FUTURE RESEARCH PERSPECTIVES IN MOBILITY AND SUSTAINABLE LIVING SPACES – RESULTS OF THE GERMAN FORESIGHT PROCESS

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ABSTRACT

In September 2007 the German Federal Ministry of Education and Research (BMBF) launched a 30 month study aiming to identify the most promising topics in several fields of research and technology as well as the potentials for strategic partnerships with a time horizon of 10 to 15 years. The objective of the study was to guide the Ministry in designing forthcoming research programmes and in assessing current proposals with regard to their future orientation. This paper describes the approach and the practical application of the BMBF foresight process, provides perspectives of the German socio-demographic future and – screened against this background – discusses the findings in the broader future fields of "mobility and logistics" and "sustainable living spaces". The results of the research are meant to open the discussion on the orientation of transport research policy in Europe and worldwide.

Keywords: RTD, foresight, transport, mobility, logistics, land use, living spaces, sustainability, technology

INTRODUCTION

Background

In September 2007 the German Federal Ministry of Education and Research (BMBF) launched a new foresight process scheduled to last for 30 months aiming to identify new priority fields and interdisciplinary themes in several fields of research and technology. The study looks 10 to 15 years and longer into the future and aims to guide the Ministry in designing forthcoming research programs and assessing current proposals with regard to their future orientation. The research was carried out in very close co-operation between two Fraunhofer Institutes – the Institute for Systems and Innovation Research (ISI) and the Institute for Industrial Organisation (IAO) and several departments at the German Research Ministry BMBF (Cuhls *et al* 2009b).

Purpose of the paper

In the first instance, the objective of this paper is to describe the German foresight activity and to highlight its strengths and complexity, but also its pitfalls and weaknesses. In doing so, we hope to encourage other countries or research entities to launch similar exercises and to benefit from the German experience if they do so.
The second objective is to convey the results obtained in the foresight project. Here we concentrate on two specific key areas which are, on the one hand, very closely interlinked, and, on the other hand, represent the two different approaches taken in the foresight process. These future fields are:

- mobility and logistics, and
- sustainable living spaces.

However, we cannot present research results which are now nearly one year old without looking at the development of the scientific community in the meantime. We allow ourselves to take a more detached look at what we recommended to the German government in summer 2009 concerning their future research policy in the fields of transport and spatial development. The results of the research are meant to kick-start the discussion on the orientation of transport research policy in Europe and worldwide.

THE FORESIGHT PROCESS

General structure of the process

The foresight activity looked about 15 years into the future. In other words, the challenge was to elaborate research themes which will be relevant around 2020 to 2025. To meet this challenge, research topics were classified into three categories in an initial review process:

- Themes which are just appearing on research agendas and which promise to receive more attention in the coming decade ('green topics')
- Topics which are already being investigated, and which will most likely remain relevant for research throughout the next 15 years ('golden topics')
- Themes which are currently interesting, but will probably be resolved in the coming decade ('red topics')

The identification and classification of the research topics was carried out and critically reviewed throughout the whole process in a multi-step procedure. In the end, 14 topic areas were selected, including basic and applied science areas. The initial set of research areas comprised the German government's High-Tech Strategy. Throughout the process, the golden and green topics were further qualified by criteria addressing the novelty of the topics and their contribution to scientific and technological progress, to economic development and to global challenges and sustainability goals.

The foresight process was organised in a sequence of different steps with diverging objectives. Figure 1 illustrates the elements and their function in the overall process.

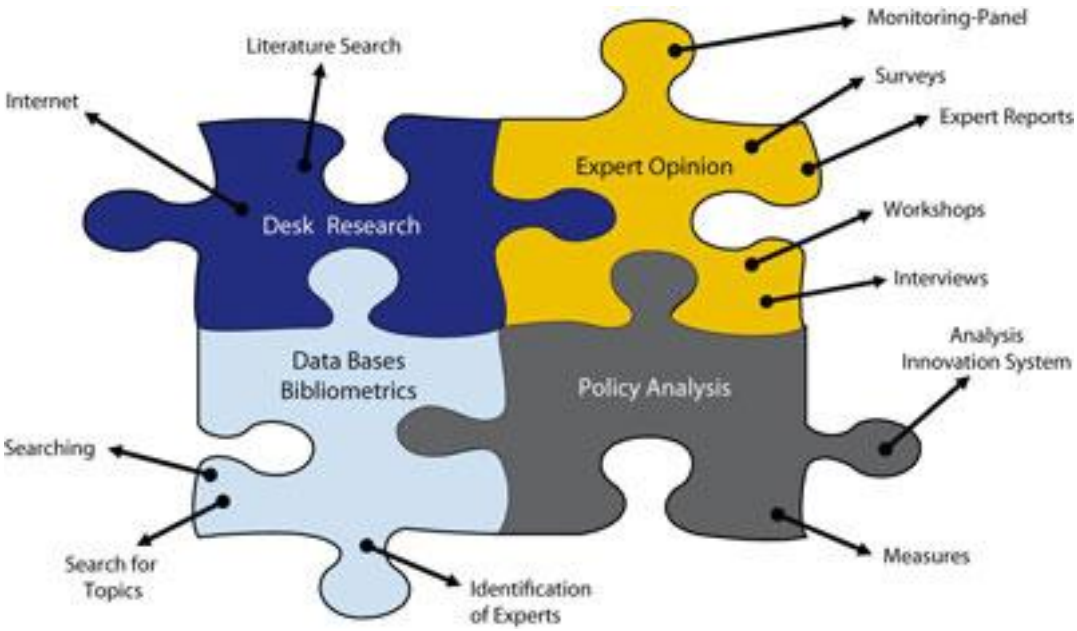

Figure 1: Elements of the foresight process (*Source: Cuhls and Ganz, 2008)*

The detailed description steps in the foresight process are shown in

. The process consisted of three monitoring phases and was accompanied by two major workshops and a final conference.

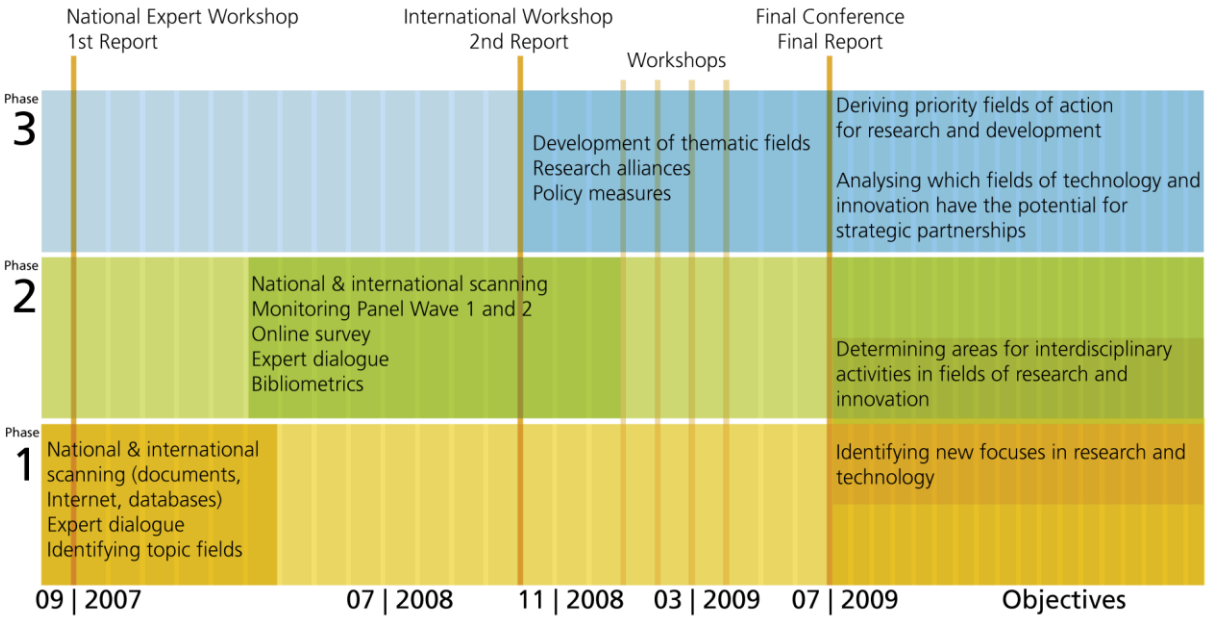

Figure 2: Schematic step diagram of the foresight process *(Source: Cuhls and Ganz, 2009)*

In the following, we select some of the most important elements of the foresight process and briefly discuss their design and their impacts on the results.

Workshops, surveys and monitoring

Involving research communities was considered to be of the utmost importance for the identification of research fields with potentially high relevance in the coming decades. Thus, the process was initiated by a workshop with around 80 invited experts representing 12 research areas including mobility, energy, environment and infrastructures. Scenario techniques mind mapping and matrices for matching topic fields in the specific questions and the development of prepared mind maps were all used to encourage the experts to see themselves in a world 15 years ahead in time. Another important issue was looking at the links between research fields in order to identify interesting themes at the border between two areas. Thus, in a final step, the experts were asked to visit parallel workshops and contribute their views and experiences there as well.
The spatial focus of the research community was widened to outside Germany by setting up an international panel of experts in the different research fields. In face-to-face and telephone interviews, the panel members contributed to a monitoring process which was structured in two waves performed in summer 2008 and spring 2009. The monitoring process was used to gain insights into the perception of the evolvement of current research priorities and to obtain an outlook. In the second interview wave, the identified future topics were re-assessed by the panellists and measures for their implementation were discussed (Cuhls and Ganz, 2009). Besides this official monitoring process, a great number of additional interviews were undertaken to identify future topics that meet the criteria of the BMBF.

An internet survey with around 2000 experts from Germany was conducted to evaluate the identified topics. The questions and statements in the survey were derived from the previous activities, including the initial workshop, literature reviews and the first monitoring wave. The results of the internet poll then served as input to the second monitoring wave and directly for the description of the future fields. The foresight process concluded with a final conference in Bonn, Germany's former capital and still the location of many federal ministries and agencies.

Bibliometrics

Bibliometrics constitutes a set of methods to measure the impact of a particular publication or a certain research topic on other scientific areas. The standard toolbox includes citation indices and content analyses. In the present foresight study, bibliometrics was applied to identify the cross-disciplinary relations between initial thematic research fields and to study the dynamics of the new cross-disciplinary research topics. Citation indices were applied to selected initial research topics and to all of the new research fields, including sustainable living spaces. Mobility and logistics were excluded from this methodological step in the foresight process because of the broadness of the topic and because its core terminology also appears in other disciplines but with entirely different meanings. Nevertheless, some elements of mobility and logistics were addressed in the bibliometric assessment of the research area sustainable living environments by considering search terms like "flexible transport systems", "mobility management" and "traffic demand management",.

The evolution of topics

The initial thematic fields comprised 14 of the 17 "High-Tech Strategy" areas designated by the German government in 2007. These were mainly technology fields, such as nano technologies, white biotechnology, optical sciences, plus a number of application fields, such as energy, environmental sciences, mobility, sustainable living spaces (human habitats) as well as production and consumption. During the foresight process, these topics have been refined in line with experts' votes, new literature or discussions in dedicated meetings. The search for interdependencies between single thematic areas has been especially important in pursuing the objective of identifying interesting new developments at the intersections of these fields of science and technology.

As a result, a number of new topics with high relevance for future research, technology development and policy design have been identified. These include future research fields like "Production Consumption 2.0", "Human-Technology Co-operation", "Energy Concert" and "Sustainable Living Spaces". While most of the initial research fields belong to a specific scientific discipline, the new fields are more cross-disciplinary in nature. In the following sections, the paper presents the results for the initial topic area "mobility and logistics" and the new research field "sustainable living spaces".

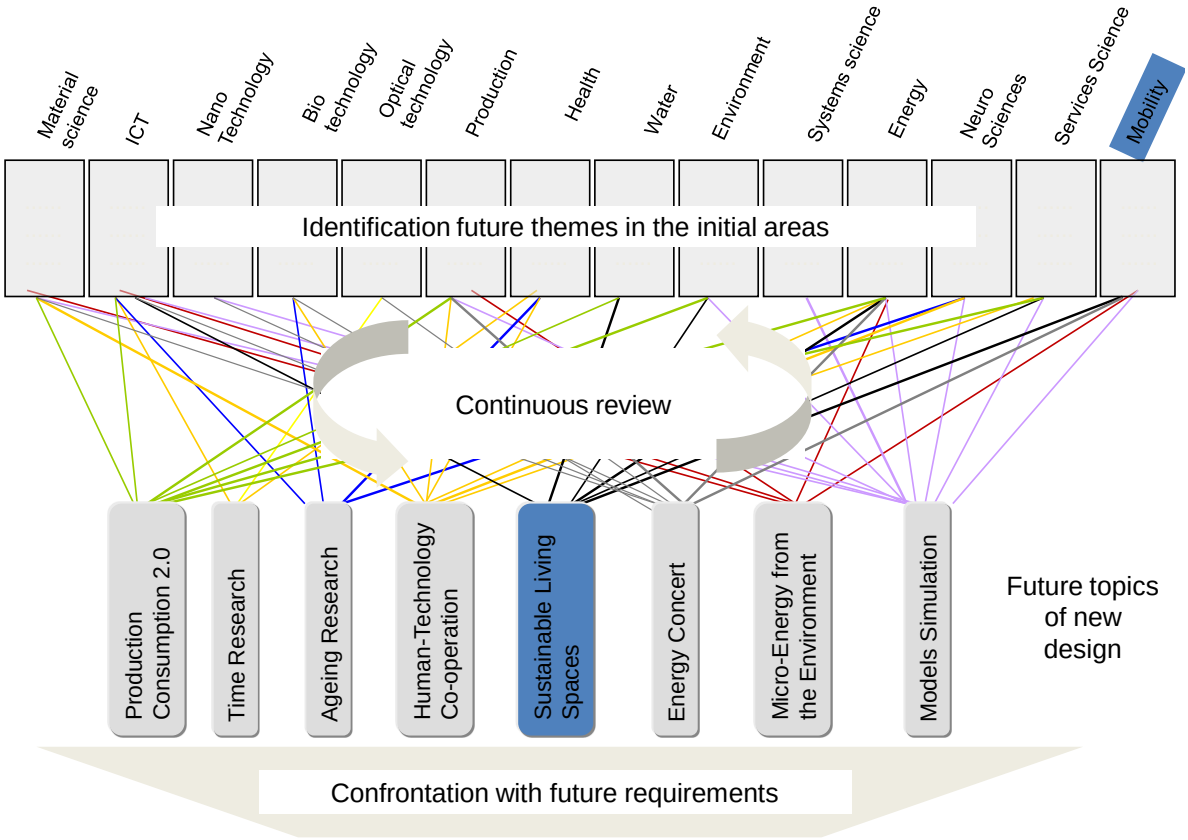

Figure 3: Evolution of identified research areas (*Source: Cuhls et al 2009a)*

RESULTS FOR MOBILITY AND LOGISTICS

Several application areas are of direct importance in the wider field of mobility: (1) mobility and logistics, (2) 'energy concert', (3) environmental sciences and (4) sustainable living spaces. Drawing on Germany's extremely diverse demographic development and its high energy dependency, some topics have been identified as the most relevant and dynamic: the flexibility and reversibility of the infrastructure stock, decentral and self-sustaining energy supply systems, alternative fuels and propulsion technologies, co-operative mobility services and finally the social inclusion of an aging population through diversified lifestyle models and adaptive and ambient assisted living technologies. Throughout the 30 months of research the focus has turned from technical solutions to social models providing answers to current socio-economic trends and challenges.

Initial setting of the topic

Driven by the emerging visibility of the consequences of demographic change and the worsening of economic conditions, the perception of what sustainable transport should look like and which challenges it should address has changed significantly over the past years and decades. While one of the top priorities in transport research throughout the 1970s and

1980s was to combat congestion and to increase infrastructure capacities with traffic demand management systems, rising environmental concerns and a slowdown in demand growth rates in the 1990s turned attention towards sustainability and the design of our living environment. Tight public budgets and the sharpening of the diverse demographic developments in different German and European regions finally called more and more on the issue of flexible and affordable public transport systems. Though capacity and efficiency still play a major role in regional as well as international transport, the deep cuts due to the global economic crisis and the current uncertainty about future growth rates have removed this issues from the top priorities in goods transport and logistics research (OECD and ITF 2009).
The foresight process in the research area of mobility and logistics began with topics whose selection was mainly driven by the sharply rising energy prices at that time, environmental and energy efficiency considerations and the result of patent analyses. An assessment of patent statistics in Walz *et al.* (2008) reveals that in particular green technologies at the borders between the traditional engineering disciplines show above average patent and innovation dynamics. Based on these insights and on literature reviews, the following research topics were identified to start with as being particularly relevant in the coming decades:

- efficient vehicles and propulsion systems,
- alternative fuels,
- safety of vehicles and infrastructure systems,
- traffic management and
- efficient logistics.

Evolution throughout the process

At the initial national expert workshop of the foresight process, which took place in December 2007 in Berlin, the participants already voted strongly for an inclusion of ‘soft topics’, such as regional development, equity issues and social inclusion. Despite the long tradition of researching and testing alternative mobility concepts, the transport market is rather conservative in its development and its greenhouse gas emissions have continued to increase in most sectors. It is observed that new mobility concepts often do not take off once their public funding has been terminated or that they only serve small niche markets. The view that future transport research needs to be focused on people and lifestyles was strongly supported by members of the international panel. The understanding of behavioural patterns plays a crucial role in this discussion as does the establishment of adaptive behavioural models with an interdisciplinary focus able to design and assess integrated alternative mobility solutions. While Europe, and probably Japan, is at an advanced stage of development here, car-centred nations like the US and some of the Asian mega cities should pay more attention to conceptual questions of mobility, logistics and land use planning.
A second topic which has changed its perspective over the process is capacity and traffic management. Booming international trade flows with 10 % growth rates at seaports and pressure on port hinterland networks were not unusual right up until mid 2008. Triggered by the subsequent world economic crisis, the initial strong support for new concepts in infrastructure management and capacity enlargement in international maritime and air transport had ebbed away in the second monitoring wave. In late 2008, questions like co-

operative and green logistics systems, regional production cycles and the treatment of monopolistic tendencies in the transport market entered the discussion. In order to balance and secure the freight flows, in particular with regard to the "last mile", ICT and sensor technologies have been identified by the experts as highly important for future research. At the same time as the financial crisis appeared, in July 2008, the European Commission issued their "Greening of Transport" package (EC 2008), following the 2007 strategy "keep freight moving" (EC 2007). It can be suspected that the ensuing discussion contributed to this changed view of the infrastructure and freight transport sector to some extent.

Throughout the process, transport technical issues have remained more or less stable in the perception of the experts involved and the literature sources analysed. As it will take a long time to replace combustion engines by alternative propulsion technologies, further research on improving their efficiency and combining them with alternative propulsion systems to obtain efficient hybrid solutions will be an ongoing RTD topic in road, air and waterway transport. Transport modes other than cars will most likely continue to be oil-dependent for a long time, which gives the research into alternative fuels and propulsion techniques a long perspective. In this context the question of cost efficient production of large quantities of second and third generation biomass-to-liquid (BTL) fuels is considered to be particularly relevant for future RTD activities. The focus of this topic area has moved towards the question of which infrastructure systems are required to supply the various alternative energy options for transport.

The discussions about the future development of ICT and assistance systems in cars and for public transport users, as well as the role of hydrogen in future transport systems were rather controversial. In contrast, the need to make transport more climate- and environmentally-friendly, in particular in the rapidly growing mega cities of Asia and South America, was not questioned throughout the foresight process.

The internet surveys, asking about the socio-political relevance and the research horizon of 56 selected research areas, did not contribute much to modify the findings of the expert panels. Nearly all the questions covered by the poll were assessed as highly important, with some differences in the time perspective. Figure 4 shows the three highest ranked topic groups with their most important sub-topics. Scores were awarded from 1: not relevant to 5: highly relevant for future research.

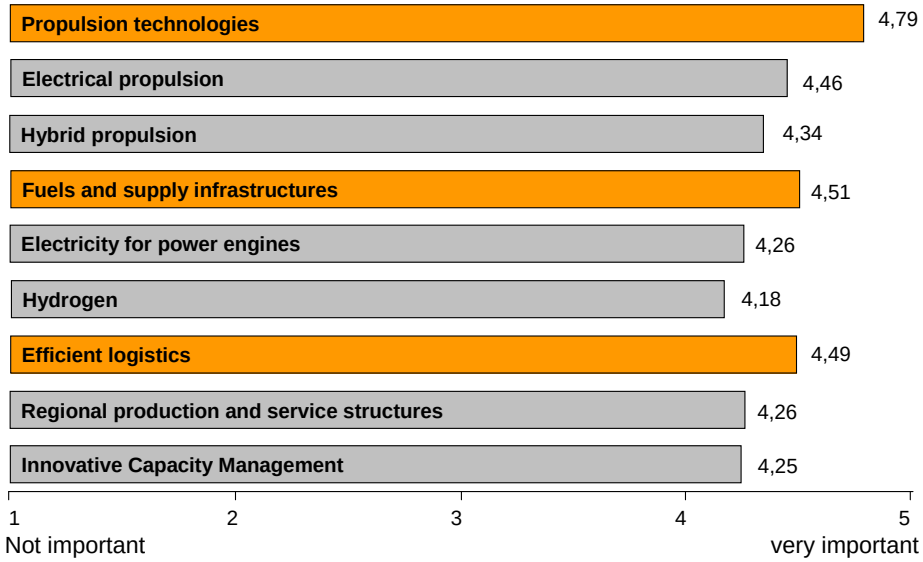

Figure 4: Highlight results from the internet survey

Unlike the interviewed experts, the survey participants disagree in their assessment of non-technical measures. However, the verbal comments made show,that concepts of mobility systems were seen as questions closely linked to pure technology development.

Topics for future research in mobility and logistics

Despite the diverging votes on the various technology lines and concepts of mobility and logistics research, we were still able to identify three major streams along which future research will most likely develop. These are not new, but given the demographic, economic and environmental challenges ahead, they are more than ever needed for a sustainable development path:

1. Co-operative mobility design. Single technological or behavioural sustainable transport measures are only of limited effect in most cases. In order to achieve ambitious climate, environmental and safety targets, technology and behavioural measures need to be co-ordinated to work in the same direction. Furthermore, a large number of citizens should be involved and support the system. Thus, a better understanding of peoples' needs and activity patterns is required, calling for interdisciplinary models and approaches.
2. Infrastructures for future propulsion systems. It is anticipated with a high degree of certainty that future transport systems will rely on a variety of energy sources, including gasoline and diesel, synthetic fuels, gas, electricity and hydrogen. Supplying this fuel mix safely across wider areas at affordable costs requires new infrastructure concepts. In particular, electric vehicles and the vehicle-to-grid concepts require intelligent networks and sustainable business concepts.
3. Green and efficient logistics. The security and standardisation of intelligent transportation systems (ITS) plays a vital role for smooth communication and co-operation across networks, modes and operators. Institutional questions also have to be tackled concerning the establishment of large-scale international co-operation

networks as well as small-scale local distribution co-operations. Regulation, policy design and handling capacity bottlenecks are also important determinants of the success of co-operative and green logistics networks.

Co-operation and governance aspects can be identified as extremely important in passenger as well as freight transport. The respective activities, however, should not neglect the essential role of technology research and development in the success of sustainable transport solutions.

Links to other topic areas

The foresight process placed special emphasis on identifying links between transport technology and system research and other future research fields. As the field “mobility and logistics” represents an area of applied research, manifold relations to other application areas and to the basic sciences can be identified. The most important ones are discussed in turn.

- Environment and Energy Concert: These application areas are naturally and closely linked to transport through the development of filter technologies, noise reduction and renewable energy supply.
- Material science and nano technologies are relevant for the construction of light and safe vehicles using metal foams and elements, as well as aerodynamic surfaces.
- Trends and research in industrial production are of the utmost importance for large-scale provision of hydrogen and synthetic fuels, such as biomass-to-liquid (BTL) and gas-to-liquid (GTL).
- ICT and systems are linked to traffic management and assistance systems, but the link is not considered particularly relevant.

An emerging research field of specific interest was the connection via the spatial sciences between transport and the design of sustainable human habitats in the future. This very broad, interdisciplinary field is described by the term “Sustainable Living Spaces”. It covers social trends like population decline and aging, migration and altering lifestyles which affect infrastructures like water supply, energy transmission, telecommunication, transport and public services in a similar way. Its concepts and solutions are discussed in the subsequent section.

RESULTS FOR SUSTAINABLE LIVING SPACES

Living spaces are subject to continuous structural change. However they are also determined by long-lived urban structures including infrastructures, in which any changes require enormous effort in both monetary terms as well as in terms of natural resources (Koziol and Walter, 2006; Siedentop *et al* 2006). Many current technologies and research approaches are concentrating on today’s settlement structures and ways of life, without acknowledging that these structures may undergo considerable changes in the future. Thus a research perspective is needed which accounts for sustainable spatial development and also considers the challenges of greater technical flexibility and the dynamics of land use and

infrastructure. In addition to this, the focus of future research interest will shift to the design and provision of pubic and private urban services as well as questions of the governance of human habitats , e.g. in context of local sustainability strategies. This will require interdisciplinary cooperation and networking across the different fields of research and technology, such as spatial development, mobility, materials, energy, water, ICT, production concepts, biotechnology, architecture and building materials research.
Important aspects of this research topic are

- structures and concepts to enable greater dynamics in the expansion, structural change or re-naturalisation of human habitats,
- technologies and concepts for greater flexibility in the supply and disposal infrastructure (e.g. by promoting decentral and semi-central supply concepts) and
- governance concepts to enable sustainable urban management as well as innovations for new service concepts in housing and the living environment – by redefining the role of spatial planning and the involved stakeholders.

Current state of the topic

In spite of a number of urban planning approaches which target compact and sustainable cities, current urban development is dominated by land consuming urban sprawl and expanding transport infrastructures in Germany's towns and city regions (BBR, 2005). This trend is, however, also accompanied by a stagnating or shrinking population.
Spatial research traditionally deals with spatial development phenomena based on demographic development and migration such as suburbanisation and urban sprawl and their interrelations with mobility. There are a number of model projects and research programmes aiming to gain applicable, scientific and practical insights for decision-makers in the fields of regional planning, town planning and transport in Germany. Infrastructure systems and their interaction with spatial development are also playing a greater role. Special importance is assigned to governance, since public infrastructure is regarded as a public service and is thus provided or regulated by the state.
Recently, the consequences of several megatrends have become the subject of research interest. These include demographic and societal changes (e.g. ambivalent demographic development across regions, compare Figure 5) as well as climate change.

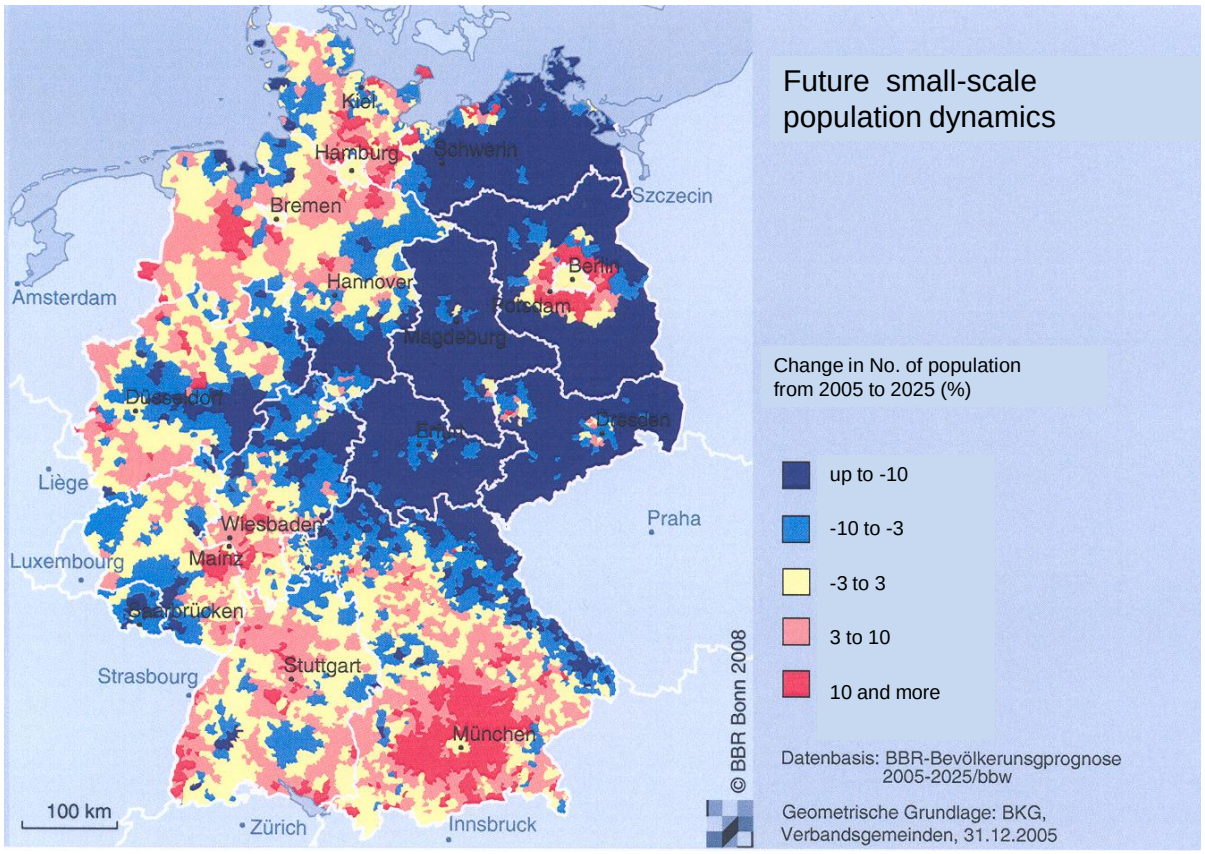

Figure 5: Regional changes in population (2005-2025). Source: BBR (2009)

Considering the tight fiscal situation of the public sector, cost optimisation is another important aspect, especially in decentralized suburban or rural settlement areas (cf. Reidenbach *et al* 2005). In order to be able to react in a resource- and cost-efficient way, it is necessary to turn long-lived supply and disposal systems towards greater flexibility. This triggers the need for research and actions in relation to technology, organisational concepts and materials. There are several current model and demonstration projects, which are characterised by the replacement of traditional centrally-organised systems by decentralised innovative concepts which have the advantage of lower costs and higher flexibility and are thus better suited to future requirements.[1] Besides the technical infrastructure, the social facilities to meet society's basic needs are also under pressure to change due to demographic changes. These include educational facilities such as kindergartens and schools, cultural facilities, and also those providing civil security services (police, fire service). Within spatial sustainability sciences, several approaches to local production and consumption of goods and services, combined with extended concepts of life cycle assessment (LCA), have been developed.

Beyond the technological changes, there is the strong future need to change static settlement structures in a conceptional way. Thus the dynamics within settlement concepts is

1 A good example is the interdisciplinary AKWA 2100 project (Hiessl et al 2005), which undertook a scenario study of long-term alternatives to the conventional urban water infrastructure using two German municipalities as case studies.

an important future research topic. To foster this topic, a certain amount of public money needs to be invested, e.g. in model projects investigating the impact of climate change.
Currently there are a number of projects related to water use within human habitats (e.g. funding priority “Klimazwei – Research for Climate Protection and Protection from Climate Impacts”). Moreover, research on innovations in building materials is being promoted by the German Federal Ministry of Transport, Building and Urban Development (BMVBS). The research initiative “Future Building” (Forschungsinitiative Zukunft BAU) was motivated by shortfalls in the fields of technical, cultural and organisational innovations in Germany’s building industry within the EC domestic market. The themes covered are building quality, legal regulations, and new materials and techniques.
In order to implement the results of ongoing research projects, other important areas are political control and strategic planning (BBR 2009). There are several current research approaches to foster sustainable settlement management and service concepts by innovations in the field of governance**.** These include all the approaches aiming at improvements by involving new planning techniques and stakeholders. An expert interview showed the importance of the proper coordination of interests among stakeholders, especially in the necessary urban regeneration processes in regions with a shrinking population. Moreover, there are several approaches to calculate and internalize the public costs of urban developments. Within the Funding Priority REFINA (Research for the Reduction of Land Consumption and for Sustainable Land Management) at the BMBF, a new GIS-based software tool has been developed, which can forecast the fiscal impact of certain local housing strategies taking demographic development into account.

Topics for future research in sustainable living spaces

The previous chapter described several current approaches to tackle the emerging problems in the fields of infrastructure and human habitats. However, most of the mentioned projects have showcase character and only partly result in general recommendations for stakeholders. The starting point for current projects is often the spatial impact of demographic changes, e.g. declining urban density and changes in age distribution leading to under-utilisation of technical systems, such as water supply and sewage.
Besides these spatial changes, there are a great number of interdependencies between the topographical, ecological, social, cultural and technical conditions of each human habitat, which have not been subject to scientific investigation so far. Conceptional dynamics and the flexibility of technical systems and their spatial application to new and existing developments are important future research fields. In order to show their long-term perspective, the future research topics have been structured by their application potential as presented in Figure 6.

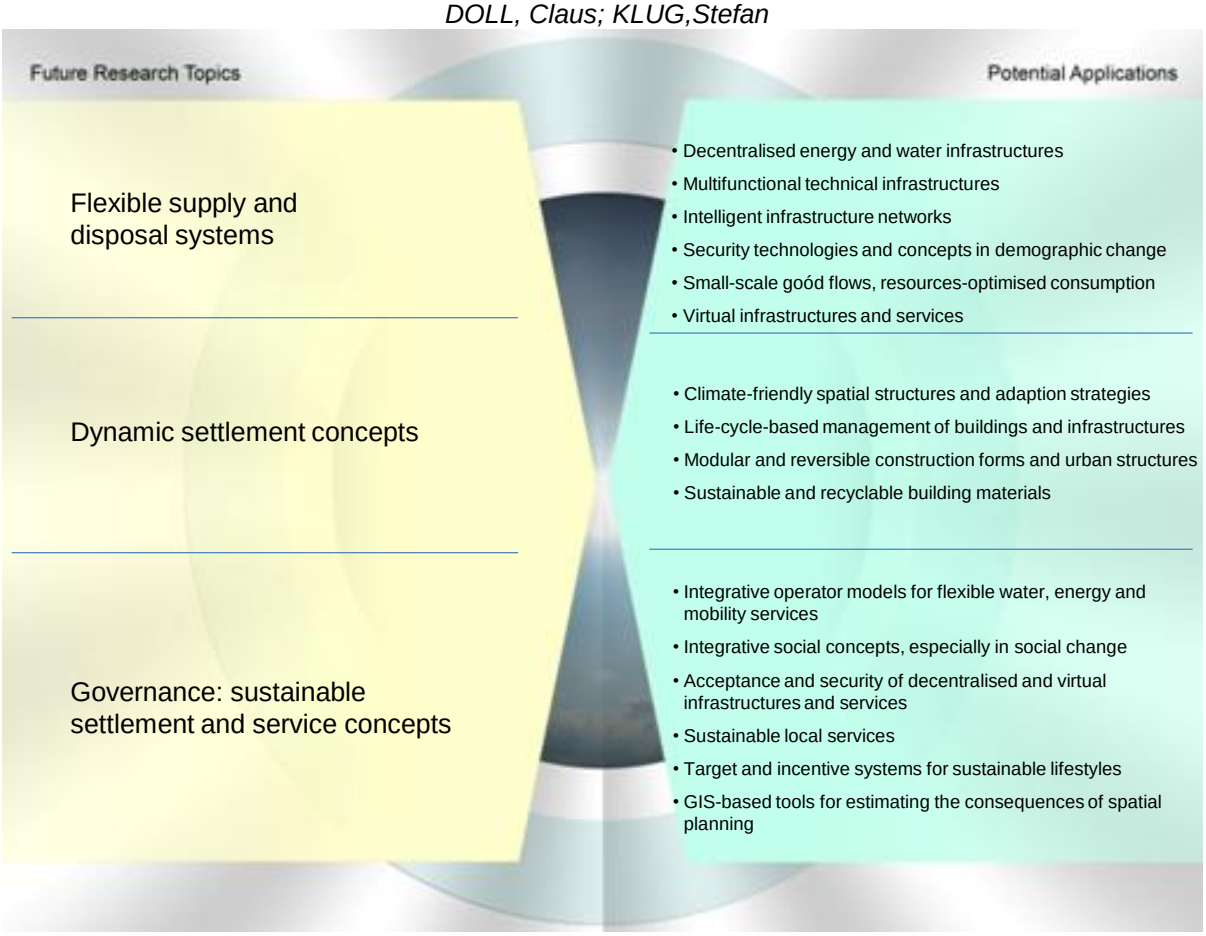

Figure 6: Future research topics and application potential within the broader field “Sustainable Living Spaces”

Flexible supply and disposal systems

A major part of the existing network infrastructures have expected useful lives of up to 80 years. On the other hand certain megatrends such as demographic and climate changes also strongly influence the general framework of such networks. An important question for sustainable infrastructure planning is the future layout and design of networks, plants and technical facilities in order to allow future adaptation or downscaling with minimized costs. How can we reconstruct existing technical networks? Approaches range from guaranteeing the recyclability of each component to carefully considered future options of complete abolishment. A specific aspect is the question of the sustainable implementation of decentral, localized supply and disposal concepts. One example is the progress made in membrane technology used to enhance the reliability of local wastewater treatment systems facing changes in inflows and environmental conditions. However the decentral supply of water, as well as of energy and telecommunications still holds a lot of research potential.
Another aspect is the challenge presented by the optimized use of resources in consumption products. Previously, the finiteness of energy resources was the biggest factor of consideration, but the availability of and risks to other resources such as precious metals, copper and chrome has now become of similar importance (Angerer *et al* 2009). Thus optimising recycling management predominantly on a local scale is an important subject of research.

Along with declining fiscal resources, the maintenance of a basic level of safety and security (e.g. police surveillance) is considered a challenging task for peripheral regions. Thus virtual infrastructures which support or replace this task will become more important. In the domestic environment, systems related to »Ambient Assisted Living« will be extended in an aging society (Georgieff 2010). This is narrowly connected with the question of the required level of virtual services, the influence of alienation and social living together in contrast to the manifestation of distance.

Advancing the currently running field projects within the BMBF's "health regions" (Gesundheitsregionen) concerning the utility and reliability of technical systems, the required ICT infrastructure, operator models and implications for health and nursing systems is of strategic importance. A future health care system will have to solve these challenges.

Dynamic settlement concepts

Settlement policy and related urban planning need to be pervaded by greater dynamics. Based on previous research activities on climate change adaptation measures, it is necessary to implement proactive measures rather than short-term reactions to the consequences of climate change such as sudden heavy rainfalls.

A recent survey among regional planning institutions showed that the role of spatial planning in dealing with the consequences of climate change has not been properly defined so far. On the other hand, climate *adaptation* measures are regarded as one of the biggest challenges to regional planning (cf. Overbeck *et al.* 2009: 196, 199). According to an expert interview the major challenge facing today's settlement structures and infrastructures is the necessity to adapt them to and protect them from frequent and heavy weather phenomena. One good example is given by the city of Rotterdam: A comprehensive implementation of climate protection technologies is being planned to protect the city against both extreme weather and floods. These include several facilities for short-term storage of water – basin-shaped water squares, which can be used for recreation and sports during dry periods as well as water basins within residential areas and on green building roofs (de Greef/ Zsiros 2008). However, in order to contribute to minimizing future climate changes, *mitigation* measures are also necessary. This means that the local and regional development concepts need to focus on minimizing the emissions of greenhouse gases, e.g. by compact urban development to minimize the need for transport or by using modern building materials, which cause comparably fewer CO_2 emissions during their life cycle.

Thus the future research questions include: How can climate *adaptation* and *mitigation* measures be strategically implemented in the design, development and regeneration of human habitats? How can spatial structures help to both mitigate climate change and adapt to its consequences? Are new planning instruments necessary on national, regional or local levels to – for example – avoid urban development in retention areas which are exposed to floods close to rivers and coasts? One option would be the obligatory use of regionalized data on climate and small-scale mapping of hazard potentials. The results of "Klimazwei" and other model projects indicate that future research needs to include the local level.

Governance: sustainable settlements and service concepts

Human habitats develop as a result of the actions and interactions of stakeholders. Thus the question arises: Who are the important actors and how do they interact within decision processes? The institutional establishment of sustainable, decentralized, modular and flexible (infrastructure) systems mentioned above requires a long-term approach of the involved stakeholders. In order to enable coordinated and goal-oriented cooperation, the question of governance is an important issue. In this context two important questions arise:
How can integrated infrastructure management be properly organised to account for all the interests of the diverse stakeholder groups? These include the suppliers of electricity, gas and other heating energy, telecommunications and those responsible for wastewater disposal and local planning as well as public transport.
How can this "team play" be adjusted to the designs for life of employees and residents? Which economic and legal incentives can be used? The development and introduction of innovative operator models represents a major challenge, especially if the market shares or businesses of established stakeholders are affected. Sustainable business concepts are supposed to consider ecological, economic and social aspects for the involved actors.
Next to technical infrastructure systems, social facilities are also important in shaping future human habitats. Major challenges lie in handling the problem of skills shortage - which especially affects health care and assistance – by new funding and business concepts, as well as by urban regeneration projects.
In order to estimate the "expiry date" of settlements and their infrastructure from the outset, spatially limited forecasts are necessary. These can form the basis for implementing innovative legal instruments with regard to buildings and real estate, e.g. by limited building permission, hereditary building rights, building leases etc. What needs to be done to establish and standardize life cycle based management of buildings and infrastructure systems? Which technological innovations are necessary to realize and evaluate these innovations? An important issue is the investigation of legal options to realise the "causer pays" principle within existing settlements.
Local planning authorities are one of the key actors within this future topic. Due to the ongoing development of ICT technology and competence within the public sector, small communities can also potentially control and calculate the consequences of their spatial planning concepts. One important tool is based on Geographic Information Systems (GIS), which enables communities to evaluate spatial policy while taking into account the long-term fiscal consequences (Dittrich *et al* 2009).

CONCLUSIONS AND RECOMMENDATIONS

The aim of the foresight process was to identify future topics of research with the time horizon of 2020 to 2025. In this paper we presented the basic methodology and the main results for two of the 17 thematic fields investigated: "mobility and logistics" and "sustainable living spaces". In both fields, the intensive consultation of national experts through targeted workshops and the international research community through numerous interviews and the monitoring panel had a major influence on the stated results. Though the sudden emergence

of the financial and economic crises were clearly visible in the expert statements, in particular in the research areas concerned with questions of sustainable development, several very clear and constant statements were made by the experts. These were underpinned by the bibliographic methods applied, indicating the need for multi-disciplinary research approaches to address the various challenges of designing sustainable living environments, production systems or mobility services.
The consultation of experts in the online-survey, the international panel and the numerous interviews constituted the main pillar for defining and refining the results of the literature review. The experiences gained from the foresight process strongly recommend the institutionalisation of these instruments, e.g. by setting up regularly consulted expert panels. This approach is, however, only fruitful if the panellists are actively included in the foresight process by receiving up-to-date information on the status of the process and the impact of their contributions.
The systematic analyses of the literature databases made in the course of the bibliometric assessment of research fields provided valuable inputs to the study. As concerns sustainable living spaces, bibliometrics helped to structure the numerous sub-topics and identify new literature sources. Secondly, the actors and institutions involved in the research community were able to be identified and thus the process directly supported setting up the expert interviews. A general problem reported by many research areas was the excessive expectation of the output of the bibliographic process. The method is frequently misinterpreted as the autodetection of new topics. This is not the case as it can only report on pre-defined keyword searches. Moreover, the resources required for a proper definition of search terms are frequently underestimated.
The foresight process took a positive rather than a normative look into the future. The societal research fields, in particular, such as mobility and sustainable living spaces, would have benefited from a more general orientation. This could have helped to identify urgent R&D requirements not yet covered and to more accurately rank the associated research topics. Moreover, working with visions of the future could have inspired the involved researchers and experts.
The process covered a huge number of topics, ranging from very specific themes like nano technologies or white biotechnologies to broad application areas including mobility, energy and environmental sciences, and cross-disciplinary ones such as living spaces. The broadness of the process required an enormous co-ordination effort and entailed the risk of individual topic areas being overlooked in the process. The manifold borderline aspects between the research areas were particularly difficult to monitor and to compile into a complete picture across the full bandwidth of topics. But despite these risks which are inherent to huge projects, a wide scope is essential when investigating new fields of research.
In the field of mobility and logistics research, the process has not led to a simplistic, one-dimensional statement of the direction in which research efforts should be developed in the coming decades. Technology research on reducing both CO_2 emissions and the dependence on fossil fuels is deemed increasingly important in the future. But it must be accompanied by the development of behavioural concepts of mobility management, which can be sustained under real world conditions. There are important parallels between such “co-operative” concepts in passenger and freight transport and the concept of integrated governance

structures in the research field of sustainable living spaces. This is particularly valid for Germany with its dramatic and regionally diverse demographic development.

Within the topic field sustainable living spaces, one important aspect is the future need for more flexibility or dynamics of the built environment (settlements and infrastructures) due to demographic changes and the need for sustainable, resource-conscious development. One of the key stakeholders here are the municipalities. This lowest tier of the German government system has great political power compared to other European states. Due to the constitutional autonomy right to basically control all matters on the level of the community, it is very difficult in Germany to implement concepts on a regional or national base, such as common regulations for flexible supply and disposal systems.

REFERENCES

Angerer, G.; Erdmann, L.; Marscheider-Weidemann, F.; Scharp, M.; Lüllmann, A.; Handke, V.and M. Marwede (2009): Rohstoffe für Zukunftstechnologien. Einfluss des branchenspezifischen Rohstoffbedarfs in rohstoffintensiven Zukunftstechnologien auf die zukünftige Rohstoffnachfrage, Fraunhofer-Institut für System- und Innovationsforschung ISI (= ISI-Schriftenreihe „Innovationspotenziale“)

BBR (2005): Raumordnungsbericht 2005, Bundesamt für Bauwesen und Raumordnung (BBR). Bonn

BBR (2009): Tendenzen der Stadtentwicklung. Bundesamt für Bauwesen und Raumordnung (BBR). Bonn, Internet-Ressource: http://www.bbr.bund.de/cln_015/nn_115406/BBSR/DE/Fachthemen/Stadtentwicklung/StadtentwicklungDeutschland/Tendenzen/tendenzen__node.html?__nnn=true

Cuhls, K. and W. Ganz (Eds.) (2008), Der Foresight-Prozess des BMBF, 1. Bericht an das BMBF, Fraunhofer-Institute for Systems and Innovation Research (ISI), Karlsruhe and Fraunhofer-Institute for Industrial Engineering (IAO), Stuttgart.

Cuhls, K. and W. Ganz (Eds.) (2009), Der Foresight-Prozess des BMBF, 2. Bericht an das BMBF, Auf der Suche, Fraunhofer-Institute for Systems and Innovation Research (ISI), Karlsruhe and Fraunhofer-Institute for Industrial Engineering (IAO), Stuttgart.

Cuhls, K., Ganz, W. and P. Warnke (2009a): Foresight-Prozess im Auftrag des BMBF: Zukunftsfelder neuen Zuschnitts. Karlsruhe, Stuttgart. IRB-Verlag.

Cuhls, K., Beyer-Kutzner, A.; Ganz, W. and P. Warnke (2009b): The methodology of a national foresight process in Germany. in: Technical Forecasting & Social Change 76 (2009), 1187-1197

de Greef, P./ Zsiros, C. (2008) : Ein Wasserplan für Rotterdam, in : Garten + Landschaft 11, S.22-25

Dittrich, A.; Krause-Junk, K,; Osterhage; F.; Beilein, A.; Frehn, M., Suhl, K.; Tack, A.; Suhre, R.; Schwarze, B.; Klemme, M. (2009): LEAN^2. Kommunale Finanzen und nachhaltiges Flächenmanagement. Projektbericht, ILS-Institut für Landes- und Stadtentwicklungsforschung gGmbH, Planersocietät - Stadtplanung, Verkehrsplanung, Kommunikation; Ingenieurgesellschaft nts mbH, IRPUD-Institut für Raumplanung der Technischen Universität Dortmund; RWTH Aachen

EC (2007): European strategies: logistics – keeping freight moving. European Commission, Brussels, October 2007. http://ec.europa.eu/transport/strategies/2007_logistics_en.htm

EC (2008): European strategies: the greening transport package. European Commission, Brussels, June 2008. http://ec.europa.eu/transport/strategies/2008_greening_transport_en.htm

EC (2009a): European strategies: future of transport. European Commission, Brussels, June 2009. http://ec.europa.eu/transport/strategies/2009_future_of_transport_en.htm

EC (2009b): A sustainable future for transport. Towards an integrated technology-led and user-friendly system. European Commission, Directorate-General for Energy and Transport. Brussels.

Georgieff, P. (2010): Aktives Alter(n) und Technik. Nutzung der Informations- und Kommunikationstechnik (IKT) zur Erhaltung und Betreuung der Gesundheit älterer Menschen zu Hause, Fraunhofer-Institut für System-und Innovationsforschung ISI (= Diskussionspapier in Vorbereitung)

Hiessl, H.; Toussaint, D.; Dyrbusch, A.; Geisler, S.; Herbst, H.; Prager, J.U. (2005): AKWA 2100: Alternativen der kommunalen Wasserversorgung und Abwasserentsorgung. Stuttgart: Fraunhofer IRB Verlag, (=ISI-Schriftenreihe Innovationspotenziale)

Koziol, M. and J. Walther (2006): Ökonomische Schwellenwerte bei der Rücknahme von technischer Infrastruktur in der Stadt, in: Informationen zur Raumentwicklung 5, S.259-269

King, J. (2007a): King Report - Low Carbon Cars - Part I. The potential for CO2 reduction und Part II Recommendations for action, London: The Stationery Office.

McKinsey 2008: Pathways to a Low Carbon Economy. Version 2 of the Global Greenhouse Gas Abatement Cost Curve.

OECD and ITF 2009: Transport Outlook 2009: Globalisation, Crisis and Transport. OCED, International Transport Forum Joint Research Centre. Discussion Paper 2009-12, Mai 2009

Overbeck, G.; Sommerfeldt, P.; Köhler, S.; Birkmann, J. (2009): Klimawandel und Regionalplanung. Ergebnisse einer Umfrage des ARL-Arbeitskreises „Klimawandel und Raumplanung“. Raumforschung und Raumordnung - RuR 2/09: 193-203

Reidenbach, M.; Henckel, D.; Meyer, U.; Preuß, T. and D. Riedel (2005): Neue Baugebiete: Gewinn oder Verlust für die Gemeindekasse? Fiskalische Wirkungsanalyse von Wohn- und Gewerbegebieten. Bd. 3 der Edition Difu – Stadt Forschung, Deutsches Institut für Urbanistik (difu)

Siedentop, S.; Koziol, M.; Walther, J. and J.-M. Gutsche (2006): Siedlungsentwicklung und Infrastrukturfolgekosten – Bilanzierung und Strategieentwicklung. Internet-Ressource, Bundesamt für Bauwesen und Raumordnung (BBR), URL: http://www.bbr.bund.de/cln_015/nn_21840/BBSR/DE/FP/AO/Infrastruktur/SiedlungsentwicklungInfrastrukturfolgekosten/05__Veroeffentlichungen.html

TNO, INFRAS, IVL, IFEU, TU Graz, 2008: Cost-Effectiveness of Greenhouse Gases Emission Reductions in various Sectors - Final Report - Framework Service Contract No Entr/05/18. Delft, Zürich, Heidelberg, Stockholm, Graz

Walz, R.; Ostertag, K.; Doll, C.; Eichhammer, W.; Frietsch, R.; Helfrich, N.; Marscheider-Weidemann, F. Sartorius, C.; Fichter, K.; Beucker, S.; Schug, H.; Eickenbusch, H.,

Zweck, A.; Grimm, V. and W. Luther (2008): Innovationsdynamik und Wettbewerbsfähigkeit Deutschlands in grünen Zukunftsmärkten. Final Report to the Federal Environment Agency (UBA) No. 2006 14 132/05, Berlin. Fraunhofer-Institute for Systems and Innovation Research (ISI), Karlsruhe. Borderstep, Berlin, ZTC/VDI Technology Center, Berlin.