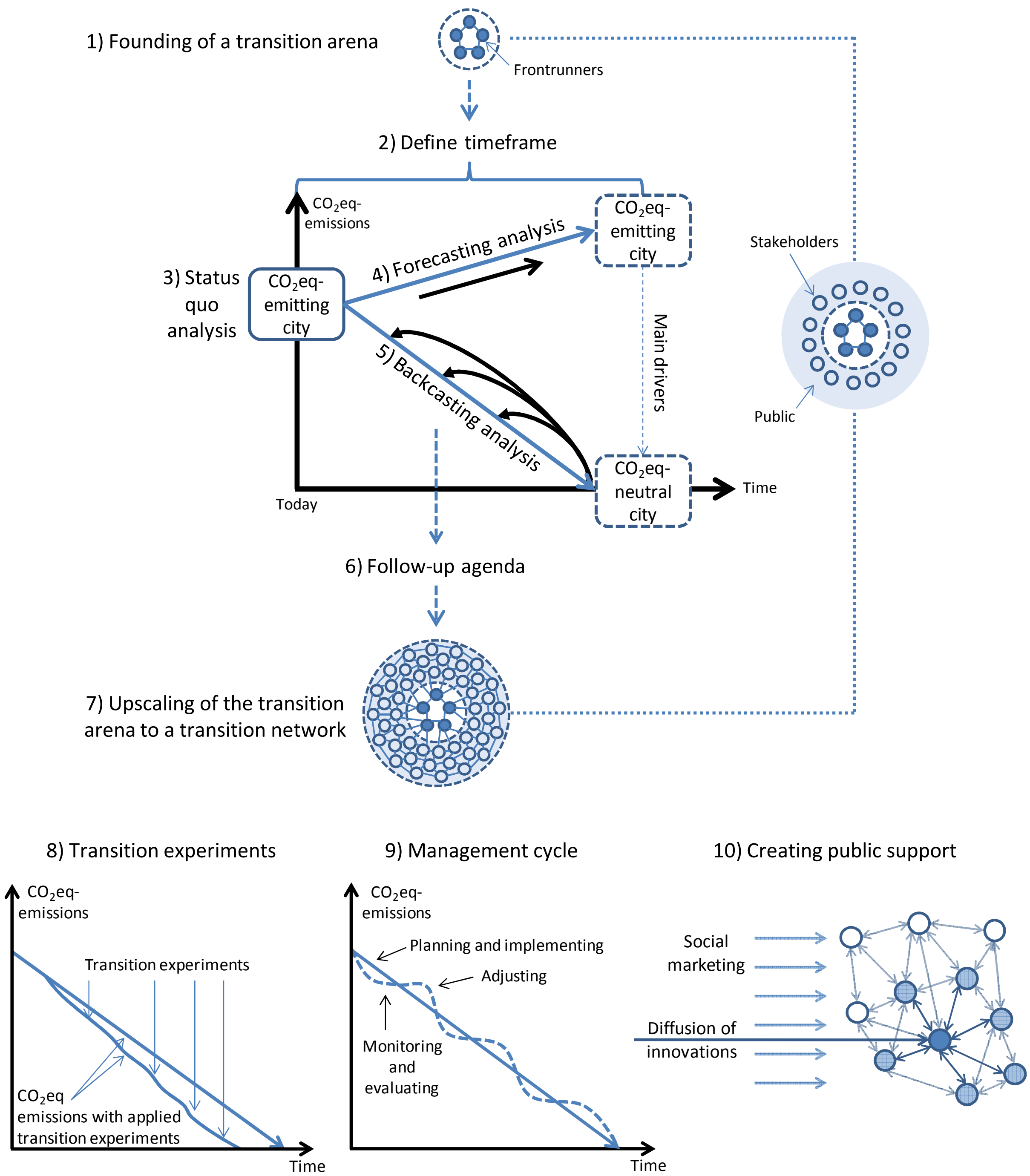


Figure 4.1: *Novel methodology for cities aiming to obtain CO_2eq-neutrality*

Step 1: Founding of a transition arena To start and establish the process of climate protection on a city-scale, a group of locally rooted stakeholders is founded. Stemming from transition management this group is called a "transition arena". The transition arena promotes the idea of local climate protection by using their existing networks and stimulating the formation of new coalitions. In the beginning of the climate protection process on a city-scale the transition arena is a small network of frontrunners (10 to 15 people) with different backgrounds. The transition arena acts independently from traditional political networks to avoid a domination of established interests. The transition arena is responsible for ensuring the long-term continuation of the transition towards a CO_2eq-neutral city. The transition arena is largely involved in the next steps of the newly developed methodology.

Step 2: Define timeframe The second step of the novel methodology is to define the timeframe for achieving the goal of a CO_2eq-neutral city. The target year is determined by the transition arena in a participatory way. Taking the specifics and challenges of different city sectors and branches into account, an ambitious but feasible target is set that allows all sectors of a city to achieve the goal.

Step 3: Status Quo analysis After defining the timeframe for achieving a CO_2eq-neutral city, a status quo analysis is performed. The status quo analysis is used to quantify energy demand and CO_2eq-emissions within the city borders. To improve the manageability, the city is divided into subdivisions, which are the household, industrial, commercial and transport sectors. After the division of the city into sectors an energy and CO_2eq-balance is created. An energy and CO_2eq-balance is a systematic form of data collection with the purpose of determining sector-specific and total energy demand and CO_2eq-emissions of a city over a certain period of time. In order to set up the energy and CO_2eq-balance, a reference year and a base year is fixed. In addition to collecting data on the city's energy demand and CO_2eq-emissions, the status quo analysis includes the identification and involvement of relevant stakeholders. Including as many stakeholders as possible in the process from early on is a crucial aspect from both network-strategy and psychological perspectives. Involving and gaining the support of the local stakeholders for the process in the beginning increases the chance of commitment to the goal of a CO_2eq-neutral city later in the process. The status quo analysis lays the foundation of the forecasting and backcasting analysis.

Step 4: Forecasting analysis Using the results from the status quo analysis as a foundation a forecasting analysis is performed to determine how energy demand and CO_2eq-emissions of a city would develop over time if current trends were continued. The main drivers of energy demand and CO_2eq-emissions are identified by analysing historical data. The future development of the drivers is determined by extrapolating historical trends, including forecasts from other future studies and by incorporating existing regulations with an influence on future energy demand and CO_2eq-emissions. Analysing the future development of drivers prevents over- or underestimating the necessary amount of climate protection measures to take. From a psychological perspective the results from the forecasting analysis provide, when continuing business as usual is not sufficient to achieve the emission reduction target, motivation by showing how emissions would develop without additional climate protection measures.

Step 5: Backcasting analysis Based on the results of the status quo and forecasting analysis a backcasting analyses is performed. During the application of the backcasting analysis climate protection measures are determined for the achievement of a CO_2eq-neutral city. The knowledge and the experience of the stakeholders is used to develop a climate protection concept with the best possible specific solutions for the city in question. Conducting a variety of workshops with the stakeholders for each city sector, a scenario is constructed that identifies and quantifies specific climate protection measures. Measures from different sectors may mutually reinforce, weaken, or even eliminate each other. To develop an effective and comprehensive climate protection concept on the city-scale, climate protection measures are considered in a sectoral and inter-sectoral context to achieve an integrated point of view. The sector specific scenarios are integrated in one overall backcasting scenario for the city. The backcasting scenario contains the information about when, what and to which extent climate protection measures should be applied to achieve a CO_2eq-neutral city.

Step 6: Follow-up agenda After the development of a climate protection scenario during the backcasting analysis, the associated climate protection measures have to be implemented. To increase the chance of implementation, the step “follow-up agenda” is included in the novel methodology. The follow-up agenda contains objectives, projects, instruments and responsibilities for planned activities to achieve the CO_2eq-emission reduction target. These are the climate protection measures that have been discussed and agreed upon during the backcasting analysis. The agenda is also used to identify barriers for the transition to achieving a CO_2eq-neutral city. Barriers in the context of a participatory process are those that hinder the stakeholders and the public to gain and maintain the acceptance of climate protection measures on the city-scale and its implementation. Identifying and addressing barriers in advance of the implementation of climate protection measures is important to reflect on the developed climate protection measures and to develop suitable strategies to reduce barriers. The follow-up agenda also includes an implementation strategy. The main goal of an implementation strategy is to gain and to maintain the acceptance of climate protection measures among the target groups to achieve short-, mid- and long-term emission reduction goals. The last aspect of the follow-up agenda is to transfer the developed climate protection concept on paper and to make the concept report widely accessible.

Step 7: Upscaling of the transition arena to a transition network Climate protection cannot only be achieved by a small number of people. At the end, every stakeholder and the public have to contribute to achieve a CO_2eq-neutral city. Therefore, in step seven of the novel methodology, the transition arena is upscaled to a transition network. Five phases are distinguished for upscaling the transition arena to a transition network. By following the presented steps of the novel methodology the process of upscaling the transition arena to a transition network is already partly achieved. The first phase is the foundation of a transition arena, which engages and involves more stakeholders over time. The second phase is the status quo analysis, which is performed together with different stakeholders. The third phase is the performance of the forecasting analysis, which fulfils a motivational purpose and therefore increases the chance of future involvement. The fourth phase is the backcasting analysis. Previously established contacts are used to engage stakeholders and the public to participate in the backcasting analysis and to commit them to the process. This already established connection is helpful to finally upscale the transition arena to a transition network in the fifth phase. As described in Chapter 3, the social norm, influenced by the social environment, is a strong influencing factor on human actions. Overall the upscaling of the transition arena to a transition network is a continuous process from the beginning of the climate protection process.

Step 8: Transition Experiments By including the step "transition experiments" into the novel methodology it is expressed that the climate protection process has to have the flexibility to respond to new developments. Transition experiments are normally high risk, expensive and time consuming projects, but when successful, contribute greatly to the reduction of CO_2eq-emissions. First, possible transition experiments are identified and then prioritised for testing. The tested transition experiments are evaluated and the decision is made about whether or not the transition experiments should be upscaled to a widely applied technology.

Step 9: Management cycle The creation of a climate protection concept is the start of a long-term process, which needs to be monitored and controlled on a regular basis. Therefore, a management cycle for the achievement of a CO_2eq-neutral city is included in the novel methodology. The management cycle includes the following phases: planning, implementing, monitoring, evaluating and adjusting. Every year of the implementation phase, the question is raised as to whether the intermediate goals have been fulfilled. If this is the case, the process continues as planned, to achieve a CO_2eq-neutral city. If the goals were not fulfilled, adjustments to the climate protection process and the defined climate protection measures are necessary. Setting up a well functioning management cycle is also important from a psychological point of view. Only when progress can be measured, can the stakeholders adjust their behaviour for the achievement of the set goal. Therefore, the management cycle is not only an instrument for evaluating the development of CO_2eq-emissions, but also a tool for motivation.

Step 10: Creating public support The focus of the participatory approach is on motivating local stakeholders and raising awareness of the general public. Successful stakeholder involvement is dependent on strong public support. Involved stakeholders may be required to take business risks, such as increasing prices of their goods (e.g. due to the use of sustainable materials), and thus public support and awareness of these changes will help to safeguard the stakeholders' businesses and their long-term involvement in the climate protection concept. Therefore, a continuous task for climate protection at the local level is to gain and maintain public support, which is achieved using the theories of diffusion of innovations and social marketing. Using both approaches, effective tools for the communication and distribution of behavioural changes are applied.

In the following sections the individual steps will be described in detail and the adaptation of the backcasting and transition management approach discussed.

4.1 Step 1: Founding of a transition arena

To start and establish the process of climate protection on a city-scale, a transition arena (cp. Section 2.4.7.1 on page 62) is formed. The members of the transition arena (10 to 15 people) are local frontrunners who are deeply rooted in society. To avoid a domination of particular interests from different commercial or industrial branches, the members of the transition arena are having different professional, educational and social backgrounds. Furthermore, the transition arena acts independently from traditional political networks to avoid a domination of established interests.

The foundation of the transition arena is driven by the incentives of the frontrunners. Understanding the need for climate protection, local frontrunners are triggered to actively promote the idea of local climate protection. Once a few local frontrunners are engaged, their networks are utilised for the foundation of a transition arena. Following findings from motivational theory, intrinsic motivation results in higher engagement and performance than extrinsic motivation (Miserandino 1996). Incorporating this theory, the foundation of a transition arena driven by the incentives of the frontrunners is advantageous.

The founding of a transition arena is a part of the network strategy in transition management. The transition arena promotes the idea of climate protection on the city-scale by using their existing networks and stimulates the formation of new coalitions. The transition arena is responsible for ensuring the long-term continuation of the transition towards a CO_2eq-neutral city. The transition arena is largely involved in the next steps of the newly developed methodology.

4.2 Step 2: Define timeframe

In step two of the novel methodology, a target year for obtaining CO_2eq-neutrality is defined. This is a precondition for applying goal orientated approaches such as backcasting. The target year for CO_2eq-neutrality of a city is determined by the transition arena in a participatory way. Taking the specifics and challenges of different city sectors and branches into account, an ambitious target is set that still allows all sectors of a city to achieve the goal. In addition to establishing the final target of obtaining CO_2eq-neutrality by a certain year, intermediate reduction targets can be set.

From a psychological point of view it is advantageous to avoid too ambitious emission reduction targets time-wise. When intermediate goals are not achieved frustration and de-motivation of stakeholders is likely. Goal setting will only be successful if people have the ability and knowledge to fulfil a certain task (Locke et al. 1981, p. 125) (Locke 1968, p. 184). If people believe that by their contribution the goals are achieved, their commitment to the climate protection process is higher. Higher commitment leads to higher task performance (Locke and Latham 2002, p. 707) and therefore increases the chance of achieving a CO_2eq-neutral city. Psychological findings also showed that goal setting works independently from the question if the goal was self-determined by an individual or set externally (Latham and Locke 1979, p. 73). It is important that the individual believes that the target can be fulfilled and they have the knowledge to work towards that target Locke and Latham (2002, p. 707).

In contrast to setting too ambitious emissions reduction targets time-wise, also the setting of too long timeframes is disadvantageous. Research indicates that goal commitment will be most relevant and goal setting most promising if difficult goals are set (Klein et al. 1999, p. 893). Setting ambitious goals leads to a higher performance than setting easy goals (Locke 1968, p. 157).

4.3 Step 3: Status quo analysis

After defining the timeframe for achieving a CO_2eq-neutral city, a status quo analysis is performed. The status quo analysis is used to quantify energy demand and CO_2eq-emissions of a city. The status quo analysis lays the foundation of the climate protection process. Possible climate protection measures and their reduction potential will be quantified and prioritised during the backcasting analysis based on the results of the status quo analysis. Performing a status quo analysis is a necessity for a tailored climate protection concept for cities.

The importance of the status quo analysis is also recognised by the backcasting approach with its focus on strategic problem orientation. It requires that the system under research is well understood and data for detailed analysis is available. Already in 1982 Ackerman (1982, p. 50) stated, that after realising that changes are necessary, a depiction of the actual situation needs to be performed. The importance of the status quo analysis is also reflected by the characteristics of the researched 16 climate protection concepts from northern Germany. All concepts had conducted a status quo analysis.

The status quo analysis of the novel methodology consists of four general steps. The steps are listed below and will be explained in detail in the sections to follow.

- Specification of the research area
- Determination of the form of energy and assignment principles of emissions to be used
- Identification and involvement of stakeholders
- Data collection and creation of an energy and CO_2eq-balance

4.3.1 Specification of the research area

As a first step of the status quo analysis, the research area is specified. In the case of cities, the geographic area is defined by the city borders. Unfortunately a unified definition for the term city does not exist on the global scale. Each country has its own definition of a city and the borders between urban and rural areas are not always well defined. For each city under research, the city borders are therefore determined individually.

A city with its social-, political- and infrastructure is an enormously complex system (Zellner et al. 2008, p. 474). Therefore, after clarifying the city boundaries the city is divided into subdivisions or sectors to improve the manageability. This paper follows the sector approach of AG Energiebilanzen (2009), which subdivides the energy consumption of Germany into four sectors, and may also be applied to smaller units such as cities. These sectors include the household sector, the industrial sector, the commercial sector and the transport sector. The sectors are briefly described in the following.

Household A household is commonly defined as a person or a group of people living in the same dwelling (O'Sullivan and Sheffrin 2006, p. 29). All energy consumption and CO_2eq-emissions of and in the dwelling and the surrounding property including the yards and garden are a part of the household sector.

Industry Following the definition of the German Federal Statistical Office (Statistischen Bundesamt Deutschland), all economic activities in mining, quarrying and manufacturing in companies larger than 20 employees are included in the industrial sector. Industrial companies with less than 20 employees are considered commercial.

Commercial The commercial sector is the most heterogeneous sector and encompasses all areas that are not covered by the household, industrial or transport sector. It includes public buildings, trade, hand-craft, retail and wholesale, agriculture and services (AGEB 2010, p. 7).

Transport The transport sector includes motorised private traffic, public passenger transport and freight transport.

4.3.2 Determination of the form of energy and assignment principles of emissions to be used

After specifying the research area, the form of energy and assignment principles of emissions for the analysis is determined for the status quo analysis. Energy demand as well as CO_2eq-emissions can be calculated and assigned using different approaches. In the following first the form of energy to be used and then the assignment principles of emissions will be introduced.

In general, energy is defined as the ability of a system to perform work. The thermodynamic law of conservation of energy states that energy cannot be produced or consumed. Therefore the widely used term “energy consumption” cannot be understood in a literal way. Energy can only be transformed into different forms which “occurs by the consumption of quality” (Wall 1977, p. 6). In this thesis “energy consumption” is understood as the reduction of energy by an exergy loss (exergy = usable energy).

There are four different forms of energy, which include primary, secondary, final and useful energy. A clear distinction is made between these forms of energy (Dhakal 2008, S. 179). Primary energy refers to the calorific value of the energy source as it can be found in nature. For providing secondary energy, a conversion process is necessary. Secondary energy is, for example, electricity from a generator. Final energy is defined as the share of primary energy that can be used by the consumer, e.g. electricity after transmission through the grid or petrol at the petrol station. Useful energy is the energy that the consumers can use for their tasks. This is, for example, mechanical energy, light or heat. The relationship between the four forms of energy is described through measurements of efficiency, conversion and transmission losses. Having understood the different forms of energy and the relationship between them, a decision is made which form of energy is used for the status quo analysis of the city.

Similar to the different forms of energy, different concepts exist on how to determine CO_2eq-emissions. There are no given rules for the assignment of CO_2eq-emissions (Fischer and Kallen 1997, p. 90). For the novel methodology, it is not argued further for one or the other approach. In the future, however, one standard approach for assigning CO_2eq-emissions should be used on how to assign emissions to unify the calculation basis and to guarantee comparability as well as avoiding double counting of emissions (Satterthwaite 2011, p. 1767) in the city and between cities. At present, there exist three different approaches, or "principles" commonly used to assign GHG emissions to a city (Fischer and Kallen 1997, p. 93-95):

Territorial principle The territorial principle is a common methodology used for assigning pollutants with local impacts. The principle states that only emissions which are released directly in the defined reference area are used for the emission calculation.

Residents principle The residents principle follows the idea that a certain amount of CO_2eq-emissions can be assigned to every good that a resident of that area consumes, independent from the question where the good is bought or consumed. By knowing the overall number of goods that are consumed by the residents, the CO_2eq-emissions can be calculated.

Inland principle The inland principle follows the idea that emissions in the reference area include those that are induced by the activities in that area. Using this principle it is not important where the emissions occurred. For example an area that is importing electricity will be made responsible for the CO_2eq-emissions that are occurring for the electricity production somewhere else. Following this principle all emissions by the production of goods in the reference area will be taken into account. In contrast to the residents principle the emissions of goods produced in the reference area are taken into account regardless of whether it will be used in that area or not.

4.3.3 Identification and involvement of stakeholders

In addition to collecting data on the city's energy demand and CO_2eq-emissions, the status quo analysis includes the identification and involvement of relevant stakeholders. A status quo analysis requires, to a certain degree, company specific data. Including company specific data allows for the most suitable development of climate protection measures. From a network-strategy perspective, the status quo analysis is a crucial step to include as many stakeholders as possible in the process from early on. Having stakeholders to deliver data is also useful from a psychological point of view. Stakeholders are supporting the general climate protection process by delivering data, without having to commit to the ambitious CO_2eq-emission reduction targets. According to the findings from the foot-in-door theory (Swim et al. 2011, p. 248) (McKenzie-Mohr 1999, p. 3), the support of a process in the beginning increases the chance of later commitment to more ambitious targets. Therefore the networking and involvement of stakeholders is as equally important for local climate protection as the data collection for the status quo analysis. Furthermore, during the status quo analysis the need for ambitious emission reduction targets is explained to the stakeholders and an environment created that supports future cooperation. The process is depicted in Figure 4.2.

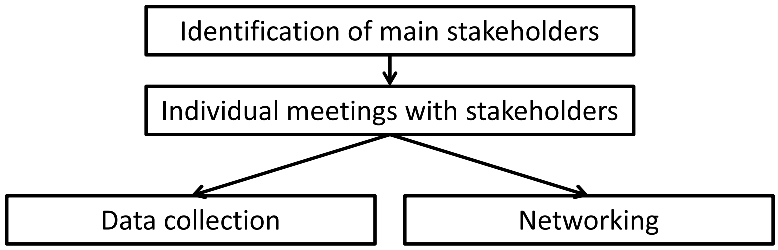


Figure 4.2: *Stakeholder identification and involvement in the status quo analysis*

4.3.4 Data collection and creation of an energy and CO_2-balance

After determining the form of energy to be used and agreeing on an assignment principle of emissions, an energy and CO_2eq-balance is created. An energy and CO_2eq-balance in the novel methodology fulfils the purpose of determining specific, sector-specific and total energy demand and CO_2eq-emissions of a city over a certain period of time.

To set up the energy and CO_2eq-balance, a base year and a reference year are fixed. In the case of climate change mitigation the reference year is often the year 1990. This is the nationally and internationally acknowledged reference year for percent emission reduction targets. It is used among others in the Kyoto-Protocol. Also the IPCC uses the year 1990 as the reference year for the comparison of emission reductions. In addition to the reference year, a base year is determined. The base year is normally set to one to three years before the creation of the energy and CO_2eq-balance. Developing an energy and CO_2eq-balance, it is often the case that not all data is available already from that current year. Therefore, to increase data availability an earlier year is chosen.

Different tools and instruments can be used to create an energy and CO_2eq-balance. Commercial as well as free tools for the creation of an energy and CO_2eq-balance are available (e.g. ECORegion). Also self-made highly individual solutions may be applied. Depending on the requirements and the degree of individualisation, a variety of tools can be used.

Setting up an energy and CO_2eq-balance requires detailed information on the energy demand and the specific CO_2eq-emissions of energy sources used in the city. Not all of the data might be available on a city-scale. Therefore, a trade-off between data accuracy and the availability of data on different levels is made while setting up the energy and CO_2eq-balance. The different levels of valuable information are depicted in Figure 4.3. First, the data available for the city is identified and evaluated. Data derived from the next level is considered for the energy and CO_2eq-balance when information is not available on the city level. Taking data from the next level helps to fill gaps even though it makes the energy and CO_2eq-balance less specific for the city under research.

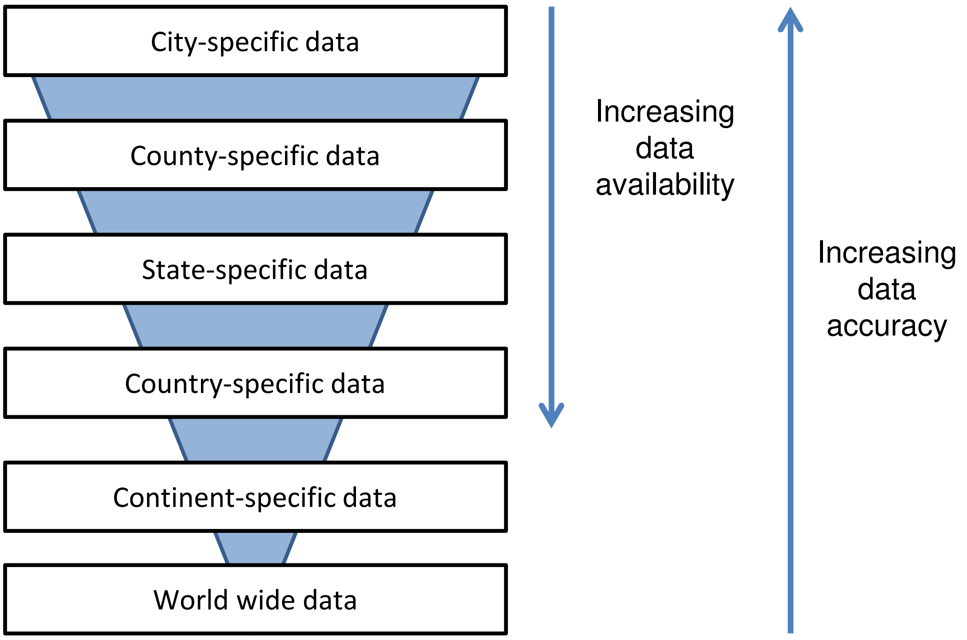


Figure 4.3: *Systematic data collection for the creation of an energy and CO_2-balance*

Depending on the financial equipment of the project, surveys on the city-scale are a valuable way to gain further information on the energy consumption and CO_2eq-emissions of a city. A survey or interviews with companies provide a stepping-stone to get in contact with local actors and to start a broader participatory approach (cp. foot-in-door effect, Section 3.2.5 on page 92).

Figure 4.4 on page 123 shows the structure of an energy and CO_2eq-balance. For each year the individual energy demand for different stakeholders or city sectors is determined. When summed up, the individual energy equals the total energy demand of a city. Consecutively the energy supply sources are determined to match each energy demand with a specific CO_2eq-emission value of the fuel source. Multiplying the individual energy demand by the matching specific CO_2eq-emissions equals the total CO_2eq-emissions of that energy demand. Adding up those CO_2eq-emissions results in the total CO_2eq-emissions of the city.

In addition to the information on energy demand and CO_2eq-emissions, an energy and CO_2eq-balance includes data to determine the specific development of energy demand and CO_2eq-emissions. For example, for calculating the development of the specific heating demand of the household sector, the total area of living space in a city must first be determined. Other useful data to develop specific indicators on energy demand and CO_2eq-emissions include the

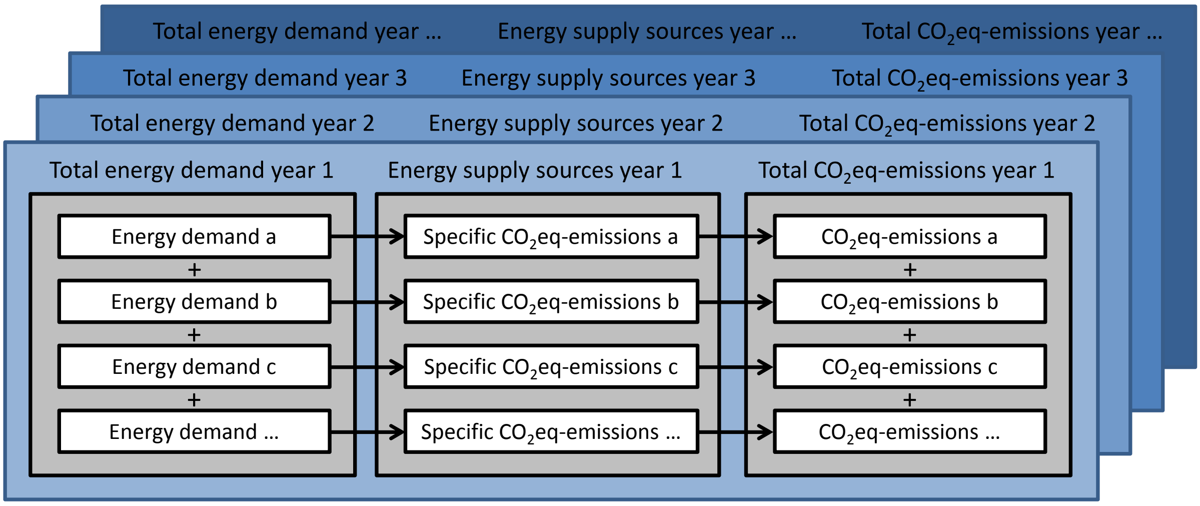


Figure 4.4: *Structure of an energy and CO_2eq-balance*

total population, demographic factors, number of businesses, number of cars and number of apartments.

4.4 Step 4: Forecasting analysis

Using the results from the status quo analysis as a foundation, a forecasting analysis is performed to determine how energy demand and CO_2eq-emissions of a city will develop over time if current trends are continued. According to Höjer and Mattsson (2000, S. 613) and Sondeijker (2009, p. 51) backcasting and forecasting are complementary approaches and are often seen used in combination. The results of the forecasting analysis determine whether backcasting is needed to achieve the emission reduction target. If the forecasting analysis shows that the desired result is not achieved with a continuation of given trends, the next step, the backcasting analysis, is performed. Backcasting then is applied to identify solutions on how the desired future can be achieved. The results of the forecasting analysis also show how much additional effort is necessary to achieve the desired emission reduction. A long-term forecast will also serve as a mode of motivation to change the forecasted development, if continuing business as usual is not sufficient to achieve the emission reduction target. Following these arguments, a forecast analysis is performed prior to the backcasting analysis.

Figure 4.5 shows possible forecasting and backcasting results. In this example, it is assumed that the continuation of given trends will result in a steady increase of CO_2eq-emissions. Applying climate protection measures from the backcasting analysis lowers CO_2eq-emissions. As a third option, the CO_2eq-emissions are held constant over time. Assuming a constant CO_2eq-emission value over time might over- or underestimate the necessary effort for reducing the CO_2eq-emissions. The reason for this is that the influence of the driving factors on the development of CO_2eq-emissions, e.g. economic growth, is not taken into account. Developing climate protection measures for a city based on the forecasting results allows those influences to be taken into account. If a forecasting scenario is developed and the driving factors are determined the chances of over- or underestimating the necessary efforts will be kept to a minimum.

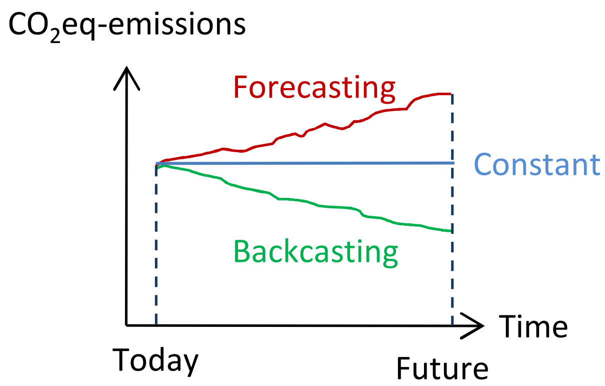


Figure 4.5: *Comparing exemplary CO_2-emission developments of backcasting and forecasting scenarios*

To summarise, a forecasting step is included into the methodology because it (1) shows whether backcasting is needed or if the goals will be fulfilled by a continuation of given trends; (2) identifies the main drivers for energy demand and CO_2eq-emissions in the future; (3) prevents over or underestimating the amount of climate protection measures to take and (4) provides motivation by showing what the future would be like without additional climate protection measures. The methodology for a forecasting analysis is shown in Figure 4.6. The methodology is further explained in the following paragraphs.

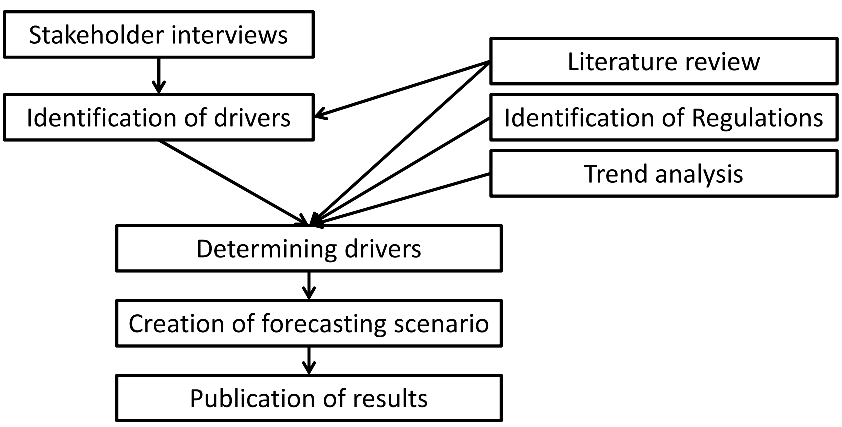


Figure 4.6: *Methodology for the forecasting analysis*

For the development of a forecast scenario first of all the driving factors are determined. As a starting point for identifying the main drivers, stakeholder interviews are performed and a literature review about driving factors for energy demand and CO_2eq-emissions is carried out. Once the main driving factors are identified, their future development over time is determined. For the analysis of the development of the drivers a literature review including other studies with mid- and long-term forecasts is performed. Additionally, regulations that have an influence on energy demand or CO_2eq-emissions are quantified and included. Forecasts are otherwise mainly based on the extrapolation of past and current trends.

Following the methodology allows for an effective development of a forecast scenario. The results of the forecast scenario show whether the emission reduction target is reached with a continuation of given trends. As a part of the methodology, the results of the forecast are widely published as a mode of motivation to change the forecasted development if emission reduction targets are not achieved with a continuation of given trends. Therefore the stakeholder involvement during the forecast analysis, other than the expert interviews, is characterised by informing rather than actively contributing to the development of the forecast.

4.5 Step 5: Backcasting analysis

In the case that a forecast analysis shows that with a continuation of given trends the emission reduction targets cannot be achieved, the next step in the novel methodology is to conduct a backcasting analysis. Backcasting starts with the definition of a desired future. In this case, the desired future is to achieve a CO_2eq-neutral city. The backcasting analysis is the first step where climate protection measures are developed. The methodology for the backcasting analysis is depicted in Figure 4.7 on page 126. The methodology is further explained in the following paragraphs.

It is recommended that the coordination and moderation of the process of the backcasting analysis is carried out by one or more moderators depending on the size of the project. It must, however, be ensured that the moderator(s) has/have no self-interest to steer the result of the backcasting analysis in a particular direction. The moderator plays an important role in concept development. One of the first steps of the backcasting analysis is for the moderator to gain a broader understanding of the special issues and possibilities for climate protection in cities. Climate protection concepts of other municipalities are analysed and a list of measures that can be adapted to the situation of the city under research are created. The advantage of creating a

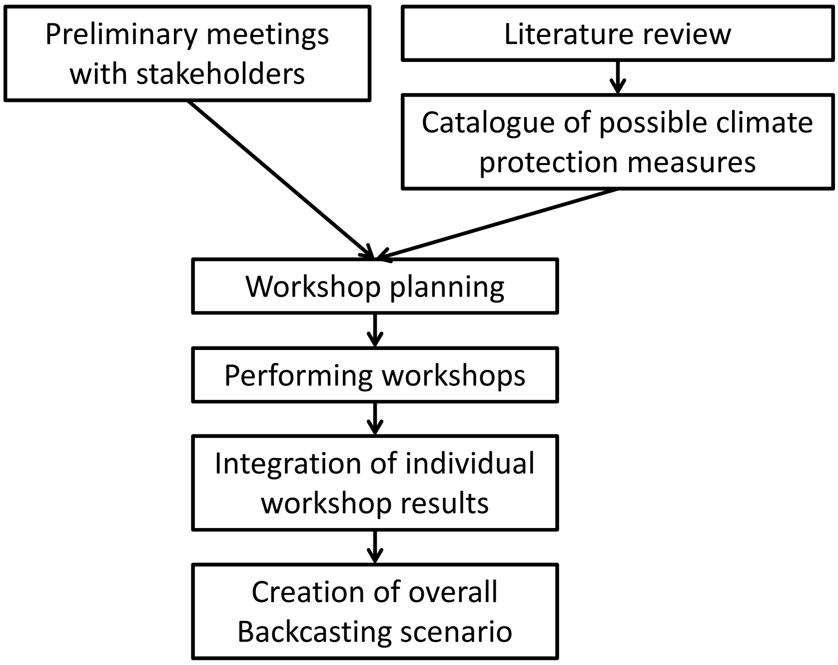


Figure 4.7: *Backcasting methodology*

list of measures before the actual workshops begin is that the process does not start at zero, but rather concrete measures are discussed right from the beginning. From a psychological aspect it is also better if the moderator can provide good knowledge himself/herself instead of only receiving information from the stakeholders. If both sides benefit from working together, a more trustworthy relationship will be formed.

Stakeholders are involved in the backcasting analysis as soon as possible. This is accomplished by holding meetings preliminary to the workshops during which individual stakeholders and the moderator(s) are present to introduce and discuss the concept development. During the meetings, the general process is explained, questions regarding the importance of climate protection addressed and possible measures discussed at the preliminary level. The meetings also serve the purpose of gaining useful information about existing city networks, e.g. those between stakeholders or stakeholder groups. In the beginning of the backcasting analysis, the meetings help to establish personal contact and trust between the moderator(s) of the process and the stakeholders. Meetings early in the process allow stakeholders to express their views and expectations from the beginning and to play a role in setting up the backcasting workshops later in the process in a way that is most beneficial for them. Together with the stakeholders the agenda for the individual workshops is set. This procedure allows for the highest level of participation right from the beginning.

After the preliminary meetings are held and the creation of a catalogue of possible measures is completed, the workshops are planned in detail by the moderator(s). There are in general three main steps involved with planning workshops and they include: (1) determining the number of workshops and their topics; (2) determining the target group for each workshop and (3) developing the agenda and time schedule for the workshops.

Planning individual workshops is time consuming and therefore a good time-management strategy is key. In the beginning of the process, the number of workshops to be performed, the number of participants of each workshop and the specific topic discussed in the workshops need to be determined. As many stakeholders as possible with the given resources should be involved into the development of climate protection measures. Following the principles of the transition management approach, stakeholders with different backgrounds are participating to ensure that not specific interest from certain individuals are dominating the concept development.

In contrast to enforceable laws, local climate protection is voluntary. In particular, planning public workshops presents difficult challenges, such as identifying and motivating the right people. Therefore the identification of stakeholders is done early in the process during the status quo analysis. Using information gained from the literature review and the preliminary meetings with stakeholders, the agenda and time schedule of each workshop is developed. Once the agenda and time schedule is set up the workshop is planned in detail. This includes choosing the best workshop methodologies for each individual part of a workshop, such as open discussions, group work, individual brain storming or presentations. Once the workshop is planned in detail, possible workshop participants are determined and invitations are send out. One of the last steps before performing a workshop is choosing the locations used for the workshops and setting up of the rooms.

During a workshop, the measures that are applicable to the city under research and the share of CO_2eq-emissions that they are able to reduce is discussed with the workshop attendees (local stakeholders and/or the public). The knowledge and the experience of the stakeholders is used to develop a climate protection concept with the best possible specific solutions for the city in question. To structure the determination of climate protection measures, they are classified into three steps in this methodology. These include (1) a reduction in demand; (2) an increase in energy efficiency and (3) a substitution of fossil fuels. First, climate protection measures are identified that reduce the energy demand. This could be for example lowering the heating or turning off the lights when leaving a room. Second the energy efficiency of the residual energy being used is increased where possible. This could be, for example, the insulation of a building or the use of energy saving light bulbs. Once the first two steps have been carried out, the remaining energy being used is supplied with renewable energy sources to achieve CO_2eq-neutrality. The reduction of CO_2eq-emissions in three steps is depicted in Figure 4.8.

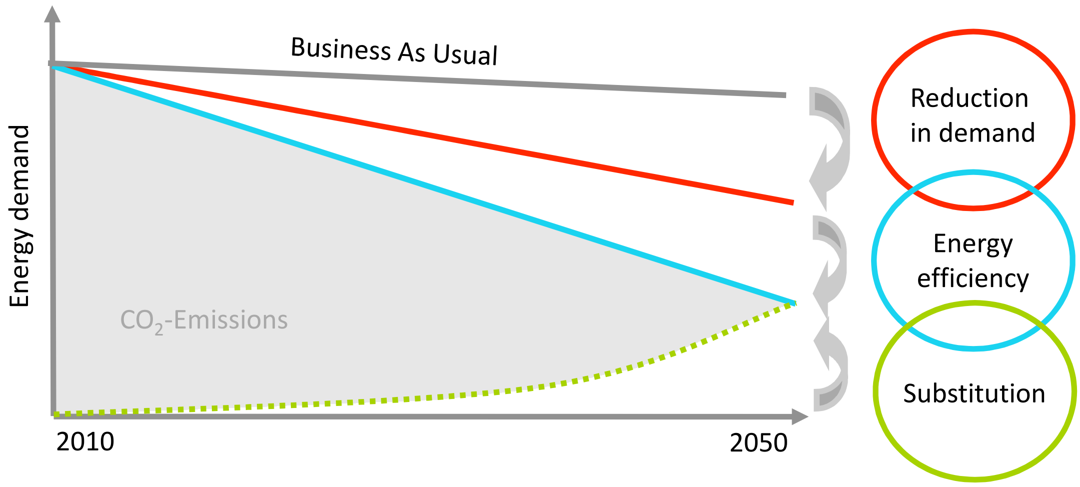


Figure 4.8: *Classification of climate protection measures*

During the workshop, the general methodology of the backcasting approach is explained and specific climate protection measures are developed using this approach. The participatory backcasting analysis is performed to show how the emission reduction targets can be achieved. A scenario is constructed in the backcasting analysis that shows a defined pathway throughout time with intermediate objectives. For each intermediate year, climate protection measures are identified, discussed and quantified with the defined CO_2eq-emission reduction target in mind. The identified climate protection measures are then quantified and included in the scenario.

The construction of a scenario using backcasting in a workshop is depicted in Figure 4.9. Beginning with the years that are the closest to the present date, climate protection measures are determined to develop a first pathway for emission reduction. Defining climate protection measures beginning with the years that are the closest to the present date has the disadvantage that the necessary effort to achieve the final emission reduction target might be underestimated on first try. Therefore additional climate protection measures might be necessary to develop a pathway throughout time where the achievement of the final CO_2eq-emission reduction target is possible. In the example in Figure 4.9 a pathway for CO_2eq-emission reduction is determined using development rounds. Developmental rounds help to find the optimal pathway to achieve the long-term objectives. In “first round a)” intermediate goals are set but they are not enough to finally reach the target. Slightly different is “first round b)” in Figure 4.9. It follows the same pathway except the final stage where major effort is needed to fulfil the target. In some areas for emission reduction this might be possible. Other areas cannot change that rapidly in small timeframes. If the first backcasting round does not lead to achieving the target, the backcasting analysis should be performed a second time with more or alternative climate protection measures applied right from the beginning. Using this approach, the backcasting analysis helps to understand the magnitude of measures that are necessary already in an early stage of a climate protection process to achieve the target. Possible bottlenecks as shown in “first round a)” are identified that must be addressed in the early stages of the process. At the end of the participatory backcasting analysis, a scenario has been developed that shows when and to what extent climate protection measure have to be applied.

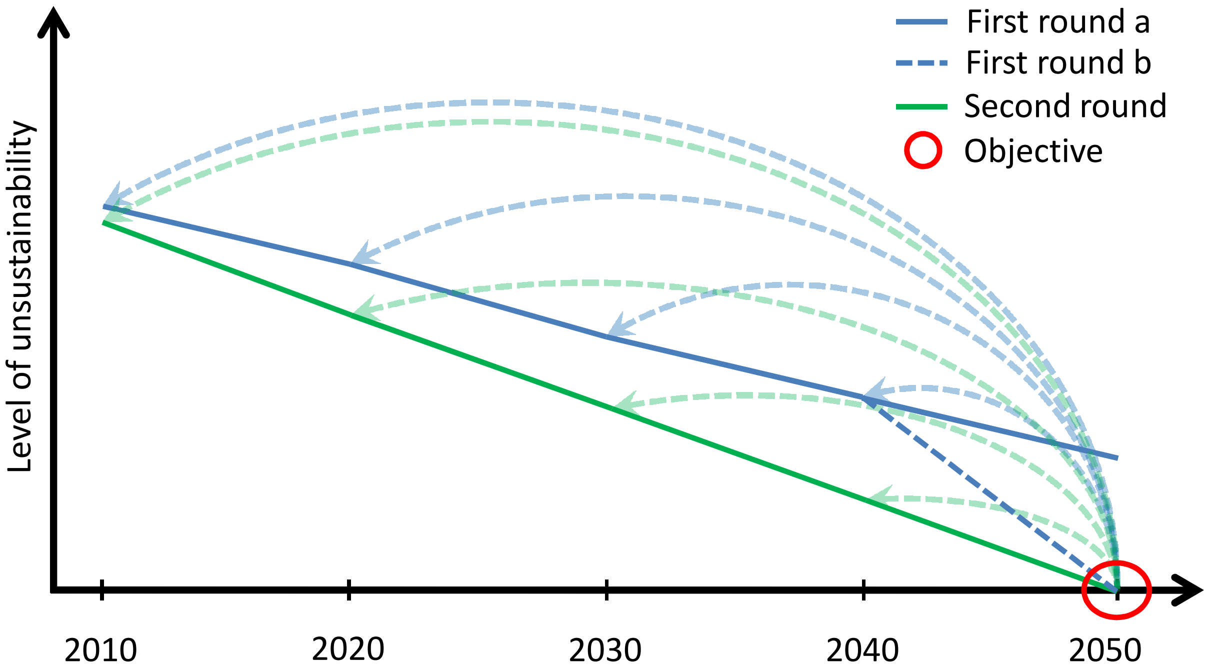
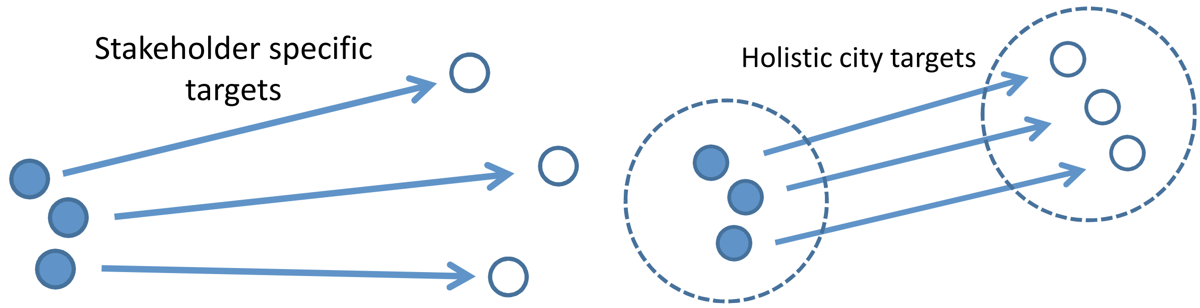


Figure 4.9: *Construction of a scenario with its pathway in a sequence of development rounds*

Measures from different sectors developed in the individual topic-specific workshops may mutually reinforce, weaken, or even exclude each other. To develop an effective and comprehensive climate protection concept on the city-scale, climate protection measures are considered in a sectoral and inter-sectoral context to achieve an integrated point of view. After performing sector-specific workshops and developing sector-specific climate protection measures, an integration of the individual results is done. As an additional benefit of using synergies, emission reductions might be less cost-intensive. Nine out of the 16 analysed northern German climate protection concepts included all sectors in the development of climate protection measures. Using an integrated approach therefore seems common but is not always applied. In Figure 4.10 on page 130 a systematic depiction of the differences between a disintegrated and an integrated approach are shown.

After performing the individual workshops and the integration of the overall workshop results, the overall backcasting scenario for the city is created. The backcasting scenario contains the



(a) Disaggregated approach (b) Integrated approach

Figure 4.10: *Comparison of a disintegrated with an integrated approach (adapted from Ravetz (2000, p. 57))*

information when, what and to which extent climate protection measures are applied to achieve the set target. Developed together with the stakeholders and the public, the backcasting analysis shows how the energy demand and CO_2eq-emissions can be decreased.

4.6 Step 6: Follow-up agenda

After the development of a climate protection scenario during the backcasting analysis, the associated climate protection measures have to be implemented. To increase the chance of implementation, the steps "Elaborate future alternative and define follow-up agenda" as well as "Embed results and agenda and stimulate follow-up" were included into the generalised backcasting approach. Quist (2007a, p. 29) points out that the two steps are occasionally seen as one step. Due to the close inter-linkage this is also done in this methodology. In transition management this step is called the transition agenda. In the novel methodology, the step is simply called "follow-up agenda". As depicted in Figure 4.11 the follow-up agenda contains the following aspects: (1) determination of objectives, projects and responsibilities for planned activities; (2) identification of barriers; (3) implementation strategy and (4) a written and published report.

Some of the aspects of the follow-up agenda are already being addressed during the backcasting analysis. Synergies are utilised when the workshops during the backcasting analysis are also used to develop the follow-up agenda. A direct link exists between the development of climate protection measures and the first aspect of the follow-up agenda. The follow-up agenda contains objectives, projects, instruments and responsibilities for planned activities to achieve the CO_2eq-emission reduction target. These are the climate protection measures that have been discussed and agreed upon during the backcasting analysis.

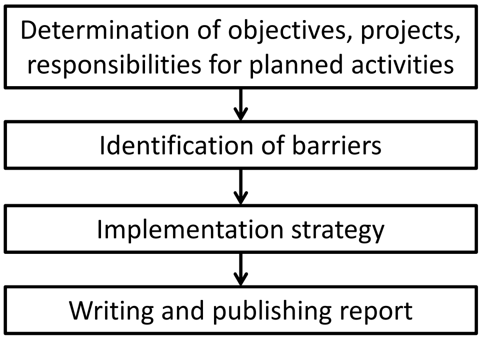


Figure 4.11: *Methodology for the follow-up agenda*

Including ideas from transition management, the agenda is also used to identify barriers for the transition to CO_2eq-neutrality (Loorbach 2010, p. 175). Barriers in the context of a participatory process are those that hinder the stakeholders and the public to gain and maintain the acceptance of climate protection measures on the city-scale and its implementation. Identifying and addressing barriers is important to reflect on the developed climate protection measures and to evaluate the likely success of applying certain measures. Additionally, when barriers are identified in advance, suitable strategies to reduce barriers can be developed. Proactive thinking is critical for achieving a transition. In the last step of the novel methodology, the gained knowledge is applied to social marketing and community based social marketing to obtain and maintain further public support for local climate protection (Section 4.10 on page 136).

The follow-up is actively stimulated by further embedding the agenda to further increase the chance of implementation of climate protection measures. Therefore the follow-up agenda also includes an implementation strategy, which is based on developed climate protection measures, the identified structural barriers and the possibilities for the extension of the transition network. In the researched northern German cities with climate protection concepts, half of the cities had an implementation strategy included into their climate protection concept. The main goal is to gain and to maintain the acceptance of climate protection measures among the target groups. The acceptance is positively influenced by the participatory approach which is applied. Achieving acceptance will lead to a high level of participation and successful implementation of climate protection measures. An implementation strategy increases the chance of the achievement of the short-, mid- and long-term goals.

The last aspect of the follow-up agenda is to transfer the developed climate protection concept on paper. The report serves as an orientation for the climate protection process for the city and should be widely published.

4.7 Step 7: Upscaling of the transition arena to a transition network

Climate protection cannot only be achieved by a small number of people. At the end every stakeholder and the public have to contribute to achieve a CO_2eq-neutral city. Therefore the transition arena is upscaled to a transition network. A detailed description of the process from the foundation of a transition arena to a transition network is shown in Figure 4.12 on page 133.

Five phases can be distinguished for upscaling the transition arena to a transition network. By following the steps of the novel methodology, the process of upscaling the transition arena to a transition network is already partly achieved. The first phase is the foundation of a transition arena (cp. Section 4.1 on page 115). The members of the transition arena are highly committed to the climate protection on the city-scale. The transition arena serves as the basis for the further development of the climate protection process and the engagement and involvement of more stakeholders and the public over time. The second phase is the status quo analysis. The status quo analysis is performed together with different stakeholders. Interviews are done and data gathered from a variety of stakeholders for setting up the status quo analysis. The interactions between the transition arena and the stakeholders are based on information and data exchange. There is not necessarily a commitment of the stakeholders to the ambitious emission reduction goals of the transition arena. These first interactions during the status quo analysis are crucial for the later process. This relates back to the foot-in-door effect (Section 3.2.5 on page 92). The third phase is the performance of the forecasting analysis. The forecasting analysis focuses less on data exchange but rather on informing stakeholders and the public about the future development if ongoing trends were continued. A commitment to the climate protection process is not directly achieved. The forecasting analysis fulfils a motivational purpose and therefore increases the chance of future involvement of the stakeholders and the public. The fourth phase is the backcasting analysis. By performing a status quo and forecasting analysis, first contacts and small networks have been established. These contacts are then used to engage stakeholders and the public to participate in the backcasting analysis and to commit them to the process. During the backcasting analysis climate protection measures are developed and discussed together with the stakeholder and the public. Performing workshops for the backcasting analysis has the advantage that the different stakeholders and the public are already becoming acquainted. This established connection is helpful to finally upscale the transition arena to a transition network in the fifth phase. The transition network than is a network of committed stakeholders and the public participating in the climate protection process. This step is crucial to increase the commitment of the participants not only during the development of a climate protection concept but also for the implementation of climate protection measures.

As described in the Chapter 3, the social norm, influenced by the social environment, is a strong influencing factor on human actions. By following the presented phases the internal personal norm is addressed stepwise (c.p. figure 3.1 on page 87). During the status quo and forecasting analyses, the awareness for climate change mitigation is raised. During the backcasting analysis and the follow-up agenda, solutions for climate protection are developed and the consequences discussed with the stakeholders. Therefore, following the presented phases, both the social norm and the internal personal norm are addressed (c.p. norm activation theory Section 3.2.1 on page 86).

Overall the upscaling of the transition arena to a transition network is a continuous process from the beginning of the climate protection process. The insights from psychology help to facilitate the process of involving stakeholders and the public in the development of climate protection measures and achieve a commitment to the climate protection process on the city-scale.

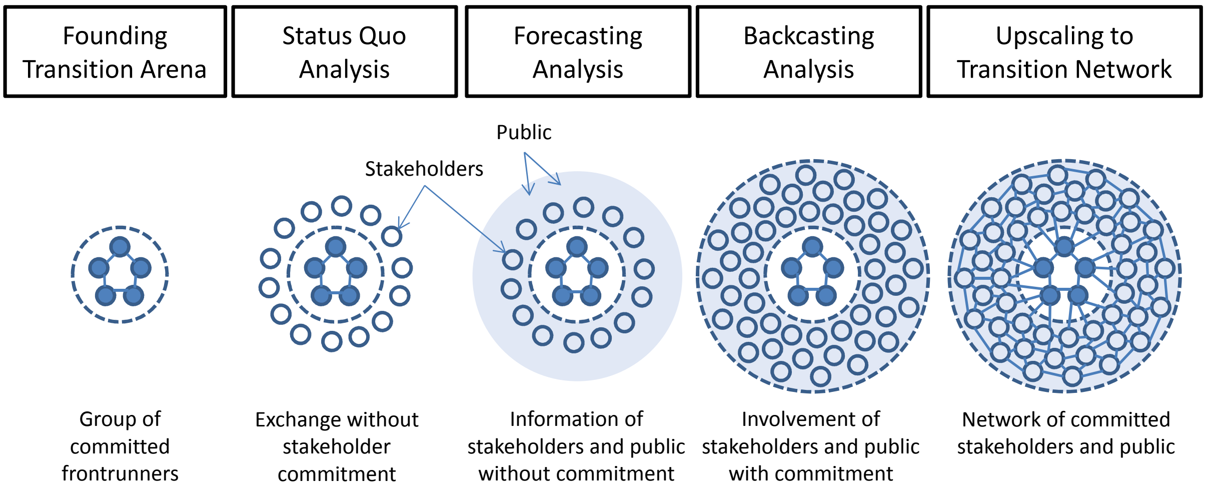


Figure 4.12: *The development process from the foundation of a transition arena to the transition network*

4.8 Step 8: Transition experiments

Transition management, in particular, focuses on creating concepts that are flexible to new developments. This is additionally expressed by including the step "Transition Experiments" into the novel methodology. Transition experiments are normally high risk projects, expensive and time consuming, but when successful, largely contribute to reducing CO_2eq-emissions. Figure 4.13 shows the process of applying transition experiments for climate protection on a city-scale. First, possible transition experiments are identified. Developing a portfolio of transition experiments helps to constantly develop and test ways to achieve the goal of obtaining CO_2eq-neutrality in a more efficient way. Continuously, transition experiments are developed and carried out as new technological developments are identified. Due to the circumstance that transition experiments are normally expensive and time consuming, a prioritisation of the transition experiments that should be tested is done. This is especially important on the city-scale where there is a small number of stakeholders and therefore small number of companies and organisations that can perform transition experiments. The transition experiments are evaluated after testing and decided whether or not the transition experiments are upscaled to a widely applied technology to reduce CO_2eq-emissions. As shown in Figure 4.13, the applied transition experiments help to facilitate the process of emission reductions or will allow a faster achievement of the reduction target time-wise in comparison to the CO_2eq-emission reductions according to the climate protection concept.

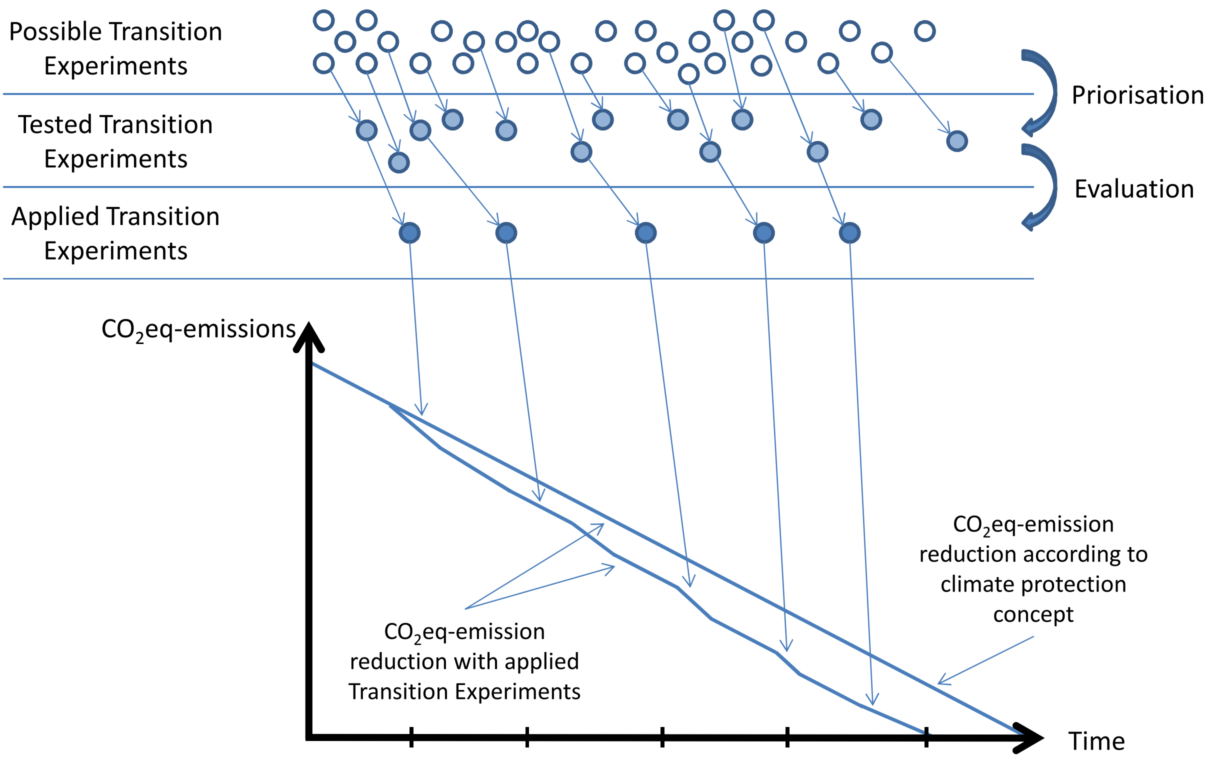


Figure 4.13: *Process of transition experiments*

4.9 Step 9: Management cycle

Continuous control is an essential part of the evaluation and learning process of a transition (Loorbach 2010, S. 177) (Taanman 2008). The creation of a climate protection concept is the start of a long-term process, which needs to be monitored and controlled on a regular basis. A management cycle for the achievement of CO_2eq-neutrality on a city-scale is depicted in Figure 4.14 on page 136. The achievement of intermediate goals is evaluated applying the management cycle in the implementation phase of climate protection measures. If an intermediate goal is not achieved, adjustments need to be discussed and in some cases additional measures taken to further reduce the emissions. The management cycle includes the following phases: planning, implementing, monitoring, evaluating and adjusting (Wiek et al. 2006, p. 742). In the case of cities, the planning phase includes the status quo, the forecasting and backcasting analyses with the development of climate protection measures. After the initial planning phase, the implementation of measures is carried out. The resulting decrease of CO_2eq-emissions is monitored and evaluated. Every year of the implementation phase, the question is raised whether the intermediate goals have been fulfilled. If this is the case, the process continues as planned and the city is on the right path to achieve the goal of CO_2eq-neutrality. If the intermediate goals were not fulfilled, adjustments to the climate protection process and the defined climate protection measures are necessary. At this point the management cycle is closed and starts again.

During the participatory development of the climate protection concept, the monitoring and controlling options for the implementation process are discussed. The stakeholders must agree on general conditions for the monitoring and controlling during the implementation phase. The main aspects for monitoring and controlling are the frequency and type of information or data delivered and the fixation of a responsible contact person at the local institution, company or organisation. Discussion of the monitoring and controlling process in detail before the first update round helps to determine the necessary stakeholder workload.

Setting up a well-working management cycle is also important from a psychological point of view. As described in Section 3.2.5 on page 92 (goal setting theory), setting specific difficult goals increases the motivation of the participants. To keep the motivation up the progress needs to be measured. Only if progress can be measured, the stakeholders will be able to adjust their behaviour for the achievement of the set goal. Therefore, the management cycle is not only an instrument for evaluating the development of CO_2eq-emissions but also a tool that can be used for motivational purposes.

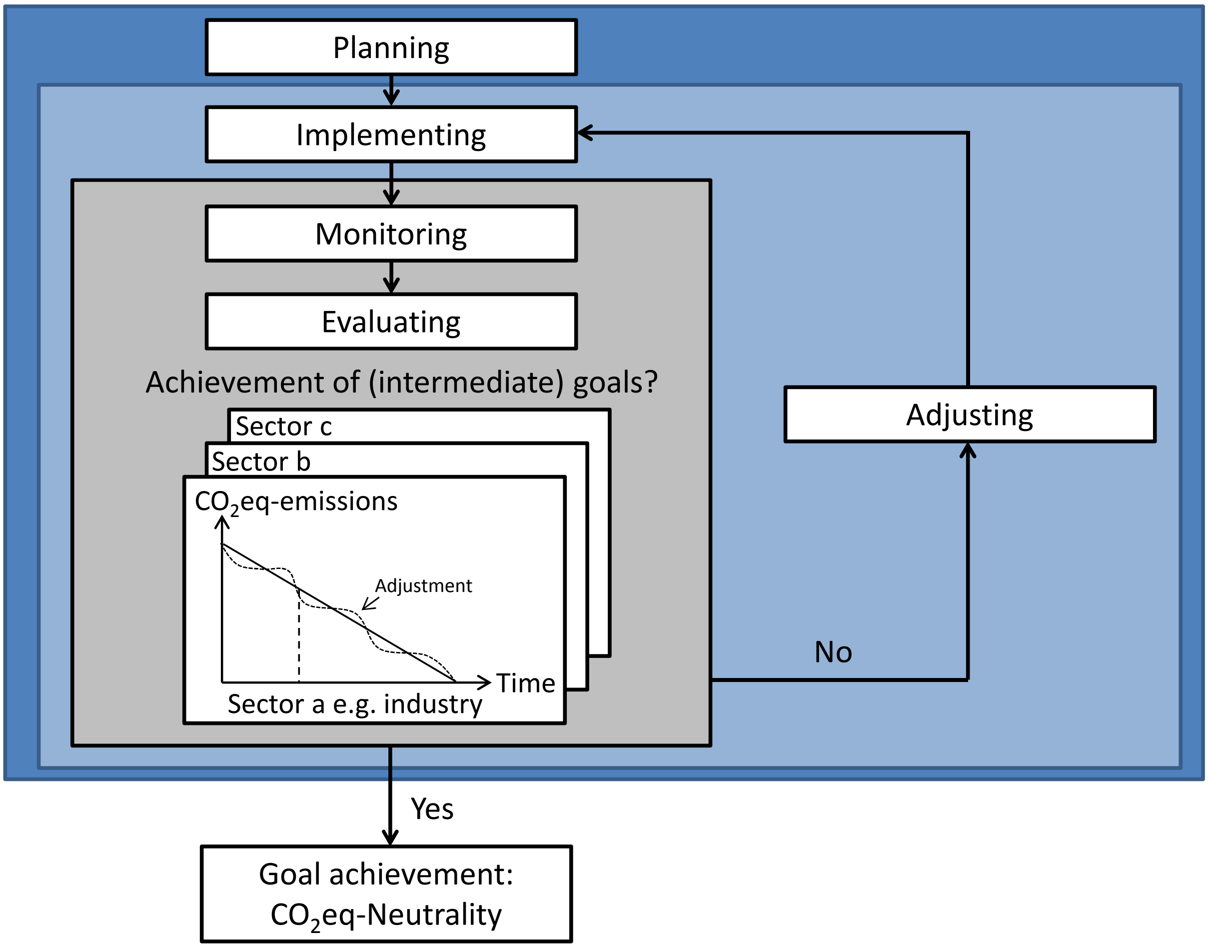


Figure 4.14: *Management cycle for a city*

4.10 Step 10: Creating public support

The focus of the participatory approach is on motivating local stakeholders and raising awareness of the general public. Successful stakeholder involvement is dependent on strong public support. Involved stakeholders may be required to take business risks, such as increasing prices for their goods (e.g. due to the use of sustainable materials), and thus public support and awareness of these changes will help to safeguard the stakeholders' businesses and their long-term involvement in the climate protection concept. Additionally, the pubic should be actively involved in the process of reducing their energy demand and CO_2eq-emissions. Thanks to the participatory concept development, the support of a certain percentage of the public will already be achieved.

Creating public support is achieved applying two separate approaches. The first approach utilises the theory of diffusion of innovations described in Section 3.3 on page 96. It delivers useful information on how to engage more people in the process in a structured way over time, including multiplier effects. The second approach utilises social marketing and community based social marketing. Using social marketing knowledge for climate protection purposes allows the designing of an effective process of addressing social issues from a marketing perspective. Community based social marketing offers an alternative to information campaigns by using the insight of psychology to create effective tools for the communication and distribution of behavioural changes. Social marketing was described in detail in Section 3.3.2 on page 101 and community based social marketing in Section 3.3.3 on page 104. Also a comparison of the social marketing to community based social marketing was made. As a result of the comparison a marketing approach for climate protection on a city-scale to gain and maintain public support was developed. It is presented in Figure 4.15.

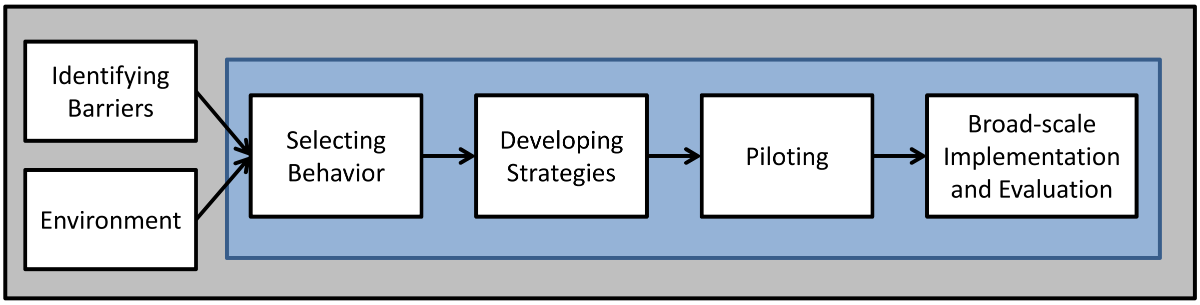


Figure 4.15: *Marketing approach for climate protection on a city-scale*

The two boxes with a grey background (Identifying Barriers and Environment) are aspects that have already been performed in the novel methodology for cities. Identifying barriers is part of the follow-up agenda described in Section 4.6 on page 130. As a part of the social marketing theory, the surrounding environment with its economic, political, technological, cultural and competitive developments is analysed. This is to a large extent part of the status quo analysis performed for the city. The boxes with the blue background are the basics of the marketing approach. These are the selection of behaviour to be targeted by the developed marketing strategy, the development of a suitable strategy to address and change that behaviour, the piloting and finally the broad-scale implementation and evaluation.

4.11 Conclusion

Incorporating transition management, backcasting and insights from psychology, a novel methodology for cities was developed and introduced in this chapter. The overview of the main steps of the newly developed methodology for cities which aim to obtain CO_2eq-neutrality is presented again in Figure 4.16. Detailed information was provided in this chapter on how to apply each individual step on a city-scale.

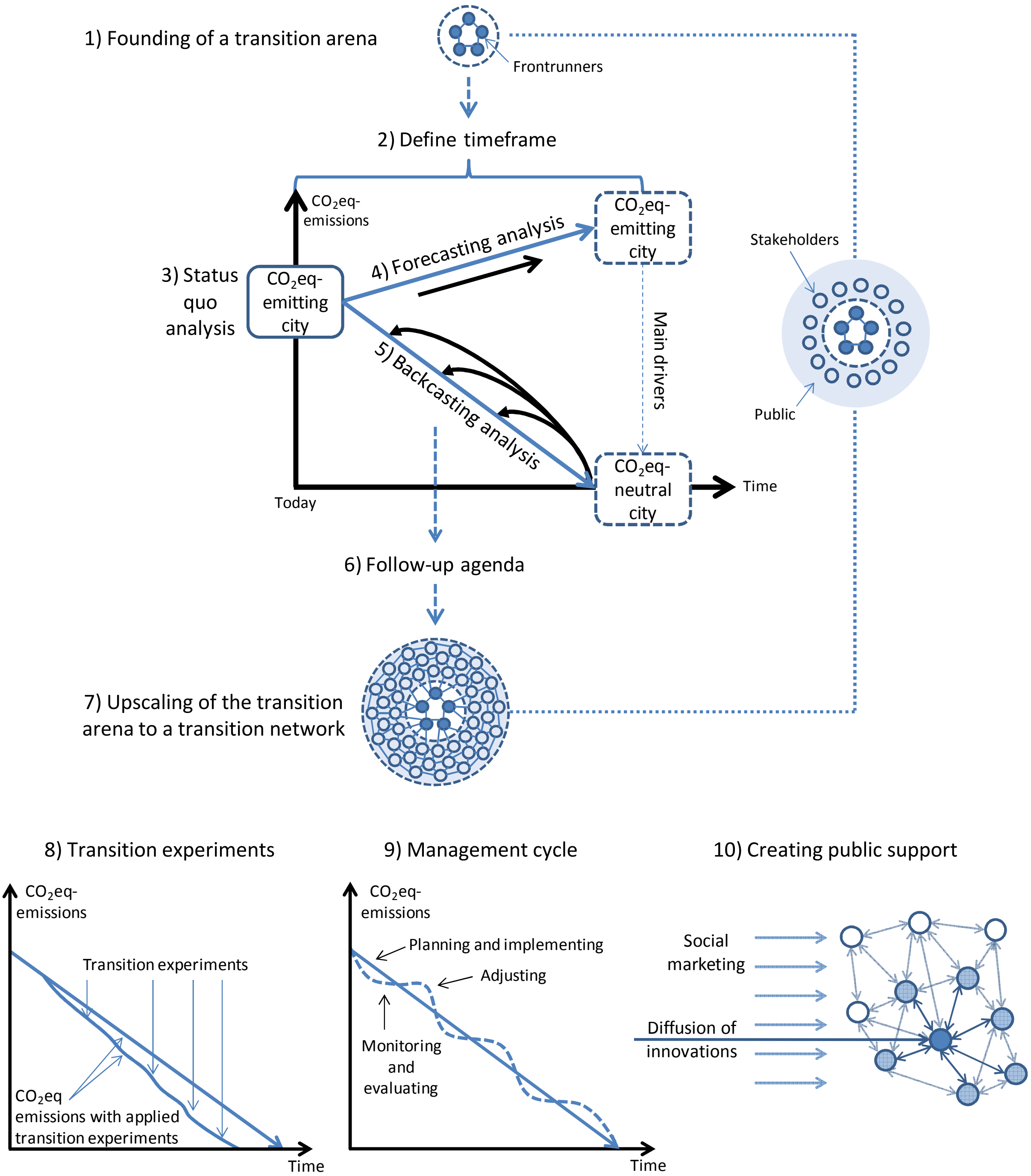


Figure 4.16: *New methodology for cities which aim to obtain CO_2eq-neutrality*

The developed methodology shows how the two approaches of backcasting and transition management can be used together in a holistic way. Both approaches were further developed and used in tandem to achieve a long-lasting participatory climate protection process on a city-scale. The short-coming of backcasting that it lacks a management strategy was revoked. By incorporating backcasting into the transition management process, relevant management and implementation strategies were adapted. The transition management process was improved by the use of backcasting for the development of climate protection scenarios due to the goal-orientated approach for scenario development respectively climate protection measures.

The development of a novel methodology for cities with the aim of achieving CO_2eq-neutrality incorporating backcasting and transition management provides the necessary knowledge and in-depth insights to answer some of the defined research questions of this thesis.

The first research question was the following: “Can the two approaches of backcasting and transition management be used together in a holistic way for climate protection on a city-scale, and do they complement each other?” This research question was partly already addressed in Chapter 2 with the conclusion that the two approaches of backcasting and transition management complement each other and can be used in tandem. Based on this finding, a novel methodology for cities was developed in this chapter. The novel methodology shows that backcasting and transition management can be used together in a holistic way for climate protection on a city-scale. Using the core aspects of backcasting and transition management, the approaches were slightly modified to be applicable on the city-scale. In conclusion the first research question can be answered with “Yes”.

The second research question was: “How can backcasting and transition management be used to set up a highly ambitious participatory climate protection process on a city-scale?” This research question was also partly addressed in Chapter 2 and finally answered in this chapter. Backcasting, in particular participatory backcasting, as well as transition management are both approaches that are either already based on participation or have included a network strategy for participation. Furthermore both approaches are applicable to cases where a transition to sustainability is the target goal, and thus similar to the achievement of a CO_2eq-neutral city. The specific characteristics of backcasting and transition management allow an application of the approaches also for highly ambitious participatory climate protection processes on a city-scale. In addition to backcasting and transition management, incorporating psychological aspects further advanced the two approaches and the applicability to the specific case of highly ambitious climate protection on a city-scale.

The third research question is as follows: “How can insights from psychology be used to facilitate the process of climate protection on a city-scale and to establish and maintain a long-lasting process?” This research question was addressed in Chapter 3 as well as in this chapter. Theories and ideas from the field of psychology can be used to increase the effectiveness of changing people's behaviour, increasing the willingness of people to act and to remain motivated when confronted with choices and challenges pertaining to climate change. Additionally, psychology may be used to increase the effectiveness of spreading information through communication and diffusion methods, and may also be applied to social marketing strategies, including those on the community, or city-scale. The psychological theories and approaches incorporated further advanced and specified the novel methodology.

The fifth research question was: "Is it possible with the use of the developed methodology to establish structures in the city that will carry on the climate protection process and can the establishment of structures be accomplished in a short period of time?" This research question was addressed in this chapter and will be further addressed in Chapter 5. In particular the network strategy included in transition management helped to develop a methodology that establishes structures in the city that will help to carry on the climate protection process. Furthermore, utilising the theory of diffusion of innovations and social marketing, the establishment of structures can be accomplished in a short amount of time. The timeframe needed to set up those structures was researched in the case study and therefore a final answer will be provided in Chapter 5.

The developed methodology was applied to the city of Flensburg and the results of the application are presented in Chapter 5. At the end of Chapter 5 the fourth research question is answered and Chapter 6 will answer research question no. 6.

5 Application in practice

Case studies are a research strategy (Yin 1981, S. 58) that can provide fertile soil for the process of theory development (Flyvbjerg 2001; Flyvbjerg 2006). In the social sciences, a single case study can deliver valuable in-depth knowledge and help with the advancement of a methodology (Flyvbjerg 2006). When the methodology includes a participatory approach, testing the theory in “real-life” has the advantage of gaining direct feedback as the process actually unfolds. As Flyvbjerg (2006) argues, one detailed case study can help the advancement of a theory and be more valuable than several, less comprehensive, examples. Due to the involvement of human beings, every case study will have a different outcome, depending on the general circumstances.

The city of Flensburg, Germany was chosen for testing and advancing the newly developed methodology that was introduced in Chapter 4, for achieving CO_2eq-neutrality on the city-scale. The application is presented in this chapter as a case study. The main objective of this case study is to test this particular methodology and to gain in-depth insights into the participatory concept development for cities. Furthermore the fourth research question “how can the developed methodology be applied in practice?” will be answered by the application of the novel methodology to the city of Flensburg.

The novel methodology was applied to the city of Flensburg over a time period of three years (December 2008 to October 2011). An overview of the process timeline is depicted in Figure 5.1. Most of these steps were organised and performed by a team of scientific researchers at the University of Flensburg, including the author of this dissertation. The results of the status quo analysis, the forecasting analysis, the backcasting analysis and the follow-up agenda were published in the following German reports: Hohmeyer et al. (2010a), Hohmeyer et al. (2010b) and Hohmeyer et al. (2011). The aforementioned German reports have been made accessible to the public and the stakeholders online (www.klimapakt-flensburg.de). The application of the individual steps of the newly developed methodology will be described in detail in the following sections.

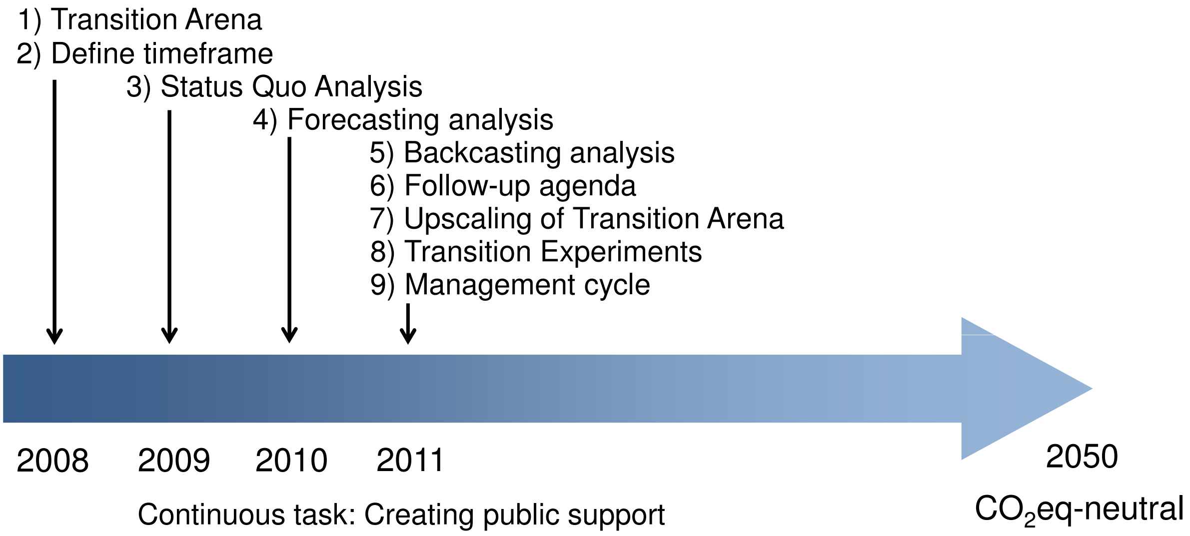


Figure 5.1: *Timeline of application of the novel methodology to the city of Flensburg*

5.1 Step 1: Founding of a transition arena

In December of 2008, nine local institutions, companies, and organisations founded the transition arena, titled Klimapakt Flensburg. The first members were the city of Flensburg, the local energy utility (Stadtwerke Flensburg), two housing associations (Flensburger Arbeiter Bauverein and Selbsthilfe Bauverein Flensburg), the University of Flensburg, the Flensburg University of Applied Science, the Chamber of Trade and Industry (Industrie- und Handelskammer) and a local bus company (Aktiv-Bus Flensburg). Klimapakt Flensburg is a small network of frontrunners with different backgrounds, which are all deeply rooted in the community. To be independent from traditional political networks, in order to avoid a domination of established interests, Klimapakt Flensburg excluded the participation of politicians and political parties. In addition to implementing climate protection measures, every member pays a membership fee of 5,000 € per year, which is used towards climate protection projects and the marketing of climate protection on the city scale.

The housing associations were key advocates for the foundation of Klimapakt Flensburg. They understood that to achieve the ambitious CO_2eq-emission reduction targets, a holistic approach was needed, as well as the cooperation between local companies and energy utilities. A cooperation allows utilising of synergies to achieve the CO_2eq-emission reduction targets. Klimapakt Flensburg was founded on intrinsic motivations.

5.2 Step 2: Define timeframe

The timeframe for achieving CO_2eq-neutrality was determined by Klimapakt Flensburg. An emission reduction target for achieving CO_2eq-neutrality for the whole city of Flensburg by the year 2050 was set. Additionally an intermediate reduction goal of 30 %, to be achieved by the year 2020, was set by Klimapakt Flensburg. The set timeframe of a CO_2eq-neutral city is supported by IWU & ZIV (2002, p. 14), which argue that a 40 year time-span (in this case, the year 2050) is an ambitious but still realistic target year for cities to achieve CO_2eq-neutrality.

5.3 Step 3: Status quo analysis

After founding Klimapakt Flensburg and deciding on the target year, a status quo analysis was performed. Following the methodology described in Section 4.3 on page 117, the four following steps for the status quo analysis were carried out:

- Specification of the research area
- Determination of the form of energy and assignment principles of emissions to be used
- Identification and involvement of stakeholders
- Data collection and creation of an energy and CO_2eq-balance

Carrying out the status quo analysis for the city of Flensburg was a ten month long process. In the following sections, the Flensburg specific methodology applied and the results are described. Detailed results of the status quo analysis are available in a 70 page report published for Flensburg (Hohmeyer et al. 2010a).

5.3.1 Specification of the research area

In Germany, the term “ city ” is not clearly defined; there are several different sets of guidelines (e.g. Bundesinstitut für Bau-, Stadt- und Raumforschung (2011), European Commision (Eurostat) (2011), EUR-Lex (2007), European Commision (Eurostat) (2008), DG AGRI and DG REGIO (2010), DG AGRI and DG REGIO (2010, p. 2,3)). Therefore, instead of trying to work with a unified definition for a city in Germany to determine the research area, the city administration of Flensburg was contacted and provided the necessary information on the city borders.

Flensburg is the most northern city and urban district in Germany, directly located on the German-Danish border. The city is characterised by a historic harbour and the Flensburg Fjord. The geographical system boundary of Flensburg is defined by the area located within the city borders. The city of Flensburg contains 13 districts with a population of 86,630 people (2006; Flensburg in Zahlen). The location of Flensburg and the system boundary (green line) is depicted in Figure 5.2. The residential areas are marked in red. With an area of 56 km^2, the population density of the city area is 1,600 citizens per square km.

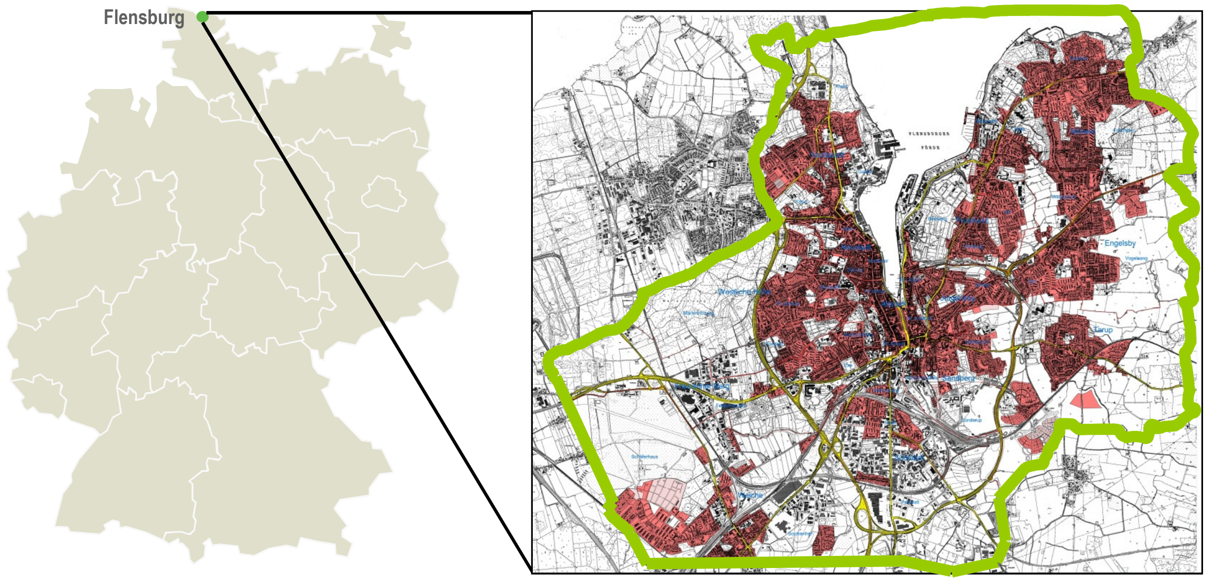


Figure 5.2: *Location and geographical system boundary for Flensburg (city map provided by the Flensburg City Administration, 2006)*

For the division of the city sectors, the definitions presented in Section 4.3.1 on page 118 were used, with one exception. In Germany, the industrial sector covers all economic activities of companies in the field of mining, quarrying, and manufacturing, that have 20 employees or more (Wirtschaftszweigsystematik 2008 of the federal statistical office Germany). In the federal state of Schleswig-Holstein, where Flensburg is located, the staffing limit was reduced to ten employees in certain fields (information provided from the statistical office Statistikamt Nord). Throughout this thesis the definition for Schleswig-Holstein from the Statistikamt Nord was applied.

5.3.2 Determination of the form of energy and assignment principles of emissions to be used

In Section 4.3.2 on page 119, the four forms of energy (primary, secondary, final, and useful energy), and the three assignment principles for CO_2eq-emissions (territorial, residents, and inland principle) were introduced. Depending on the circumstances, energy demand as well as CO_2eq-emissions can be calculated and assigned using different approaches.

As a part of a status quo analysis, the form of energy used has to be determined. Using primary energy represents the most holistic approach. Not only is the local energy demand taken into account, but also the conversion and transmission losses in the up-and-downstream process, which are caused by the local energy demand. Renewable energies, with the exception of biomass, do not have a calorific value to determine the primary energy and where no up-and-downstream process exists, are calculated with a primary energy factor of one. As a consequence, a reduction in primary energy demand due to energy savings has the same effect on the energy balance as the switch to wind and solar power. Therefore in agreement with AG Energiebilanzen (p. 9), the concept of primary energy was not applied for conducting the status quo analysis in Flensburg. Using final energy allowed for a clear identification of final energy demand reductions due to reduced demand or energy efficiency measures and was applied in the case study. Additionally, a further division into useful energy was performed for a few companies for detailed analysis. Data availability on useful energy for the entire city was very limited and performing a status quo analysis based purely on useful energy would have been extremely time consuming. Thus the form of final energy was used for the status quo analysis of Flensburg. In the following, the term energy will refer to final energy.

After determining the form of energy to be used, principles for CO_2eq-emissions were determined. Following the arguments of Fischer and Kallen (1997), the territorial principle should not be used for counting CO_2eq-emissions. An underestimation of CO_2eq-emissions would occur because of two reasons: emissions for down-stream processes are not taken into account, and areas without their own power and heat production would have systematically lower CO_2eq-emissions while areas with a power plant would have systematically higher emissions (Fischer and Kallen 1997, p. 93). The residents principle is mainly applicable on a small scale where detailed information on consumed goods is available. Gathering information about the consumed goods in cities with larger population numbers is, at least in Germany, almost impossible. It also requires detailed information on the production chain of each individual product. Therefore the inland principle was the chosen approach for quantifying CO_2eq-emissions for energy consumption, including electricity, heat, and fuels. Therefore the basis for the CO_2eq-balance is the energy demand of the public and the stakeholders in Flensburg, which is induced by their activities. The chosen approach is depicted in Figure 5.3. Areas with a grey background symbolise intercity activities, while areas marked in light blue are activities external to the city. The text boxes with the dark blue background show the main data for the status quo taken into consideration. The energy demand in the city was taken into account independently from the location of the energy supply source. The same explains the energy demand for the transport sector. The energy demand of all vehicles registered in the city was considered. Using the specific CO_2eq-emissions from the used energy sources, the total CO_2eq-emissions of the activities of the city were calculated in accordance to the determined energy use. As shown in Figure 5.3, the production of goods and services and their consumption was not considered directly in the calculation of the energy demand or CO_2eq-emissions. Only the energy demand that was caused by the production of goods and services in the city was included into the energy balance, by determining the overall energy demand. This then also included the energy used for producing goods. To be consistent, the caused energy demand and CO_2eq-emissions of external produced goods and services was not included.

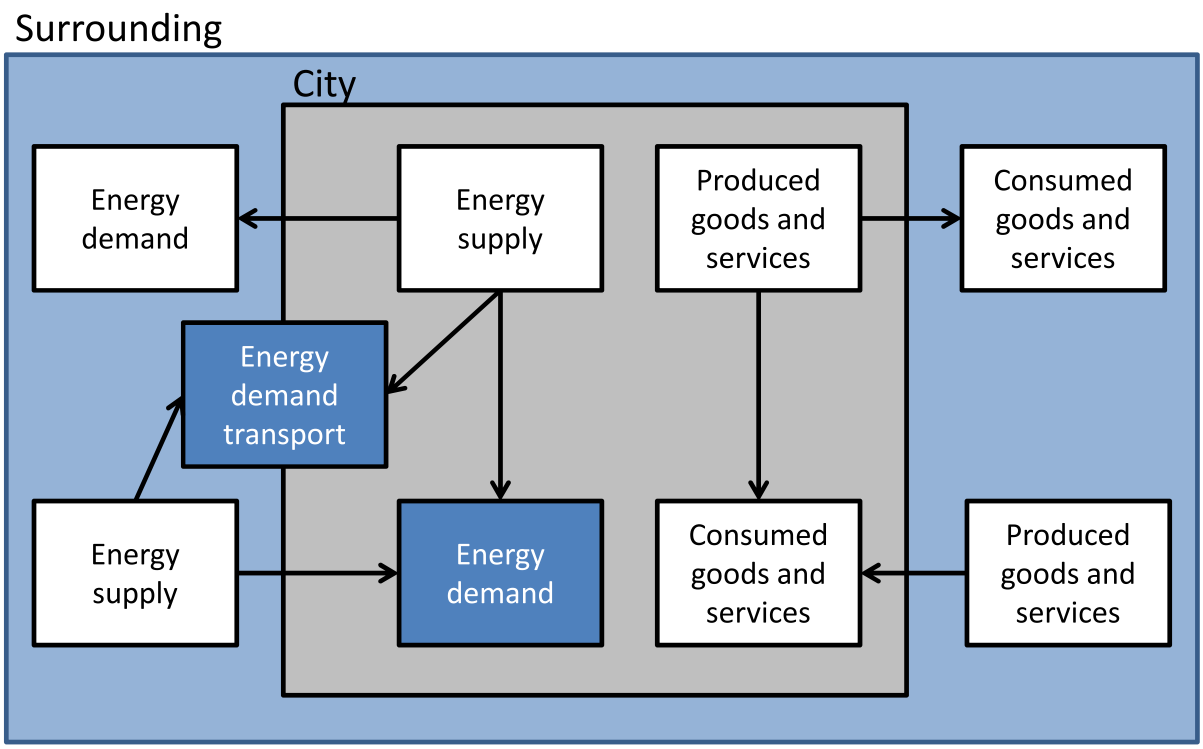


Figure 5.3: *Assignment of energy demand and CO_2eq-emission principles for Flensburg*

5.3.3 Identification and involvement of stakeholders

The identification and involvement of the different stakeholders in Flensburg during the status quo analysis was a crucial step for the participatory development of the concept. The applied methodology for the participatory development of the status quo analysis is depicted in Figure 5.4.

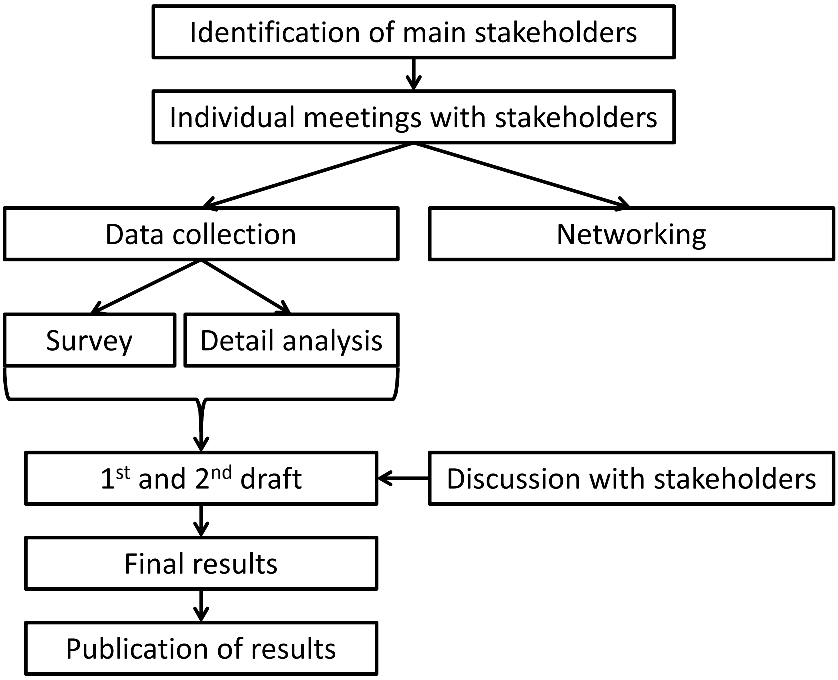


Figure 5.4: *Methodology for the participatory status quo analysis in Flensburg*

After identifying the main stakeholders, a direct link to the stakeholders was established. Meetings were scheduled with the Chairmen or the Energy Manager of companies and organisations in Flensburg. During the meetings with the stakeholders, Klimapakt Flensburg and the goal of obtaining CO_2eq-neutrality, were introduced. Furthermore, relationships with the stakeholders were established, which created a good environment for future cooperation.

Meeting with different stakeholders and becoming acquainted with their companies or organisations in Flensburg helped to gain a better understanding about the system under observation. It allowed for an inside view of the system and the mentalities that existed in the different sectors. It also allowed for a better understanding of the existing networks, which was useful for the upscaling of the transition arena to a transition network. The information gathered from this process allowed for the climate protection process to adapt to the special requirements of the city of Flensburg.

Data collection for the status quo analysis was obtained through cooperation with the local stakeholders. In addition to the 15 members of Klimapakt Flensburg at that time, the largest 21 industrial companies in Flensburg delivered data for the status quo analysis. The stakeholder involvement for the procurement of data served as a crucial step for including as many stakeholders in Flensburg into the process as possible, right from the beginning. The main advantage was that by delivering data, the stakeholders were able to participate in the process without committing themselves to the ambitious CO_2eq-emission reduction targets. Through this approach, the psychological aspects of the foot-in-door effects were applied. The delivering of data for the status quo analysis made the stakeholders feel invested in the outcome. According to the findings from the foot-in-door theory (Prose 1994, Swim et al. 2011, p. 248 and McKenzie-Mohr 1999, p. 3), this increased the chance of later commitment for the more ambitious goals of the climate protection concept and for the participation in the process in general.

5.3.4 Data collection and creation of an energy and CO_2-balance

Data for energy supply and demand was collected for each of the four city sectors of Flensburg, which include the household, industrial, commercial, and transport sectors. Data was collected for the time period from 1990 (reference year) to 2006 (base year), for each consecutive year.

To gather the most detailed and accurate information about the energy supply and demand, the following methodology was applied for data collection in Flensburg, in the presented order:

- Identification of specific data for Flensburg
- Identification of data from the federal state of Schleswig-Holstein, applicable to Flensburg
- In case of no data availability on a Flensburg or Schleswig-Holstein scale, national data was used and adjusted to the situation in Flensburg

An energy and CO_2eq-emission balance was created using Microsoft Office Excel. In comparison to commercially available energy and CO_2eq-emission balance software, Excel allowed for a very specific and detailed examination of the balance. Furthermore, the developed Excel balance was extendible to be used as the basis for further calculations and scenario development for the forecasting and backcasting analysis. In the following tables the values for every fourth year are listed.

5.3.5 Household sector

The energy demand of the household sector in Flensburg results from the usage of heat for room heating, warm water, and electricity. In the following, the development of the heat and electricity demands are described.

5.3.5.1 Development of heat demand

Flensburg is unique in that almost all households (98 %) are supplied with heat by the district heating network from the local energy utility. The remaining two percent of households are using heating oil. There is no natural gas grid connection for households in Flensburg.

The local energy utility in Flensburg does not distinguish between the supply of private households and clients from the commercial sector. Therefore the local energy supplier was only able to deliver the total heat demand for the two sectors combined. Using the approach depicted in Figure 5.5, the heat demand of the household sector was calculated. For the specific heat consumption of households, the average number for Germany as a whole was used. In 1990 the specific heat consumption was 171.8 kWh/m^{2}a and in 2006 150.1 kWh/m^{2}a (Hauser 1997, p. 14) (BMVBS 2009b, p. 76). The Statistical Office of Hamburg and Schleswig-Holstein provided information on the development of the total heated living area from 1990 to 2006. An overview of the total and specific development of the living area and the population development in Flensburg is listed in Table 5.1.

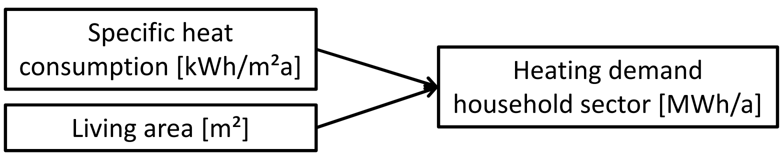


Figure 5.5: *Calculation of heat demand of the household sector in Flensburg*

Table 5.1: *Development of living area and population in Flensburg from 1990 to 2006*

	1990	1994	1998	2002	2006
Living area [thousand m^2]	3,088	3,189	3,301	3,437	3,516
Living area per person [m^2]	35.5	36.3	38.9	40.6	40.6
Population	86,977	87,939	84,742	84,704	86,630

Using the information on the specific heat consumption and the heated living area in Flensburg, the heat demand of the household sector was calculated. A list of the total and specific heat demands of the households in Flensburg is provided in Table 5.2. Interestingly, the specific heat demand decreased while the total heat demand for Flensburg households stayed almost on a constant level; depicting the trend towards increased living space per capita (cp. Table 5.1).

Table 5.2: *Development of the total and specific heat demand of the households in Flensburg from 1990 to 2006*

	1990	1994	1998	2002	2006
Heat demand [MWh]	534,962	535,067	535,498	538,634	531,702
Specific heat demand [kWh/m^{2}a]	171.8	166.4	160.9	155.5	150.1

5.3.5.2 Development of electricity demand

Information on the electricity consumption of the private households in Flensburg was made available by the local energy utility. The development of the electricity consumption of the households in Flensburg is listed in Table 5.3. The electricity consumption in total increased by 11 % between the years 1990 and 2006. The specific electricity consumption per capity raised from 1.6 MWh per capita in the year 1990 to 1.78 MWh in the year 2006. This development reflects the average trend in Germany as a whole, where the per capita electricity consumption was 1.72 MWh in the year 2006 (AG Energiebilanzen 2009) (Statistisches Bundesamt 2008, p. 35).

Table 5.3: *Development of the total and specific electricity demand of the households in Flensburg from 1990 to 2006*

	1990	1994	1998	2002	2006
Electricity demand [GWh]	139.18	146.88	151.28	155.70	154.60
Electricity demand per capita [MWh/capita]	1.60	1.67	1.79	1.84	1.78

5.3.6 Commercial sector

Due to the heterogeneity of the commercial sector, no specific data for the energy consumption of this sector was available. The energy demand therefore was calculated by subtracting the energy demand of the remaining sectors by the total energy demand of the city. In addition to determining the total energy demand and CO_2eq-emissions, an in-depth analysis of certain clusters of the commercial sector was performed. Specific data was collected for the energy demand of the following sub-categories in the commercial sector:

- Public buildings owned by the municipality
- Public buildings owned by the federal state or country
- Sewage plant
- Activities from the technical operation centre (Technisches Betriebszentrum - TBZ)
  - Buildings
  - Traffic lights
  - Street lighting
  - Parking ticket terminals
  - Pumping stations for sewage system and district heating
- Hospitals

5.3.6.1 Development of heat demand

As previously mentioned, no specific data on the energy demand of the commercial sector was available. The heat demand of the commercial sector was calculated by subtracting the heat demand of the remaining sectors from the total energy demand in Flensburg. Data was provided by the local energy utility. The development of the heat demand of the commercial sector in Flensburg is listed in Table 5.4. In comparison to the other sectors the variation over time of the energy demand is quite high. The cause of this is the heterogeneity of the sector and the calculation method.

Table 5.4: *Development of the heat demand of the commercial sector in Flensburg from 1990 to 2006*

	1990	1994	1998	2002	2006
Heat demand [MWh/a]	220,656	259,935	194,245	311,780	261,530

5.3.6.2 Development of electricity demand

Similar to the heat demand, no specific data for the electricity consumption of the commercial sector was available. The data from the local energy utility did not distinguish between the commercial and industrial sector. A thorough data-set from the industrial sector, available from another source, made it possible to calculate the electricity demand of the commercial sector. The development of the electricity demand of the commercial sector is provided in Table 5.5. In the year 1990 the commercial sector used 151 GWh of electricity. From 1990 to 2006 the electricity consumption was reduced by 16 % to an absolute value of 126 GWh.

Table 5.5: *Development of the electricity demand of the commercial sector in Flensburg from 1990 to 2006*

	1990	1994	1998	2002	2006
Electricity demand [MWh/a]	151,089	144,820	149,466	132,029	126,082

5.3.7 Industry sector

In the year 2006, there were in total 44 industrial companies with almost 7,500 employees in Flensburg. For 21 of the 44 companies, information on energy demand was gathered using surveys. For the five largest energy consumers in Flensburg (Mitsubishi Hitec Paper Mill, Flensburger Brauerei, Flensburger Fahrzeugbaugesellschaft, Flensburger Schiffbaugesellschaft, HaGe Raiffeisen), detailed analyses (final and useful energy) were performed including factory inspections. One company in Flensburg (Mitsubishi Hitec Paper Mill) is producing its own electricity with a chp plant. The other companies are mainly using heating oil for the production of process heat. Parallel to the surveying and company specific analyses, data from the Statistical Office of Hamburg and Schleswig-Holstein was used to calculate the overall energy consumption of the industrial sector in Flensburg. Using this two-step approach, the energy consumption for the industrial companies in Flensburg was calculated.

5.3.7.1 Development of heat demand

Data on the heat demand of the industrial sector was provided by the statistical office of Schleswig-Holstein and by the industrial companies participating in the survey. In Flensburg, the energy sources of oil, natural gas, and district heating, make up the heat demand of the industrial sector. The development from 1990 to 2006 can be found in Table 5.6. The development of the energy demand is characterised by a relocation of companies from Flensburg to other cities, resulting in a reduction in energy demand. Mainly due to this occurrence, the natural gas consumption decreased in that time-span by 48 %. The heating oil demand decreased by 50 %. The demand for district heating, which is mainly used for room heating, depends less on the big companies, which in most cases provide their own energy supply. Only a slight decrease of the district heating demand was noticeable.

Table 5.6: *Development of the heat demand of the industrial sector in Flensburg (Statistikamt Nord 2009, own calculations based on survey)*

Heat demand [MWh/a]	1990	1994	1998	2002	2006
Natural gas	204,024	166,376	199,974	131,910	105,576
Heating oil (light)	32,070	16,915	38,856	33,224	30,012
Heating oil (heavy)	51,715	64,205	0	0	11,968
District heating	39,137	29,181	28,517	31,886	35,746
Total heat demand	326,946	276,677	267,347	197,021	183,302

5.3.7.2 Development of electricity demand

Similar to heat demand, the electricity demand in Flensburg is also driven by the installation and delocalisation of companies. From 1990 to 2006, the electricity demand decreased by 12 %. The development of the electricity demand is listed in Table 5.7.

Table 5.7: *Development of the electricity demand of the industrial sector in Flensburg*

	1990	1994	1998	2002	2006
Electricity demand [MWh/a]	181,932	204,230	203,599	161,645	159,591

5.3.8 Transport sector

In the transport sector, three sub-categories were established. These are the motorised private transport (MPT), the public transport, and the freight transport. The public transport was further divided into local versus regional transport. The supra-regional transport was not taken into account in the status quo analysis because it is not part of the defined system boundary. In general the energy demand of the transport sector in 2006 was mainly covered by the use of diesel and gasoline. The share of electricity was negligibly low.

5.3.8.1 Energy demand of the motorised private transport

Motorised private transport includes private cars and motorcycles. Motorcycles with an approximate share of less than one percent of the energy demand of the MPT were not further taken into account. The energy demand of the MPT largely depends on daily individual decisions made by every car owner in the city. An exact determination of the energy consumption and CO_2eq-emissions in Flensburg or for Germany as a whole was not possible, which is why official statisticians use calculation models (e.g. BMVBS) for the accumulation of data for mileage and fuel consumption. The methodology employed for calculating the MPT energy consumption of Flensburg is depicted in Figure 5.6.

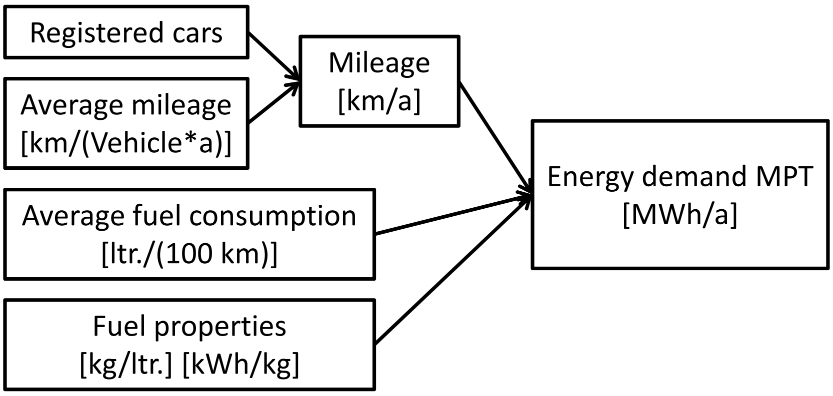


Figure 5.6: *Necessary data for the calculation of the energy demand of the motorised private transport*

Specific information on mileage and average fuel consumption was not available at city or district levels for the city of Flensburg. Therefore, average values for Germany as a whole were used when calculating the energy consumption (BMVBS 2009a). The only Flensburg-specific value available was the number of registered cars. From 1990 to 2006, the numbers of cars in Flensburg increased from 35,300 to 52,600; an increase of 49 % (Stadt Flensburg 2001, p. 153) (Statistikamt Nord 2006, p. 1). Also, the specific value increased by almost 50 %. The number of cars increased from 406 to 607, per 1,000 persons. It was assumed that for Flensburg, the share of diesel and gasoline cars is equal to the average of Germany as a whole. The share of cars with Diesel engines almost doubled in the analysed timespan (1990 to 2006) (BMVBS 2009a, p. 134). The average mileage of private cars decreased from 1990, with a value of 14,100 down to 12,600 km/a in the year 2006 (BMVBS 2009a, p. 134). Even though the specific mileage per car is decreasing, the total number of driven km increased by 34 % due to the increased numbers of cars. In 2006, 657 million km were driven by cars in Flensburg. The total energy demand of Flensburg's motorised private transport sector was calculated by multiplying the total number of driven km in Flensburg by the average fuel consumption of diesel and petrol engines in Germany. The resulting energy demand is listed in Table 5.8. In total, the energy demand increased by 13.7 % from 1990 to 2006.

Table 5.8: *Development of the energy demand of the motorised private transport in Flensburg from 1990 to 2006*

Energy demand [MWh/a]	1990	1994	1998	2002	2006
Diesel	60,217	70,297	68,313	88,966	154,397
Gasoline	351,280	328,450	321,288	289,317	313,271
Total	411,497	398,747	389,600	378,283	467,668

5.3.8.2 Energy demand of public transport

Public transport for the city was distinguished into the sub-categories of local and regional public transport. In the following, first the local and then the regional public transport will be described.

Local public transport in Flensburg is run by two bus operators and by a variety of taxi companies. The energy demand of Flensburg taxis is not analysed separately because it is already included in calculations of motorised private transport. This is because the statistics about registered cars in Flensburg do not delineate between private and commercially operated cars. The bus companies reported the necessary data relating to mileage and fuel consumption. The development of the energy demand is listed in Table 5.9.

Regional public transport directly effects the CO_2eq-emissions for Flensburg commuters. Regional public transport is difficult to assign to the individual municipalities. For this case study, the main train and road commuter routes from Flensburg were analysed (routes from Flensburg to Eckernförde, Rendsburg, Niebüll, Kappeln, and Husum). They are responsible for the biggest share of regional public transport from Flensburg (traffic-Kontor 2009). For the calculation of the share of the emissions of Flensburg, it is assumed that 10 % of the persons using regional public transport are from Flensburg. For the trains connecting to Eckernförde and Rendsburg, specific energy demands per transported person were available (DB/ifeu 2008). In combination with the numbers of travellers per day (LVS 2009, p. 36), the total energy demand was calculated. For road public transport via the bus system, the routes from Flensburg-Niebüll, Flensburg-Kappeln and Flensburg-Husum were analysed. The bus operating companies provided the information that the average fuel consumption was 33 litres of diesel per 100 kilometers. In combination with the mileage per year, the total fuel consumption was calculated.

Table 5.9: *Energy demand of public transport in Flensburg*

Energy demand [MWh/a]	1990	1994	1998	2002	2006
Local	10,411	10,509	10,457	10,404	12,601
Regional	2,557	2,647	2,738	2,828	2,919
Total	12,968	13,156	13,195	13,232	13,520

5.3.8.3 Energy demand of freight transport

There was no Flensburg-specific data available for freight transport in Flensburg. For the calculation of the energy demand, the average values for Germany as a whole were extrapolated for Flensburg. Only the rail and road freight play a role in the transport of goods for Flensburg, because there is no commercial airport.

Annual statistical information was available for the energy consumption of the German road freight (BMVBS 2009a, p. 286). It was assumed that the consumption of goods per capita in Germany as a whole is equal to the consumption of goods by people living in Flensburg. Therefore, the energy demand for delivering these goods should be equal. The energy demand per person for freight transport was multiplied by the population of Flensburg, resulting in the calculation for the energy consumption and emissions for the freight transport of Flensburg.

Different sources were used to calculate the energy consumption for rail freight (e.g. BMVBS 2009a, p. 236,284 Allianz pro Schiene 2008, p. 5). In the time period from 1990 to 2006, rail freight transport volume increased by 67 %. The energy demand of the road and rail freight are listed in Table 5.10.

Table 5.10: *Energy demand of road and rail freight for Flensburg (BMVBS 2009a, p. 286)*

Energy demand [MWh/a]	1990	1994	1998	2002	2006
Rail freight	8,031	9,086	9,113	9,913	13,398
Road freight	158,664	186,007	198,235	166,651	170,201
Total	166,695	195,093	207,348	176,564	183,599

5.3.9 Energy supply sources and specific CO_2-emissions

CO_2eq-emissions were calculated based on the energy balance of Flensburg. Every energy source in the energy balance had an emission factor assigned to it. The emission factor contains the direct and indirect CO_2eq-emissions. For the calculation of the direct emissions, emission factors specific to Flensburg were used. No Flensburg-specific information was available for indirect emissions of the energy sources used in Flensburg. Therefore, data averages for Germany from the project Global Emissions Model for integrated Systems (GEMIS, homepage http://www.iinas.org/gemis.html) were used. The indirect emissions in GEMIS include emitted CO_2eq for production or mining, and the initial treatment and transport of the energy product. It also contains information about the necessary energy used for the production of mining machinery. The specific information on the direct emissions was combined with the information on indirect emissions, to one value for each energy source used in Flensburg. The resulting values are the specific CO_2eq-emissions per unit of used final energy.

The main energy supplier in Flensburg is the chp plant of the local energy utility. Heat and electricity are supplied to the household, commercial, and industrial sectors. The allocation of the total CO_2eq-emissions of the chp plant to the products of heat and electricity can be achieved using various methodologies (Fritsche and Rausch 2008, pp. 5). For Flensburg, the Finnish Method was used in accordance with Directive 2004/8/EC of the European Parliament, and of the Council of 11 February 2004 on the promotion of co-generation based on a useful heat demand in the internal energy market (EU-CHP-Directive). Following this directive, the energy saving due to chp in comparison to a separate heat and electricity production are set in relation to the higher efficiency of the chp production. Using this methodology, the specific emissions for heat and electricity were calculated and are listed in Table 5.11. Other important emission factors for Flensburg are depicted in Table 5.12.

Table 5.11: *Emission factors for heat and electricity of the energy supplied by the local energy utility [own calculation;Fritsche and Schmidt (2007, p. 11-14) Fritsche and Rausch (2008, p. 11)]*

	direct	indirect	total
District heating [gCO_2eq/kWh_{th}]	357.9	59.7	417.5
Electricity [gCO_2eq/kWh_{el}]	805.2	134.2	939.4

Table 5.12: *Emission factors of fuels used in Flensburg (DEHSt 2007, p. 1); (Fritsche and Schmidt 2007, p. 11-14)*

gCO_2eq/kWh	direct	indirect	total
Coal	338.2	56.7	394.9
Heating oil	266.0	43.3	309.3
Natural gas	201.6	31.8	233.4
Gasoline	271.9	58.2	330.1
Diesel	270.3	43.3	313.6

In addition to the listed emission factor of heat and electricity from the chp plant and the emission factors for fossil fuels, further specific CO_2eq-emissions had to be determined. Depending on the data availability, individual solutions were used to determine the case specific CO_2eq-emissions. This was, for example, done for calculating the CO_2eq-emissions of the regional public transport. Specific data was available and utilised (DB/ifeu 2008) (LVS 2009, p. 36). A detailed description of all calculations for determining the specific CO_2eq-emissions are available in Hohmeyer et al. (2010a).

In addition to the determination of specific fossil fuel CO_2eq-emissions, the share of renewable energies to the energy consumption of Flensburg was analysed. The development of renewable energies in Flensburg is quite small. In addition to 57 photovoltaic systems, one wind power plant was operated in 2006. The local grid operator provided the data. In addition to photovoltaic and wind power, there was no further use of renewable energies in Flensburg. The results of analysing the data are listed in Table 5.13. The specific CO_2eq-emissions of the renewable energies listed are zero.

Table 5.13: *Development of the annual power output of photovoltaic and wind plants in Flensburg*

Power output [MWh/a]	1990	1994	1998	2002	2006
PV	0	0	5	11	239
Wind	0	0	480	480	480

5.3.10 Results of the status quo analysis

In the following segment, the development of the total energy demand and CO_2eq-emissions of Flensburg from 1990 to 2006 will be presented. In addition to the identification of the main stakeholders in Flensburg, the development of energy demand and CO_2eq-emissions provide the core of the status quo analysis. The results of the status quo analysis were the basis for the further climate protection process in the city.

The energy demand of the city of Flensburg in 1990 was 2,152 GWh. In 2006 the energy demand was 2,090 GWh (a decrease of 2.9 % from 1990). In the same time-span, the energy demand in Germany decreased by 3.4 %. The results of the energy consumption for Flensburg are shown in Table 5.14. The household and the transport sector had the largest energy demand in Flensburg in 2006 with each being almost one third of the total energy demand. The commercial sector had a share of 19 %, whereas the industry had a share of 17 % of the total energy demand in Flensburg. Furthermore, almost half of the energy is used for heating purposes. One third is used for fuels for transport and the remaining fifth is supplying electricity.

Table 5.14: *Development of the energy demand in Flensburg from 1990 to 2006*

GWh/a	1990	1994	1998	2002	2006
Sector Total	**2,152**	**2,180**	**2,117**	**2,071**	**2,090**
Household	692	700	704	711	704
Industry	510	482	472	360	345
Commercial	354	387	327	427	370
Transport	596	611	614	572	671
Heat	**1,079**	**1,068**	**993**	**1,044**	**973**
Household	552	553	552	556	549
Industry	327	277	267	197	183
Commercial	200	238	173	292	240
Transport	0	0	0	0	0
Electricity	**474**	**497**	**506**	**451**	**441**
Household	139	147	151	156	155
Industry	182	204	204	162	160
Commercial	151	145	149	132	126
Transport	2	2	2	2	2
Fuel	**599**	**615**	**618**	**576**	**676**
Household	0	0	0	0	0
Industry	2	1	1	2	2
Commercial	4	4	4	3	4
Transport	594	610	613	571	669

In 1990, Flensburg's total CO_2eq-emissions was 1.05 million tCO_2eq. This equals specific CO_2eq-emissions of 12.1 tCO_2eq per capita each year. By 2006, total CO_2eq-emissions were only slightly reduced (by 3,7 %). Hence total CO_2eq-emissions in the year 2006 were 1.01 Mio. tCO_2eq-emissions and the specific emissions were 11.7 tCO_2eq per capita. The development of the CO_2eq-emissions for Flensburg are shown in Table 5.15. The household sector of Flensburg emitted 36 % of the total CO_2eq-emissions in the year 2006. The commercial sector was responsible for 23 % of the overall CO_2eq-emissions in Flensburg. The transport sector in Flensburg emitted 21 % and the industrial sector 20 %.

Table 5.15: *Development of the CO_2-emissions in Flensburg from 1990 to 2006*

tCO_2eq/a	1990	1994	1998	2002	2006
Sector Total	**1,050,638**	**1,082,811**	**1,071,867**	**1,004,450**	**1,011,938**
Household	360,793	367,906	379,194	367,180	366,819
Industry	262,787	270,231	266,513	203,078	200,948
Commercial	236,239	248,853	229,506	251,386	231,039
Transport	190,820	195,821	196,654	182,806	213,132
Heat	**408,380**	**413,078**	**384,951**	**404,167**	**385,872**
Household	227,386	227,239	231,594	222,342	221,589
Industry	90,721	76,973	71,074	54,260	52,678
Commercial	90,273	108,866	82,284	127,565	111,605
Transport	0	0	0	0	0
Electricity	**449,819**	**472,300**	**488,545**	**415,952**	**410,919**
Household	133,408	140,667	147,600	144,839	145,230
Industry	171,588	192,937	195,113	148,295	147,603
Commercial	144,824	138,695	145,831	122,819	118,086
Transport	307	307	307	307	307
Fuel	**192,439**	**197,433**	**198,371**	**184,331**	**215,147**
Household	0	0	0	0	0
Industry	478	321	327	523	667
Commercial	1,142	1,291	1,391	1,002	1,348
Transport	190,820	195,821	196,654	182,806	213,132

5.4 Step 4: Forecasting analysis

A forecast scenario shows how the energy demand and the CO_2eq-emissions of a city will develop when no additional climate protection measures are applied. Depending on the results, the scenario will show how much additional climate protection is needed to achieve the given target, or if a continuation of given trends is already enough to achieve the emission reduction targets.

As Börjeson et al. (2006, p. 15) observe, forecast scenarios are largely based on historical data. In addition to analysing historical data, a literature review was performed on already existing forecasting scenarios, such as the energy demand development of the commercial sector. The literature review also aided in determining the main drivers of energy demand and CO_2eq-emissions. In Section 2.2.1 on page 43 drivers for energy demand and CO_2eq-emissions for cities were introduced. The determined drivers were also used for the scenario development during the backcasting analysis.

The forecasting analysis was performed in a time period of ten months, almost parallel to conducting the status quo analysis. In the following sections the Flensburg-specific methodology and the results of the forecasting analysis are described. Detailed results of the forecasting analysis are available in a report published for Flensburg (Hohmeyer et al. 2010b).

5.4.1 Methodology and stakeholder involvement

The first objective of the forecasting analysis was to determine the main drivers of Flensburg's energy demand and CO_2eq-emissions. Individual members of Klimapakt Flensburg and key players of the main companies in the industrial sector were contacted as a first step of the forecasting analysis using a participatory approach. Applying the methodological approach of stakeholder interviews, the main driving factors were identified and possible future developments were discussed with the various stakeholders.

After conducting these interviews, it became clear that the future development of the energy demand largely depends, not on the individual plans of the company, but rather on the future economic development as a whole. For the city of Flensburg, the historic development of the energy demand can only be used as a first indicator to determine the future development of the drivers. Single events, such as the closing-down of one of Flensburg's major companies, had too much influence over the energy demand to allow the results to apply for the forecast. Therefore national trends were used to base the forecasting scenario on a wider statistical database. For analysing the German trend, a ten-year time span was applied; from 1996 to 2006. Using earlier data, for example from the year 1990, might lead to false trends due to complexities associated with the reunion of Western and Eastern Germany during that time.

Incorporating the identified drivers for the scenario development for energy demand and CO_2eq-emissions in Flensburg, a first draft of the forecasting scenario was developed. For the development of the forecast, currently existing regulations and forecasted developments from other future studies were included. Following this first phase, the first draft of the forecasting scenario was then introduced to different stakeholders in Flensburg for their opinions. The forecasting scenario was then adapted according to the assessments of the stakeholders, and a second meeting scheduled to finalise the forecasting scenario. The final results were first presented to the members of Klimapakt Flensburg, then the results were made available to the stakeholders and the citizens of Flensburg. The local press aided in informing local citizens about the current energy demand and CO_2eq-emissions in Flensburg and how they may develop in the future when no additional climate protection measures are being applied.

The participatory approach applied for to the forecasting analysis in Flensburg is depicted in Figure 5.7. Applying this approach, the results of the forecasting analysis in Flensburg are presented for each city sector in the following sections. First the main drivers considered are presented, followed by the forecasted development of the energy demand. Finally the overall development of CO_2eq-emissions in Flensburg is presented.

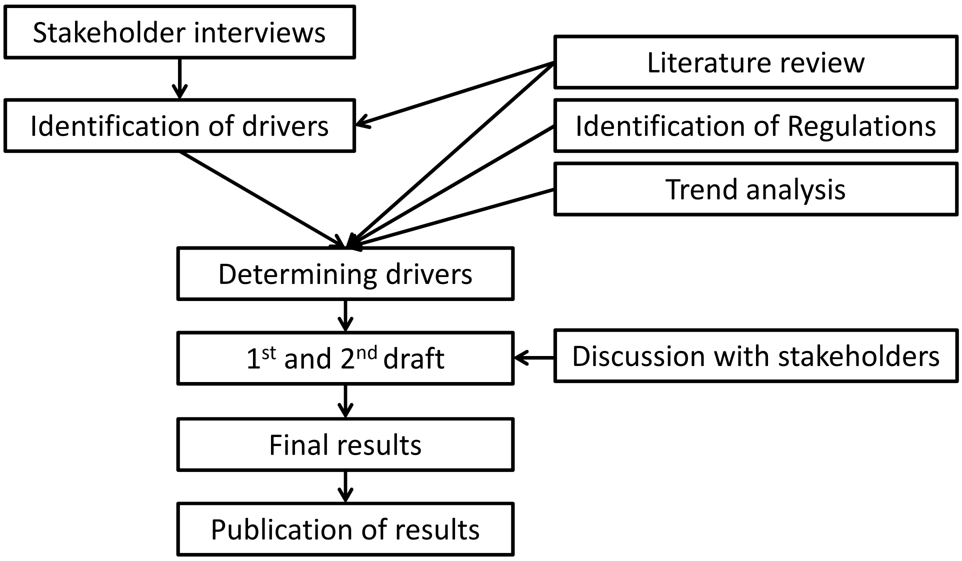


Figure 5.7: *Participatory approach applied to the forecasting analysis conducted for Flensburg*

5.4.2 Household sector

The following main drivers of energy demand for the household sector were identified: (1) population number; (2) living space per person; (3) specific heat demand per living space; (4) refurbishment rate of the building stock and (5) average electricity consumption per person. The first four points are drivers of the heat demand, while the first and last point are drivers for the electricity demand. Existing laws were used to forecast the development of the energy demand.

The population number in Flensburg influences the heat and electricity demand. Therefore it is introduced as the first driver. The development of the population in Flensburg from 1990 to 2006 was provided by the city administration of Flensburg. For the development of the population from 2006 to 2025, Flensburg specific forecasts from the Statistical Office of Hamburg and Schleswig-Holstein were used (Statistikamt für Hamburg und Schleswig-Holstein 2008, p. 6). According to the forecast, Flensburg will have a population of 90,100 in the year 2025. Beginning in the year 2026, no Flensburg-specific data is available. The 12th coordinated population projection from the Federal Bureau of Statistics for Germany was used to project population development for Flensburg. The forecasted percentages for annual population growth in Germany were used for Flensburg to calculate the development for the year 2050. According to this data, a population size of 83,040 people is expected for Flensburg for the year 2050.

5.4.2.1 Development of heat demand

In addition to the population development, the heat demand of the household sector is influenced by the living space per person, the specific heat demand per living space and the refurbishment rate of the building stock.

For the future development of the living space in Flensburg, no Flensburg-specific data was available. Therefore predictions for the development in Germany as a whole were used (Prognos 2009). In the Prognos study, a forecasted development of the living space in Germany from 2010 to 2050 is provided. Based on the data provided in the Prognos study, the specific living space per capita was calculated for Flensburg. Following the Prognos study, the current living space per capita with a value of 41 m^2 will increase to 50 m^2 in the year 2050; an increase of 25 %. The specific and total development of the living space in Flensburg for each decade is listed in Table 5.16.

Table 5.16: *Development of the total and specific living space in Flensburg*

Living space [m^2]	2010	2020	2030	2040	2050
Total	3,636,425	4,065,271	4,209,521	4,211,431	4,181,042
Per Capita	41	45	47	49	50

A model was developed to forecast the development of heat demand for new buildings and for buildings being refurbished for energy efficiency. In addition to the existing data, it was necessary to distinguish different categories of construction years of the building stock in the energy and CO_2eq-balance. Using the CO_2eq-building stock report (BMVBS 2009b) average specific heat demands for each category of construction years were determined for Flensburg. The categories for the construction years were chosen as listed: before 1948, 1949-1968, 1969-1987, 1988-2002, 2003 and earlier.

After determining the specific heat demand for each category the calculation model for the building refurbishment specific to Flensburg's situation was used. The renovation rate forecasted from Prognos was used (Prognos 2009, p. 58) for the future development. The data from

Prognos is based on the historical development of the renovation rate in Germany as a whole. The renovation rates are listed in Table 5.17 according to the construction year.

Table 5.17: *Development of the renovation rate of the households in Flensburg according to the construction year (Prognos 2009, p. 58)*

Building year	2001-2005	2006-2010	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050
1500-1968	1.6%	1.5%	1.4%	1.3%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
1969-1978	1.6%	1.5%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%
1979-1987	1.5%	1.5%	1.4%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%
1987-1991	1.1%	1.3%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%	1.3%
1992-1995	0.1%	0.7%	1.3%	1.3%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%
1996-1997	0.1%	0.7%	1.3%	1.3%	1.4%	1.3%	1.3%	1.3%	1.3%	1.3%
1998-2000	0.0%	0.1%	0.7%	1.3%	1.3%	1.4%	1.3%	1.3%	1.3%	1.3%
2001-2005		0.1%	0.7%	1.3%	1.3%	1.4%	1.4%	1.3%	1.3%	1.3%
2006-2010			0.1%	0.7%	1.3%	1.3%	1.4%	1.4%	1.3%	1.3%
2011-2015				0.1%	0.7%	1.3%	1.3%	1.4%	1.4%	1.3%
2016-2020					0.1%	0.7%	1.3%	1.3%	1.4%	1.4%
2021-2025						0.1%	0.7%	1.3%	1.3%	1.4%
2026-2030							0.1%	0.7%	1.3%	1.3%
2031-2035								0.1%	0.7%	1.3%
2036-2040									0.1%	0.7%
2041-2046										0.1%

For the building stock, the German Energy Saving Regulation 2009 was taken into account for the further development of the specific energy consumption per household. An assumption of the forecast scenario was that new buildings achieve a specific heat demand of 70 kWh/m^{2}a as required by the Energy Saving Regulation from the Federal Government (EnEV 2009). According to the study from Prognos, refurbished buildings achieve values that are, on average, 30 % higher than new buildings (Prognos 2009, p. 57,58), resulting in 91 kWh/m^{2}a. The annual building demolition rate in Flensburg is 0.06 % (IfS 2008, p. 27). It was assumed that this value would remain constant until the year 2050. Taking the demolition rate and the development of the living area in Flensburg into account, the rate of new constructions was determined.

According to the calculation model, the average specific heat demand in Flensburg for the household sector will be 107.5 kWh/m^{2}a in the year 2050. This is a decrease of almost 40 %, in comparison to the value for 1990 with 171.8 kWh/m^{2}a. The specific and total development of the heat demand of the household sector is listed for each decade in Table 5.18.

Table 5.18 shows that the total heat demand almost stays constant from 2010 to 2020, even though the specific heat demand is decreasing. The almost constant development of the heat

Table 5.18: *Development of the total and specific heat demand of the household sector in Flensburg*

Heat demand	2010	2020	2030	2040	2050
Total [GWh]	523	523	506	479	449
Specific [kWh/am^2]	144	129	120	114	107

demand is due to the predicted population growth and the increasing living space per person. After the year 2025, the total heat demand decreases considerably. The heat demand is expected to decrease by 15 % from the year 1990 to 2050.

5.4.2.2 Development of electricity demand

For the time span from 2009 to 2020, the enforcement of Meseberg Resolutions was assumed for the household, commercial, and industrial sectors in Germany. As a part of their Climate and Environment Protection Program, the German Federal Government initiated the Meseberg Resolutions with the goal of reducing energy demand and CO_2eq-emissions by the year 2020 (Garz et al. 2009, p. 19). Applicable to the city of Flensburg is the aim to decrease the electricity consumption by 11 % by 2020, in comparison to 2005. This statistic was applied to the forecast scenario. After the year 2020, no additional federal or state climate change regulations apply.

Once the effects of the Meseberg Resolutions for the household sector in Flensburg were applied to the years 2010 to 2020, the average specific development of the electricity consumption of households in Germany as a whole was applied for Flensburg (time period from 2021 to 2050). The average annual electricity consumption per person increased from 1996 to 2006 by 0.5 %. For the forecast it was assumed that this development does not continue until 2050, but rather a certain level of saturation of the household's electricity demand will occur. Therefore the annual growth rate will be reduced every ten years by 10 % of the annual value. This results in an increase of the per capita electricity consumption from 1.6 MWh in the year 1990, to 1.71 MWh in the year 2050. The total and specific development of the electricity demand of the household sector in Flensburg is provided in Table 5.19. The electricity demand is expected to increase by 2 % by 2050 (from 1990).

Table 5.19: *Development of the total and specific electricity dremand of the Flensburg household sector*

Electricity demand	2010	2020	2030	2040	2050
Total [GWh]	151	137	142	143	142
Specific [MWh/person]	1.70	1.53	1.59	1.65	1.71

5.4.3 Commercial sector

The following main drivers of energy demand for the commercial sector were considered for the forecast: (1) gross value added per year; (2) refurbishment rate of the building stock; (3) energy efficiency; (4) structural changes towards more or less energy-intense commercial branches. Considering the parameters of the existing laws, the development of the energy demand was forecast.

The development of the gross value added per year has an influence on the heat and electricity demand. Therefore, it is introduced as the first driver before discussing the development of the heat and electricity demand separately. In Germany, the historical growth of the gross value added per year in the commercial sector between 1996 and 2006 was an average of 0.5 %. In the same time period, the average gross value added for Flensburg was -0.22 % (Statistische Ämter des Bundes und der Länder 2011) (Destatis 2009). In agreement with other studies predicting the development of the commercial sector in Germany, a higher growth rate of 1.45 % in the future was assumed (Schmitt and Forsbach 2009, p. 41). The higher growth rate is justified by the ongoing trend in Germany towards a service society.

5.4.3.1 Heat demand development

For the forecast of the heat demand, the development of the gross value added and the refurbishment rate of the building stock were taken into account. The building stock of the commercial sector in Flensburg consists mainly of household-like buildings. Therefore the same refurbishment rates and building standards as in the household sector were applied. In addition the development of the gross added value was taken into account. With an average growth rate of 1.45 %, the heat demand for the commercial sector is predicted to increase by 47 % from the year 1990 to 2050. The development of the heat demand in the commercial sector in Flensburg is provided for each decade in Table 5.20.

Table 5.20: *Development of the heat demand of the commercial sector in Flensburg*

	2010	2020	2030	2040	2050
Heat demand [GWh]	221	228	246	269	293

5.4.3.2 Development of electricity demand

In Flensburg, the electricity demand of the commercial sector decreased from 1996 to 2006 by an average annual value of -1.67 %. This strong decrease was due to a structural change towards less electricity-intense commercial branches. A further strong development in this direction was seen as unlikely for Flensburg. Therefore the development from Germany as a whole was used. These numbers also include an increase in efficiency over time. The electricity demand in the German commercial sector annually increased by 0.81 % from 1996 to 2006 (AG Energiebilanzen 2009).

The Meseberg Resolutions were considered when making calculations for the commercial sector. As a consequence, the electricity consumption will decrease by 11 % between 2009 and 2020. Beginning in 2021, the development of the gross added value highly influences the electricity consumption. In comparison to 1990, the electricity demand will decrease by 23 % by 2050. Table 5.21 provides the development of the electricity consumption of the commercial sector in Flensburg for each decade.

Table 5.21: *Development of the electricity demand of the commercial sector in Flensburg*

	2010	2020	2030	2040	2050
Electricity demand [GWh]	120	119	118	117	116

5.4.4 Industry sector

The following main drivers of energy demand for the industrial sector were considered: (1) gross value added per year and (2) energy efficiency. Considering the parameters of Meseberg Resolutions and European Emission Trading Scheme, the development of the energy demand was forecast.

Similar to the commercial sector, the development of the gross value added is one of the main drivers of energy demand in the industrial sector. In Germany, the historical growth of the gross value added per year in the industrial sector between 1996 and 2006 was an average of 0.93 % (AG Energiebilanzen 2009). This development was continued in the forecast scenario. In the years 1990 to 2006, the average annual growth rate of the industrial sector in Flensburg was 0.92 % (Statistische Ämter des Bundes und der Länder 2011) (Destatis 2009). Using a value of 0.93 % for the forecast scenario is consistent with the assumptions made by the Federal Environment Ministry of Germany for the Leitszenario, which assume a long-term development of gross value added of 1 % (Nitsch and Wenzel 2009, p. 28).

5.4.4.1 Development of heat demand

The legislation has set no binding regulations for the future development of the heat demand for the industrial sector in Germany. Therefore, the German trend from 1996 to 2006 is continued until 2050. It is an annual increase of 0.18 %. As a result, the heat demand decreases from 1990 to 2050 by 42 %. The main share of the decrease is due to the delocalisation of companies in the time from 1990 to 2010. The forecasted development from 2010 to 2050 is provided in Table 5.22.

Table 5.22: *Development of the heat demand of the industrial sector in Flensburg*

	2010	2020	2030	2040	2050
Heat demand [GWh]	176	179	183	186	189

5.4.4.2 Development of electricity demand

In the industrial sector, the enforcement of the Meseberg Resolutions was assumed, which means a reduction of the electricity demand by 11 % from 2005 to 2020. Only one company in Flensburg participates in the European Emission Trading Scheme (DEHSt 2009). To achieve the required emission reduction, a partial substitution of fossil fuels was taken into account.

Starting in 2021, the average development of the German industrial sector as a whole from 1996 to 2006 was assumed for the electricity demand. The average annual growth rate was 1.99 % (AG Energiebilanzen 2009). In Table 5.23 the forecasted development of the electricity demand of the industrial sector in Flensburg is provided.

Table 5.23: *Development of the electricity demand of the industrial sector in Flensburg*

	2010	2020	2030	2040	2050
Electricity demand [GWh]	126	115	138	159	177

5.4.5 Transport sector

In this section, the results of the forecasting analysis for motorised private transport, public transport, and freight transport are presented. For the forecasting analysis in the transport sector of Flensburg, it was assumed that the general infrastructure and the urban form and function of the city remain the same.

5.4.5.1 Motorised private transport

The following main drivers of energy demand for motorised private transport were considered: (1) number of cars; (2) share of fuels used; (3) annual average mileage and (4) average fuel consumption. Considering the parameters of the EU-regulation (EU 443/2009), the development of the energy demand was forecasted.

It was assumed that the number of cars would further increase in Flensburg, due to the demographic development. The trend from the forecasted demographic development predicts that there will be fewer people under eighteen years of age with no driver's licence, and more motorised older people, by 2050. From 1990 to 2006, the number of cars per 1,000 inhabitants increased by an annual average of 2.6 % in Flensburg. The high value of 2.6 % is partly due to a large unexplained increase in cars from the year 2005 to 2006, according to the officially provided statistics. Not taking the year 2006 into account, the average annual automobile growth rate in the time period from 1990 to 2005 was 1.8 %. A value of 2 % was used for the automobile growth rate for the forecast. In addition to this growth rate, a saturation level of 750 cars per 1,000 inhabitants was applied. The number of cars in Flensburg is predicted to be 18 % higher in the year 2050, in comparison to 2006.

The Transport Emission Model (TREMOD) was used to predict future development in motorised private transport. The model was developed by the Institute of Energy and Environmental Research (Institut für Energie- und Umweltforschung) in Heidelberg, to forecast the development of annual mileage, fuel consumption, and emissions from motorised transport in

Germany, up to the year 2030. The forecasted trend obtained from TREMOD was extended to 2050.

TREMOD forecasts that the share of diesel-operated cars will increase to 41 % by 2020 and 43 % by 2030 (Knörr 2005, p. 13). From 2030 to 2050, it was assumed that the share of diesel-operated cars would increase to 50 %. In the year 2006, the average annual mileage for a diesel-operated car was 19,600 km (BMVBS 2009a, p. 286-287). For gasoline-operated cars, the average mileage per year was 10,500 km (BMVBS 2009a, p. 286-287). For the forecast from 2006 to 2050, it was assumed that the specific mileage would remain constant.

For the future development of the average fuel consumption the EU-regulation (EU 443/2009) was applied. The EU 443/2009 defines thresholds for the specific CO_2eq-emissions in gCO_2eq per km for new registrations of motor vehicles (EU 2009, p. 140/2). It was assumed that the thresholds from 130 gCO_2eq/km from 2012 and 95 gCO_2eq/km from 2020 would be achieved for all new registered motor vehicles. The specific CO_2eq-emissions equals a fuel consumption of 4.9 l/100 km for diesel and 5.5 l/100 km for cars running with gasoline starting in 2012. From 2020, the fuel consumption is 3.6 l/100 km for diesel and 4.0 l/100 km for gasoline.

As a result of the described developments, the overall energy demand of motorised private transport in Flensburg will be 332 GWh in the year 2050. This is a reduction of 19.4 % in comparison to the year 1990. Due to the increasing number of cars per citizen, the highest energy demand is predicted to occur in 2017, before the energy demand is lowered by the EU-regulation (EU 443/2009). Table 5.24 lists the forecasted development of the fuel demand for motorised private transport in Flensburg for each decade.

Table 5.24: *Development of motorised private transport in Flensburg*

Fuel demand [GWh/a]	2010	2020	2030	2040	2050
Diesel	199	268	215	210	217
Gasoline	305	232	163	128	115
Total	503	500	378	338	332

5.4.5.2 Public transport

For Flensburg's local and regional public transport it was assumed that there would be no significant changes due to political decisions. It was also assumed that the bus lines would not be reorganised. A positive effect on the energy demand will be due to an increasing fuel efficiency of 0.5 % per year (Knörr 2005, p. 15). As a result, the energy demand of public transport in Flensburg will decrease in the forecasted time period. Comparing the energy demand of public transport in 2050 to the energy demand of public transport in Flensburg in 1990, there is no overall increase or decrease. Both energy demands are 13.0 GWh/a. Table 5.25 lists the forecasted development of the fuel demand for public transport for Flensburg for each decade.

Table 5.25: *Development of the energy demand of public transport for Flensburg*

Fuel demand [GWh/a]	2010	2020	2030	2040	2050
Local	12.4	11.7	11.2	10.6	10.1
Regional	2.9	2.9	2.9	2.9	2.9
Total	15.3	14.7	14.1	13.5	13.0

5.4.5.3 Freight transport

Following the assumption from Knörr (2005, p. 15), the energy consumption of road and train freight transport will increase from 2010 to 2020 by 1 % per year. From 2020, a decrease of 0.2 % per year was assumed (Knörr 2005, p. 15). The total energy demand is predicted to decrease from 2006 to 2050 by 1.6 %, to a value of 180 GWh. In comparison to the year 1990, this is an increase of 8.4 %. Table 5.26 lists the forecasted development of the fuel demand for freight transport in Flensburg for each decade.

Table 5.26: *Development of freight transport for Flensburg*

Fuel demand [GWh/a]	2010	2020	2030	2040	2050
Rail	13.9	13.9	13.7	13.4	13.2
Road	177.1	177.1	174.3	170.8	167.5
Total	191.1	191.1	188.0	184.3	180.6

5.4.6 Energy supply sources

The development of the energy supply sources is driven by the demand in the different sectors and the fuel mix of the chp power plant operated by the local energy utility (Stadtwerke Flensburg). It was assumed that the share of energy sources is constant for the household, commercial, and industrial sectors. In the transport sector, the fuel demand is mainly determined by the development of the number of cars operated with diesel or gasoline. For the development of renewable energies, it was assumed that no new capacity would be installed in Flensburg. Therefore the PV systems and the wind power plant are only considered until the end of their lifetime. The remaining energy supply source where additional assumptions were needed was the chp plant.

For the forecast scenario, the local energy utility will only substitute fossil fuels with renewable energy sources as a response to political regulations. The European Emission Trading Scheme was taken into account. The goals of the second trading phase were fulfilled by the local energy utility without any additional changes. Between the years 2013 and 2020, the third phase of the emissions trading begins and the emissions will have to be decreased by 1.74 % per year. For Flensburg, it was assumed that the companies involved are reducing their CO_2eq-emissions by the annual 1.74 %, instead of buying additional emission certificates. This goal is achievable by the local energy utility by using up to 25 % of the total fuel input to burn refuse-derived fuel. After the year 2020, it was assumed that the total emissions of the chp plant would not be increased above the 2020 value. Therefore a higher demand has to be supplied by burning biological fuels, such as wood chips. The resulting fuel mix for the chp plant is depicted in Figure 5.8.

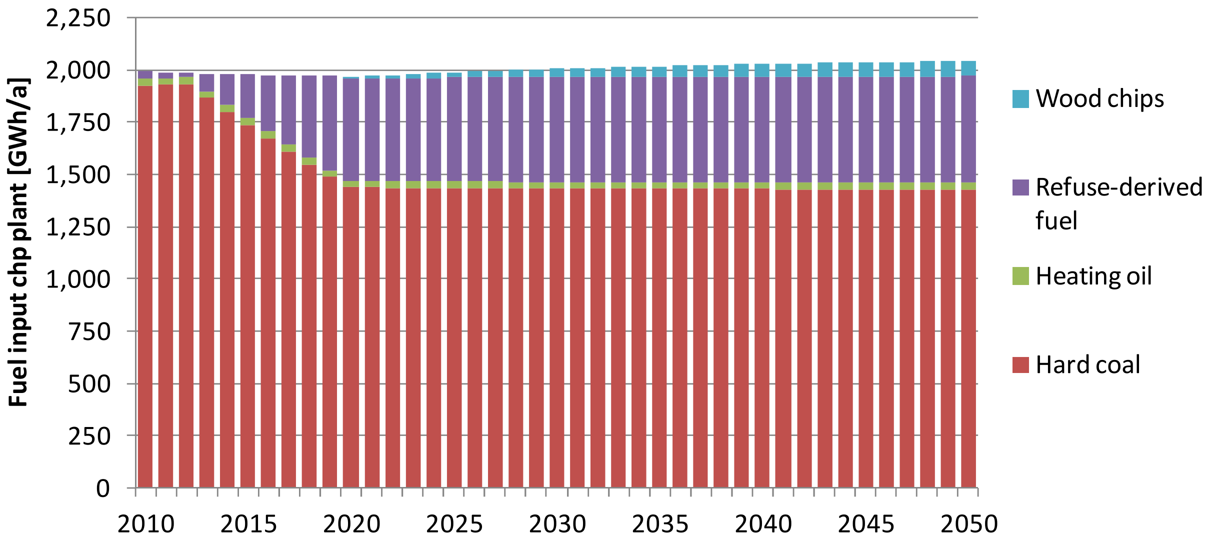


Figure 5.8: *Development of the fuel mix in the chp plant in Flensburg*

5.4.7 Results of the forecasting analysis

After analysing the forecasting development of the electricity, heat, and fuel demands for each individual sector, the total energy demand and CO_2eq-emissions in Flensburg were calculated and forecast for 2006 through 2050.

5.4.7.1 Development of energy demand

The energy demand of Flensburg for the years 1990 to 2050 is shown in Figure 5.9. In comparison to the year 1990, the energy demand will decrease by 11 % by the year 2050. The main share of the reduction is found in the industrial sector with a decrease of 27 %. The household and transport sectors will decrease by 12 % and 11 % respectively. The only sector with a growing energy demand is the commercial sector, with a total increase of 16 %.

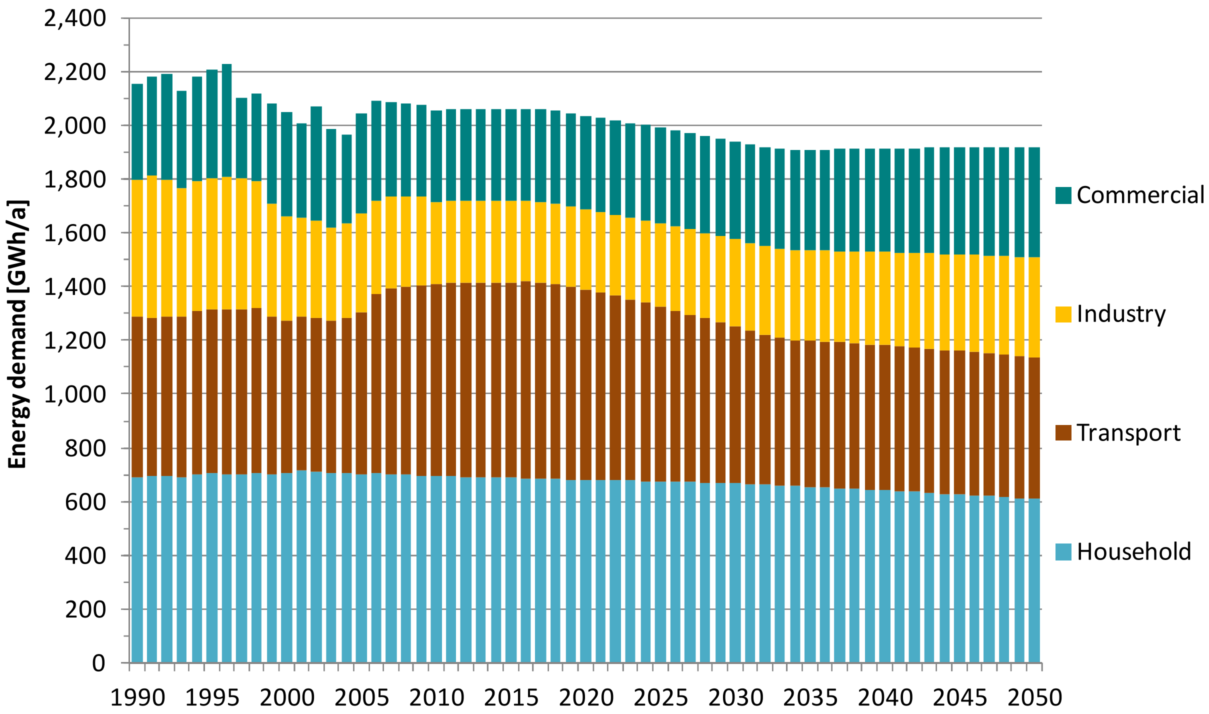


Figure 5.9: *Development of the energy demand as a result of the forecasting analysis*

5.4.7.2 Development of CO_2-emissions

The forecasting development of total CO_2eq-emissions in Flensburg is depicted in Figure 5.10. For comparison, the reduction target of Klimapakt Flensburg is included as a black line. The black line shows the necessary reduction of the emissions by 30 % in the year 2020, and 100 % in the year 2050, compared to the year 1990.

If business continues as usual, the CO_2eq-emissions in Flensburg will only be reduced by 20 % by the year 2050, in comparison to the year 1990. In 2050, 837,000 tCO_2eq will be emitted if no further climate protection measures are taken in Flensburg. The CO_2eq-emissions per capita will be decreased by 17 %, from 12.1 to 10.1 tCO_2eq per capita and year. The comparison of

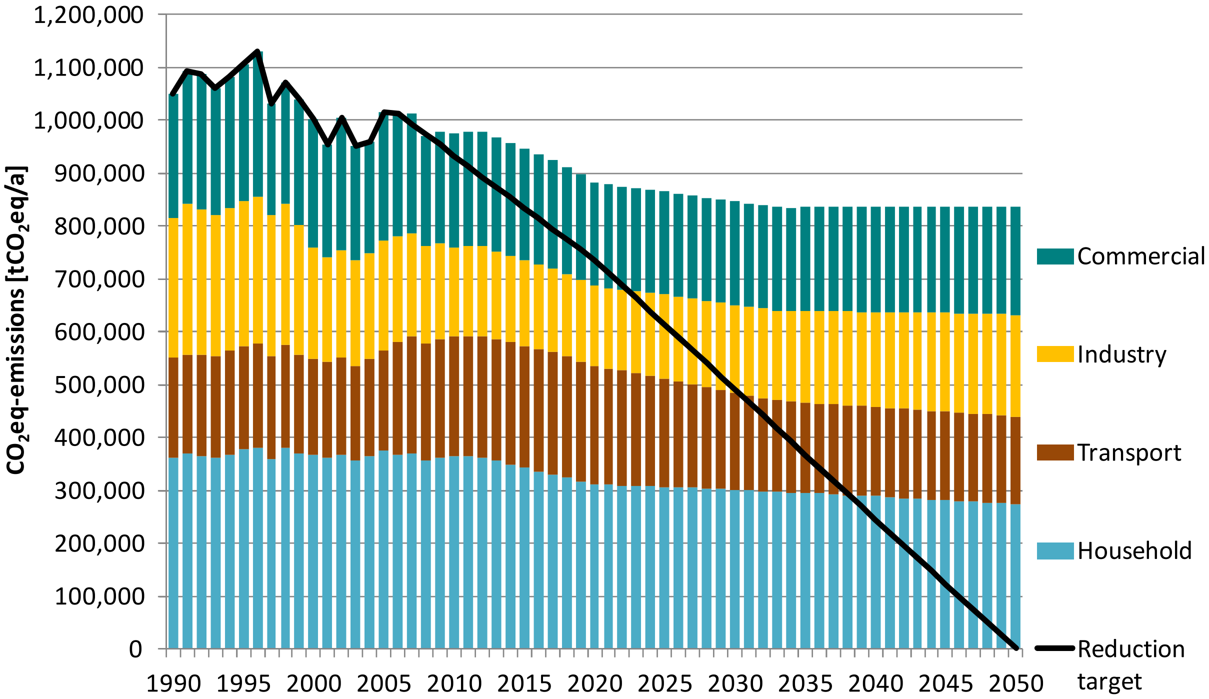


Figure 5.10: *Development of CO_2-emissions in Flensburg as a result of the forecasting analysis*

the results of the forecast scenario to the reduction targets shows that over 16 Mio. tCO_2eq will be emitted into the atmosphere over the time period of 2010 to 2050 if reduction targets are not met.

The results of the forecasting analysis illustrate that a continuation of given trends is, by far, not enough to achieve CO_2eq-neutrality by the year 2050. After an initial predicted reduction of CO_2eq-emissions between the year 2010 and 2020, mainly driven by the European Emission Trading Scheme, emissions will stay on a relatively constant level. Flensburg's reduction target of achieving CO_2eq-neutrality by the year 2050 will not be possible without major additional climate protection measures.

5.5 Step 5: Backcasting analysis

A climate protection concept for the city of Flensburg was developed using the participatory backcasting approach. In October 2010, the University of Flensburg officially began the development of an integrated climate protection concept for Flensburg. The German Federal Ministry of Environment (BMU), the city of Flensburg, and Klimapakt Flensburg funded the project. The timeframe was twelve months.

In the following section, first the methodology and stakeholder involvement will be introduced, followed by the defined climate protection measures with the resulting development of energy demand and CO_2eq-emissions. During the twelve month project, climate protection measures were defined in detail. Over one hundred climate protection measures were defined together with the stakeholders. Only the most important measures will be listed in the following sections. More information on the detailed concept development (including a list of all measures) can be found in the integrated climate protection concept of Flensburg (Hohmeyer et al. 2011). The concept is available in a short- (160 pages) and long-version (500 pages). The long-version contains the short-version, plus a detailed description of the process and the results from each individual workshop performed for the backcasting analysis.

5.5.1 Methodology and stakeholder involvement

The main objective of performing the backcasting analysis was to determine whether the goal of obtaining CO_2eq-neutrality is possible for the city of Flensburg by the year 2050. The general methodology introduced in Section 4.5 on page 125, was applied. The general methodology as it was applied in the case study is depicted in Figure 5.11, and will be described in detail in the following sections.

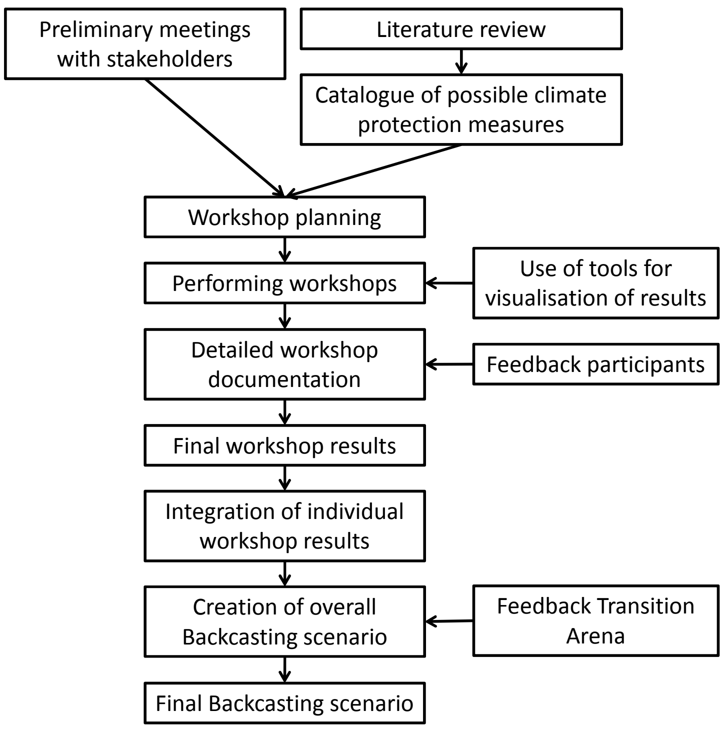


Figure 5.11: *Methodology used in Flensburg for the backcasting Analysis*

5.5.1.1 Literature review

A literature review on existing climate protection concepts for cities in Germany was performed before starting with the participatory backcasting analysis. The purpose of the literature review was to gain a broader understanding of the unique issues for climate protection in cities, and to develop a catalogue of possible climate protection measures. Over 30 climate protection concepts for cities were analysed and a list of over 1,000 climate protection measures was created. Out of the 1,000 climate protection measures, 300 were identified as applicable to the city of Flensburg. To reach the goal of CO_2eq-neutrality, the list of applicable climate protection measures needed to be specified to the situation in Flensburg, and additional, more specific, climate protection measures had to be developed. From the climate protection measures researched, those measures already applied or implemented in Flensburg were also identified and removed from the list.

5.5.1.2 Preliminary meetings with stakeholders

After the literature review and the creation of a list of possible climate protection measures, preliminary meetings with stakeholders were performed as a next step. Individual members of Klimapakt Flensburg and key players of the main companies and organisations in Flensburg were contacted. In these interviews, the main topics for workshops and the focus points of the individual workshops were identified. Also, a first discussion about possible and already applied climate protection measures was performed. The previously created list of possible climate protection measures was used during this process and further narrowed down, specified to the situation in Flensburg and also extended by additional climate protection measures. The preliminary meetings were also used to identify existing networks in Flensburg, which could also be utilised for the climate protection process. From a psychological point of view, the preliminary meetings helped to further the personal contacts and to gain a larger commitment of the stakeholders to the overall process.

5.5.1.3 Workshop planning

The three steps introduced in Section 4.5 on page 125 were followed to plan the workshops. These were (1) determining the number of workshops and their topics; (2) determining the target group for each workshop and (3) developing the agenda and time schedule for the workshops.

It should be pointed out that when planning a workshop in detail, there is a lot more to be considered than the aforementioned three steps. A very thorough introduction of how to conduct a workshop is provided by Rabinowitz (2013). In the following sections, the workshop planning procedure for the case study is described.

5.5.1.3.1 Determining the amount and topics of workshops Planning individual workshops is time consuming. Therefore in the beginning of the process, the number of workshops to be performed and the specific topics to be discussed were determined. The number of workshops was decided by the different individual topics that needed coverage, as well as the available human resources to prepare and perform the workshops. In total, 16 workshops were planned for the development of a detailed and widely agreed upon catalogue of climate protection measures for the city of Flensburg. The workshops were performed over a time period of six months; two to three workshops being held per month. The topics of the workshops were determined by their importance for CO_2eq-emission reduction and the complexity of the relevant sector. The following lists the individual workshop topics, in the order they were performed:

- Housing Association Workshop
- Energy Utility Workshop
- Public Transport Workshop
- Industry I Workshop
- Municipal Real Estate Workshop
- Finance Workshop
- Urban Development Workshop
- Motorised Individual Transport Workshop
- Public Workshop
- Future of District Heating Workshop
- Public Workshop for Transport
- District Workshop
- Commercial Workshop
- Industry II Workshop
- Implementation / Follow-Up Strategies Workshop
- Overarching Workshop

5.5.1.3.2 Determining target groups After deciding on the amount and topics of the workshops, the target groups for each event were determined. The chosen target groups for each workshop are listed below:

- Housing Association Workshop: housing associations, real estate companies, housing industry
- Energy Utility Workshop: local energy utility
- Public Transport Workshop: local and regional bus operators, city administration, transport planning companies
- Industry I Workshop: industrial companies
- Municipal Real Estate Workshop: city building administration, building administration of state and country buildings, hospitals
- Finance Workshop: financial sector, local banks, companies with green investment funds
- Urban Development Workshop: city planning, architects, housing associations, bus operators
- Motorised Individual Transport Workshop: city planning, driving schools
- Public Workshop: citizens
- Future of District Heating Workshop: Local energy utility and housing industry
- Public Workshop for Transport: citizens
- District Workshop: citizens, organisations and clubs from a specified district in Flensburg
- Commercial Workshop: commercial companies, (guild of) craftsmen, Chamber of Trade and Industry, supermarkets and malls
- Industry II Workshop: industrial companies
- Implementation / Follow-Up Strategies Workshop: members of Klimapakt Flensburg, marketing companies, adult education centre (VHS)
- Overarching Workshop: members of Klimapakt Flensburg

Depending on the workshop topic, the workshops were either designated as open workshops or invitation only workshops. For the open workshops (Public Workshop, Public Workshop for Transport, and District Workshop) all citizens of Flensburg were invited to participate. For the other workshops, invitations were sent out to a specified group of people. For the invitation only workshop the target was to have between nine to twelve people participating. For the open workshops, no limitation on the number of participants was set. The number of participants for each workshop during the backcasting analysis is listed in Table 5.27. In addition, nine people from Klimapakt Flensburg took part in a Kick-Off-Workshop, which was held in September 2010.

Table 5.27: *Workshops carried out during the backcasting analysis*

Date	Workshop	Participants
09.02.2011	Housing Association Workshop	10
03.03.2011	Energy Utility Workshop	9
18.03.2011	Public Transport Workshop	8
22.03.2011	Industry I Workshop	11
31.03.2011	Municipal Real Estate Workshop	9
15.04.2011	Finance I+II Workshop	10 + 13
11.05.2011	Urban Development Workshop	10
18.05.2011	Motorised Individual Transport Workshop	8
21.05.2011	Public Workshop	19
16.06.2011	Future of District Heating Workshop	12
18.06.2011	Public Workshop for Transport	18
30.06.2011	District Workshop	9
01.07.2011	Commercial Workshop	4
20.07.2011	Industry II Workshop	10
26.07.2011	Implementation / Follow-Up Strategies Workshop	11
04.08.2011	Overarching Workshop	16

Over 185 people participated in the 16 workshops. Beside private citizens, representatives from companies and organisations attended the workshops. In the following, the participating stakeholders are listed. The first 15 are members of Klimapakt Flensburg. In one year, it was possible to include over 50 local companies, organisations, clubs, and institutions in the process.

- Klimapakt Flensburg:
  - Aktiv Bus GmbH
  - Allgemeine Flensburger Autobusgesellschaft GmbH
  - Ev.-Luth. Diakonissenanstalt Flensburg
  - Fachhochschule Flensburg
  - FFG Flensburger Fahrzeugbaugesellschaft mbH
  - Flensburger Arbeiter-Bauverein e. G.
  - Industrie- und Handelskammer zu Flensburg
  - Kreishandwerkerschaft Flensburg Stadt und Land
  - Malteser Krankenhaus St. Franziskus-Hospital gGmbH
  - Nord-Ostsee Sparkasse
  - Selbsthilfe-Bauverein e. G. Flensburg
  - Stadt Flensburg
  - Stadtwerke Flensburg GmbH
  - Technisches Betriebszentrum Flensburg

  - Universität Flensburg
- Other local stakeholders:
  - Abfallwirtschaftszentrum Flensburg GmbH
  - Arbeitsgemeinschaft schleswig-holsteinischer Wohnungsunternehmen e.V. (ASHW)
  - Arbeitskreis Flensburg Nord
  - Autokraft
  - B.A.U.M. Zukunftsfonds eG
  - Bequa Flensburg
  - Büro Oeding
  - Büro Urbanus
  - CITTI
  - Danfoss Silicon Power GmbH
  - Densch & Schmidt
  - Fahrschule Simonsen
  - Feddersen Ökologische Kapitalanlagen
  - Flensburger Schiffbau Gesellschaft
  - Flensburger Brauerei Emil Petersen GmbH & Co KG
  - Gebäudemanagement Schleswig-Holstein
  - Haus & Grund Flensburg
  - IHR Sanierungsträger FGS mbH
  - Ing.-Büro Energieberatung
  - Krones AG
  - KWKon Kraft-Wärme-Konzepte GmbH
  - Mitsubishi HiTec Paper Europe GmbH
  - Mittelstraß GmbH
  - oeko planfinanz GmbH
  - Otis - Outdoortrainings und Indoorseminare
  - Queisser Pharma GmbH & Co KG
  - Raiffeisen HaGe Nord AG
  - Seniorenbeirat Flensburg
  - Sportpiraten
  - Verband norddeutscher Wohnungsunternehmen e.V.
  - Verbraucherzentrale Flensburg
  - Verein Flensburger Norden
  - Volkshochschule Flensburg
  - VR Bank Flensburg-Schleswig eG

5.5.1.3.3 Developing the agenda and time schedule for the workshops The workshops were moderated and coordinated by either the author of this thesis, or another scientific researcher at the University of Flensburg. The moderator of the workshops developed the agenda and time schedule for each workshop. The information gained from the literature review of other climate protection concepts and the preliminary meetings with stakeholders were integrated into the workshop planning. Most workshops were scheduled for an entire day, beginning at nine a.m. and ending between four and five p.m.. Even though the workshop topics were highly individual, a general agenda was followed by the moderators. The general agenda used is provided below:

- Introduction
  - Aim and time schedule of the workshop
  - Introduction round of the participants
  - Presentation of results from status quo and forecasting analyses
  - Explanation of the importance of the topic / sector for climate protection
- Participatory development of climate protection measures
  - Reduction in demand
  - Increase in energy efficiency
  - Substitution of fossil fuels
- Discussion of concrete steps for follow up including monitoring and controlling
- Summary of the results

Each workshop consisted of four parts. Each workshop began with an introduction. After explaining the aim and time schedule of the workshop, the stakeholders were asked to introduce themselves in an introductory round. Having an introductory round had the advantage that the stakeholders got to know each other and initial relationships were established. After the introductory round, the results of the status quo and forecasting analyses were presented. In addition, the importance of the workshop in the context of local climate protection was explained.

In the second part, climate protection measures were developed with the stakeholders. In general, climate protection measures were developed for the following categories respectively: (1) reducing the energy demand; (2) increasing energy efficiency and (3) the substitution of fossil fuel. The workshops were planned in such a way that stakeholders worked mainly on identifying measures in their own sphere to reduce energy demand and CO_2eq-emissions. This method kept the focus on developing individual solutions rather than on "blaming" others.

The specific methodology used for each workshop (e.g. group work, presentation, discussion group, working with tools, etc.) varied depending on the topic and the attendee number. The general set-up and physical layout of the workshop room was also dependent on these factors. The goal of an optimal workshop set-up was to create an effective working environment.

After the development of climate protection measures, an open discussion on a suitable follow-up agenda with concrete steps was carried out. The amount and type of data, and time intervals for submitting data to be monitored and controlled were also agreed upon during the discussion. At the end of the workshop the results were summarised by the moderator for the stakeholders.

5.5.1.4 Performing workshops

During a workshop, the measures applicable to the city of Flensburg, and the particular share of CO_2eq-emissions that stakeholders are able to reduce, were discussed with the workshop attendees. The knowledge and the experience of the stakeholders was used to develop a climate protection concept with the best possible specific solutions for the city.

Climate protection measures were created beginning with the years that were the closest to the present date. For each intermediate year, climate protection measures were identified, discussed, and quantified. In different development rounds, as introduced in Figure 4.9 on page 129, the optimal pathway, according to the workshop participants, to achieve the long-term objectives was developed. The result of each development round was visualised during the workshop.

One of the most important and very unique features of most workshops was the visualisation of intermediate results during the workshops, using specially developed tools. The tools were developed in Microsoft Office Excel and aided the visualisation of the effects of implementation of measures for different sectors. The tools either showed the development of the energy demand, the CO_2eq-emissions, or both, for the particular sector. Using the tools helped the stakeholders' understanding of the magnitude of measures that are necessary to achieve the targets, and to identify potential bottlenecks. For the development of the tools, the previous knowledge gained from the literature review of other climate protection concepts and the preliminary meetings with the stakeholders were used. The tools were designed so that measures discussed during the workshop could be included immediately in the tool, and the resulting reduction in energy demand and CO_2eq-emissions were then shown on a time-line. It helped not only to quantify effects of climate protection measures and to place them time-wise, but also to show the stakeholders the interrelation of different measures. During the backcasting analysis it was found that the use of tools provided a key instrument for the quantification of effects. Because these tools were able to produce visual aides, it became immediately clear to the stakeholders whether the defined measures where sufficient enough to fulfil the given reduction targets or if additional measures were necessary.

The use of tools during the workshops increased the stakeholders motivation (goal setting theory), increased the transparency of the process (calculations were made right away instead of later on), increased the clearness about the effect / quantification of climate protection measures, enabled direct feedback to the stakeholders about whether or not the measures were sufficient, and finally, encouraged the examination of the objectives.

5.5.1.5 Workshop documentation and feedback loop

For each workshop, a detailed workshop documentation was created. During the workshops a researcher from the University of Flensburg was assigned to take the minutes. Thorough documentations of the workshops were created, which included the results from the tools and the workshop presentations. The documentations were then sent to the workshop attendees for feedback. After the feedback round, the results of the workshops were finalised.

In addition, workshop participants were asked to fill out a feedback form at the end of each workshop. The feedback form contained questions about the usefulness of the performed workshops, how satisfied the participants were with the workshop results, and if they would continue to participate in the process of local climate protection in the future.

The feedback from the workshop participants was positive and commitments for future collaborations for the implementation and further development of climate protection measures were achieved. The positive feedback from the workshop participants confirmed that carrying out participatory workshops was the right approach for developing climate protection measures for the city of Flensburg. Ninety percent of the participants were “happy or very happy” with the quality of the workshops. Over 97 % of the participants checked on the feedback form that the workshops were useful or very useful towards the long-term goal of achieving CO_2eq-neutrality for the city of Flensburg (Figure 5.12 on page 184).

The success of the implementation of the climate protection measures will largely depend on the continuation of involving decision makers in the process. Almost all workshop participants want to be active in the implementation phase (Figure 5.13 on page 5.13).

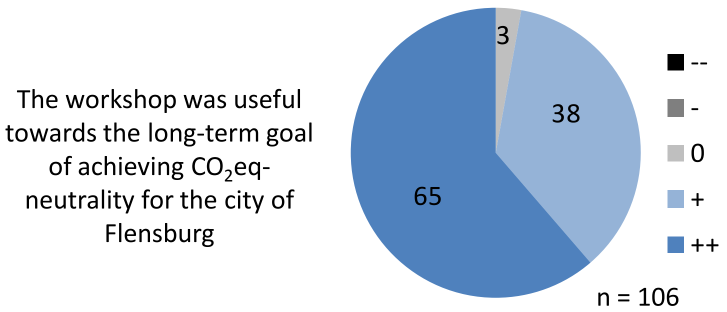


Figure 5.12: *Evaluation of the workshops by the participants*

The positive feedback from the workshops and the workshop documentations showed that the chosen approach with the newly developed methodology was well received by the stakeholders and the citizens.

5.5.1.6 Integration of individual workshop results

The integration of individual workshop results into one holistic climate protection concept was a continuous task. Once a workshop was performed and the results finalised, the information was used to adjust the content of the workshops to follow. The integration of results can be understood as an evolutionary process developing further with every workshop. The immediate integration of results facilitated the identification of possible synergies between the different sectors. One example would be the Housing Association Workshop. The results of this workshop influenced the development of climate protection measures for the Energy Utility Workshop, Municipal Real Estate Workshop, Finance Workshop, Urban Development Workshop, and Public Workshop.

In addition to the continuous integration of results, a final overall integration was done once all topic specific workshops were completed. The results were presented and discussed in a

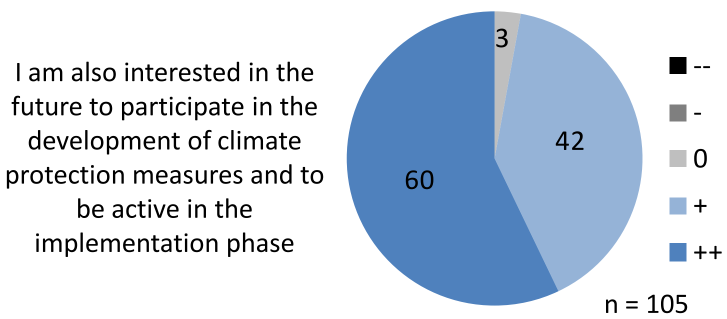


Figure 5.13: *Willingness of future participation in the process of the workshop participants*

final workshop, the Overarching Workshop. Workshop participants for this workshop were the members of Klimapakt Flensburg.

5.5.1.7 Creation of an overall backcasting scenario

After the last workshop, final adjustments were made and an overall final backcasting scenario was created. The developed backcasting scenario shows when and to what extent climate protection measure must be applied for all city branches and sectors. The results of the backcasting analysis are presented in the following sections, where first the results are presented for each city sector and afterwards the results for the entire city are presented.

5.5.2 Household sector

According to the results of the status quo analysis, the household sector of Flensburg, with its 48,000 households and 90,000 residents, is responsible for the use of one third of Flensburg's total energy demand and CO_2eq-emissions. The characteristic structure of households was considered when developing climate protection measures for this sector. In Flensburg, 37 % of the households are single-households (BulwienGesa 2011, p. 23). The high share of single-households is an indicator for higher per capita living area, which is, in general, linked to higher total energy demand (Hautzinger and Pfeiffer 1996, p. 57).

Five workshops were held to cover the most important energy- and emission-related aspects of the household sector. The titles of the workshops held are listed below:

- Housing Association Workshop
- Energy Utility Workshop
- Future of District Heating Workshop
- Public Workshop
- District Workshop

5.5.2.1 Climate protection measures

The Housing Association Workshop, Energy Utility Workshop, and Future of District Heating Workshop focused on the heat demand of the households. Those workshops were stakeholder workshops with formal invitations. Whereas the Public Workshop and the District Workshop were focusing on heat and electricity demand and were open to the public.

For a reduction of electricity demand in the household sector, potentials were defined for the categories of television, sound systems, video systems, personal computers, warm water, dish washers, clothes dryers, washing machines, electric stoves, freezers, refrigerators, and other household appliances. Together with the participants of the Public Workshop and the District Workshop, potentials for electricity demand reduction were discussed. Furthermore, studies on the technological development and electricity reduction potentials of households were reviewed and incorporated. The results are listed in Table 5.28 and depicted in Figure 5.14 on page 188, and are mainly due to increasing energy efficiency for the appliances. The reduction of warm water is mainly due to a switch from electric water heating to district water heating. It is assumed that LED lighting technology is becoming a standard in households by the year 2050, allowing for the highest energy reduction potential with 87 %. By the year 2050 a decrease of electricity demand by 45 % is assumed. Further information can be found in the Climate Protection Concept of Flensburg (cp. Hohmeyer et al. 2011).

Table 5.28: *Measures for electricity demand reduction in the household sector*

Measure	Percentage energy reduction in that section
(1) Others	32% by 2050
(2) TV, Audio, Video, PC	47% by 2050
(3) Warm water	48% by 2050
(4) Dish washer	33% by 2050
(5) Clothes dryer	41% by 2050
(6) Washing machine	45% by 2050
(7) Electric stove	38% by 2050
(8) Freezer	55% by 2050
(9) Refrigerator	53% by 2050
(10) Lighting	87% by 2050

The main measures for the reduction of heat demand in the household sector are listed in Table 5.29. The two main measures for the reduction of heat demands are the increase in the renovation rate and increase in renovation energy standards. The implementation of the measures will be carried-out continuously. These measures were mainly developed in the three workshops with the stakeholders. In addition to the information provided in Table 5.29, cost calculations for the implementation of measures were made and can be found in the Climate Protection Concept of Flensburg (cp. Hohmeyer et al. 2011).

Table 5.29: *Measures for heat demand reduction in the household sector*

Measure	Energy reduction potential
(1) Increase of renovation energy standard (insulation of top floor ceiling, roof insulation, external wall insulation, window replacement, air conditioning with heat recovery, insulation of the cellar ceiling)	30 % of district heating demand
(2) Increase of renovation rate	10 % of district heating demand
(3) Lower return temperatures for district heating	5 % of district heat demand
(4) Substitution of electric water heater by district water heater	Potential unclear

During the Housing Association Workshop and Future of District Heating Workshop it was discussed with the stakeholders which energy standards can be achieved for different construction year categories and new buildings. The results of the discussions are shown in Table 5.30. The stakeholders agreed that a realistic specific heat demand for new buildings is zero kWh/m^2, by the year 2050. Air conditioning with heat recovery will also become standard for building refurbishment. For the energy standard of building refurbishment, the stakeholder defined the measure of reducing the energy refurbishment standard by 1 kWh/m^{2}a each year, starting in the year 2020. Buildings with a construction year category of before 1949 should achieve specific heat demands of 91 kWh/m^{2}a.

Table 5.30: *Achievable energy standards for different construction year categories*

Energy standard [kWh/m^2]	by 2009	2009 -2014	2015 -2019	2020 -2029	2030 -2039	2040 -2050
Before 1949	130	91	91	91	91	91
1949 - 2008	130	91	60	50	40	30
New buildings (2009 - 2050)		70	40	20	10	0

The renovation rate of buildings indicates in percentage how many buildings of the building stock are renovated each year. The higher a renovation rate is, the more buildings are being energy-wise refurbished every year. With each energy-wise renovation, the energy demand and therefore also the CO_2eq-emissions of the building stock are being reduced. In 2012, the renovation rate in Germany as a whole was 1.1 %. For climate protection in Flensburg, an increase in the renovation rate to a maximum of 2 % over a certain time is seen as a realistic target by the stakeholders. The results of the future renovation rate for the households in Flensburg is shown in Table 5.31.

Table 5.31: *Achievable renovation rates for buildings*

	Historic	2009 -2014	2015 -2019	2020 -2029	2030 -2039	2040 -2050
Renovation rate	1,10 %	2,0 %	2,0 %	1,5 %	1,4 %	1,2 %

5.5.2.2 Development of energy demand

In this section, the results from the five workshops for the household sector are presented. Due to the different characteristics of the heat and electricity demand, the two sets of data are depicted as separate figures. The electricity demand can be found in Figure 5.14, whereas the heat demand is shown in Figure 5.15 for different construction year categories.

The electricity demand of the household sector has the potential to be reduced by 45 % by the year 2050 in comparison to the year 2010. It decreases from a value of 152,000 MWh per year to 84,000 MWh per year.

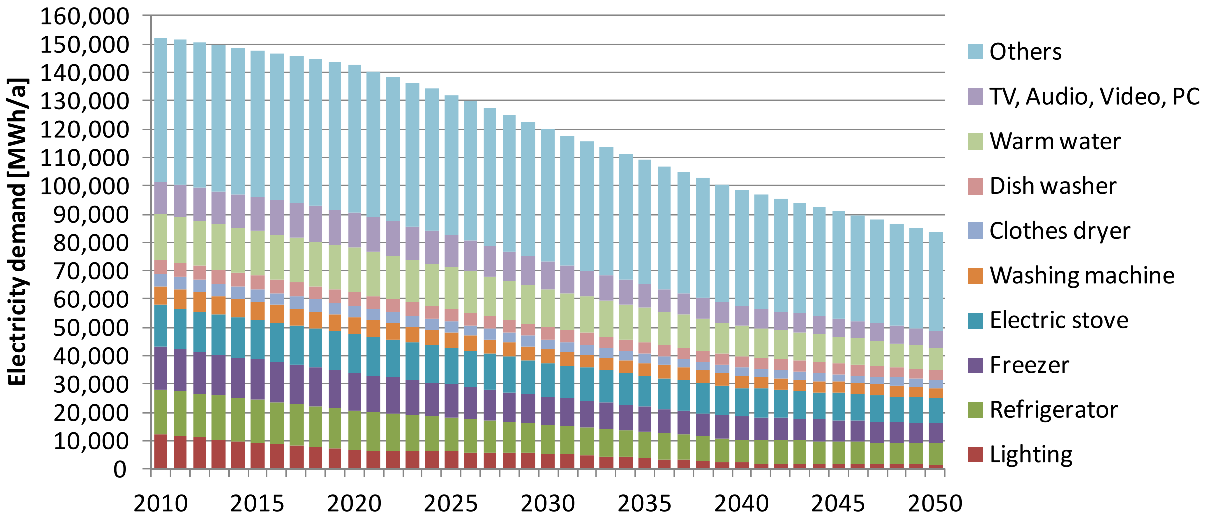


Figure 5.14: *Development of electricity demand in the household sector*

The heat demand of the household sector can be reduced by 37 % by the year 2050 in comparison to the year 2010. In total, this is a reduction from 536,000 MWh per year down to 339,000 MWh per year.

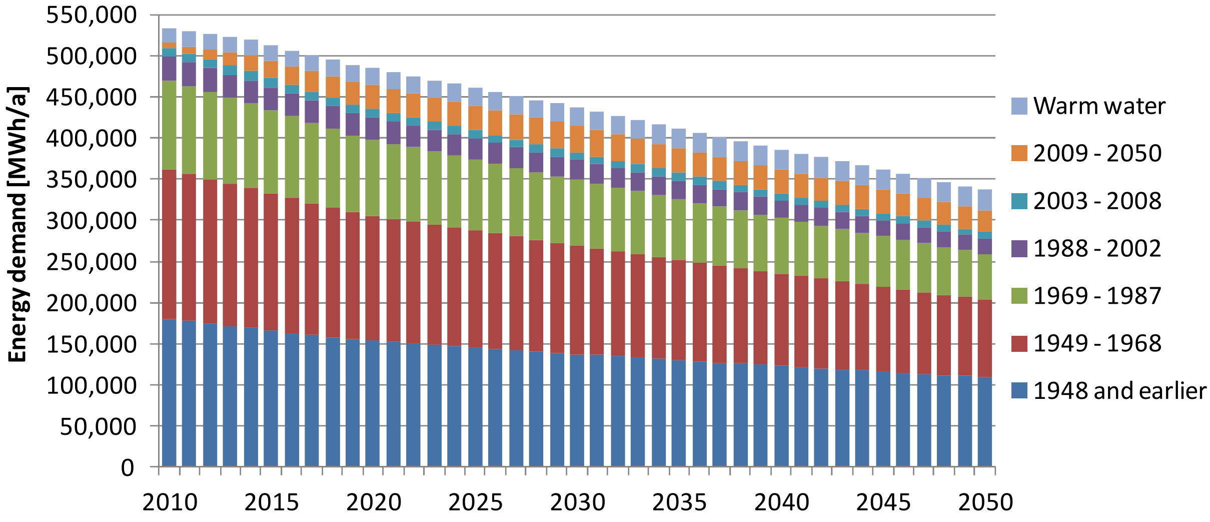


Figure 5.15: *Development of heat demand in the household sector*

5.5.3 Commercial sector

The commercial sector consists of a large number of individual stakeholders and is very heterogeneous. It includes commerce, craftsmen, services, trading, logistic companies, and public buildings. Depending on the type and size of the business, the energy demand can vary largely. For the development of climate protection measures for this sector, the commercial sector was divided into manageable categories. These categories are the industry-like, household-like, as well as trading and logistic companies. Climate protection measures already defined for the household and industrial sectors were then reviewed to see which ones could already be applied to the specific categories of the commercial sector.

Two workshops were performed for the commercial sector. The first workshop was focusing on the commercial sector in Flensburg as a whole. The second workshop was addressing in particular the public buildings in Flensburg. During the workshops a detailed catalogue of climate protection measures for the commercial sector was developed. Together with the stakeholders it was discussed how the electricity and heat demand can be reduced and how CO_2eq-neutral ways of energy production can be included.

5.5.3.1 Climate protection measures

Energy reduction potentials for cross-sectional technologies such as electric drives, cooling and air-conditioning, lighting, compressed air, and low and high level temperature were defined during the workshop. A differentiation between short-, mid-, and long-term potentials was made. The defined measures can be found in detail in the Climate Protection Concept of Flensburg (cp. Hohmeyer et al. 2011).

In Table 5.32, measures are listed. The percentage shows the estimation of the workshop's participants regarding the possible reduction in relation to the total energy demand of that cross-sectional technology. All measures are planned to be implemented continuously over the entire time-span from 2012 to 2050. The stakeholders decided that measures that apply specifically to companies will be implemented in companies when it is economic to do so. Measures that are believed not to be economic were not considered and thus not included in the list.

Table 5.32: *Measures defined for the commercial sector and their energy reduction potential in percentage of the actual energy demand for that cross-sectional technology*

Measure	Percentage energy reduction in that section
(1) Lighting	60 % by 2050
(2) Electric drives	75 % by 2050
(3) Process heat	10 % by 2050
(4) Air conditioning	0 % by 2050
(5) Communication	10 % by 2050
(6) Electric room and water heating	15 % by 2050
(7) Building refurbishment	24 % by 2050
(8) Other heat conservation measures	11 % by 2050

The achievement of CO_2eq-neutrality also depends on the usage of non-fossil energy sources. Before the workshop, the technical potential for the instalment of PV units on company rooftops was analysed. During the course of the workshop, the possibility and likeliness of PV-cell installation was discussed. It was assumed by the workshop participants that in the year 2050, 400 MWh per year of electricity would be produced by PV-cells. This is less than 1 % of the electricity demand of the commercial sector.

5.5.3.2 Development of energy demand

The development of the electricity demand for the commercial sector is depicted in Figure 5.16. The columns provide information about the share of the different cross-sectional technologies in the total electricity demand. For the identification of the reduction potentials, the development of the economic growth and its effect on energy demand were not initially taken into account. Therefore the columns show the potentials without the effects of economic growth. During the workshops, in a second step, the economic growth was included (1.45 % economic growth per year). The black line in Figure 5.16 shows the development of the electricity demand, taking the economic growth into account. A decrease of electricity demand by 30 % by the year 2050 is seen as a realistic target. This is mainly due to the strong reduction of electricity for lighting purposes, which will be achieved by using LED-technology.

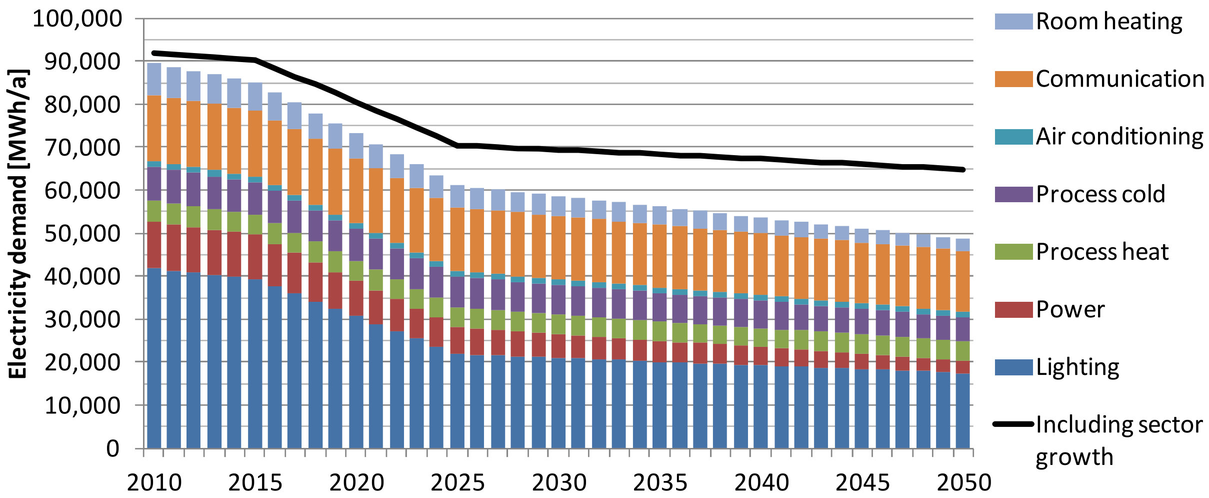


Figure 5.16: *Development of electricity demand in the commercial sector*

The expected development of the heat demand in the commercial sector is depicted in Figure 5.17. When the defined measures are applied, the district heat demand of the companies will decrease by 25 % by the year 2050.

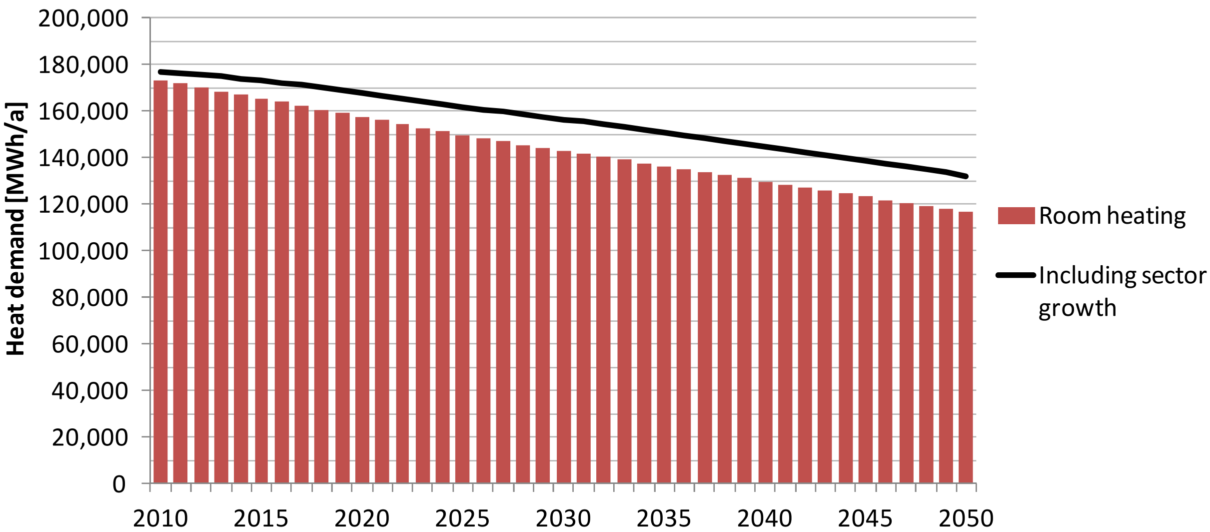


Figure 5.17: *Development of heat demand in the commercial sector*

5.5.4 Industry sector

The industrial sector is the only sector in Flensburg where fossil fuels, such as natural gas and heating oil, are used in large amounts for supplying heat and electricity. In contrast to the household and commercial sectors, the achievement of CO_2eq-neutrality is only possible when, in addition to a CO_2eq-neutral district heating, the fossil fuels can be substituted by renewable energy sources.

It is particularly crucial for the industrial sector that special attention is paid to the economic requirements of the companies. If companies are not competitive in the short-term, the chance is high that they will not survive in the long-term. It was found that only climate protection measures with a payback period of less than three years are realistic for implementation. Due to the complex nature of the industrial sector, with each company having specific requirements, company-specific climate protection measures were developed during the two workshops held for this sector. Prior to the workshops, interviews with the involved companies were performed and possible measures were identified. The seven largest companies in Flensburg took part in the development of the climate protection concept and included:

- Danfoss Silicon Power GmbH
- Flensburger Brauerei Emil Petersen GmbH & Co. KG
- Flensburger Fahrzeugbau Gesellschaft mbH
- Flensburger Schiffbau-Gesellschaft mbH & Co. KG
- Hauptgenossenschaft Nord AG
- Krones AG
- Mitsubishi HiTec Paper Europe GmbH

The listed companies are responsible for 81 % of the total electricity and 88 % of the total heat demand in the industrial sector. Therefore, the developed measures for those seven companies present a very good proxy for the entire sector. Together with the workshop participants, short-, mid-, and long-term measures for energy reduction were defined. Afterwards the possibilities for using CO_2eq-neutral energy sources were analysed.

5.5.4.1 Climate protection measures

Climate protection measures were first defined for the short-term (until 2015) and afterwards long-term measures (until 2050) were discussed. Together with the stakeholders, a variety of measures for energy demand reduction were identified. Following the approach taken for the commercial sector, measures were structured according to the cross-sectional technologies electric drives, air conditioning and cooling, lighting, compressed air, and low- and high-temperature heat. Table 5.33 lists the main measures for the industrial sector. The implementation of the measures will be carried-out continuously. Detailed information about the measures for this sector can be found in the Climate Protection Concept of Flensburg (cp. Hohmeyer et al. 2011).

Table 5.33: *Measures defined for the industrial sector and their energy reduction potential in percentage of the actual energy demand for that cross-sectional technology*

Measure	Percentage energy reduction in that section
(1) Electric drives	25 % by 2050
(2) Air conditioning and cooling	30 % by 2050
(3) Lighting	50 % by 2050
(4) Compressed air	30 % by 2050
(5) Low temperature heat (< 100 °C)	25 % by 2050
(6) High temperature heat (> 100 °C)	15 % by 2050

In addition to the district heating and electricity supply from the local energy utility, industry in Flensburg also uses fossil fuels. To obtain the goal of CO_2eq-neutrality by the year 2050, measures were defined, together with the companies from this sector, for substituting fossil fuels with renewable energies. One possibility that was discussed was the installation of PV cells on the rooftops of the company buildings. Prior to the workshops, an analysis of the technical potential for PV cells instalment was performed. Based on the analysis of the technical potential for PV cells instalment, a photovoltaic electricity production of 3,600 MWh per year in the year 2050 was estimated by the workshop participants.

Two of the industrial companies in Flensburg use natural gas. During the workshop it was agreed that, in this case, natural gas should be substituted with CO_2eq-neutral energy sources, such as bio-methane. A switch from natural gas to bio-methane has the large advantage that the existing infrastructure can be maintained. According to the workshop results, natural gas will be completely substituted by bio-methane by 2050. In the year 2025, 18 %, and in 2035, 55 % of the gas supply will be bio-methane. In the case of companies using heating oil, a switch to wood chips was agreed upon during the workshop.

5.5.4.2 Development of energy demand

In Figure 5.18, the electricity demand of the participating companies representing 81 % of the total electricity demand of the sector is shown. In the initial defining of climate protection measures, the development of the economic growth and its effects on the energy demand was not considered. In a second step, the economic growth of the sector with a defined 0.93 % from the forecasting analysis was included. Together with the stakeholders, the effect of the economic growth on the energy demand was determined. The black line in Figure 5.18 shows the electricity demand from 2010 to 2050, including the economic growth. The electricity demand will decrease by 10 % by the year 2050.

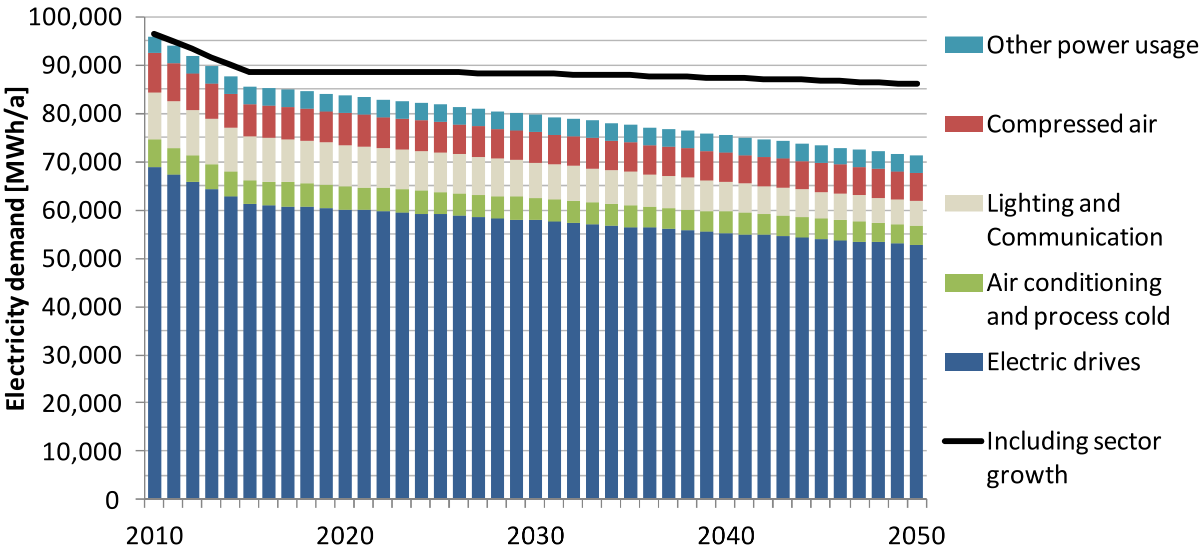


Figure 5.18: *Development of electricity demand in the industrial sector*

The heat demand for the industrial sector of Flensburg is mainly driven by high-temperature requirements in the form of steam or process heat at a temperature above 100 °C. High temperature heat cannot be supplied by district heating. The development of the heat demand is depicted in Figure 5.19. The measures for heat demand reduction compensate for the additional demand due to economic growth.

5.5.5 Transport sector

Three workshops were held in order to carry out the participatory backcasting analysis for the transport sector. The first workshop (Public Transport Workshop) was a stakeholder-workshop with the focus on public transport. The second workshop, titled Motorised Individual Transport

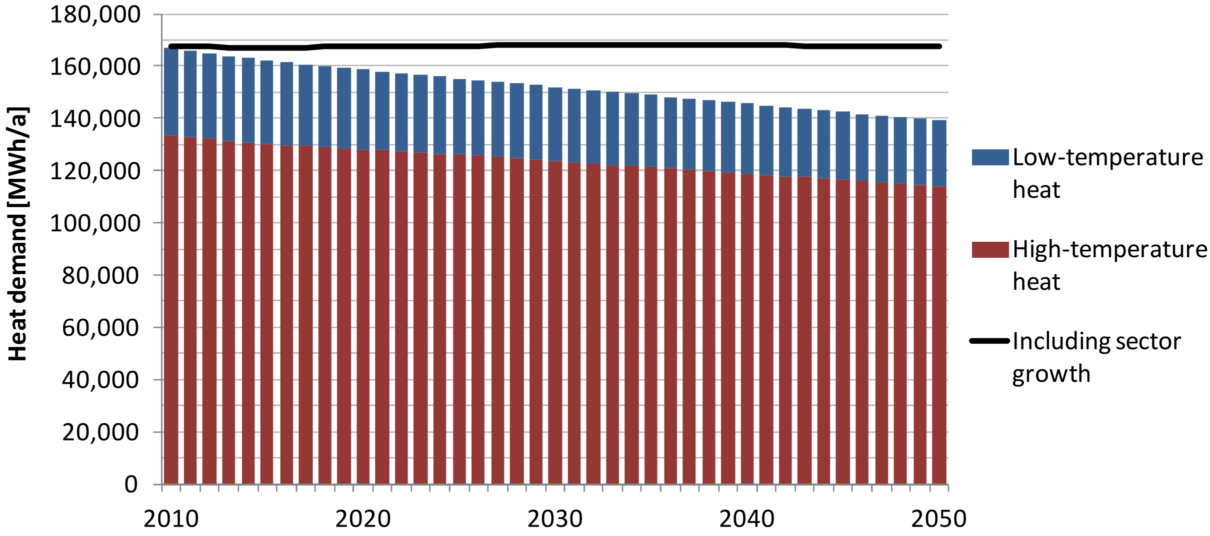


Figure 5.19: *Development of low and high temperature heat demand in the industrial sector*

Workshop, focused on individual transport and the third workshop, titled Public Workshop for Transport, on public transport. Both workshops were open to the public. It is especially the case in the transport sector, that the realisation of fuel and CO_2eq-emission reduction potentials largely depends on the behaviour of the people and availability of green options. Due to the tight interconnection of the different modes of transport, climate protection measures need to be implemented as packages.

During the workshops six preconditions valid for all transport modes have been identified for obtaining CO_2eq-neutrality. These are:

- An attractive inter-urban public transport, due to the circumstance that only 35 % of the annual car mileage is inner-city traffic (ifeu 2010, p. 28)
- A good local public transport system
- An attractive environment for cyclists, including good bike infrastructure
- Attractive conditions for pedestrians
- Establishment of car-sharing
- Mobility management on the municipality, company, and city district level

5.5.5.1 Climate protection measures

Climate protection measures will be described first for public and then individual transport. All measures were developed during the workshops together with the stakeholders of the city.

The implementation of the measures will be carried-out continuously. Detailed information about the measures for the transport sector can be found in the Climate Protection Concept of Flensburg (cp. Hohmeyer et al. 2011).

5.5.5.1.1 Public transport Public transport accounts for 0.5 % of the total CO_2eq-emissions in Flensburg. However, the potential for CO_2eq-emission reduction is significantly higher. The main potential lies in the possibility of a modal shift from individual motorised transport to public transport, resulting in a CO_2eq-emission reduction of individual motorised transport. The measures for climate protection therefore can be split into two categories: (1) the increase of users of public transport and (2) the substitution of fossil fuel usage. During the workshop entitled Public Transport, it was determined that the modal split should be doubled from 10 % to 20 % of the inner-city traffic. The improvement of the combination of bicycles and buses is estimated to increase the bike traffic from 19 % to 20 %. Also the bus routes, the frequency, new transfer points, tariffs, operation hours will be improved over time beginning with the implementation of the first measures in 2012. A dynamic electronic passenger information system will be launched in 2015.

For the achievement of CO_2eq-neutrality, emissions from public transport need to be reduced to zero. CO_2eq-neutral public transport has the additional benefit of helping to raise awareness and strengthen the city's green image. A first step for emission reduction is the use of more efficient technology. Using newly developed lightweight buses reduces the fuel consumption. Diesel-electric operation of buses with the option of contact line operation should be used starting in 2016. Later, the complete switch from diesel-run buses to purely electric operation in combination with contact line has to be made. The contact lines will be located at the bus stops for recharge.

5.5.5.1.2 Individual transport In contrast to public transport, individual motorised transport consumes a large share of the total energy demand in Flensburg (24 %). Priority is given to measures that promote a modal-split change towards green modes of transportation. The residual individual transport will have to undergo a major transformation of the applied technology. At the time of the workshop, electric cars seemed most promising. A precondition for electric cars is that the energy will be provided from a CO_2eq-neutral source. An electric car running on power from a fossil fuel power plant is not a solution for a sustainable development; it would be only a reallocation of emissions.

For the calculation of energy demand and CO_2eq-emission reduction, the electricity demand of an electric car is assumed to have a value of 15 kWh per 100 km. Prioritising the model-split change, the participants of the workshop estimated that 57,000 people in Flensburg will change their choice of transport in a way that will reduce their annual vehicular mileage to 10,000 km. Furthermore it is assumed that approximately one third of the total population will dramatically change their modal split, driving cars for only 2,200 km per year. This can only be achieved with an effective car-sharing offer, in combination with an efficient public transport system, including well-developed and safe pedestrian and bicycle ways. Following these measures, the additional electricity need for electric cars will be 98 GWh in the year 2050, which accounts for 9 % of the total energy demand in that year.

All measures were developed during the workshops and also relative costs were identified. An overview of measures for individual transport is found in Table 5.34. Detailed information is provided in the Climate Protection Concept of Flensburg (Hohmeyer et al. 2011).

Table 5.34: *Measure defined for individual transport*

Measure	Implementation
(1) Improvement of bus operation	Starting 2012
(2) Mobility education in secondary school	2012 - 2050
(3) Car sharing trial offers for novice drivers	As soon as car sharing is established
(4) New citizens campaigns	2012 - 2050
(5) Trial offers for bike equipment	2012 - 2050
(6) Delivery service	2012 - 2050
(7) Corporate mobility management	2012 - 2050
(8) Bike station at central train station	2012 - 2050
(9) Co-operative grocery store in cities districts	2012 - 2050

5.5.5.2 Development of energy demand

Figure 5.20 depicts the energy demand of the transport sector over time. The results of the workshop concluded that individual and public transport will become electric. This allows for significant reduction of the energy demand. The freight road transport is assumed to use sustainable bio-diesel. Figure 5.20 shows the energy demand for electric cars, electric public transport, petrol, diesel, and bio-diesel. An overall reduction of energy demand by 62 % from 2010 to 2050 is achievable when these measures are implemented.

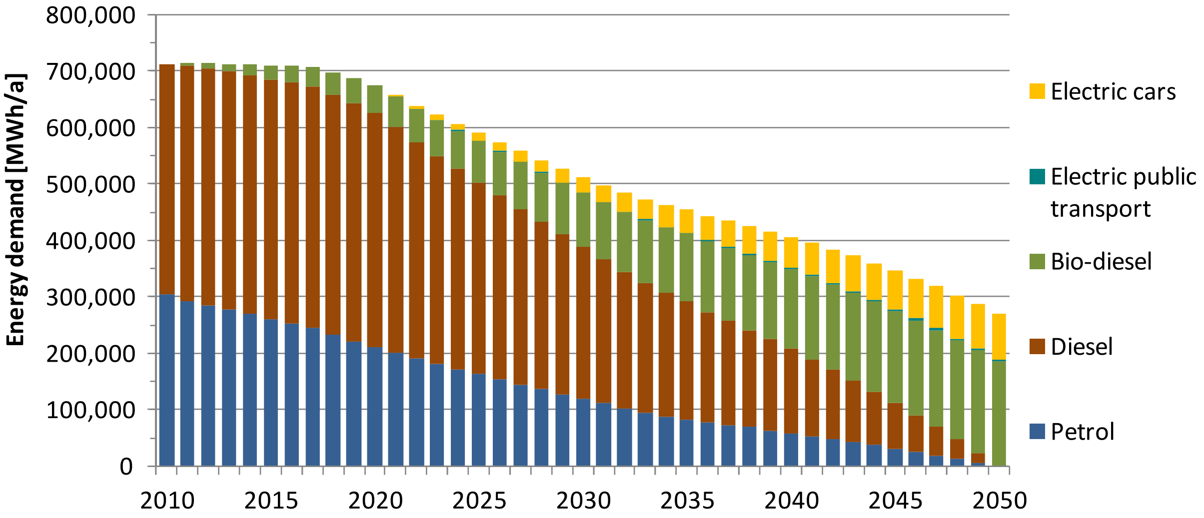


Figure 5.20: *Development of energy demand in the transport sector*

5.5.6 Centralised energy supply

The centralised energy supply is a crucial factor for achieving the goal of CO_2eq-neutrality for Flensburg. Almost 100 % of the household and commercial sectors and a large share of the industrial companies of Flensburg are connected to the district heating network. Most households and companies in Flensburg are being supplied with electricity from the local energy utility. This Flensburg-specific situation has the large advantage that when the local energy utility substitutes the fossil fuels with renewable energies, district heating as well as electricity will become CO_2eq-neutral. The local energy utility emits three fourths of the total CO_2eq-emissions in Flensburg with their coal fired chp plant, and thus holds the main emissions reduction potential in Flensburg.

5.5.6.1 Climate protection measures

During the Energy Utility Workshop, which was attended by the top-level management of the local energy utility, a long-term strategy was established for achieving CO_2eq-neutrality by the year 2050. It was found that the duration and lifetime of the existing facilities and furnaces are crucial for a cost optimal achievement of the goal. The schedule for replacement of furnaces and the increase of renewable energies of the local energy utility consists of the following steps:

- 2012: Doubling the possible wood chip feed-in by replacing a provisional feed station with a fixed one

- 2015 - 2016: Replacement of pulverised coal furnaces (furnace 7 and 8)
- 2022 - 2028: Replacement of fluidised bed boiler (furnace 9 and 11)

The management from the local energy utility assumes that by replacing furnaces 7 and 8, an efficiency improvement of 3.5 % is realistic. Furthermore an efficiency increase of 1 % should be possible for furnaces 9 and 11 before they are replaced. When those are replaced, an efficiency increase of 3 % is assumed.

5.5.6.2 Development of CO_2-emissions

The technical advancement and the substitution of fossil fuels by renewable energy sources in the local chp plant should reduce the CO_2eq-emissions by 750,000 tCO_2eq, by the year 2050. This value includes direct and indirect CO_2eq-emissions of the total production of the chp plant, which is not only supplying Flensburg with district heat and electricity, but also some neighbouring municipalities. From this value, the specific CO_2eq-emissions per kWh are calculated with the energy demand in Flensburg to achieve Flensburg-specific numbers.

The results of the technical advancement and the substitution of fossil fuels by renewable energy sources are depicted in Figure 5.21 and Figure 5.22 on page 200. Figure 5.21 shows the development of the overall emissions specific to the boilers that are used. It also indicates the target development by a red line.

Figure 5.22 shows the matching development of the fuel-mix used to run the chp plant. In addition to every decade, intermediate steps are shown in the figure (2014 and 2024) when replacements of existing boilers are made. It shows how, over time, the fossil fuels are being substituted by renewable energies. The results of the workshop concluded that solid biomass and bio-methane will completely supply the energy demand in the year 2050. Natural gas and RDF (refuse derived fuels) will be used as the interim stepping-stones to lower CO_2eq-emissions in between.

5.5.7 Results of the integrated backcasting analysis

After the 16 participatory workshops were completed, the results from the individual sectors were combined into one backcasting scenario. This is a crucial step because it is possible that

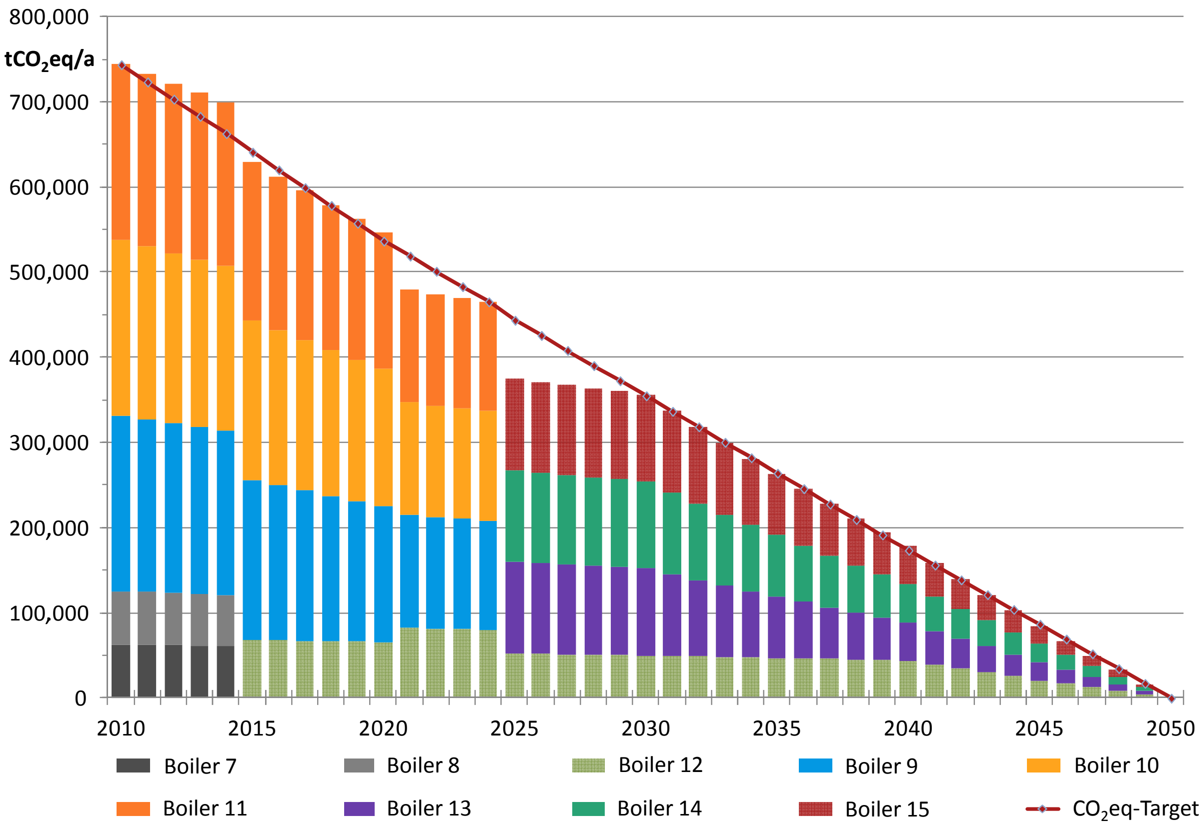


Figure 5.21: *Development of overall CO_2-emissions of the chp plant of the local energy utility*

measures from different sectors mutually reinforce, weaken, or even exclude each other. Climate protection measures were considered in a sectorial and inter-sectorial context, to develop an effective and comprehensive climate protection concept on a citywide scale, with an integrated point of view. As an additional benefit of the integration of the individual workshop results, synergies for emission reductions were utilised to brainstorm possible cost-reduction

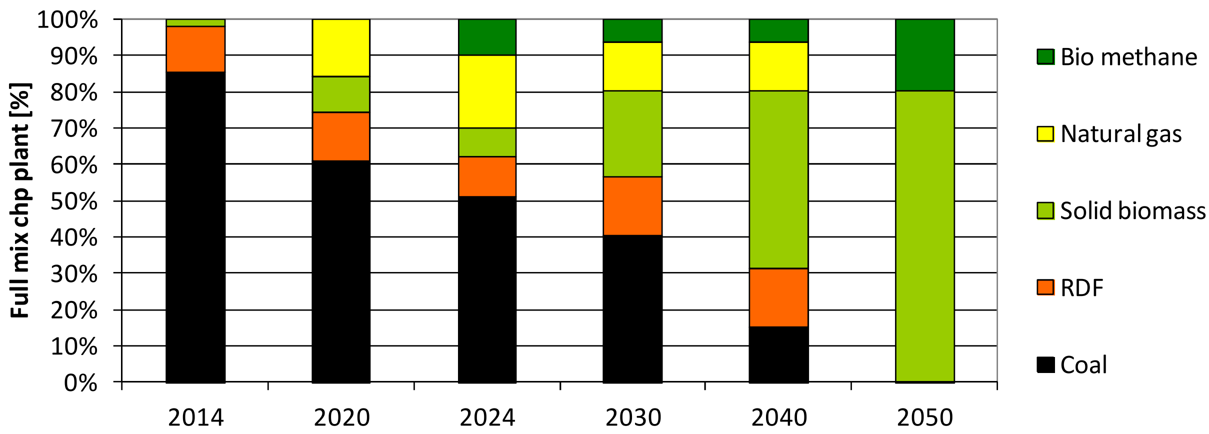


Figure 5.22: *Fuel-mix of the chp plant*

potentials. The overall results of the backcasting analysis are presented in the following sections.

5.5.7.1 Overview of most important measures

In Table 5.35 the ten most important climate protection measures, according to the CO_2eq-emission reduction potential in their sector, are listed. In total, over 100 measures were developed during the participatory backcasting analysis. The implementation of measures is a continuous process starting in 2012 and ending in 2050. The development of total energy demand and CO_2eq-emissions will be shown in the following sections.

Table 5.35: *Main climate protection measures identified using participatory backcasting*

Measure	Effect / Sector specific reduction
Energy utility: Replacement of old furnace and continuous increase of renewable energies	Ca. 550,000 t CO_2eq
Household: Increasing of renovation rate and energy standards	40 % district heating
Household: Consequent use of efficient appliances	45 % electricity
Industry: Increased implementation of energy efficiency improvements and energy demand reduction	10 % electricity, 0 % heat
Commercial: Increased implementation of energy efficiency improvements and energy demand reduction	30 % electricity, 25 % district heating
Public buildings: Building refurbishment and employee training	0 % electricity, 30 % district heating
Individual transport: Operation of car sharing	Not quantified, precondition for other measures
Individual transport: Electric cars	Ca. 73,000 t CO_2eq/a, 62 % energy demand
Local public transport: Implementation of contact lines	Ca. 3,000 t CO_2eq/a
Local public transport: Measures to increase model split share of public transport	Doubling of inner-city public transport share

5.5.7.2 Development of energy demand

In Figure 5.23, the development of the total energy demand for Flensburg is depicted. It is separated into the sectors of household, transport, industry, and commercial. The energy demand in all sectors in Flensburg is expected to decrease by 39 % from 2 TWh to 1.3 TWh in the period from 2010 to 2050. The largest reduction is expected for the transport sector. Mainly due to the transition to electric cars (15 $kWh_{electric}$/100 km instead of 68 kWh_{fuel}/100 km), the energy demand will decrease by 62 % by the year 2050. The second highest reduction is seen in the household sector. With the increasing renovation rate and increasing energy standard, as well as the focus on energy efficient appliances, the energy demand reduction is 39 %. The results from the workshops indicated that energy demand in the commercial sector can be decreased by 25 %. The main contribution to this decrease is the use of efficient lighting, such as light-emitting diodes, and the renovation of buildings to make them more energy efficient. The industrial sector has the smallest energy reduction potential with only 4 %.

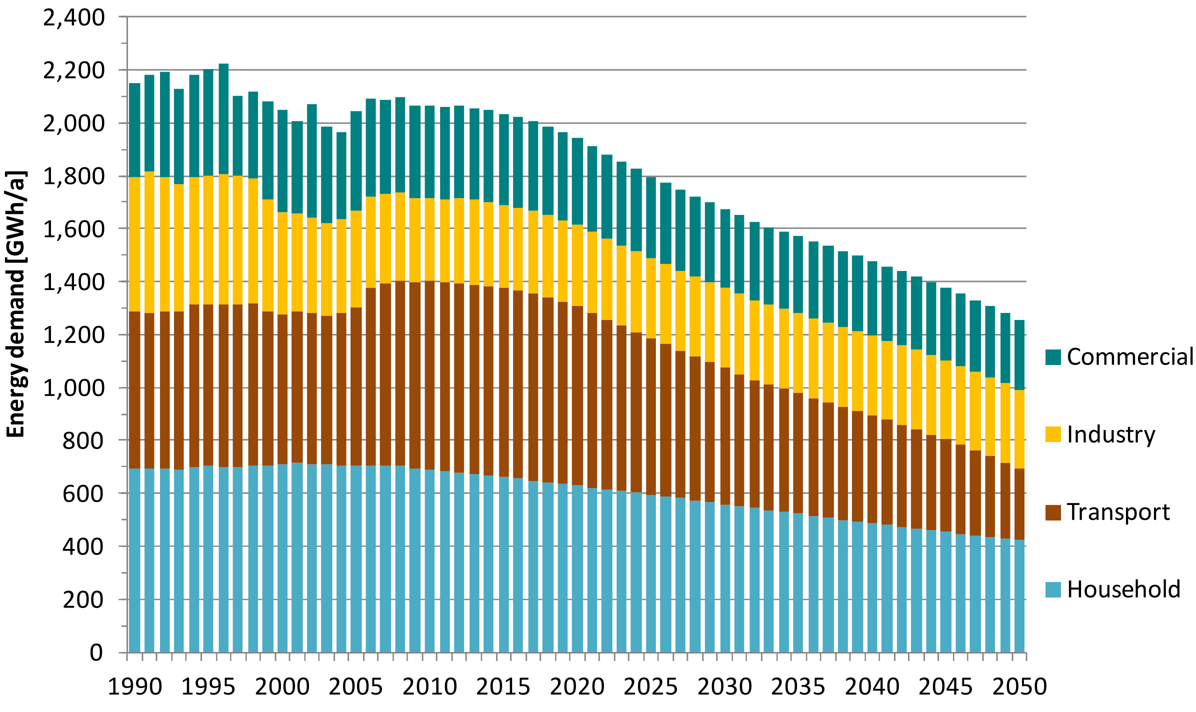


Figure 5.23: *Development of energy demand in Flensburg by the year 2050 according to the results of the participatory backcasting analysis*

5.5.7.3 Development of CO_2-emissions

Almost 100 % of the households are connected to the district heating network of the local energy utility in Flensburg, and are being supplied with the electricity from the local energy utility. A switch from fossil fuels to renewable energy sources will therefore result in the vast majority of Flensburg being supplied with CO_2eq-neutral energy. For industrial companies in Flensburg, who supply a portion of their energy demand themselves, case-specific solutions were developed to enable them to entirely reduce their fossil fuel consumption.

The total development of CO_2eq-emissions in Flensburg is illustrated in Figure 5.24. The results developed with stakeholders during 16 participatory workshops show that both the intermediate goal of an emission reduction of 30 % by the year 2020 and the long-term goal of achieving CO_2eq-neutrality by the year 2050 are possible when the defined climate protection measures are applied.

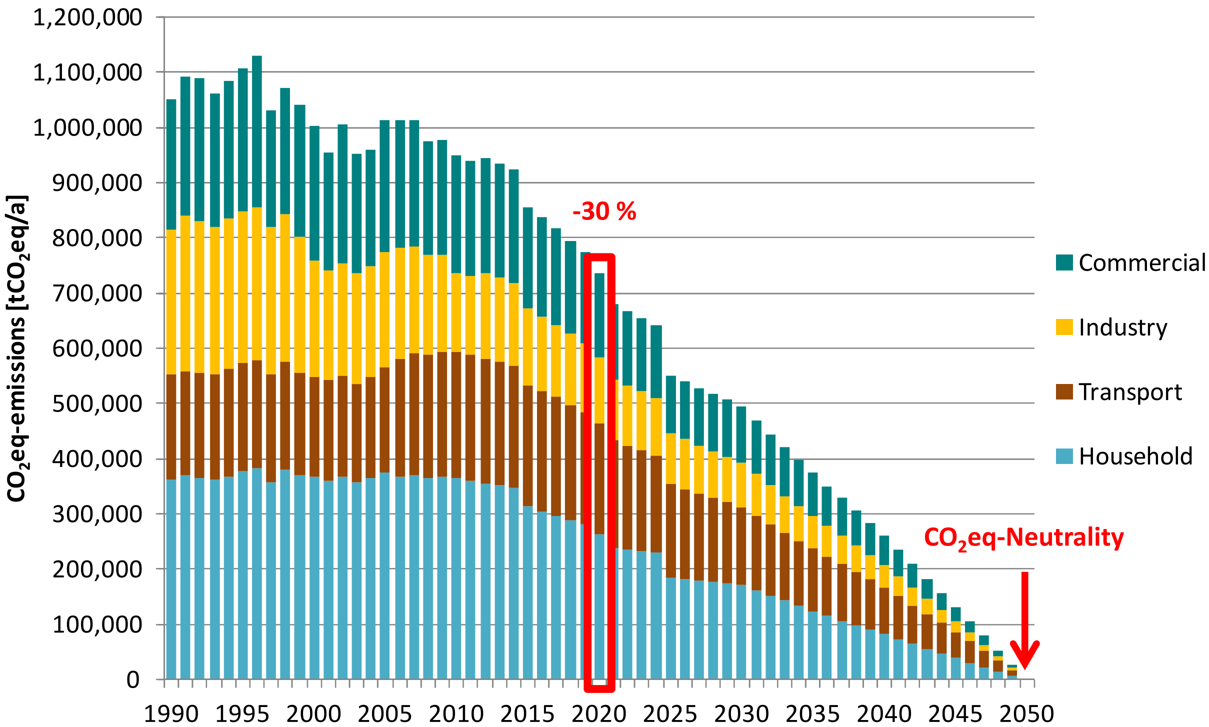


Figure 5.24: *Development of CO_2-emissions in Flensburg by the year 2050 according to the results of the participatory backcasting analysis*

5.6 Step 6: Follow-up agenda

The follow-up agenda ensures the continuation of the process in the future and the implementation of climate protection measures. As a part of the backcasting analysis, the CO_2eq-neutral scenario was elaborated, and the follow-up agenda was defined together with the stakeholders during the workshops. As described in Section 4.6 on page 130, the follow-up agenda contains the following aspects: (1) determination of objectives, projects and responsibilities for planned activities; (2) identification of barriers; (3) implementation strategy and (4) a written and published report.

The follow-up agenda contains a number of objectives as well as projects, instruments, and responsibilities for planned activities for climate protection. These measures have been discussed and agreed upon during the backcasting analysis. These include the over one-hundred developed climate protection measures, from which the most important were introduced in Section 5.5 starting on page 174. The Flensburg-specific climate protection measures are detailed in the Climate Protection Concept of Flensburg (cp. Hohmeyer et al. 2011). The Climate Protection Concept of Flensburg was published in print (160 pages) and online (500 pages). In addition to the climate protection measures, the online version of the concept contains not only the results, but also a detailed description of the process, and the results from each individual workshop performed for the backcasting analysis. The report serves as an orientation for the climate protection process for Flensburg and was sent to all workshop participants and stakeholders. Furthermore, a brochure was developed outlining the most important climate protection measures. The brochure was sent to all households in Flensburg.

For the development of the climate protection concept of Flensburg, the follow-up agenda was extended by an identification of barriers to the implementation of climate protection measures. These are barriers related to the gaining and maintaining of support from the stakeholders and the public, of local climate protection and its implementation. The idea of identifying barriers for the transition to achieving CO_2eq-neutrality stems from transition management. The identification of barriers in advance helped to develop suitable strategies to reduce those barriers. Barriers to the participatory process were identified together with the stakeholders during the backcasting analysis.

The follow-up agenda should actively stimulate the follow-up strategies. To further increase the chance of adopting climate protection measures, an implementation strategy was developed. The strategy was based on the developed climate protection measures, the identified structural barriers, and the possibilities for the extension of the transition network. An implementation strategy was developed together with the stakeholders during the “Implementation / Follow-Up Strategies Workshop”.

5.6.1 Identification of barriers

The chance of implementing climate protection measures can be increased if possible barriers are addressed in advance. Thinking about potential barriers to implementation allows for building strategies on how to handle possible upcoming challenges. In the following, examples of barriers identified are presented for each city sector separately. Afterwards possible solutions are presented. The gained information was also useful for applying community based social marketing for gaining and maintaining public support (section 5.10 on page 218).

5.6.1.1 Household sector

One of the main barriers identified for the household sector was the low involvement of private property owners. In the Housing Association Workshop, the housing associations and property management companies participated. Their property or management property accounted for an estimated one third of the overall residential units in Flensburg. The workshop showed that for private property owners, attending a daylong workshop on a workday is typically not possible. Private property owners hold 25 % of the residential units in Flensburg. When implementing the climate protection measures for reducing the energy demand, a higher involvement of private property owners will be necessary.

Another crucial point was the question whether the supply of district heating can still be economic when heat demand continuously decreases due to building refurbishment. A non-economic district heating system is unlikely to maintain stakeholder and public acceptance. A model was developed to simulate the specific district heating costs when heat demand is decreasing. The calculation shows that by the year 2050, district heating will be competitive to other renewable energy sources. At the end of the time span, heat pumps become an economically feasible alternative. Therefore the areas in Flensburg that are supplied with district heating today should also still be connected to the district heating network in the future. Starting in 2020, the supply of new development areas with district heating will not necessarily be economic, and therefore socially, accepted any longer. For the achievement of CO_2eq-neutrality in these areas, solar-thermal energy in combination with a heating system that burns renewable energies must be installed in those homes.

5.6.1.2 Commercial sector

Participation in the Commercial Workshops was low, even though a lot of effort was made by the University of Flensburg to include commercial companies. In addition to two members of Klimapakt Flensburg, Chamber of Trade and Industry, and the Guild of Craftsmen, only two representatives from companies attended. It showed that in the future even more focus needs to be put towards this heterogeneous sector. For the implementation of the defined measures it will be crucial to motivate more companies to become active in climate protection.

The largest share of companies in Flensburg's commercial sector are companies that only have a few employees (on average, a company in the commercial sector in Flensburg has eight employees). Those companies often do not have the means to optimise energy usage or to implement measures. Often those companies also do not know about energy reduction potentials and the resultant possible energy cost savings. Over the long-term, energy efficiency measures could improve their competitiveness. The long-term advantages need to be addressed when trying to involve more small companies in the climate protection process.

Some commercial companies are part of a national or internal operating company. This is often found in the retail and wholesale trade. The local staff is not necessarily in charge of energy efficiency measures. Rather, decisions are made for the company as a whole. Also it needs to be understood that the primary aim of the retail and wholesale trade is not to save energy but to present their products in the best possible way by appealing to the customer. Without compromising the presentation of goods, economic aspects are the main reason for these companies to pursue energy efficiency.

5.6.1.3 Industry sector

For the implementation of climate protection measures in industrial companies, it needs to be considered that most companies are operating in international markets and need to remain competitive, not only in the long-term but also in the short-term. When planning climate protection measures, the cost-benefit ratio needs to be analysed carefully. During the participatory backcasting analysis, a variety of measures were found to be economic due to energy savings. One of the main criteria for investments in industry is the payback period. The payback period is the time needed for an investment to pay back its investment. A payback period of more than three years is, in most cases, too long for industrial companies. This limits the technical potential for energy reduction significantly. Measures such as building refurbishment with an amortisation time greater than ten years were therefore not considered. As a result, the defined energy reduction in the industrial sector analysis was quite low.

5.6.1.4 Transport sector

In addition to technical solutions, the main potential for CO_2eq-emission reduction in this sector lies in behavioural changes. The energy consumption of the transport sector largely depends on daily decisions made by individuals. Achieving higher shares of green transport in the modal split is therefore difficult to estimate in advance. Successful examples from other cities can serve as reference values but do not take local circumstances into account. Climate protection measures in the transport sector that work for some cities are not necessarily successful when applied to other cities.

5.6.1.5 Centralised energy supply

In addition to technical and economic aspects, the choice of energy sources is important for the centralised energy supply. During the backcasting analysis, the advantages and disadvantages of different energy sources (RDF, wood chips, bio-coal, natural gas, bio-methane) were discussed. In general for intermediate emissions reduction, none of these sources can be ruled out. Generally speaking, a usage of solid fuel is recommended for base load, while peak load should be provided with gaseous fuels. Also geothermal energy may become an option over the long-term when prices of geothermal energy become competitive. The sustainability of different fuels was also considered in this process. When, for example, wood chips are used, sustainable forestry is a fundamental requirement. The same accounts for bio-methane. Only bio-methane that is produced in a sustainable way should be used as a replacement fuel. It is a goal of the climate protection concept that the city of Flensburg becomes more sustainable, and that this is not achieved at the expense of another location.

5.6.2 Implementation strategy

The implementation strategies that are presented in the following sections were developed within the workshops in a participatory way. They are seen as an applicable strategies to address, involve, and motivate different groups to continuously work towards implementing the defined measures of Flensburg's climate protection concept. The focus of the implementation strategy is on how to achieve a higher chance of continued participatory process.

5.6.2.1 Household sector

In the private household sector it is especially difficult to identify suitable early adopters for climate protection. Measures that are taken by these people are typically not publically documented. It was proposed during the workshops that early adopters from the household sector be identified using the Guild of Craftsmen. This assumes that citizens who are particularly active and interested in climate protection would be noticed by the local craftsmen employed to do the work. It was further assumed that some of the identified good examples would agree to serve as a positive representative and thus be ambassadors. Depending on the type of climate protection measures, the following platforms could be used to demonstrate what the identified people did:

- District forums for the general public
- Consumer association
- Clubs (e.g. service club organizations, cultural associations, etc.)
- Adult education colleges and universities

5.6.2.2 Commercial and industry sectors

In the following paragraphs, the workshop results from the commercial and industrial sector are described for the implementation strategy. Due to the similarities between the implementation strategies of both sectors, they are being presented together.

The workshop participants proposed that best-practice examples in the commercial and industrial sectors should be identified and widely communicated in order to demonstrate that climate protection measures help the climate in a positive way and can be beneficial in terms of other aspects. Advantages include the financial aspects of climate protection measures such as increasing energy efficiency and also other aspects, such as corporate social responsibility, and improved customer relations. An exchange of experiences and best-practice examples can be especially useful for smaller companies, which typically do not have enough manpower to optimise the energy demand by employing self-conceptualised measures.

The leading companies in applying green technologies can actually push their competitors towards adopting climate protection measures, by informing the public about their own activities. When well received by the public, the pressure on the competitors is increased to follow the good example. As a suitable instrument to quantify how environmental friendly a company is, the implementation of company benchmarks with defined key indicators for electricity and fuel usage was proposed during the workshops. One possibility for benchmarking is integrative co-operative climate protection controlling. It allows for the quantification of the financial and energy reduction of implemented measures. The monitoring and controlling that is mainly found in companies today focuses on business management performance figures. Oftentimes, these figures do not provide detailed information on the economic effects of implemented climate protection measures. This makes it difficult to show the positive effects of effort put towards climate protection. Motivation can only stay at a high level if the success can be documented.

According to the workshop participants, one of the main barriers for implementing green technologies in the industrial sector is the expected payback period of less than three years. During the backcasting analysis, the participants from the industrial sector defined short-term measures for the time period from 2010 to 2015. All discussed short-term measures are cost-effective and will be implemented. Additionally, a strategy was developed, together with the seven largest industrial companies, on how further measures after the year 2015 can be chosen, applied, and implemented as efficiently as possible.

As part of the implementation strategy, regular meetings of the seven largest industrial companies in Flensburg were proposed by the workshop participants and have already been established. The aim of the meetings is to exchange knowledge, experiences, and solutions having to do with particular technologies used to improve energy efficiency. Even though the companies are from different branches they face the same strategic, organisational, and cross-sectional technical challenges. The attendees of the workshops identified it as crucial that the topics discussed at the meetings be relevant for all participating companies.

5.6.2.3 Transport sector

The aim of the implementation strategy in the transport sector was determined together with the workshop participants. The implementation strategy should both inform the citizens about possibilities of (a) climate conscious transport and (b) to stimulate interest in and make it possible to experience integrated multi-modal urban-transport.

One of the main characteristics of private motorised transport is that it is highly individualised. Every single person is deciding on a daily basis what mode of transport to use. The question for the transport sector is therefore how to raise the awareness of as many people in Flensburg as possible to support climate-friendly transport. During the backcasting analysis, marketing campaigns were identified as one way to raise the awareness of a wide spectrum of local people for climate conscious transport. Marketing campaigns could show well-known local people, such as the Mayor of Flensburg, using green modes of transport. Additionally, raising the pertinent issue of increasing fuel prices by comparing fuel costs of normal cars to those of green modes of transport can be useful. In addition to marketing campaigns it was proposed during the backcasting analysis that, similar to the household sector, early adopters should be targeted.

It was also found that having accessibility to test different modes of transport is crucial. During two workshops, the participants were given the opportunity to try out Pedelecs (bicycles with an electric engine). The feedback was very positive and some of the participants were considering Pedelecs for future short-distance commutes. In general, when individuals have gained practical experiences with new modes of transport (e.g. Pedelecs or car-sharing) and they are seen as useful, a first step in the right direction is achieved. Test offers with special advertising can help to get more people acquainted with green modes of transport. Further ideas which stemmed from the workshops were, for example: (1) people moving to Flensburg could receive information from the city hall on environmentally friendly transport modes available; (2) novice drivers could receive special deals for car-sharing offers and (3) parents to be could be offered to borrow bicycle trailers during birth preparatory courses.

5.6.3 Responsibilities of Klimapakt Flensburg

So far, each city sector's implementation strategy to continue the participatory process has been introduced. Besides the implementation strategy with a focus on participation, the transition process needs, in agreement with the transition management literature, a certain amount of control or steering in the right direction in order to be successful. It is the responsibility of the transition arena, in Flensburg's case, Klimapakt Flensburg, to ensure that the process of local climate protection continues. So far, the idea behind the implementation strategy has been achieved and maintained, due to the participation and commitment of the stakeholders. In addition to maintaining the established participatory process in Flensburg, the implementation of the defined climate protection measures needs to be monitored and controlled. A management cycle with monitoring and controlling is introduced as a separate step of the overall methodology in Section 5.9 on page 217.

Additionally, a project steering committee was organised by Klimapakt Flensburg, which is partially responsible for follow-up. The steering committee consists of representative members of Klimapakt Flensburg. Since the founding of Klimapakt Flensburg, the project steering committee meets, in general, every second month. At the steering committee meetings, local companies, organisations, and institutions are invited to introduce their current and planned projects for climate protection. Measures are discussed and possible synergies with other projects identified. The committee keeps the stakeholders engaged, and ensures, to a certain extent, the continuation of the process.

Furthermore Klimapakt Flensburg has established a Public Relations Committee. The committee is responsible for continuously raising awareness on climate change and climate change mitigation. More information on the committee and its work are presented in Section 5.10 on page 218.

5.7 Step 7: Upscaling of the transition arena to a transition network

Upscaling the transition arena to a transition network is crucial for the achievement of largely ambitious CO_2eq-reduction targets. Climate protection cannot be exclusive. It can only work effectively if as many people as possible are involved. At the end of the day, everyone will have to understand their responsibility to reduce CO_2eq-emissions, thus underlining the importance of an expanding transition network. A detailed description of the process in theory, from the founding of a transition arena to a transition network, was visualised in Figure 4.12 on page 133. In this section, the development observed in the case study will be described, following the presented five phases in the mentioned figure.

The first step towards a CO_2eq-neutral Flensburg was the founding of Klimapakt Flensburg, the local transition arena. Klimapakt Flensburg, at the time of its foundation consisted of 10 members. The early members can be considered frontrunners, stemming from different educational, occupational, and business backgrounds. They were highly committed to climate protection in Flensburg. The members of Klimapakt Flensburg provided the basis for further development of the climate protection process and the engagement and involvement of more stakeholders over time. Only half a year after the foundation of Klimapakt Flensburg, the transition arena had gained six new members, and by 2013 had 22 members in total; all of whom are committed to the reduction targets.

After founding Klimapakt Flensburg, a status quo analysis was performed for Flensburg. The status quo analysis was performed together with different stakeholders. Interviews were performed and data gathered from a variety of stakeholders. Following the psychological insights from the foot-in-door effect, a commitment to the goal of CO_2eq-neutrality was not expected from the stakeholders at this stage. Rather, these first interactions with the stakeholders were focussed on information- and data-exchange. These first interactions with stakeholders were found to be crucial for the later process. All personally addressed stakeholders participated in the development of the climate protection concept for Flensburg. Some also became members of Klimapakt Flensburg.

After the status quo analysis, a forecasting analysis was performed. The forecasting analysis was focussed on informing stakeholders and the public about the future development when ongoing trends are continued. A commitment to the goal of CO2-neutrality was also not expected at this stage. The results of the forecasting analysis were presented concurrently with the results of the status quo analysis, and were well received by the local media. The forecasting analysis fulfilled a motivational purpose and therefore increased the chance of future involvement from the stakeholders and the public.

During the participatory backcasting analysis more stakeholders became involved in the process. It was at this point where the transition arena began to transform into a transition network. To avoid a domination of certain interests, a variety of social groups and stakeholders with different backgrounds were invited to participate in the process. By performing a status quo and forecasting analysis first, contacts and small networks had been established. These contacts were used to engage stakeholders and the public to participate in the backcasting analysis. The backcasting analysis was the first step in the process, where stakeholders, other than the members of Klimapakt Flensburg had to commit to the goals. By this point, the participatory concept development involved more than 200 people in the process; some of them being from the transition arena, Klimapakt Flensburg, but the majority of them being outside stakeholders.

As described in the Chapter Three, the social norm influenced by the social environment, is a strong influencing factor on human actions. The networks established during the workshops were helpful to finally upscale the transition arena to a transition network. Stakeholders making contacts with other stakeholders was an additional benefit of this phase.

In summary, upscaling of the transition arena to a transition network is crucial for the future success and effectiveness of the implementation of climate protection measures. The Flensburg case study showed that the participatory backcasting analysis acts as a first important step in this process. Upscaling the transition arena to a transition network was a continuous process from the beginning of the climate protection process and is on-going. The psychological insights discussed in Chapter Three helped to facilitate the involvement of stakeholders and the public in the development of climate protection measures, and, in turn, achieve a commitment to the climate protection process.

Possibilities on how to further extend the transition network were discussed during the backcasting analysis with the stakeholders. The following ideas were presented. Upscaling the transition network is most efficient when multiplier effects are considered and used. In a city like Flensburg, with a population number of less than 100,000, people's daily lives are largely impacted by personal intercommunication and therefore influenced by the relationships and networks between the stakeholders and public. Applying the theory of diffusion of innovations for the diffusion of climate protection, in particular, the targeting of early adopters (as introduced in Section 3.3.1 on page 97) is ideal for this situation. The success of the concept depends on whether the "right" people can be mobilised for the process.

As previously mentioned, interpersonal communication between people plays a much more important role for the diffusion of innovations than communication via mass media (Rogers 2003, p. 210). Multipliers, as well as early adopters, should be identified and targeted. They are respected and deeply rooted in society. They are opinion leaders and role models. They will use their networks to spread ideas and promote climate protection measures. When on board they will create a critical mass of people, who are needed to start a continuous diffusion of information into society. Early adopters should be identified in the different city sectors. Early adopters could be citizens that already successfully applied climate protection measures themselves and are willing to provide their individual experience or company's experience. Early adopters can be identified by using the established networks in the city and by talking to different stakeholders.

When suitable people are identified, they can carry out interpersonal communication with stakeholders and citizens who have not yet been included in the process. Existing communication platforms and network structures should be used for this purpose. This may be in the form of events or meetings, where a presentation might be held to inform those invited about possibilities and to show examples of good practice. In cities, existing structures or networks could be citizen forums or different communities of interest from local companies. An example of a local organization that serves as a multiplier in Flensburg is the Guild of Craftsmen or the Chamber of Trade and Commerce, which both have a large number of members that potentially adopt climate protection measures. Through local campaigns and the distribution of relevant information and/or special offers, members and clients could be convinced to adopt climate protection measures. In addition to organisations that serve as multipliers, independent groups with pre-existing green initiatives should be considered. They might have developed their own approaches and strategies for reducing emissions in their specific field, which can be integrated into the climate protection concept.

Different ways of structural organisation need to be applied to not only extend but also maintain the transition network during the implementation phase. The creation of working groups can be an important part of the extension of the transition network. This allows interested stakeholders and citizens to become actively involved, not only in the individual implementation of climate protection measures, but also in the overall process. The participants in the working groups can help to diffuse the idea of climate protection by attracting new activists for the implementation of climate protection measures. Establishing topic-specific working groups was recommended. The idea of working groups was discussed in the workshop "Implementation strategies". Working groups were widely viewed as an effective measure and structure for maintaining and extending participation during the implementation phase.

The first working groups began to be established during the backcasting analysis. The members of the different working groups are either representatives of different stakeholder groups or interested members of the public. Due to the high interest of the participants from different fields, the knowledge exchange and the coordination of climate protection measures were already established at the end of the backcasting analysis. Representatives of the seven biggest industrial companies meet in a working group, twice a year. Also ten representatives from different commercial companies have formed a working group and hold regular meetings. A car-sharing working group has also been established. The successful formation of working groups shows that working groups can be formed over time, a process that extends the transition network. For example the commercial group is currently working on the development of a climate protection label to attract and gain more companies to participate in the process.

5.8 Step 8: Transition experiments

Climate protection measures might be the introduction of a “state of the art technology“, or new development. With these innovations, whether or not they should be implemented comes down to a question of cost-benefit. New developments or experiments are called, according to the transition management approach, transition experiments. Transition experiments are seen as a part of the overall learning process for the transition to sustainability. Transition experiments are normally expensive and time consuming, but when successful, will help with the achievement of a CO_2eq-neutral Flensburg. Figure 4.13 on page 134 showed the process of applying transition experiments for climate protection on the city-scale. The process of identifying transition experiments will be ongoing until CO_2eq-neutrality is achieved for Flensburg. Due to continuous technological advancements, there will always be new or further developed technologies that might help with emission reductions.

During the backcasting analysis different possible transition experiments were identified. Some will be introduced in the following paragraphs. The transition experiments will be tested and evaluated during the implementation phase. Then it will be decided whether or not the transition experiments should be up-scaled to a widely applied technology for the reduction CO_2eq-emissions.

From a technical standpoint, the main challenge for the local energy utility, the Stadtwerke Flensburg, is to achieve a steady increase in the amount of renewable energy fuel sources until a full substitution of fossil fuels is achieved. In 2010 the Stadtwerke Flensburg started the co-combustion of wood chips on a small scale using a provision. After a successful initiation, a fixed feed-in way for wood was installed. Problems with the moisture content or storage options, such as freezing of the material in the winter, were analysed to find effective and economic solutions for the handling of wood chips. Also, methods of delivering the wood chips to the plant from the source in a sustainable way were investigated (e.g. using sailing ships, as the plant is located in the Baltic region on a Fjord). Gaining knowledge through these small-scale transition experiments will help the local energy utility to achieve the substitution of fossil fuels in the best possible way. Testing different renewable fuel sources in advance also stimulates public discussion. Including the public into the process of substituting the fossil fuels will help the concept to gain acceptance early on.

The achievement of CO_2eq-neutrality for a chp plant supplying over 100,000 customers with heat and electricity is already a transition experiment in itself. A comparable situation with a district heating coverage of almost 100 % and the goal of CO_2eq-neutrality currently does not exist.

Another aspect where Flensburg is on the forefront of research is the energy-oriented city district refurbishment. One of the housing associations performed an energy-oriented city district refurbishment of almost 750 apartments. They were either energy-wise refurbished or demolished and newly built with higher energy standards. The energy demand was reduced down to one third of the original specific heat demand. The project received several awards. Energy-oriented city district refurbishment should also actively include the public. A project for the year 2013 is the energy-oriented city district refurbishment of “Rude” (a city district in Flensburg). Possible synergies will be researched on how to combine district refurbishment and energy efficiency improvements in the district-heating network.

For the commercial sector, methods are being researched on how to involve as many stakeholders from the commercial sector as possible into the process of local climate protection. One of the experiments is focused on the development of a local climate protection label. As of the year 2013, there was no local climate protection label existing in Germany. It will be researched how many companies would be attracted, and if a label provides an incentive for companies to implement further climate protection measures.

In the transport sector, the local bus operators are testing diesel-electric operation of buses and lightweight concepts for higher fuel efficiency. In the near future, diesel-electric operation of buses with the option of purely electric contact line drive will also be tested. This development and testing of different bus options is also seen as a transition experiment. Even though the technology is developed somewhere else, testing new approaches for the suitability to Flensburg is a transition experiment. The term transition experiment is therefore not only seen for experiments on a national or international scale, but also on the local scale. Testing new developments on a local scale also contributes to the advancement of technological development at a higher level. This point of view goes hand in hand with transition management’s multi-level approach.

Not only the buses but also the individual private transport will become electrically operated, according to the results from the backcasting analysis. On a German-wide level mainly electric car concepts with hard-wired batteries were researched and funded. In 2011, the University of Flensburg, in cooperation with many local and national companies, worked on a funding proposal for electric cars with replaceable batteries. The proposal was not successful but the idea still exists. This project also has a large potential as a transition experiment.

To conclude, working in a participatory way on a highly innovative topic, such as the achievement of CO_2eq-neutrality for an entire city, was found to trigger transition experiments. The involved stakeholders have gained specific interest in existing and new solutions for energy efficiency and CO_2eq-reduction by working on the climate protection concept.

5.9 Step 9: Management cycle

The management cycle is a part of the general learning process for the city to obtain the goal of CO_2eq-neutrality. In addition to the depicted figure for the management cycle, as shown in Figure 4.14 on page 136, an up-datable energy and CO_2eq-balance was created. The energy and CO_2eq-balance includes the energy consumption and CO_2eq-emissions of all sectors in Flensburg. In addition to recording the status quo, this instrument is used to control the effectiveness of measures. It allows an early detection of weaknesses in defined climate protection measures or their implementation. Different software is available for the monitoring and controlling of energy demand and CO_2eq-emissions for cities. In Flensburg, with a large quantity of company specific data, instead of using an externally developed software, a comprehensive tool for the annual monitoring and controlling of energy demand and CO_2eq-emissions was developed using Microsoft Excel.

It was important to consider and agree upon the time intervals of which data is collected from the stakeholders, for the monitoring and controlling of the process. Collecting and processing data can be time consuming for the stakeholders. During the workshops the monitoring and controlling approach was introduced to the stakeholders and the implementation discussed. All stakeholders agreed on a yearly data delivery for the monitoring and controlling process. Additionally, during the workshops the participants that are in charge of the data collection named responsible contact persons. Most companies are already required to provide information on energy consumption to other institutions such as statistical offices. The introduction of a new city-based structure for the data collection was not considered to be efficient, given the additional workload this would produce. Therefore it was agreed on that existing structures be used for data collection for the monitoring and controlling process.

In addition to the control mechanism of the management cycle, the monitoring and controlling process needs to be checked at regular time intervals. This includes both the workload of the participants and also the amount and quality of available data. It was proposed during the workshops that after a few years for the management cycle to be established, it should be evaluated whether or not the data collection is necessary every year or every other year. In general, it was agreed upon that the University of Flensburg is responsible for regulating the monitoring and controlling process. This was largely due to the university being trusted as the most neutral participant in the process. The university staff is then responsible for keeping the data anonymous and for publishing reports about the development of the city's CO_2eq-emissions and energy demand.

5.10 Step 10: Creating public support

A continuous task for climate protection in Flensburg is to gain and maintain public support. Due to the participatory concept development, the support of a certain percentage of the public was already achieved. It is important that the process continues. Therefore the step "Creating public support" was included into the methodology. For gaining and maintaining public support, the two approaches described in Section 4.10 on page 136 were followed. These are the theory of the diffusion of innovations and social marketing, combined with community based social marketing.

5.10.1 Diffusion of climate protection

The overall goal for diffusion of climate protection is to gain an understanding of how environmentally conscious behaviour can reach a stage where it becomes endemic in a society. An important aspect is the targeting of early adopters. The diffusion of innovations applied to the diffusion of the local climate protection process was already described in detail in the previous sections. It was applied during the participatory backcasting analysis (section 5.5, page 174), the upscaling of the transition arena to a transition network (section 5.7, page 211) and for the follow-up agenda (section 5.6, page 203).

5.10.2 Marketing of climate protection

Klimapakt Flensburg applied social marketing to popularise local climate protection. The approach followed by Klimapakt Flensburg was similar to the general marketing approach for cities described in Section 4.10 on page 136. Climate protection on the local scale presents an ideal situation for applying social marketing and community based social marketing. In the following sections, the marketing techniques applied by Klimapakt Flensburg will be described. Klimapakt Flensburg's marketing, to a large extent, helped to raise public awareness of climate protection and to create further support of the local climate protection process.

5.10.2.1 Organisational structure and marketing concept

In Klimapakt Flensburg's first two years of being established, public relations were handled by its members, which included the University of Flensburg, on a Public Relations Committee. They were responsible for organising the opening event when Klimapakt Flensburg was founded, and organised various small events which aimed to promote the initiatives of Klimapakt Flensburg. A public relations firm, "Buero Oeding" was employed by Klimapakt Flensburg, starting in July 2010 and supported the Public Relations Committee.

A public relations concept was developed for Klimapakt Flensburg by the public relations firm in 2010. The public relations concept focused on raising public awareness about local climate protection and promoting local climate protection measures. The purpose of the concept was to achieve amongst the public (1) a positive perspective change towards climate friendly behaviour; (2) a positive emotional identification with climate protection measures and (3) the creation of local possibilities for climate mitigation in daily life. The principles of the concept are depicted in Figure 5.25.

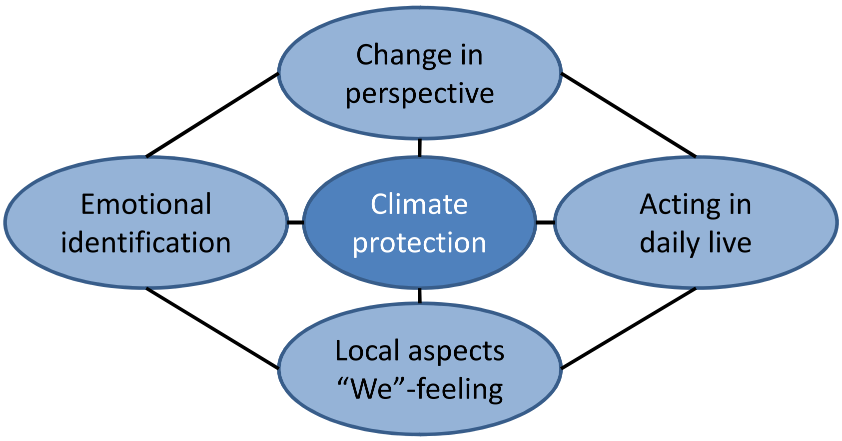


Figure 5.25: *Principles of the communication concept from Klimapakt Flensburg (modified from PR Agency Büro Oeding)*

Following the described basic aspects of the public relations concept that Buero Oeding performed, in addition to the gained knowledge from the status quo analysis for Flensburg, a detailed SWOT (strengths, weaknesses, opportunities and threats) analysis was conducted. The following target areas were identified for the public relations of Klimapakt-Flensburg to target:

- Energy saving in daily life
- Energetic building refurbishment
- Energy efficiency in motorised private transport
- Public transport and bicycle traffic
- Energy production
- Climate oriented investments
- Environmental education

5.10.2.2 Marketing equipment

A variety of different communication instruments such as a webpage, brochures, booklets, presentations, flyers, and posters were developed for Klimapakt Flensburg, using a unified corporate design. An important part of the corporate design was Klimapakt Flensburg's previously developed logo. The use of a corporate design helped to increase the identification of Klimapakt Flensburg. In addition to the colours of the flag of the state of Schleswig-Holstein, the logo includes the font from the city of Flensburg's logo. The logo of Klimapakt Flensburg is shown in Figure 5.26.

Figure 5.26: *Logo of Klimapakt Flensburg*

Using the corporate design, a homepage was developed for Klimapakt Flensburg. Since April 2011, Klimapakt Flensburg is online and available at the web address klimapakt-flensburg.de. A screen copy of the Homepage is shown in Figure 5.27. Interested citizens and local stakeholders can find the latest updates and useful information on global climate and local climate protection possibilities on the website. To date, approximately 600 people are using the homepage every month. As an additional service, a quarterly e-mail newsletter exists.

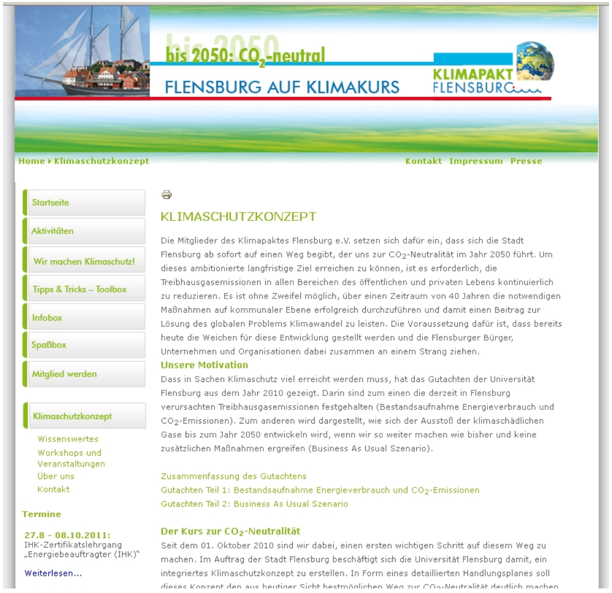


Figure 5.27: *Klimapakt Flensburg homepage*

Marketing equipment such as an exhibition stand, flyers, and brochures were also developed. Three to four events on the topic of climate protection are held annually, where this equipment is used. A picture of the marketing equipment is shown in Figure 5.28.

Figure 5.28: *Picture of the marketing equipment of Klimapakt Flensburg*

5.10.2.3 Overview of past marketing activities

Klimapakt Flensburg together with Buero Oeding organised three to four marketing activities every year. For each marketing activity, the targeted behaviour was selected and then a marketing strategy developed. The activity was then performed and evaluated (cp. Figure 4.15 on page 137). Piloting of activities and marketing campaigns was not performed in most cases, as it was not found to be efficient, from a time or financial standpoint. Instead, after every campaign or event, the response of the public, for example the expected number of participants in comparison to the real participants, was analysed. Depending on the success of the activity, it was determined whether or not the activity should be repeated in the following years. The following details two successful marketing activities carried out by Klimapakt Flensburg.

During the backcasting analysis workshop, participants identified the weather conditions in Flensburg as a barrier to a more frequent bicycle usage. The rate of using bicycles despite the weather was targeted for organising a marketing campaign aimed at the employees of Flensburg's companies and organisations. The month of September in Flensburg is characterised by rainy and windy weather. Employees of Flensburg's companies were asked to take their bicycle to work as often as possible during this month. The number of days commuted by bike and distances were recorded. Friendly competition between colleagues and companies was encouraged by the formation of teams. Companies were contacted both directly and indirectly through press releases. The campaign was carried out the first time in September 2012. Over 149 teams (500 individuals) from 75 companies participated and achieved a total distance of 62,000 km ridden by bicycle in the month of September. Due to the campaigns success, it was also carried out in 2013 and is intended to be an annual event.

One of the main barriers identified for the household sector was how to achieve a larger involvement of private property owners in the climate protection process. Private property owners hold 25 % of the residential units in Flensburg. Attending a daylong workshop on a working day was found to be not possible for private property owners. A marketing strategy was developed on how to involve private property owners in the process of climate protection. A combination of different ways to contact private homeowners was used. A telephone hotline was set up for private property owners to ask energy related questions and gain information on how to improve energy efficiency in their home. Furthermore, on weekend days in different locations (e.g. town hall) information on building insulation and guidance by professional energy advisers was provided. Additionally, vouchers were provided to have energy advisers visit people at home and analyse possibilities for increased energy efficiency for electricity and heat. The evaluation of the presented activities for private property owners showed that, in particular, the telephone hotline and the vouchers were well-received by the property owners. There is a plan for these activities to be performed biennially.

In addition to the chosen marketing activities, the public relations committee and Buero Oeding supported the University of Flensburg in publishing the results of the status quo, forecasting, and backcasting analyses. Over 400 of Flensburg's citizens attended the presentation of the final results of the backcasting analysis. In addition to the presentation, a brochure with the main findings for climate change mitigation in Flensburg was produced and sent to every household in Flensburg (ca. 40,000 copies).

5.11 Conclusion

In the overall timeframe of the project, less than three years, a status quo analysis, forecasting scenario, and climate protection concept were developed in a participatory way, incorporating the main ideas from transition management and backcasting. With the use of a transition arena as well as having established a follow-up agenda and a management cycle, the achievement of the ambitious CO_2eq-emission reduction targets seems to be a realistic target for the city of Flensburg.

Applying the newly developed methodology for cities with ambitious CO_2eq-reduction targets would not have been possible in this way without the broad support and participation of local stakeholders and the public. Climate protection in Flensburg will largely depend on the continuation of the participatory approach, a constructive cooperation from the stakeholders and most of all, continual observation and analysis of future developments in all relevant areas. The consideration of psychological insights facilitated the process of climate protection on the city-scale. The positive feedback from the workshop participants showed that a strong commitment to climate protection on the city-scale was achieved.

The forecasting analysis showed that a continuation of given trends is insufficient to achieve ambitious CO_2eq-emission reductions. Introducing the forecasting scenario provided a strong starting point for illustrating, on a scientific level, the need for the implementation of a climate protection concept for the city of Flensburg. The forecasting analysis helped to motivate the relevant stakeholders to participate in the development of the climate protection concept and perhaps more importantly, to understand why it is necessary to be proactive about climate change.

The experience gained from holding 16 workshops showed that a high degree of participation by stakeholders and the public is advantageous for the development of a climate protection concept. First, knowledge and expertise of the workshop participants can be used to define realistic measures for achieving the goal of CO_2eq-neutrality. This allows the concept and the solutions to be developed for the specific situation in Flensburg. Second, the participants were able to gain insight into improving energy efficiency and furthermore, were able to see their work at their respective companies from a different perspective. Often they were able to bring their momentum into the company, serving as a multiplier.

The visualisation of the possible emissions reductions using tools and model calculations also proved to be very advantageous for the development of climate protection measures. Backcasting was a new approach for most involved. The visualisation of intermediate results helped the workshop participants to understand the idea of backcasting. Furthermore the visualisation allowed a discussion of different climate protection measures in accordance with their CO_2eq-emission reduction potential.

Including aspects from transition management and psychology helped to develop a process for a transitioning towards a CO_2eq-neutral city of Flensburg. The founding of Klimapakt Flensburg, the local transition arena, and the upscaling of the transition arena to a transition network fit very well into the general process, and was further supported by the participatory backcasting analysis. The application of the novel methodology to the city of Flensburg therefore confirms the answer given in Chapter 4 to the fifth research question ("Is it possible with the developed methodology to establish structures in the city that will carry on the climate protection process and can the establishment of structures be accomplished in a short amount of time?"). In less than three years it was possible for the novel methodology to establish structures in the city of Flensburg that will, from today's perspective, carry on the climate protection process on the city-scale.

The target set by Klimapakt Flensburg of obtaining CO_2eq-neutrality by the year 2050 for the city of Flensburg is ambitious. Due to the active involvement of local stakeholders and the public in the process, a solid basis for climate protection in the city of Flensburg has been established and, as of today, the ground-work has been laid for Flensburg to successfully achieve the goal of CO_2eq-neutrality by the year 2050.

6 Critical assessment and conclusion

In this final chapter, the lessons learnt from the application of the novel methodology in the case study are presented. Additionally, further research needs are addressed and a critical assessment of the novel methodology is presented. Before the final conclusion, the wider applicability of the novel methodology is discussed.

6.1 Lessons learnt from the case study and further research needs

This section serves the purpose of answering the final research question, which is "What lessons can be learnt from the exemplary application of the methodology for other cities, and where is further research needed?" To address the question, each individual step of the novel methodology will be critically reflected, and the applicability of the methodology for other cities discussed.

6.1.1 Step 1: Founding of a transition arena

According to the developed methodology, the foundation of a transition arena is the beginning of the climate protection process on the city-scale. A transition arena is responsible for initiating and continuing the climate protection process on a city-scale, and actively encouraging more people and stakeholders to become involved in the process over time. The foundation of a transition arena is therefore a critical step in the developed methodology. Based on transition management, characteristics of a transition arena were defined, and possibilities for the foundation of a transition arena were discussed.

In the case of Flensburg, a transition arena, the “Klimapakt Flensburg”, had already been founded. Klimapakt Flensburg was set up to embody the characteristics of a transition arena. Klimapakt Flensburg had members with different professional, educational, and social backgrounds, acted independently from traditional political networks, and started with ten members, all of them considered frontrunners. The foundation of Klimapakt Flensburg was triggered by the rising inclination of certain individuals to become actively involved in climate change mitigation at the local level.

For cities where a transition arena has not already been founded, recommendations on how to start the process were described in Section 4.1 on page 115. Further research is necessary on how to identify and best enable frontrunners to actively promote the idea of local climate protection utilising their own networks, and finally, to found a transition arena.

6.1.2 Step 2: Defining of timeframe

In the second step of the novel methodology, the timeframe is defined for achieving the goal of a CO_2eq-neutral city. In Flensburg, the target year for a CO_2eq-neutral city was set by the transition arena in a participatory way. It was found during the case study research that the goal set by Klimapakt Flensburg was widely accepted. The defined timeframe of the year 2050 was seen as an ambitious but still realistic target, especially by stakeholders from the housing industry and the energy utility. Due to the long-investment cycles of these two groups, a much shorter target was not seen as economically manageable.

Based on the experience gained from the development of climate protection measures, together with more than 50 of Flensburg’s companies and organisations, the target year of 2050 is seen as an ambitious but realistic target for the city of Flensburg to achieve CO_2eq-neutrality. Applying the novel methodology to cities where a more or less ambitious target is set may change the dynamics of the process and requires further research.

6.1.3 Step 3: Status quo analysis

In order to discuss the lessons learnt from the exemplary application of the status quo analysis, two parts of this phase are distinguished. The first is the networking between and the involvement of stakeholders (non-transition arena members) in the process. The second is data collection and the creation of an energy and CO_2eq-balance for the city.

The status quo analysis was the first step in the case study that required an active involvement of stakeholders outside the transition arena. The status quo analysis not only required company-specific data, but was a crucial step for including as many stakeholders as possible in the process from early on. As a first step, the main stakeholders needed to be identified. This step was more difficult and time-consuming than originally thought. Even though information on the size of businesses was available at the respective chambers or statistical offices, due to privacy protection, useful information to identify the main stakeholders was not provided. Therefore a stakeholder analysis was performed based on internet research and company listings (e.g. yellow pages). When applying the novel methodology to cities smaller than Flensburg, the identification of stakeholders will most likely be easier. In cities larger than Flensburg, a limitation on the number of stakeholders involved in the status quo analysis might be set (with a focus on companies with the highest energy demand), with the goal of, for example, 80 % of the energy demand from a certain sector being able to be tracked back to known companies.

Gathering data for the energy and CO_2eq-balance was well received and supported by the stakeholders in Flensburg. All stakeholders with relevant energy consumption provided the necessary data. During the status quo analysis, the need for ambitious emission reduction targets was explained to the stakeholders and an environment was created that supported future cooperation. Utilising the knowledge from the foot-in-door theory especially helped to involve the stakeholders in the local climate protection process and increase their commitment to reaching the goal of a CO_2eq-neutral city. All stakeholders that were actively involved in the status quo analysis participated later on in the development of climate protection measures.

Setting up an energy and CO_2eq-balance required that the form of energy and assignment principles of emissions for the analysis be determined. Energy demand, as well as CO_2eq-emissions, can be calculated and assigned using different approaches. So far, no standard approach has been applied for the development of climate protection concepts for cities. At the end of this thesis (in the year 2013) a first discussion among 20 municipalities in Germany was initiated to evaluate the advantages and disadvantages of different principles for the assignment of CO_2eq-emissions (project Masterplan 100 % Klimaschutz from the Federal Ministry of Environment). Further research is needed to develop a unified approach to the assignment of CO_2eq-emissions on the city-scale.

After deciding on one principle for the assignment of emissions for Flensburg, data was gathered for the energy and CO_2eq-balance. The data collection for Flensburg was simplified by the specific energy supply situation. The household and commercial sectors are almost entirely supplied by heat and electricity from the chp plant operated by the local energy utility, Stadtwerke Flensburg. In other cities with a more diverse energy supply, the structure of the process is likely to be more complex. Even though a status quo analysis might be more complex for other cities, the results from the reviewed climate protection concepts showed that a status quo analysis can be performed for all different energy supply structures of cities. Data for the status quo analysis of the industry sector was also either provided by the local energy utility, the individual companies, or statistical offices. One of the main challenges for data collection was the transport sector. Other than the number of registered cars in Flensburg, no information was available on total annual mileage or fuel consumption. As presented in the case study, average data from Germany as a whole was used to estimate total energy demand of Flensburg's transport sector. Further research is needed for the development of more accurate models in the transport sector, which allow for an incorporation of regional characteristics for a better estimate of the energy demand and CO_2eq-emissions of cities.

Depending on the available human resources, the available time for performing a status quo analysis, and the availability and accessibility of data, a more or less detailed status quo analysis can be performed. The circumstances of every city will be different in this respect, and therefore the degree of detail (and accuracy) of the status quo analysis must be decided on an individual basis.

6.1.4 Step 4: Forecasting analysis

Based on the results of the status quo analysis, a forecasting analysis was performed. The results of the forecasting analysis illustrated that a continuation of given trends is, by far, not enough to achieve a CO_2eq-neutral Flensburg by the year 2050. The results of the forecasting analysis provided a powerful argument, illustrating the need for the implementation of a climate protection concept for the city of Flensburg. The forecasting analysis helped the relevant stakeholders to understand why it is necessary to be proactive about climate change. With the help of the media, it also raised awareness among the general public. It was found that presenting the results from the forecasting analysis further motivated stakeholders and the public to participate in the development of the climate protection concept.

Furthermore, incorporating the step of a forecasting analysis helped to systematically analyse the driving factors for energy demand and CO_2eq-emissions, preventing an over- or underestimation of the necessary effort for climate protection. Presenting the results of the forecasting analysis made stakeholders aware of how a continuation of current trends can influence future energy demands and CO_2eq-emissions.

To determine the main drivers of Flensburg's energy demand and CO_2eq-emissions, individual members of Klimapakt Flensburg, and key players of the main companies in the industry sector, were contacted and stakeholder interviews were performed. After conducting these interviews, it became clear that the future development of the energy demand largely depends, not on the individual plans of the company, but rather on the future economic development as a whole. Furthermore, for the city of Flensburg, the history of the energy demand was analysed to determine the future development of the drivers by an extrapolation of that trend. It was found though, that single events, such as the closing-down of one of Flensburg's major companies, significantly influenced the development of the total energy demand. Therefore national trends were used to base the forecasting scenario on a wider statistical database. As a lesson learnt for the application of the approach to other cities, it is recommended to base the forecast directly on either previously existing local forecasts, forecasting studies, or national trends, instead of conducting individual company interviews first.

6.1.5 Step 5: Backcasting analysis

From the exemplary application of the backcasting analysis, lessons for applying the approach to other cities can be learnt from two perspectives. The first perspective focuses on the involvement of stakeholders and the social process, whereas the second perspective addresses the more technical aspects of the concept development.

The results of the backcasting analysis provided a plan for the city of Flensburg and its 90,000 citizens, for how the goal of CO_2eq-neutrality could be achieved by the year 2050. During the course of one year, together with the public and representatives from over 50 companies, organisations, and institutions, over 100 climate protection measures were developed in a participatory way. Sixteen workshops were carried out during this time, as well as many interviews with various stakeholders in Flensburg. The participatory process initiated for the concept was very well received in Flensburg. The general public and stakeholders' participation in the climate protection process and the development and agreement on climate protection measures was purely voluntarily. The success is assumed to have been largely contributed by the foundation of the transition arena, utilising existing networks, and including psychological aspects. The question how the process would have developed in Flensburg without incorporating the previously stated aspects will remain unanswered. Further research should be focused on comparing the commitment of stakeholders between climate protection concept development for different cities, as well as investigating further the factors driving the commitment of various stakeholder groups.

A further question to be considered is, what is the optimal number of stakeholders or people to be involved in the process of climate protection development? In the case of Flensburg, over 200 people, which included the public and representatives from over 50 companies, organizations, and institutions were involved in the backcasting analysis phase of the concept development. In order for CO_2eq-neutrality to be achieved on the city-scale, there must be an adequate number of participants involved and strategies need to be developed to encourage more people to engage over time. Research in the direction of obtaining an optimal proportion of the population of a city for climate protection development is needed. Comparisons made between cities, which adapt the newly developed methodology for climate protection but have different numbers of stakeholders involved in the development of the concept, may be one way of investigating if an optimal number or proportion exists.

Another aspect which influenced the results of the backcasting analysis was how the participants internalised the development of climate protection measures by the defined target year. In Flensburg, the target year was set at 2050. Interestingly, the ability of participants to envision long-term climate protection concepts was largely sector dependent. The housing industry and the local energy utility were used to thinking on the long-term, and climate protection measures from these sectors were developed for the entire defined time-frame. Participants from the commercial, industrial and transportation sectors, even though participants had a tendency to focus more on the short- and mid-term, were able to ultimately internalise the long-term target year and developed climate protection measures accordingly. Only in the public building sector were climate protection measures only defined to the year 2030. In general, the long-term goal was very well received by the workshop participants, and the need for the development of long-term climate protection measures recognised. The same applied to the ultimate goal of obtaining a CO_2eq-neutral city, which was rarely questioned. In summary, setting highly ambitious long-term CO_2eq-emission reduction goals was very well received in Flensburg, and other cities should be encouraged to follow in the same direction.

From a technical point of view, it was found that the goal of achieving a CO_2eq-neutral city of Flensburg is a realistic target. Together with the stakeholders and the public, climate protection measures were developed accordingly. The high share of district heating in Flensburg allows a central solution for the substitution of most fossil fuels for heat demand. The substitution of coal with renewable energies will decrease the CO_2eq-emissions in Flensburg by three fourths. But it is equally important that industrial companies substitute heating oil and natural gas for renewable energy sources. For the household, commercial, and industry sectors, the development and quantification of climate protection measures using backcasting was as expected. Energy and emission reduction potentials were identified together with the stakeholders, and further information was provided by the literature (e.g. future energy demand of light emitting diodes). In the transport sector, the identification of climate protection measures was also possible. The challenge was the quantification of individual climate protection measures. This was due to the following circumstances: (1) Flensburg specific data on transport was not available (only the number of registered cars); and (2) climate protection measures for the transport sector are often based on behavioural changes, rather than on technological solutions. Further research is required in order to better estimate the effects of applying climate protection measures to the transport sector for an individual city.

For the status quo, forecasting, and backcasting analyses, direct and indirect emissions were considered. Taking indirect emissions into account prevents the development of climate protection measures, decreasing the direct but increasing the indirect CO_2eq-emissions. An example would be a city promoting the use of hydrogen cars, where the hydrogen is supplied by a coal fired power plant outside the city. The direct emissions for the city would decrease but the CO_2eq-emissions outside of the city would increase. Therefore, direct and indirect emissions are considered throughout the novel methodology. The disadvantage of this approach is, that indirect emissions can only partly be influenced by the stakeholders of the city. It is assumed though, that by avoiding indirect emissions to the greatest possible extent and influencing external parameters in a proactive manner, CO_2eq-neutrality can also be achieved for indirect emissions. Further research is needed to develop climate protection measures which extend beyond the city borders to drastically reduce indirect CO_2eq-emissions.

The visualisation of intermediate and final results during the workshops was extremely helpful for the participatory backcasting analysis. The visualisation of intermediate results during the workshops using specially developed tools was one of the most important and very unique features of workshops. The tools were designed in a way that measures discussed during the workshop could be included right away, and the resulting reduction in energy demand and CO_2eq-emissions shown on a timeline. The use of tools during the workshops increased the participants' motivation, increased the transparency of the process, increased clarity about cause-and-effect, enabled direct feedback to the stakeholders about whether the measures were sufficient, and finally, encouraged the examination of the objectives. The clear benefits of the participants being able to visualise intermediate and final results during the workshops with the use of specialised tools, promotes the idea that specialised tools should also be utilised during this step when the developed methodology is applied to other cities.

6.1.6 Step 6: Follow-up agenda

The follow-up agenda consisted of the following four aspects: (1) determination of objectives, projects, and responsibilities for planned activities; (2) identification of barriers; (3) development of implementation strategy and (4) writing and publishing of report. It was found during the case study research, that most aspects of the follow-up agenda were already performed during the backcasting analysis. Synergies were utilised using the workshops during the backcasting analysis to also develop the follow-up agenda together with the stakeholders. Therefore, instead of only identifying climate protection measures in general, climate protection measures were discussed in detail together with the stakeholders to determine specific objectives, projects, and responsibilities. Instead of merely being an addendum to meetings, one workshop was conducted entirely focused on the follow-up and implementation strategy. Identifying and addressing barriers in advance of the implementation was found to be important for reflecting on the developed climate protection measures and for developing suitable strategies to reduce barriers. The same accounts for the development of an implementation strategy. The question of whether the follow-up agenda increases the chance of future commitment and the implementation of climate protection measures remains unanswered. To resolve this research question, the follow-up in Flensburg will have to be evaluated in the future. The findings from Quist (2007a, p. 218), who analysed the follow-up of a variety of backcasting analyses, indicate that by emphasizing follow-up throughout the process, it's future likelihood is increased.

At the end of the backcasting analysis, a climate protection report was created and published. In addition, the results were presented at the town hall with over 400 people in attendance. Furthermore, the results were summarised in a brochure which was sent to every household in Flensburg. The feedback from the stakeholders, the public, and the local media was very good. Widely publishing the results not only helped to raise the awareness, but also got more people involved in the climate protection process in Flensburg.

6.1.7 Step 7: Upscaling of the transition arena to a transition network

In the seventh step of the novel methodology, the transition arena was upscaled to a transition network. Five phases were distinguished for this process. By following the presented steps of the novel methodology, the process of upscaling the transition arena to a transition network was already partly achieved, reducing the additional workload for networking.

In Flensburg, the process of upscaling the transition arena to a transition network was very efficient. Following the steps of the novel methodology, the number of people involved in the climate protection process for Flensburg steadily increased. The transition arena, which was founded by ten stakeholders, had gained twelve new members by the year 2013. The number of stakeholders directly involved in the climate protection process also increased significantly during the three years of the application of the novel methodology. At the end of the backcasting analysis, more than 200 people were actively involved in the development of climate protection measures. With the publishing of the final results of the climate protection concept, every household in Flensburg was informed on the process.

In summary, upscaling of the transition arena to a transition network is crucial for the future success and effectiveness of the implementation of climate protection measures. Upscaling from arena to network was continuous, from the beginning of the climate protection process. The insights from psychology helped to facilitate the process by involving stakeholders and the public in the development of climate protection measures, and by achieving a commitment to the climate protection process on the city-scale.

A good example from the case study for the continuation of the local climate protection process was the establishment of topic-specific working groups. Working groups were widely viewed by the workshop participants as an effective measure and structure for maintaining and extending participation during the implementation phase. The successful formation of working groups for the commercial, industrial, and transportation sectors shows that a transition network with close inter-linkages between the stakeholders can be established when, and while, applying the novel methodology. The working groups will continue to meet on a regular basis in the years to come.

6.1.8 Step 8: Transition experiments

Shortly after the completion of the backcasting analysis for Flensburg, the first transition experiments were carried out by local stakeholders. For example, a local bus operator tested and evaluated hybrid- and light-weight buses. Another example was the local energy utility testing the use of wood chips in their chp plant. It was found, in general, that the performance of the backcasting analysis triggered the curiosity of the stakeholders to test new technologies which might significantly reduce the energy demand and CO_2eq-emissions of their businesses.

During the case study, transition experiments were identified, along with the identification of other climate protection measures. No systematic approach was followed for the pure identification of transition experiments, or defining a portfolio of transition experiments. The case study was more focused on the identification of applicable climate protection measures, rather than on measures where an application was questionable. The main reason for this is that a city, especially a city the size of Flensburg, compared to an entire country, has a very limited number of stakeholders that are potentially willing to take the risk of testing a transition experiment. Further research is necessary to evaluate how transition experiments on the city-scale can be identified and prioritised, together with the stakeholders, in a systematic way.

6.1.9 Step 9: Management cycle

During the workshops of the backcasting analysis, the monitoring and controlling approach was introduced to the stakeholders, and the implementation discussed. All stakeholders agreed on a yearly data delivery for monitoring and controlling, and responsible contact persons were named by the participants to be in charge of the data collection. Incorporating a discussion about the management cycle in the backcasting analysis was found to facilitate the process of deciding what data should be included and the time intervals that should be used for updating the energy and CO_2eq-balance. Nearing the end of the current year of 2013, it is still too early to evaluate the proposed and implemented management cycle. In the following years, further research is needed after the development has been monitored, and there has been an evaluation of the measures taken when intermediate goals are not fulfilled.

6.1.10 Step 10: Creating public support

One lesson learnt from Klimapakt Flensburg's campaign is that interpersonal communication, as well as marketing using mass media, are important for raising awareness for climate change mitigation, and for creating and maintaining public support. It was found that, due to the participatory concept development, the support of a certain percentage of the public was already established. In addition, social marketing was applied to reach the public at large. It was found that the step of piloting of activities and marketing campaigns was not carried out in most cases. In the particular case of Flensburg, with a population size less than 100,000 citizens, piloting marketing activities before implementation of the activities was not found to be time- or financially-efficient. Therefore, when applying the developed methodology to other cities, the benefits of piloting should be evaluated on a case by case basis.

6.2 Critical assessment of the developed methodology as applied in the general case

In the previous section each step of the case study was critically reflected, and the applicability of the methodology for Flensburg was discussed. This section serves the purpose to critically assess the developed methodology and address further problems that may arise in its general application. In the following each individual step of the novel methodology will be assessed.

6.2.1 Step 1: Founding of a transition arena

The founding of a transition arena is not only the first step, but also a tipping point for the entire methodology and the participatory process. Finding locally rooted frontrunners that are highly committed to climate protection is key for the successful application of a climate protection concept. Without those people neither the upscaling of the transition arena to a transition network nor the diffusion of climate protection will be successful. Potential challenges here lie in finding frontrunners that are highly committed to climate change mitigation. The city of Flensburg presented an ideal case where a group of frontrunners had already been established. This will not be the case for every city. Locating these individuals and encouraging conversation between them and eventually the formation of a transition arena will take time and a great deal of networking. Universities, Institutes and other places of higher education might be targeted as well as local companies, the local energy utility, organizations and clubs. Ideal candidates are energy suppliers and companies with a significant energy demand, who might be willing to participate in the development of local climate protection measures. Looking into other examples of how groups such as the Klimapakt Flensburg were formed might also provide valuable information on how to initiate and form these groups.

Furthermore, it is important that the transition arena is independent from traditional policy networks in order to avoid a domination of established interests. Excluding traditional policy networks is not always possible. The municipality, in particular, politicians, have a strong influence on various areas effecting the energy demand and CO_2eq-emissions of a city. In Germany, these may include public buildings, housing associations, power plants, sewage plants, the city infrastructure, the urban development plan and the public transport system. Moreover, the municipality, in the case of Germany, is responsible for acquiring funding for the development of city-scale climate protection concepts. A focus on finding a balance between being independent from traditional policy networks and being dependent on the support of the politicians needs to be achieved when developing a transition arena from the bottom-up.

A further problem that may be faced when establishing a transition arena is the domination of certain interests. When a transition arena is founded based on already existing networks of the frontrunners, certain interests of these particular groups might dominate the process. As an example, one of the frontrunners might be from a housing association. This frontrunner is likely to utilise his/her network established with other housing associations leading to a dominance of members from housing associations, and likely resulting in a domination of the housing association's interests. Diversifying the transition arena offers a solution to the former as well as promotes the discussion of different problem solutions and encourages actors to see problems from different perspectives. Ideally, members of the transition arena should be diverse in their professional, educational and social backgrounds. By networking with individuals from many different areas of the city sectors early on in the establishment of the transition arena, a high member diversity should be able to be achieved.

6.2.2 Step 2: Defining of timeframe

The crucial aspect of defining the timeframe is the acceptance and commitment of stakeholders and the public to the set target year. Frustration and de-motivation of stakeholders is likely when goals are set externally that cannot be achieved. Therefore, a target year for obtaining CO_2eq-neutrality should be defined in a participatory way, which has the advantage that the specifics and challenges of different city sectors and branches are taken into account. Meetings with different stakeholders and people from the public to explain the need of ambitious but realistic targets for climate change mitigation might help to facilitate the decision of a target year and help maintain commitment to the goal.

A potential argument of the developed methodology might be, why the timeframe is defined before having analysed the status quo. In the backcasting literature, both sequences are commonly found (Herrmann 2010, p. 296). A potential benefit of analysing the status quo before defining the timeframe is that the status quo analysis might deliver useful information for defining a reasonable timeframe. The developed methodology in this thesis follows the approach, where first the timeframe is defined and then the status quo analysed. Backcasting is a goal-orientated approach. The focus of backcasting, in contrast to forecasting, is on how an envisioned goal can be achieved independently from the current situation. Analysing the status quo first might lead to a more restricted way of envisioning the future and defining a target goal. Therefore in this thesis the timeframe is defined previous to the status quo analysis.

6.2.3 Step 3: Status quo analysis

Two parts of the status quo analysis are being distinguished for the critical assessment. The first part of the critical assessment is the networking between and the involvement of stakeholders in the process. The second part is the methodology for data collection and the creation of an energy and CO_2eq-balance for the city.

The status quo analysis is a crucial step for including as many stakeholders as possible in the climate protection process from early on. The first step, identification of the main stakeholders, as learnt from the exemplary application of the methodology, can be difficult and time-consuming. Due to privacy protection, useful information for identifying the main stakeholders of a city is not always readily available. Conducting a stakeholder analysis based on internet research and company listings is one possible solution for identifying the main stakeholders.

In some cases it may be difficult to involve relevant stakeholders in the status quo analysis. This can especially be the case if the stakeholders do not yet have an awareness for climate protection and are therefore hesitant to support the process. Scheduling individual meetings with the stakeholders increases the chance of stakeholders to participate in the climate protection process. The need for ambitious emission reduction targets should be explained to the stakeholders and an environment created that supports future cooperation.

Individual meetings will also help to identify existing networks between stakeholders and potentially existing tensions between stakeholders. The formation of a long-lasting network for climate protection on the city-scale requires that already existing tensions between stakeholders are not negatively influencing the climate protection process. Solutions for existing tensions may have to be developed and implemented in addition to the developed methodology.

Obtaining information from stakeholders on their company or organization's energy demand and CO_2eq-emissions can also present challenges due to privacy protection. A relationship of trust first needs to be developed between the transition arena or facilitator of the status quo analysis and the stakeholder. Stakeholders need to be confident that the confidential information that they share will not be misused.

Creating an energy and CO_2eq-balance as a part of the status quo analysis for a city is a very complex and time consuming task. The energy and CO_2eq-balance lays the foundation for the forecasting and backcasting analyses. Therefore, the quality of the forecasting and backcasting analyses is sensitive to the level of accuracy and level of detail of the status quo analysis. A balance needs to be found between the level of detail and the level of accuracy of the status quo analysis and the amount of time that it takes to achieve these levels. Further research is necessary to determine the costs and benefits of different levels of accuracy and detail for the status quo analysis and their effects on the forecasting and backcasting analyses.

Another difficulty when creating an energy and CO_2eq is that data availability for earlier years may be limited in some cases. This was the case for the reference year in the case study. Gaps can, to a certain extent, be bridged by back-calculating the development in recent years. The more years that have to be bridged the less accurate the outcome is going to be.

Following the developed methodology a city is divided into the subdivisions household, industry, commercial and transport to improve manageability. In the case study, it was found, that energy demands and CO_2eq-emissions are not always sector-specific and it is not always possible to distinguish the energy demands and CO_2eq-emissions into the four sectors. For example the household sector might include energy demands and CO_2eq-emissions from the commercial sector and vice versa. This results in higher or lower energy demand and CO_2eq-emission estimates for certain city sectors only based on the chosen division of the sectors. As a consequence, the climate protection measures developed during the backcasting analysis for a specific city sector might over- or underestimate the necessary effort to obtain CO_2-neutrality in that sector. When performing a status quo analysis, different sources should be considered in order to verify the division of energy demands and CO_2eq-emissions to the city sectors. It was also found during the case study research that the official definition of sectors was changed frequently. As an example, during the timeframe from 1990 to 2008 four different definitions were used for the industry sector. As a result, the energy demands and CO_2eq-emissions vary between the sectors depending on the applied definition of the sectors. It is suggested to apply the newest definition of the sectors. This requires backwards calculation of energy demands and CO_2eq-emissions of the sector, wherever a change of the definition occurred. Applying the newest definition backwards guarantees a compatibility of the energy demands and CO_2eq-emissions of the sector with previous years.

6.2.4 Step 4: Forecasting analysis

The forecast is based on either previously existing local forecasts, forecasting studies, or national trends. Depending on the external source used, the results of the forecasting analysis might differ. The identified driving factors and their forecasted development are included in the backcasting analysis and influence the effort needed to obtain the goal of CO_2eq-neutrality. Therefore, in the developed methodology the forecast and the backcasting analysis are sensitive to the external source used. Presenting and discussing the assumptions used for the forecasting analysis helps to develop a forecast that is widely agreed upon. During the discussion, the adaptation of the data from external sources is also important for tailoring the forecasting analysis to the specifics of the city under research. The sensitivity of the forecasting and backcasting analyses to different external sources applied can potentially be analysed and documented.

6.2.5 Step 5: Backcasting analysis

The number of stakeholders actively involved in the backcasting analysis will differ for each case study. The developed methodology increases the chance of a high level of participation, but the voluntarily involvement of stakeholders and the public is not guaranteed. Low involvement of stakeholders potentially leads to a climate protection concept, which is not widely accepted and has a low level of commitment. Furthermore, a low level of involvement hampers the network development process for climate change mitigation. As a result, the partial upscaling of the transition arena to a transition network (step 7), while performing the backcasting analysis, is impaired. The additional time needed for applying a participatory approach has to be accounted for by the facilitator of the process and should not be underestimated. The methodology developed in this thesis heavily relies on a successful involvement of stakeholders and the public during the backcasting analysis.

The quality of the backcasting analysis largely depends on the involved stakeholders, their knowledge, and their ability to think on the short-, mid-, and long-term. Depending on the involved stakeholders and their backgrounds, the results of the backcasting analysis will differ. As a consequence, for the same city different climate protection measures could be defined depending on the involved stakeholders. The lower the stakeholder involvement is, the less likely the developed climate protection concept will be well rounded. Furthermore, the quality of the climate protection concept will also depend on the ability of the stakeholders to think on the short-, mid-, and long-term. Most stakeholders will be used to think for their company on the short- or mid-term. Developing measures on the long-term will be new for most participants. The facilitator of the backcasting analysis should be aware of this circumstance and should be prepared to actively encourage long-term thinking.

For obtaining a CO_2eq-neutral city, all stakeholders and the entire public need to be committed to the process on the long-term. There potentially might be companies or people that do not believe in climate change mitigation and boycott the process. Barriers that are created by companies or people need to be identified and solutions developed in a participatory way to address these barriers. Each case will be different and requires individual solutions. The developed methodology includes tools and steps based on psychological theory that may serve as a valuable tool for addressing individual issues that may arise.

The backcasting analysis is the first step in the developed methodology which determines whether the set target of CO_2eq-neutrality is achievable in the defined timeframe. Therefore, a result of the backcasting analysis could be that the goal of CO_2eq-neutrality is not achievable in the defined timeframe. In this case, two options exist. The first option is the extension of the timeframe to allow a later achievement of CO_2eq-neutrality. The second option is to agree on a lower reduction target, such as a 97.5 % emissions reduction instead of CO_2eq-neutrality. Both options should be seen as intermediate solutions. It might be the case that in the future new technologies allow for a further reduction of CO_2eq-emissions and therefore the achievement of the previously set target.

An economic evaluation of each developed climate protection measure during the Backcasting analysis might not be possible. In particular, the accuracy of an economic evaluation of measures to be implemented on the long-term is uncertain. For each climate protection measure, the stakeholders will have to perform a detailed cost-benefit analysis prior to implementation.

It is the stakeholders final decision if a climate protection measure is going to be implemented or not.

6.2.6 Step 6: Follow-up agenda

During the follow-up agenda step barriers to the climate protection on a city-scale are identified and suitable strategies to reduce barriers developed. The extent to which potential upcoming barriers can be identified in advance is uncertain. It is questionable if the work put in for identifying barriers in advance is justified. It could be argued that reacting to upcoming barriers might be less time consuming than identifying and developing solutions to barriers that might not come up. Further research is needed to evaluate the costs and benefits of identifying barriers in advance. Until then it is assumed, that a proactive approach towards potential barriers increases the chance of a successful implementation of climate protection measures and the achievement of obtaining a CO_2eq-neutral city.

The third activity of the follow-up agenda is the development of an implementation strategy. It is assumed that an implementation strategy increases the chance of the achievement of the short-, mid- and long-term goals. Based on the performed case study, this assumption cannot be verified yet. A verification or falsification requires a long-term evaluation of different case studies with and without a follow-up agenda.

In general, the question of whether the follow-up agenda increases the chance of future commitment and the implementation of climate protection measures remains unanswered. To resolve this research question, the follow-up in different case studies will have to be evaluated in the future.

6.2.7 Step 7: Upscaling of the transition arena to a transition network

Upscaling the transition arena to a transition network is a continuous process, which takes place during the first seven steps of the developed methodology. The evolvement of the transition arena to a transition network is crucial for the future success and effectiveness of the implementation of climate protection measures. The number of people involved in the climate protection process on the city-scale need to steadily increase. Reaching the goal of a CO_2eq-neutral city is only possible if the stakeholders and the public participate in the process. If the number of participants is stagnating or decreasing the self-spreading dynamic of the local climate protection process could be lost.

In the case study, the process of upscaling the transition arena to a transition network was very efficient and the number of people involved steadily increased. Utilising the first six steps of the developed methodology to upscale the transition arena reduced the workload for additional networking. Depending on the utilisation of existing networks in the city and the networks of the transition arena, this process can be more or less difficult and time consuming. In theory the upscaling of the transition arena to a transition network is a steady and continuous process. In reality extending the transition arena to a transition network is a highly complex process with many potential barriers. Stakeholders must first of all be willing to participate in the local climate protection process. Starting with the status quo analysis the involvement and the commitment of the stakeholders must increase. A potential barrier may present itself during the backcasting analysis. Stakeholders might attend the workshops but may not be willing to actively develop climate protection measures for their company or organisation and commit to the implementation of climate protection measures. Applying the presented psychological aspects might facilitate a commitment and a proactive behaviour on behalf of the stakeholders towards climate protection measures. Further research in the field of environmental psychology is necessary to analyse and quantify the effects of different psychological instruments and methodologies for encouraging stakeholder commitment.

Another potential barrier could be created by the transition arena itself. The transition arena needs to be open to the idea of extending and sharing the developed ideas with potential new members. The situation might occur that the transition arena becomes protective of the process and the climate protection on the city scale becomes exclusive. If this occurs, the structure of the transition arena might need to be changed to be able to facilitate the growing transition network. The transition arena must develop with the proceeding transition.

6.2.8 Step 8: Transition experiments

Transition management has a strong focus on innovation, in particular, on transition experiments. On the national scale, with a large number of potential stakeholders willing to test transition experiments, transition experiments are a valued addition to the methodology. On the city-scale, however, the number of stakeholders willing to take the risk of testing a transition experiment are limited, since they can be both time and cost intensive. If a transition experiment fails, the stakeholder is the one who absorbs the cost. During the case study research it was found that transition experiments play a minor role in climate protection on the city-scale. It is argued in this thesis, that due to their potential contribution to a CO_2eq-emission reduction and their innovative character they help to further develop the vision and should be a part of the developed methodology. To diversify the risk of transition experiments, transition experiments should be tested among different cities. Ways of making transition experiments more financially attractive for stakeholders should also be explored.

6.2.9 Step 9: Management cycle

The climate protection process needs to be monitored and controlled on a regular basis. Therefore, a management cycle for achieving CO_2eq-neutrality on a city-scale was integrated in the developed methodology. In Flensburg, representing an ideal case, the stakeholders agreed on an annual data delivery for the management cycle. Keeping in mind that providing data is a time consuming task for the stakeholders, a bi-annual or tri-annual update of the dataset is possible as well. The detail of the delivered data can also be adjusted at this time. As an example, every second year a detailed update of the dataset could be made. Whereas, every second year an update based on easily available data from statistical offices might be made. Further research is needed to contrast the lower accuracy with the time saved for the detailed update to a less detailed update.

A critical question concerning the management cycle is the accuracy and data availability. Depending on the data availability, climate protection measures performed on the city-scale might not quantify. As already mentioned for the status quo analysis, not all necessary data is available on the city-scale. A trade-off between data accuracy and the availability of data on different levels has to be made. The same accounts for the management cycle. As an example, specific information on the transport sector, such as the average fuel consumption, might not be available. Data from the regional or national transport sector might be used to fill the gap. As a consequence, climate protection measures reducing the fuel consumption of cars in the city will not necessarily have a noticeable effect on the emissions accounted for in the management cycle. Performing city-specific surveys might be one solution to reduce existing gaps.

The purpose of the management cycle is to monitor and control the development of energy demands and CO_2eq-emissions. Therefore, every year of the implementation phase, the question is raised whether the intermediate goals have been fulfilled. If intermediate goals are not fulfilled, adjustments to the climate protection process and the defined climate protection measures are necessary. The developed methodology does not provide a detailed concept on how additional climate protection measures could be identified and who is responsible for further emission reductions. As an example, in the case that the city misses an intermediate goal by 5 % CO_2eq-emission reduction, which sector or stakeholder is responsible for this and has to further reduce their CO_2eq-emissions to achieve the intermediate target? Pin pointing a sector might be possible, because intermediate targets are defined for each city sector during the back-casting analysis. Identifying individual stakeholders is a very sensitive endeavour. Therefore, when intermediate goals are not achieved, solutions should be developed in a participatory way to ensure balanced burden sharing.

6.2.10 Step 10: Creating public support

The involvement of stakeholders in the climate protection process is dependent on strong public support. Involved stakeholders may be required to take business risks and thus public support will help to safeguard the stakeholders' businesses and their long-term involvement in the climate protection concept. Furthermore, the public needs to be aware of their own contribution to the CO_2eq-emission in the city and their possibilities to reduce emissions. For the creation of public support, the theories of diffusion of innovation and social marketing were included in the developed methodology. Even though the case study provided the proof of concept for the first years of the process, the case study did not deliver information on the long-term success of applying diffusion of innovations and social marketing. The most important aspect of the chosen theories is that a stage of the process is reached where it becomes self-spreading in a society. An evaluation of the case study will be necessary in a few years to research whether a stage of self-spreading was reached or not.

6.2.11 Continual adaptation of the methodology

A last point for the critical assessment is the importance and influence of the economic, social and ecological environment. The application of the developed methodology largely benefited from an environment with a high awareness for climate change mitigation. Stakeholders and the public were aware of the need for climate change mitigation and willing to voluntarily commit to the climate protection process. Applying the same approach 30 years ago, when the need for climate change mitigation was not as widely understood, would have resulted in a different outcome. Therefore, it can be argued, that the developed methodology is tailored to the situation in the year 2010 (+/- 5 years). A further development of the developed methodology to new situations and changing environments will be necessary to keep the methodology up-to-date and suitable for the future.

6.3 Discussion of a wider applicability of the novel methodology

This section discusses the wider applicability of the novel methodology. It was highlighted in Chapter 2 that backcasting and transition management are applicable in situations where a transition to sustainability is desired. Both approaches are and have been applied to a large variety of cases. Therefore, the question is raised as to whether the novel methodology, which includes the core aspects of backcasting and transition management, is also applicable to cities other than those with a certain population size and the goal of obtaining CO_2eq-neutrality

The novel methodology was developed based on a review of climate protection concepts developed in northern Germany, and was applied to a northern German city. The question is, whether the approach is applicable to cities in other regions of Germany or to cities in other countries. The main aspects incorporated from backcasting and transition management are not limited to an application to certain regions. The same accounts for the included insight from psychology. The novel methodology was developed and described in Chapter 4 in a general form, not specified for any particular region. Therefore the novel methodology fulfils the requirements for an application to cities from other regions. The successful application of the novel methodology to other regions of the world needs to be tested. It is anticipated that applying the novel methodology to cities in countries with no active political support or public awareness of climate change may be a more difficult task.

The reviewed climate protection concepts were limited to cities with a population size between 50,000 and 250,000 citizens. Following the arguments presented in the previous paragraph, the novel methodology should also be applicable to smaller or larger city sizes. However, when applied in this case, a changing of social dynamics is expected in the process. In the beginning of the climate protection process on a city-scale, the transition arena is utilising their own networks to promote the idea of local climate protection. In a small city, for example with 10,000 citizens, network dynamics are assumed to be different than the dynamics of a larger city. Potentially, the networks might have a regional, opposed to local, focus. In contrast, cities with a large population number, for example 1,000,000 citizens, might have networks established for individual city quarters instead of an existing city-wide network. The novel methodology was set up to be adaptable. The coordinator of the process needs to be aware of city-specific dynamics, such as those found in the case study research for Flensburg.

To achieve highly ambitious CO_2eq-emission reductions in industrialised nations, not only cities, but also rural areas will have to drastically reduce their CO_2eq-emissions. Therefore the applicability of the novel methodology to rural areas is discussed. Performing a status quo analysis, a forecasting analysis, and a backcasting analysis is equally applicable to rural areas. The question is whether or not it is possible in these areas to establish a transition arena, with frontrunners that are deeply rooted in society, and to ultimately upscale this into a regional transition network. It is expected that the more widely dispersed the population is, the more difficult it is going to be to establish the necessary structures for a long-lasting and self-contained climate protection process.

The review of the sixteen climate protection concepts in northern Germany showed that not all cities developed a climate protection concept which included all city sectors. Although measures must be developed for all city sectors in order for a city to achieve ambitious reduction targets, the novel methodology could also be applied to city sectors individually. A challenge then, is to develop climate protection measures for a specific city sector that are not dominated by sector specific interests. Climate protection measures in one sector could increase the CO_2eq-emissions in another sector. Therefore whenever possible, it is strongly recommended to follow a holistic, integrated approach where the novel methodology is applied to all city sectors.

The last applicability issue to discuss is whether or not the novel methodology could be applied for other large scale environmental targets, such as waste reduction, in a city. The novel methodology is specially adapted to achieve highly ambitious targets. Backcasting, as well as insights from psychology, e.g. goal setting theory, were utilised to tailor the novel methodology to the specific requirement of highly ambitious emission reduction targets, in this case, CO_2eq-neutrality. Therefore, the novel methodology could also be applied to other highly ambitious emission reduction targets such as a 95 % CO_2eq-goal. The novel methodology can also potentially be applied to other environmental sustainability targets, such as a reduction in the waste production of a city. The novel methodology would have to be tailored to the specifics of waste instead of energy and CO_2eq-emissions, but the general steps could be applied, as long as the set targets are highly ambitious. If the objectives are not as ambitious, not all steps of the novel methodology will be necessary and a less complex methodology could be applied. In addition to setting highly ambitious targets, the level of commitment of the stakeholders and the public to the environmental issue is crucial for the success of the methodology. Commitment to the target and the developed concept must be achieved for a long-lasting sustainable process to be created. Therefore, in general, the novel methodology can potentially be applied to other environmental sustainability targets as long as a high commitment to the participatory process is likely to be achieved.

6.4 Final conclusion

In this thesis, a methodology for the participatory development of climate protection concepts for cities with the aim of obtaining CO_2eq-neutrality using backcasting, transition management, and psychology, was developed and successfully tested in a case study. The hypothesis of the thesis "By integrating backcasting, transition management, and psychological aspects, it is possible to develop a holistic method for the participatory development of climate protection concepts for cities that allows for the achievement of highly ambitious CO_2eq-emission reductions, such as CO_2eq-neutrality?" was successfully tested, and the outcome was positive.

During the case study research, 16 workshops were conducted to develop over 100 climate protection measures to help the city of Flensburg achieve their target of obtaining CO_2eq-neutrality. More than 200 people, including representatives from over 50 local companies, organisations, and institutions attended the workshops. The experience gained from holding the workshops showed that a high degree of participation of stakeholders and the public is advantageous for the development of a city-specific climate protection concept. Not only are the stakeholders and the public the ones that will be implementing the developed climate protection measures, but also their specific knowledge of the situation in the city helped to establish a climate protection process tailored to Flensburg's individual characteristics.

The novel methodology and its application in the case study showed that the setting of long-term goals, partnered with highly ambitious reduction targets for a city, is possible. The review of climate protection concepts in northern Germany showed that none of the 16 cities being examined had set ambitious long-term goals. It was found in the case study that setting ambitious long-term emission reduction goals was widely supported by local stakeholders and the public. Furthermore, for only one out of the 16 reviewed climate protection concepts was a goal-orientated approach applied. This led to the circumstance that in only seven cases were the city's CO_2eq-emission reduction targets actually achieved when implementing the climate protection measures defined in the climate protection concepts. The case study of Flensburg showed that the use of goal-orientated approaches in the development of climate protection concepts is a suitable approach and advances today's general practices.

For the development of the novel methodology, psychological theories were reviewed and suitable approaches were included. Mitigation of climate change depends entirely on human decisions (behavioural, as well as investment decisions). Psychology helps to understand individual behaviour, group behaviour, and social norms, as well as understand possibilities for influence and diffusion of a climate protection process. Applying insights from psychology helped to increase local participation and long-term commitment. Psychology is not a "panacea", but being aware of psychological aspects and utilising them was found to increase the chance for the successful application of the novel methodology.

Including transition management into the novel methodology helped to establish a long lasting process for a city aimed at achieving CO_2eq-neutrality. The founding of a local transition arena, and the upscaling of the transition arena to a transition network, fitted very well into the general process, and was further support by the participatory backcasting analysis. In the case study, the necessary foundation for a transition towards a CO_2eq-neutral city were established in less than three years. A solid participatory basis for climate protection was established in the city of Flensburg and from today's perspective, the groundwork has been laid for Flensburg to successfully achieve the goal of CO_2eq-neutrality by the year 2050.

As a last remark, even though the novel methodology was developed to be applicable on a city-scale independent from politics, the execution largely benefited from a political framework that was financially supporting climate change mitigation. In Germany, the Federal Ministry of Environment funded 60 % of the development of climate protection concepts during one year of the case study research. The first two years of establishing a climate protection process on the city-scale were entirely funded by the Klimapakt Flensburg. Developing and applying the novel methodology, it was found that setting up the necessary structures to generate an autonomous climate protection process on the city scale requires more time than one year. To ensure a self-contained and long-lasting climate protection process on the city scale, an extension of the funded project time from one to at least two years is recommended.

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References

Ackerman, L. S. (1982). Transition management: An in-depth look at managing complex change. *Organizational Dynamics 11*(1), 46 – 66.

AG Energiebilanzen (2008). Arbeitsgemeinschaft Energiebilanzen e.V. - Vorwort zu den Energiebilanzen für die Bundesrepublik Deutschland.

AG Energiebilanzen (2009). Arbeitsgemeinschaft Energiebilanzen e.V. - Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2008. Berechnungen auf Basis des Wirkungsgradansatzes.

AGEB (2010). *Vorwort zu den Energiebilanzen für die Bundesrepublik Deutschland*. AGEB AG Energiebilanzen e.V.

Ahlhaus, M., S. Biertümpel, R. Horenburg, T. Langner, and K. Schult (2010). Klimaschutkonzept der Stadt Stralsund.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes 50*(2), 179–211.

Allianz pro Schiene (2008). Allianz pro Schiene. Umweltschonend mobil. Bahn, Auto, Flugzeug, Schiff im Umweltvergleich.

Amt für Umweltschutz und Bauordnung Oldenburg (2012). Integriertes Energie- und Klimaschutzkonzept - Ratsbeschluss.

Andreasen, A. (1994). Social marketing: Its definition and domain. *Journal of Public Policy & Marketing*, 108–114.

Arentsen, M., R. Kemp, E. Luiten, M. Kok, W. Vermeulen, A. Faaij, and D. Jager (2002). Technological change and innovation for climate protection: the governance challenge. *Global Warming and Social Innovation the Challenge of a Climate-Neutral Society*.

Aronson, E. and M. Gonzales (1990). Alternative social influence processes applied to energy conservation.

Arrhenius, S. (1896). On the influence of carbonic acid in the air upon the temperature of the ground. *Philosophical Magazine and Journal of Science 41*, 237–276.

Ashley, C. and L. Hall (1985). Non-extrapolative strategy. In *Non-extrapolative Methods in Business Forecasting-Scenarios, Vision and Issues Management,*. J.S. Mendell, F.J. Pessolano.

Bagheri, A. and P. Hjorth (2007). Planning for sustainable development: a paradigm shift towards a process-based approach. *Sustainable Development - Bradford 15*(2), 83.

Banister, D. and R. Hickman (2006). Looking over the Horizon. *Town and Country Planning 75*(5).

Barton, H. and N. Bruder (1995). A guide to local environmental auditing.

Baumeister, R. and M. Leary (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological bulletin 117*(3), 497.

Beratungsbüros 4K (2010a). Klimaschutz Göttingen - Integriertes Klimaschutzkonzept für das Stadtgebiet Göttingen 2008 bis 2020 - Ergebnisbericht.

Beratungsbüros 4K (2010b). Klimaschutz Göttingen - Integriertes Klimaschutzkonzept für das Stadtgebiet Göuttingen 2008 bis 2020 - Materialband.

Berkhout, F., J. Hertin, and A. Jordan (2002). Socio-economic futures in climate change impact assessment: using scenarios as ‘learning machines’. *Global Environmental Change 12*(2), 83 – 95.

Bickman, L. (1972). Environmental attitudes and actions. *The Journal of social psychology 87*(2), 323–324.

Blutstein, H. (2003). A forgotten pioneer of sustainability. *Journal of Cleaner Production 11*(3), 339 – 341.

BMVBS (2009a). Bundesministerium für Verkehr, Bau und Stadtentwicklung - Verkehr in Zahlen 2008/2009.

BMVBS (2009b). Bundesministerium für Verkehr, Bau und Stadtentwicklung 2009. Bericht über die Wohnungs- und Immobilienwirtschaft in Deutschland 2009.

Boaventura, J. M. and A. A. Fischmann (2008). Is your vision consistent?: A method for checking, based on scenario concepts. *Futures 40*(7), 597 – 612.

Bood, R. and T. Postma (1997). Strategic learning with scenarios. *European Management Journal 15*(6), 633 – 647.

Brauers, J. and M. Weber (1988). A new method of scenario analysis for strategic planning. *Journal of Forecasting 7*(1), 31–47.

Börjeson, L., M. Höjer, K.-H. Dreborg, T. Ekvall, and G. Finnveden (2006). Scenario types and techniques: Towards a user’s guide. *Futures 38*(7), 723 – 739.

Brohmann, B., M. Cames, J. Voss, G. Grimpe, and S. Goetzsch (2002). Klimaschutz durch Verhaltensänderungen–Potenziale Sozialer Motivationsstrategien in Baden–Württemberg. *Forschungsbericht FZKA-BWPLUS. BWE20007. Ökoinstitut, Darmstadt*.

Bruggink, J. (2005). *The next 50 years: Four European energy futures*. Energy research Centre of the Netherlands.

Brundtland report (1987). Our common future. *Report of the World Summit on Environment and Development. United Nations*.

BulwienGesa (2011). Marktbeschreibung Flensburg. *RIWIS Online - Regional Property Market Information System*.

Bundesinstitut für Bau-, Stadt- und Raumforschung (2011). Laufende Stadtbeobachtung - Raumabgrenzungen: Stadt- und Gemeindetypen in Deutschland.

Bunn, D. W. and A. A. Salo (1993). Forecasting with scenarios. *European Journal of Operational Research 68*(3), 291 – 303.

Caldwell, J. (1976). Toward a restatement of demographic transition theory. *Population and Development Review 2*(3), 321–366.

Chan, S.-L. and S.-L. Huang (2004). A systems approach for the development of a sustainable community–the application of the sensitivity model (sm). *Journal of Environmental Management 72*(3), 133 – 147.

Chermack, T. J. (2005). Studying scenario planning: Theory, research suggestions, and hypotheses. *Technological Forecasting and Social Change 72*(1), 59 – 73.

Clements, M. P. and D. F. Henry (1998). *Forecasting economic time-series*. Cambridge, Cambridge University Press.

Cornish, E. (1977). *The study of the future: An introduction to the art and science of understanding and shaping tomorrow's world*. Transaction Publishers.

Costanza, R. and H. E. Daly (1992, Mar.). Natural capital and sustainable development. *Conservation Biology 6*(1), 37–46.

Costanzo, M., D. Archer, E. Aronson, and T. Pettigrew (1986). Energy conservation behavior: The difficult path from information to action. *American Psychologist 41*(5), 521.

Creyts, J., A. Derkach, S. Nyquist, K. Ostrowski, and J. Stephenson (2007). Reducing us greenhouse gas emissions: How much at what cost? *McKinsey*.

Daly, H. (1992). Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable. *Ecological Economics 6*(3), 185–193.

Daly, H. E. (1996). *Beyond growth: the economics of sustainable development*. Beacon Press.

Daly, H. E. (2007). *Ecological economics and sustainable development*. Edward Elgar Publishing.

Davis, K. (1945). The world demographic transition. *The Annals of the American Academy of Political and Social Science 237*(1), 1.

DB/ifeu (2008). Deutsche Bahn and Institut für Energie- und Umweltforschung Heidelberg GmbH. UmweltMobilCheck.

de Kerkhof, M. V. (2004). *Debating climate change: a study of stakeholder participation in an integrated assessment of long-term climate policy in the Netherlands*. Ph. D. thesis, Free University, Amsterdam, Lemma Publishers, Utrecht NL.

deCharms, R. (1968). Personal causation: The internal affective determinants of behavior.

DEHSt (2007). Deutsche Emissionshandelsstelle 2007. Einheitliche Stoffwerte für Emissionsfaktoren, Heizwerte und Kohlenstoffgehalte für Brennstoffe, Rohstoffe und Produkte.

DEHSt (2009). NAP-Tabelle Deutschland 2008-2012.

Department of Energy and Climate Change (2009). Guidance on carbon neutrality.

Destatis (2009). Preisindex - Volkswirtschaftliche Gesamtrechnung (Bruttoinlandsprodukt, Bruttonationaleinkommen, Volkseinkommen. Lange Reihen ab 1950), Bezugsjahr 2006.

Deutscher Bundestag (2004). Der aktuelle Begriff: Nachhaltigkeit; Wissenschaftliche Dienste des deutschen Bundestages. *Webarchiv.Bundestag.de*.

DG AGRI, Eurostat, J. and DG REGIO (2010). A new typology of predominantly rural, intermediate and predominantly urban regions.

Dhakal, S. (2008). Climate change and cities: The making of a climate friendly future. In P. Droege (Ed.), *Urban Energy Transition*, pp. 173 – 192. Amsterdam: Elsevier.

Dodman, D. (2009). Blaming cities for climate change? an analysis of urban greenhouse gas emissions inventories. *Environment and Urbanization 21*(1), 185.

Dortmans, P. J. and E. Eiffe (2004). An examination of future scenarios using historical analogy. *Futures 36*(10), 1049 – 1062.

Dreborg, K. (1996). Essence of backcasting. *Futures 28*(9), 813–828.

Dwyer, W., F. Leeming, M. Cobern, B. Porter, and J. Jackson (1993). Critical review of behavioral interventions to preserve the environment research since 1980. *Environment and Behavior 25*(5), 275–321.

Elkington, J. (2002). Cannibals with forks - the triple bottom line of 21st century business. *Capstone Publishing Limited*.

Ester, P. and R. Winett (1981). Toward more effective antecedent strategies for environmental programs. *J. Environ. Syst.;(United States) 11*(3).

EU (2009). Amtsblatt der Europäischen Union vom 5.6.2009. Verordnung (EG) Nr. 443/2009 des Europäischen Parlaments und des Rates vom 23. April 2009 zur Festsetzung von Emissionsnormen für neue Personenkraftwagen im Rahmen des Gesamtkonzepts der Gemeinschaft zur Verringerung der CO 2 -Emissionen von Personenkraftwagen und leichten Nutzfahrzeugen.

EUR-Lex (2007). Commission regulation (ec) no 105/2007 of 1 february 2007 amending the annexes to regulation (ec) no 1059/2003 of the european parliament and of the council on the establishment of a common classification of territorial units for statistics (nuts).

European Commision (Eurostat) (2008). European cities.

European Commision (Eurostat) (2011). Glossary:nomenclature of territorial units for statistics (nuts).

Finger, M. (1994). From knowledge to action? exploring the relationships between environmental experiences, learning, and behavior. *Journal of Social Issues 50*(3), 141–160.

Fischer, A. and C. Kallen (1997). *Klimaschutz in Kommunen - Leitfaden zur Erarbeitung und Umsetzung kommunaler Klimakonzepte*. Deutsches Institut für Urbanistik.

Fischer, C. (2002). Nachhaltiger Konsum: Zum Stand der Forschung.

Fishbein, M. and I. Ajzen (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*.

Flyvbjerg, B. (2001). Making social science matter: Why social inquiry fails and how it can succeed again. *New York: Cambridge*.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative inquiry 12*(2), 219.

Forman, R. (1995). *Land Mosaic: the Ecology of Landscapes and Regions*. Cambridge University Press.

Foxon, T. (2007). Technological lock-in and the role of innovation. *Handbook of sustainable development*.

Fritsche, U. R. and L. Rausch (2008). Umweltbundesamt: Bestimmung spezifischer Treibhausgas-Emissionsfaktoren für Fernwärme. *Climate Change 8*.

Fritsche, U. R. and K. Schmidt (2007). Öko-Institut (Institut für angewandte Ökologie e.V.). Endenergiebezogene Gesamtemissionen für Treibhausgase aus fossilen Energieträgern unter Einbeziehung der Bereitstellungsvorketten Kurzbericht im Auftrag des Bundesverbands der deutschen Gas- und Wasserwirtschaft e.V. (BGW).

Garz, H., R. Ötsch, A. Haas, P. Wirtz, and S. Zank (2009). German power utilities - caught in the co2 trap. *Potsdam Institute for Climate Impact Research, WestLB Study, September*.

Gausemeier, J., A. Fink, and O. Schlake (1998). Scenario management: An approach to develop future potentials. *Technological Forecasting and Social Change 59*(2), 111 – 130.

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy 31*(8-9), 1257–1274.

Geels, F. (2006). The hygienic transition from cesspools to sewer systems (1840-1930): The dynamics of regime transformation. *Research Policy 35*(7), 1069–1082.

Geels, F. W. and J. Schot (2007). Typology of sociotechnical transition pathways. *Research Policy 36*(3), 399 – 417.

Geller, E. (1981). Evaluating energy conservation programs: Is verbal report enough? *The Journal of Consumer Research 8*(3), 331–335.

Geller, E., J. Erickson, and B. Buttram (1983). Attempts to promote residential water conservation with educational, behavioral and engineering strategies. *Population & Environment 6*(2), 96–112.

Geo-Net Umweltconsulting GmbH (2010). Integriertes Klimaschutzkonzept für die Stadt Braunschweig.

Geurs, K. and B. van Wee (2004). Backcasting as a tool for sustainable transport policy making: the environmentally sustainable transport study in the Netherlands. *EJTIR 4*(1), 47–69.

Gifford, R. (2007). Environmental psychology and sustainable development: Expansion, maturation, and challenges. *Journal of Social Issues 63*(1), 199–212.

Gifford, R. (2008). Psychology's essential role in alleviating the impacts of climate change. *Canadian Psychology/psychologie canadienne 49*(4), 273.

Gigli, M. (2008). Nachhaltiger Energiekonsum als Beitrag zum Klimaschutz - Erfolgsfaktoren und Barrieren der Realisierung von energetischen Sanierungen durch Eigenheimbesitzer. Master's thesis, Universität Trier: Fachbereich 1 - Psychologie.

Glavic, P. and R. Lukman (2007). Review of sustainability terms and their definitions. *Journal of Cleaner Production 15*(18), 1875 – 1885.

Godet, M. (1987). *Scenarios and Strategic Management*. Butterworth, London.

Godet, M., A. Gerber, and K. Radford (2001). *Creating futures*. Economica London.

Grubb and Ellis (2007). Meeting the carbon challenge: The role of commercial real estate owners. *Users & Managers*.

Håkansson, H. (1987). *Industrial technological development: a network approach*. Croom Helm.

Håkansson, H. (1989). *Corporate technological behaviour: co-operation and networks*. Routledge London.

Hamacher, T. and M. Bartelt (2010a). Integriertes Klimaschutkonzept der Universitäts- und Hansestadt Greifswald - Kurzfassung.

Hamacher, T. and M. Bartelt (2010b). Integriertes Klimaschutkonzept der Universitäts- und Hansestadt Greifswald - Langfassung.

Hampton, D. (1973). The planning-motivation dilemma: Limitations and advantages of setting goals. *Business Horizons 16*(3), 79–87.

Hansestadt Rostock (2005). Klimaschutz - Ein Rahmenkonzept für die Hansestadt Rostock.

Hansestadt Rostock (2010). Klimaschutz - Ein Rahmenkonzept für die Hansestadt Rostock: 1. Fortschreibung 2010-2020.

Hardin, G. (1968). The tragedy of the commons. *Science 162*, 1243–1248.

Harlow, H. (1953). Motivation as a factor in the acquisition of new responses.

Haughton, C. and C. Hunter (1994). Sustainable cities. *Regional Policy Development 7*.

Hauser, G. (1997). Energieeinsparpotential im Bestand des Wohnungsbaus. *GRE inform 14/97*, 14–18.

Hautzinger, H. and M. Pfeiffer (1996). Gesetzmäßigkeiten des Mobilitätsverhaltens.

Hennicke, P., E. Jochem, and F. Prose (1997). Interdisziplinäre Analyse der Umsetzungschancen einer Energiespar-und Klimaschutzpolitik. *Mobilisierung und Umsetzungskonzepte für verstärkte kommunale Energie-und Klimaschutzaktivitäten Forschungsbericht, Karlsruhe, Kiel, Wuppertal*.

Herrmann, N. (2010). *Regional Energy 2050: A sustainability-oriented strategic backcasting methodology for local utilities*. Ph. D. thesis, University of Flensburg.

Höjer, M. and L.-G. Mattsson (2000). Determinism and backcasting in future studies. *Futures 32*, 613–634.

Hohmeyer, O., H. Maas, and E. Kovac (2010a). Energiebilanz und Treibhausgasemissionen in Flensburg: Bestandsaufnahme der Energieverbräuche und der CO2-Emissionen in Flensburg in den Jahren 1990 bis 2006.

Hohmeyer, O., H. Maas, and E. Kovac (2010b). Energiebilanz und Treibhausgasemissionen in Flensburg: Entwicklung des Energieverbrauches und der CO2-Emissionen ohne weitere Klimaschutzmaßnahmen bis zum Jahr 2050.

Hohmeyer, O., H. Maas, E. Kovac, and M. Beer (2011). Integriertes Klimaschutzkonzept Flensburg - Der Weg zur CO_2-Neutralität.

Höjer, M., S. Ahlroth, K. Dreborg, T. Ekvall, G. Finnveden, O. Hjelm, E. Hochschorner, M. Nilsson, and V. Palm (2008). Scenarios in selected tools for environmental systems analysis. *Journal of Cleaner Production 16*(18), 1958–1970.

Hollenbeck, J., C. Williams, and H. Klein (1989). An empirical examination of the antecedents of commitment to difficult goals. *Journal of Applied Psychology 74*(1), 18.

Homburg, A. and E. Matthies (1998). *Umweltpsychologie: Umweltkrise, Gesellschaft und Individuum*. Juventa.

Homburg, A. and F. Prose (1997). Selected social psychological contributions to climate protection processes on the community level. In R. et al. (Ed.), *Technology, the Environment and Us (Proceedings of the 6th IRNES Conference)*, pp. p. 159–165. London: Graduate School of Environment, Imperial College.

Hopkins, R. (2008). *The Transition Handbook: From Oil Dependency to Local Resilience*. Green Books.

Huss, W. R. (1988). A move toward scenario analysis. *International Journal of Forecasting 4*(3), 377 – 388.

ifeu (2010). Fortschreibung und Erweiterung Daten- und Rechenmodell: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030 (TREMOD, Version 5).

IfS (2008). Institut für Stadtforschung und Strukturpolitik GmbH - Zielgruppenorientierte Wohnungsmarktanalyse für die Stadt Flensburg – Endbericht.

IPCC (2001). Zusammenfassung für politische Entscheidungsträger Klimaänderung 2011: Synthesebericht.

IPCC (2007a). Climate change 2007: Synthesis report - summary for policymakers.

IPCC (2007b). Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)].

IPCC (2007c). Climate change 2007: The physical science basis - summary for policymakers.

IPCC (2007d). Policies, instruments and co-operative arrangements. in climate change 2007: Mitigation. contribution of working group iii to the fourth assessment report of the intergovernmental panel on climate change.

IPCC (2007e). Summary for poicymakers. in: Climate change 2007: The physical science basis. contribution of working group i to the fourth assessment report of the intergovernmental panel on climate change.

IWU & ZIV (2002). Null-Emissions-Stadt: Sondierungsstudie im Auftrag des Bundesministeriums für Bildung und Forschung. IWU: Institut Wohnen und Umwelt GmbH, ZIV: Zentrum für integrierte Verkehrssysteme.

Jaffe, A. and R. Stavins (1994). The energy-efficiency gap what does it mean? *Energy Policy 22*(10), 804–810.

Johnson, G., K. Scholes, and R. Whittington (2008). *Exploring corporate strategy: text & cases*. Prentice Hall.

Kaplan, A., A. Skogstad, and M. Girshick (1950). The prediction of social and technological events. *Public Opinion Quarterly 14*(1), 93–110.

Katzev, R. and T. Johnson (1983). A social-psychological analysis of residential electricity consumption: The impact of minimal justification techniques. *Journal of Economic Psychology 3*(3), 267–284.

Kaufmann-Hayoz, R., S. Bruppacher, R. Defila, A. Di Giulio, P. Flury-Kleubler, U. Friederich, M. Garbely, H. Gutscher, et al. (2001). *A typology of tools for building sustainability strategies*. Birkhäuser, Basel.

Kemp, R. and D. Loorbach (2003). Governance for sustainability through transition management. In *Open Meeting of Human Dimensions of Global Environmental Change Research Community, Montreal, Canada*. Citeseer.

Kemp, R. and D. Loorbach (2006). *Reflexive governance for sustainable development*, Chapter Transition Management: A reflexive governance approach, pp. 103–130. Jan-Peter Vošs and Dierk Bauknecht and Rene Kemp.

Kern, F. (2006). Transition management in der holländischen energiepolitik–ein erfolgsmodell für deutschland?

Kirk, D. (1996). Demographic transition theory. *Population Studies 50*(3), 361–387.

Kirkby, J., P. O'Keefe, and L. Timberlake (1995). *The Earthscan reader in sustainable development*. Earthscan Publications Ltd.

Klein, H., M. Wesson, J. Hollenbeck, and B. Alge (1999). Goal commitment and the goal-setting process: conceptual clarification and empirical synthesis. *Journal of Applied Psychology 84*(6), 885.

Knörr, W. (2005). ifeu - Institut für Energie- und Umweltforschung Heidelberg GmbH. Fortschreibung „Daten- und Rechenmodell“: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030. Zusammenfassung. Im Auftrag des Umweltbundesamtes UFOPLAN Nr. 204 45 139.

Kok, M., W. Vermeulen, A. Faaij, and D. Jager (2002). Towards a climate-neutral society. *Global Warming and Social Innovation the Challenge of a Climate-Neutral Society*.

Kotler, P., N. Roberto, and N. Lee (2002). *Social marketing: Improving the quality of life*. Sage Publications, Incorporated.

Kotler, P. and G. Zaltman (1971). Social marketing: an approach to planned social change. *The Journal of Marketing*, 3–12.

Kowalski, K., S. Stagl, R. Madlener, and I. Omann (2009). Sustainable energy futures: Methodological challenges in combining scenarios and participatory multi-criteria analysis. *European Journal of Operational Research 197*(3), 1063 – 1074.

Kruse, L. (1995). Globale Umweltveränderungen: Eine Herausforderung für die Psychologie. *Psychologische Rundschau 46*(2), 81–92.

Lankao, P. (2007). Are we missing the point? particularities of urbanization, sustainability and carbon emissions in latin american cities. *Environment and Urbanization 19*(1), 159–175.

Lankao, P. and J. Tribbia (2009). Assessing patterns of vulnerability, adaptive capacity and resilience across urban centres. In *Urban Symposium on Climate Change*, Volume 5.

Larsen, K. and U. Gunnarsson-Östling (2009). Climate change scenarios and citizen-participation: Mitigation and adaptation perspectives in constructing sustainable futures. *Habitat International 33*(3), 260 – 266. Climate Change and Human Settlements.

Latham, G. and E. Locke (1979). Goal setting—a motivational technique that works. *Organizational Dynamics 8*(2), 68–80.

Latham, G. and E. Locke (1991). Self-regulation through goal setting. *Organizational behavior and human decision processes 50*(2), 212–247.

Lee, E.-J. and D. W. . Schumann (2002). The in fluence of communication source and mode on consumer adoption of technological innovations. *Journal of Consumer Affairs 36*, 1–27.

Lindner, S. and A. Schmidt (2009). Klimaschutzorientiertes energiekonzept für den gebäudesektor in norderstedt.

Locke, E. (1968). Toward a theory of task motivation and incentives. *Organizational behavior and human performance 3*(2), 157–189.

Locke, E. and G. Latham (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American psychologist 57*(9), 705.

Locke, E., K. Shaw, L. Saari, and G. Latham (1981). Goal setting and task performance: 1969–1980. *Psychological bulletin 90*(1), 125.

Loorbach, D. (2007). *Transition management*. Ph. D. thesis, Dutch Research Institute For Transitions (DRIFT), Erasmus University Rotterdam.

Loorbach, D. (2008). Why and how transition management emerges.

Loorbach, D. (2010). Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance 23*(1), 161–183.

Lovins, A. (1976). Energy strategy: The road not taken? *Foreign Affairs 55*, 63–96.

Lozano, R. (2008). Envisioning sustainability three-dimensionally. *Journal of Cleaner Production 16*(17), 1838 – 1846.

Lübben, B. (2010). Integriertes Klimaschutzkonzept für die Stadt Braunschweig - Kurzfassung.

LVS (2009). Verkehrsservicegesellschaft mbH Schleswig-Holstein. Landesweiter Nahverkehrsplan 2008-2012.

MacNulty, C. (1977). Scenario development for corporate planning. *Futures 9/2*, 128–138.

Makridakis, S., S. Wheelwright, and F. Hyndman (1998). Methods and applications.

Mannermaa, M. (1991). In search of an evolutionary paradigm for futures research. *Futures 23*(4), 349–372.

Martino, J. (1983). *Technological forecasting for decision making*. Elsevier Science Publishing Company.

McGranahan, G., D. Balk, and B. Anderson (2007). The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and Urbanization 19*(1), 17.

McKenzie-Mohr, D. (1999). Community based social marketing.

McKenzie-Mohr, D. (2002). New ways to promote proenvironmental behavior: Promoting sustainable behavior: An introduction to community-based social marketing. *Journal of social issues 56*(3), 543–554.

McKenzie-Mohr, D. (2011). *Fostering sustainable behavior: An introduction to community-based social marketing*. New Society Publishers.

Miller, K. D. and H. G. Waller (2003). Scenarios, real options and integrated risk management. *Long Range Planning 36*(1), 93 – 107. Risk: The Interfaces of Strategy and Finance.

Miserandino, M. (1996). Children who do well in school: Individual differences in perceived competence and autonomy in above-average children. *Journal of Educational Psychology 88*(2), 203.

Moe, T. (2012). Green growth: Policies for transition towards low carbon economies. *The Review of Economics and Statistics 91*(1).

Moles, R., W. Foley, J. Morrissey, and B. O'Regan (2008). Practical appraisal of sustainable development–methodologies for sustainability measurement at settlement level. *Environmental Impact Assessment Review 28*(2-3), 144 – 165.

Moser, S. and L. Dilling (2011). Communicating climate change: closing the science-action gap. *The Oxford handbook of climate change and society*, 161.

Mosler, H., H. Gutscher, and J. Artho (2001). Wie können viele Personen für eine kommunale Umweltaktion gewonnen werden. *Umweltpsychologie, 5 (2)*, 122–140.

Mulder, K. F. (2007). Innovation for sustainable development: from environmental design to transition management. *Sustain Science 2*(2), 253–263.

Newman, P. and J. Kenworthy (1999). *Sustainability and Cities - Overcoming Automobile Dependence*. Island Press.

Nill, J. and R. Kemp (2009). Evolutionary approaches for sustainable innovation policies: From niche to paradigm? *Research Policy 38*(4), 668 – 680. Special Issue: Emerging Challenges for Science, Technology and Innovation Policy Research: A Reflexive Overview.

Nitsch, J. and B. Wenzel (2009). *Leitszenario 2009-Langfristszenarien und Strategien für den Ausbau erneuerbarer Energien in Deutschland unter Berücksichtigung der europäischen und globalen Entwicklung, published by Federal Ministry for the Environment*.

Notestein, F. (1945). Population: the long view. *Food for the World 36*, 57.

Nuttin, J. (1973). Pleasure and reward in human motivation and learning. *Pleasure, reward, preference*, 243–274.

O'Sullivan, A. and S. Sheffrin (2006). *Economics: Principles in Action*. Prentice Hall Science/Social Studies. Prentice Hall.

Perkins, R. (2003). Technological lock-in. *Online Encyclopaedia of Ecological Economics*.

Porter, M. (1998). *Competitive advantage: creating and sustaining superior performance: with a new introduction*. Free Pr.

Prognos (2009). Modell Deutschland - Klimaschutz bis 2050: Vom Ziel her denken. Prognos AG und Öko-Institut.

Projektgruppe Klimaschutz Celle (2011). Integriertes Klimaschutzkonzept mit Aktionsplan - Entwurfsfassung.

Prose, F. (1994). Ansätze zur Veränderung von Umweltbewußtsein und Umweltverhalten aus sozialpsychologischer Perspektive. In *Neue Wege im Energiespar- Marketing, Materialien zur Energiepolitik in Berlin*, Volume 16, pp. 14–23. Senatsverwaltung für Stadtentwicklung und Umweltschutz Berlin.

Prose, F. (2010). Partizipatives Soziales Marketing für den Klimaschutz - Ansätze zur Veränderung von Umweltbewußtsein und Umweltverhalten aus sozialpsychologischer Perspektive -. *Institut für Psychologie, Universität Kiel*.

Prose, F., C. Engellandt, and J. Bendrien (2000). Kommunale Akteure und Soziale Netze. Ein sozialpsychologisches Rahmenmodell zur Analyse kommunalen Klimaschutzes. *Klimaschutz als sozialer Prozess. Erfolgsfaktoren für die Umsetzung auf kommunaler Ebene*.

Prose, F., G. Hübner, and D. Kupfer (1993). Zur Organisation des Klimaschutzes auf der kommunalen Ebene. *Forschungsbericht / 2. Zwischenbericht*.

Prose, F. and A. Homburg (1997). Implementing energy efficiency measures from a psychological point of view and appendix. In *International Conference "Energy Efficiency in Public and Municipal Buildings", Session 5: Information, Awareness, Graz (Austria)*. EU Programme ECOS Ouverture.

Prose, F., G. Hübner, and D. Kupfer (1996). Organisation des Klimaschutzes auf kommunaler Ebene. *Umweltpsychologische Berichte aus Forschung und Praxis 3*(1996), 105–113.

Quist, J. (2007a). *Backcasting for a Sustainable Future: The Impact After 10 Years*. Ph. D. thesis.

Quist, J. (2007b). *Backcasting for a Sustainable Future: The Impact After 10 Years*. Eburon.

Quist, J. (2009). Stakeholder and user involvement in backcasting and how this influences follow-up and spin-off. In *Joint Actions On Climate Change*.

Quist, J. and P. Vergragt (2006). Past and future of backcasting: The shift to stakeholder participation and a proposal for a methodological framework. *Futures 38*(9), 1027–1045.

Rabinowitz, P. (2013). Conducting a workshop. http://ctb.ku.edu/en/tablecontents/sub_section_main_1113.aspx.

Raskin, P., T. Banuri, G. Gallopin, P. Gutman, A. Hammond, R. Kates, and R. Swart (2003). *Great transition: The Promise and Lure of the Times Ahead*. ISOE.

Ravetz, J. (2000). Integrated assessment for sustainability appraisal in cities and regions. *Environmental Impact Assessment Review 20*(1), 31 – 64.

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation 141*(10), 2417 – 2431.

Rieck, R., A. Butz, F. Fredrich, B. Schulz, A. Stech, and C. Strobl (2011). Stadt Elmshorn - Integriertes kommunales Klimaschutkonzept.

Rieck, R., B. Schulz, A. Rechberg, F. Fredrich, A. Butz, and K. Dinges (2010). Integriertes kommunales Klimaschutkonzept Stadt Emden.

Rip, A. and R. Kemp (1998). Technological change. *Human choice and climate change 2*, 327–399.

Robinson, J. (2003). Future subjunctive: backcasting as social learning. *Futures 35*(8), 839 – 856.

Robinson, J. B. (1990). Futures under glass : A recipe for people who hate to predict. *Futures 22*(8), 820 – 842.

Rogers, E. (2003). *Diffusion of Innovations, 5th Edition*. Free Press.

Rotmans, J. (2006). *Transitiemanagement: sleutel voor een duurzame samenleving*. Uitgeverij Van Gorcum.

Rotmans, J., R. Kemp, and M. van Asselt (2001). More evolution than revolution. *Transition Management in Public Policy, Foresight 3*(1), 15–31.

Rotmans, J., M. van Asselt, and P. Vellinga (2000). An integrated planning tool for sustainable cities. *Environmental Impact Assessment Review 20*(3), 265 – 276. Assessment Methodologies for Urban Infrastructure.

Ryan, R. and E. Deci (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology 25*(1), 54–67.

Sahling, U., U. Scherer, T. Wostradowski, and C. Dietrich (2010a). Ein integrietes Klimaschutkonzept für die Stadt Langenhagen - Anlagen.

Sahling, U., U. Scherer, T. Wostradowski, and C. Dietrich (2010b). Ein integrietes Klimaschutkonzept für die Stadt Langenhagen - Endbericht.

Satterthwaite, D. (2011). How urban societies can adapt to resource shortage and climate change. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 369*(1942), 1762.

Schäfer-Breede, K., M. Otten, H. Ludewig, K. Jahn, B. Eikmeier, K. Gerwien-Siegel, and B. Langer (2011b). Integriertes Energie- und Klimaschutzkonzept für die Stadt Oldenburg (InEKK) - Anhang.

Schäfer-Breede, K., M. Otten, H. Ludewig, K. Jahn, B. Eikmeier, K. Gerwien-Siegel, and B. Langer (2011c). Integriertes Energie- und Klimaschutzkonzept für die Stadt Oldenburg (InEKK) - Kurzbericht.

Schäfer-Breede, K., M. Otten, H. Ludewig, K. Jahn, B. Eikmeier, K. Gerwien-Siegel, and B. Langer (2011a). Integriertes Energie- und Klimaschutzkonzept für die Stadt Oldenburg (InEKK) - Schlussbericht.

Schmitt, D. and H. Forsbach (2009). Entwicklungsperspektiven des deutschen Elektrizitätsmarktes – Untersuchung im Auftrag der HSE AG.

Schoemaker, P. (2002). Profiting from uncertainty: Strategies for succeeding no matter what the future brings. *Free Press, New York*.

Scholz, R. and M. Stauffacher (2007). Managing transition in clusters: area development negotiations as a tool for sustaining traditional industries in a Swiss prealpine region. *Environment and Planning A 39*(10), 2518.

Schuler, H. and H. Brandstätter (1995). *Lehrbuch Organisationspsychologie*. Huber.

Schwartz, P. (1991). *The art of the long view*. Doubleday/Currency.

Schwartz, S. (1977). Normative influences on altruism. *Advances in experimental social psychology 10*, 221–279.

Simon, H. (1972). Theories of bounded rationality. *Decision and organization 1*, 161–176.

Simon, H., M. Egidi, R. Viale, and R. Marris (2008). *Economics, bounded rationality and the cognitive revolution*. Edward Elgar Pub.

Sondeijker, S. (2009). *Imagining Sustainability: methodological building blocks for transition scenarios*. Ph. D. thesis, Erasmus Universiteit Rotterdam.

Stadt Flensburg (2001). Zahlenspiegel 2001. Flensburg: Statistikstelle.

Stadt Wolfsburg Umweltamt (2009). CO2-Bilanz und -Minderungskonzept der Stadt Wolfsburg.

Stadtverwaltung Kiel (2008). Kieler Energie- und Klimaschutzkonzept.

Statistikamt für Hamburg und Schleswig-Holstein (2008). Bevölkerungsentwicklung in Schleswig-Holstein bis 2025 Ergebnisse der aktuellen Bevölkerungsvorausberechnung.

Statistikamt Nord (2006). Statistisches Landesamt für Hamburg und Schleswig-Holstein: Der Bestand an Kraftfahrzeugen und Kraftfahrzeuganhängern in den Kreisen Schleswig-Holsteins am 1. Januar der Jahre 2003 bis 2006.

Statistikamt Nord (2009). Statistisches Landesamt für Hamburg und Schleswig-Holstein - Erhebung über die Energieverwendung der Betriebe des verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden. Tabelle Regio: Energieverbrauch in 1000 MJ (einschl. nichtenergetischen Verbrauch). Berichtszeitraum: 2006.

Statistische Ämter des Bundes und der Länder (2011). Regionaldatenbank Deutschland.

Statistisches Bundesamt (2008). Statistisches Jahrbuch 2008: Bevölkerung.

Stephens, J. C. and A. C. Graham (2009). Toward an empirical research agenda for sustainability in higher education: exploring the transition management framework. *Journal of Cleaner Production In Press, Corrected Proof*, 1–8.

Stern, P. (2011). Contributions of psychology to limiting climate change. *American Psychologist 66*(4), 303.

Steuerkreis der Wolfsburger Agenda 21 (2009). Wolfsburger Agenda 21.

Street, P. (1997). Scenario workshops: A participatory approach to sustainable urban living? *Futures 29*(2), 139 – 158.

Swim, J., S. Clayton, T. Doherty, R. Gifford, G. Howard, J. Reser, P. Stern, and E. Weber (2009). Psychology and global climate change: Addressing a multi-faceted phenomenon and set of challenges. a report by the american psychological association's task force on the interface between psychology and global climate change. *Retrieved April 15*, 2010.

Swim, J., P. Stern, T. Doherty, S. Clayton, J. Reser, E. Weber, R. Gifford, and G. Howard (2011). Psychology's contributions to understanding and addressing global climate change. *American psychologist 66*(4), 241.

Taanman, M. (2008). Looking for transitions: background, framework and application of transition monitoring for the dutch energy transition. In *Berlin Conference on the Human Dimensions of Global Environmental Change*.

traffic-Kontor (2009). Stadt Flensburg: Auspendler - Statistik der Bundesagentur für Arbeit. Stichtag: 30.6.2006.

Truffer, B. and E. Stürmer (2009). Transition management at the local scale: Strategic planning for sustainable transitions in infrastructure. In *ESEE conference, Ljubiljana*.

Umweltamt der Stadt Wolfsburg (2005). Wolfsburger Erklärung über gemeinsames Handeln zum Klimaschutz.

Umweltbundesamt (2010). Nationale Trendtabellen für die deutsche Berichterstattung atmosphärischer Emissionen. 1990 - 2008 (Fassung zur EU-Submission 15.01.2010).

UN-Habitat (2011). *Global report on human settlements 2011: Cities and Climate Change*. United Nations Human Settlements Programme.

UNFPA (2008). State of world population 2008 - reaching common ground: Culture, gender and human rights.

United Nations Population Division (2010). World urbanization prospects: The 2009 revision population database. *http://esa.un.org/unpd/wup/unup/index.asp?panel=6*.

Unruh, G. C. (2000). Understanding carbon lock-in. *Energy Policy 28*(12), 817 – 830.

Unternehmensführung, I. (1997). *Kostenrechnung und Verhaltenssteuerung*. Springer DE.

URS Deutschland GmbH (2010). Klimaschutz in Lübeck - Integriertes Rahmenkonzept.

UTEC, Ingenieurbüro für Entwicklung und Anwendung umweltfreundlicher Technik GmbH (2003). Energie- und CO2 – Bilanz 2000 für die Landeshauptstadt Kiel.

Van Asselt, M., J. Rotmans, and D. Rothman (2005). *Scenario Innovation: experiences from a European experimental garden*. Aa Balkema.

van den Berg, A., T. Hartig, and H. Staats (2007). Preference for nature in urbanized societies: Stress, restoration, and the pursuit of sustainability. *Journal of Social Issues 63*(1), 79–96.

van der Brugge, R. (2009). *Transition Dynamics in Social-Ecological Systems - The Case of Dutch Water Management*. Ph. D. thesis, Dutch Research Institute For Transitions (DRIFT), Erasmus University Rotterdam.

van der Heijden, K. (1996). Scenarios the art of strategic conversation. *Willey*.

Vansteenkiste, M., W. Lens, and E. Deci (2006). Intrinsic versus extrinsic goal contents in self-determination theory: Another look at the quality of academic motivation. *Educational Psychologist 41*(1), 19–31.

Varum, C. A. and C. Melo (2010). Directions in scenario planning literature - a review of the past decades. *Futures 42*(4), 355 – 369. Learning the Future Faster.

Verbong, G. and F. Geels (2007). The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the dutch electricity system (1960-2004). *Energy Policy 35*(2), 1025 – 1037.

Vergragt, P. and H. Brown (2010). Managing urban transitions: visioning and stakeholder collaboration A case study in transforming residential housing in Worcester, MA.

Vermeulen, W. and M. Kok (2002). *Global Warming and Social Innovation: the Challenge of a Climate Neutral Society*, Chapter Contemporary practices: greenhouse scepticism?, pp. 39–58.

Wack, P. (1985). Scenarios: Unchartered waters ahead. *Harvard Business Review Sept.-Oct.*, 73–89.

Wagner, O., K. Berlo, U. Jansen, and A. Bierwirth (2008a). Maßnahmenpaket zur CO2-Reduzierung für die Stadt Osnabrück - Endbericht.

Wagner, O., K. Berlo, U. Jansen, and A. Bierwirth (2008b). Maßnahmenpaket zur CO2-Reduzierung für die Stadt Osnabrück - Kurzfassung des Endberichtes.

Wall, G. (1977). Exergy - a useful concept within resource accounting. *Report no. 77-42, Institute of Theoretical Physics, Chalmers University of Technology and University of Göteborg, S-412 96 Göteborg, Sweden*.

White, R. (1959). Motivation reconsidered: The concept of competence. *Psychological review 66*(5), 297.

Wiedmann, T. and J. Minx (2007). A definition of ‘carbon footprint’. *ISA UK Research Report 7*(01).

Wiek, A., C. Binder, and R. Scholz (2006). Functions of scenarios in transition processes. *Futures 38*(7), 740–766.

Wilde, R. and C. Tegtmeier (2010). Kommunales Klimaschutzkonzept der Stadt Hameln 2010-2020.

Wilson, I. (1992). Realizing the power of strategic vision. *Long range planning 25*(5), 18–28.

Winterkemper, A. and K. Timmermann (2010). Erster Zwischenbericht zur Begleitung und Umsetzung des Klimaschutzkonzeptes entsprechend dem Wuppertal-Gutachten aus 2008.

Woudenberg, F. (1991). An evaluation of delphi. *Technological forecasting and social change 40*(2), 131–150.

WWF (2008). Positionspapier WWF: CO2-Kompensation: Augenwischerei oder wirksamer Klimaschutz? - Leitfaden des WWF für die wirksame Anwendung eines sinnvollen Instruments. *Germany: WWF*.

Yates, S. and E. Aronson (1983). A social psychological perspective on energy conservation in residential buildings. *American Psychologist 38*(4), 435.

Yin, R. (1981). The case study crisis: some answers. *Administrative Science Quarterly 26*(1), 58–65.

Zellner, M. L., T. L. Theis, A. T. Karunanithi, A. S. Garmestani, and H. Cabezas (2008). A new framework for urban sustainability assessments: Linking complexity, information and policy. *Computers, Environment and Urban Systems 32*(6), 474 – 488. GeoComputation: Modeling with spatial agents.