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Urban Transport

Technology Options in Urban Transport: Changing paradigms and promising innovation pathways

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Changing paradigms and promising innovation pathways

Final Report

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Abstract

Urban transport is related to a wide range of unsolved problems and challenges that need to be tackled in order to guarantee a high quality of life in European cities and to make the transport system an even more efficient pillar of the European economies. This final report highlights relevant aspects and pathways for a transition to a more sustainable urban transport system. For this purpose, relevant technologies and the factors influencing end-user behaviour were analysed, as well as the interrelations between them.

The transport system is understood as a socio-technical system of five key elements: paradigms and visions, mobility patterns, technologies and infrastructures, business models, and transport policies. In this report it is illustrated that changes in all elements of the transport system are taking place:

– On the one hand, a broad range of innovative technologies and concepts to achieve sustainable urban transport are emerging or are already used.

– On the other hand, the paradigm of sustainable transport is about to dominate transport planning in many urban areas and at different governmental levels – which has by far not always been like this.

Further there is evidence that travel behaviour is not as static as it seems, but rather changes over time. In several countries, the travel behaviour of some societal groups is evidently changing. All of the five elements offer pathways to sustainable urban transport. Nevertheless, successful pathways do not only require new developments in one of these elements, but in several or in all of them, and at the same time.

Against this background it is essential that governance strategies deal with the transport system as a whole. Integrated policies need to consider technical, as well as non-technical factors and developments. The facilitation of learning opportunities is crucial. Innovations need "spaces" to be tested and demonstrated. But, for a successful transition, the transport users need to be taken into account more systematically. More research is needed in order to understand the dynamics that are currently at work in the transport system and the way users adapt to changes in the long run.

Executive Summary

An efficient transport system plays a key role in economic growth and social wealth in modern societies. At the same time, it is well known that the growth in transport is going along with negative consequences. The increased amount of traffic is a challenge for life quality in urban areas because of the associated significant environmental consequences, including emissions of air pollutants and noise, as well as reduced spaces for living and segregation effects caused by the expanding transport infrastructure. The efficiency of the system is reduced by congestions. The driving forces of the challenges mentioned above are not only the growing amount of the general traffic volume but especially the rapid increase of motorised traffic. 80 % of European citizens are living in an urban environment. Urban transport, therefore, accounts for a significant percentage of total mobility. A lot of progress has been made in recent decades in European cities. For example, cleaner technologies have been introduced, cycling and walking have been promoted and public transport has become more attractive in many urban areas. In spite of this, however, much more progress has to be made to attain sustainable urban transport systems throughout Europe. Nine out of ten EU citizens believe that the traffic situation in their area still should be improved.[1]

It is widely acknowledged that innovations are crucial for enabling of sustainable urban transport and for the strengthening of the global competitiveness of European economies. However, technologies are only a necessary but not a sufficient requirement for such a transition. Non-technical factors are also relevant. New technologies need to be accepted and adopted by the users. Against this background, this STOA project on urban transport considers technologies from an innovation-oriented angle. The overall aim is to highlight promising innovation pathways to a more sustainable urban transport system. Therefore, different technical and non-technical elements of the transport system as well as the interrelations between them are analysed. It is argued that such a holistic perspective is needed to understand and successfully govern the dynamics and potentials of new developments in urban transport. The transport system is understood as a socio-technical system. The term co-evolution has been established framing the interplay between technical and non-technical elements in socio-technical systems. In this project, a structure was chosen that should be able to provide a holistic perspective and to cope with the notion of co-evolution. The transport system is structured into elements of rather different characters: paradigms and visions, technologies and infrastructures, business models, mobility patterns and transport behaviour, and, last but not least, transport policies. These elements have a significant impact on organising and, thus, on the ability to change the system. Key findings for these 5 elements are described in this report and conclusions are drawn in relation to pathways towards sustainable urban transport system.

Visions and paradigms: It is well known from other socio-technical fields that paradigms and visions have a decisive influence on the design and the development of technological and organisational innovations. Values and norms are integral parts of such paradigms and visions. It has already been pointed out by Everett M. Rogers in his famous work on the diffusions of innovations that an idea that is incompatible with the values and norms of social systems will not be adopted as rapidly as an innovation that is compatible. It is illustrated in chapter 3 that this formative power of visions and paradigms is also evident in the transport sector.

[1] CEC (2007a).

Transport planning of the 1960s and partly as well of the 1970s was characterised by the vision of optimising cities for private motorised transport. The impact of this paradigm of the car-friendly city is still visible in many European cities and regions where large and busy arterial roads and inner-urban traffic junctions define the character and appearance of the city. In the meantime, sustainable transport has definitely become the dominating vision or paradigm in transport planning and urban development programmes for most European Cites. It can easily be shown that this is much more than rhetorical shells since a broad range of examples prove that this paradigm is getting materialised, at least partly. Many of these examples are described in the different deliverables of this project. Therefore, it can be concluded that paradigms matter and that paradigms are changing over time. Against this background, it is argued that, also in the future, paradigms will be likely to change or adapt to new challenges and trends. A major external trend will surely be the economic crises and the need to boost the international competitiveness of the European transport sector. Therefore, linking sustainable development stronger with the notion of economic competitiveness is likely to become essential for gaining the necessary long-term acceptance of pathways towards sustainable urban transport. The political realm influences the development of paradigms and visions; in particular, the European level can deliver strong political messages in this context.

Technologies and infrastructures are the essential basis for the facilitation of modern mobility patterns. It is argued that, recently, with respect to technologies, developments in two fields are mostly contributing to changes that are anticipated or already observable:

1. Technologies that affect oil-dependency, efficiency, and emissions of vehicles and could basically be labelled as alternative fuels and propulsion systems
2. Technologies that affect the way transport modes are being used which could basically be labelled as information and communication technologies (ICT)

Discussions on innovations in transport are often focused on fuels and propulsion technologies. There is a strong external pressure on innovations in this field mainly caused by the urgent need for combating climate change and by the projected running out of oil which is expected to lead to heavy increases in oil prices. Furthermore, striving for international competitiveness is another important trigger. Many alternatives to oil-based fuels are already on the market, such as Compressed Natural Gas (CNG) and biofuels; both are still using internal combustion engines. CNG is still a fossil fuel but can bring environmental benefits compared to conventional fuels. Biofuels are discussed critically for their environmental impacts on a life-cycle basis.

In particular for urban transport, an electrification of the propulsion system is expected to take place. This would mean a replacement of conventional internal combustion engines by electric engines. For several years, a combination of oil-based and electric drives has been commercialised in the form of hybrids. Regarding pure electric propulsion, the crucial issue is not the engine itself but the problem of storing the energy. Battery electric vehicles (BEV) can be rather clean and efficient, whereas, the environmental performance depends on the way the electric power is generated. The problem is that also modern batteries do not allow for a range longer that 150 to 200 km. Furthermore, the time needed for recharging is relatively long. However, it is argued that BEVs could be ideal vehicles for transport in urban areas, not only for passengers but also for the delivery of goods. Recently, several car-makers have started the commercialisation of BEVs, some of them with so-called range extenders which means that an internal combustion engine is on board but just for the generation of electricity.

Alternatively, hydrogen fuel cell vehicles are discussed. They store energy in form of hydrogen and turn it into electric power by using a fuel cell. Ranges of more than 400 km are possible. Drawbacks are the lower overall efficiency on a life-cycle basis as well as the need of a new infrastructure. Also for hydrogen, the environmental performance depends on the way the hydrogen is produced. Both, hydrogen as well as battery electric vehicles are still struggling with high production costs. Many experts argue that in future both technologies will become established, battery electric vehicles more for urban areas and hydrogen fuel cell vehicles more for longer distances.

Alternative fuels and propulsion technologies are often discussed in the context of future sustainable urban transport. However, striking changes that have already been established are related to information and communication technologies (ICT), which are increasingly penetrating the whole transport sector. Very much has already been achieved, but still, there seem to be huge additional potentials to tap. ICT contribute to a better organisation of transport, to easier access to public transport systems, or to major improvements in the transport of goods. For example, personalised information is available for travel time or multimodal route planning. ICT is also related to better control and management of the transport network. The application of ICT is not "sustainable" in itself but it might allow for changes in behaviour and in logistics that contribute to a more sustainable transport system. Some of the applications even have the potential to substitute transport by, for example, video conferences or teleworking. In logistics, ICT is a key-enabler for increasing efficiency. New concepts such as the "smart truck" illustrate that there still is space for new approaches. A distribution of ICT applications in the transport sector is well in line with an increasing relevance of these technologies in society in general, and in particular for the younger people who are the first generation to grow up completely surrounded by internet and mobile phones.

In contrast to these rapid changes in the ICT sector, urban infrastructure usually needs decades for significant changes. Especially mixed-use and dense areas can reduce the need to travel and increase the attractiveness and efficiency of public transport, of cycling, and of walking. For a long time, experts have been calling for a better integration of land use planning and transport planning.

Technologies and infrastructures have always been changing and will continue to do so in the future. It is imaginable that technologies that today are considered being rather "exotic" will become widespread in the longer-term future. It surely cannot be predicted which technologies these might be; however, a number of approaches that are discussed in more visionary contexts are also described in the report at hand. An example for it is CargoCap. This system is designed for freight transport in urban agglomerations, for long and regional distance traffic, up to 150 km. The idea is that so-called caps travel in underground pipelines. Another example is Personal Rapid Transport which is a new transport method running on a track system. It provides on-demand services for individuals or small groups travelling together by choice.

Business models and organisational innovations are being developed along with the technology infrastructure systems on the one hand, and with the transport demand on the other hand. They are the linkages between these two elements and co-evolve with them. Different business models can be observed in the transport sector: Traditionally, cars are sold to the user, so, private or company ownership is the typical business model. Other modes such as the ones related to airplanes, trains or busses, and also taxis do not aim at buying the vehicle; they usually are employed after buying a ticket for temporary access. In such cases, tariff structures and marketing strategies are the linkage to the customers.

In the freight sector the situation can be more complicated. Modern supply chain management can be a complex system that integrates various actors with different functions. In both sectors, freight and passengers, the business models and organisational concepts are not static but are changing over time.

Recently, new business concepts have emerged that have been rendered possible by new technologies and, at the same time, are enablers for technological advancement on their own. In particular, the development of ICT technologies supports new concepts and business models for "individualised collective" forms of transport, such as car sharing or bike-sharing. The public transport system also profits strongly from ICT applications since they allow for easier access to vehicles by mobile ticketing or easy access to information by mobile internet. New business models, such as car-sharing, are supposed to support the market penetration of new fuels and propulsion technologies. This is because they are intended to allow users to pick vehicles appropriate for specific, though varying purposes, from a car-sharing fleet. For example, a BEV could be chosen for trips within the city and a conventional vehicle or a vehicle with range extender for longer distance drives. It is documented in this report that car-sharing organisations are continuously growing and are becoming more and more professional in Europe. Recently, with Car2go run by Daimler and Mu by Peugeot well-established car manufacturers have begun to enter the scene with ambitious concepts based on advanced ICT. There obviously lies a larger potential in the combination of new technologies and new business models.

Mobility patterns and behavioural aspects: Behaviour, attitudes, and perceptions of the users of these transport systems are of utmost importance for the successful implementation of innovations. Several indicators point at changes in transport related habits and preferences within urban areas. In Germany, for example, there is data available illustrating different trends for younger and for older people. People older than 60 use the car more often than the same age group used to do about 10 years ago. In contrast, younger people in urban areas use the car less than the same age group about 10 years ago. Several empirical studies have proven that there is a growing group of younger people with rather pragmatic attitudes towards car ownership and transport. Younger people in urban areas are the most flexible group in using different modes of transport. Data from other countries mainly from Sweden and Norway shows a similar development. It is assumed that the strongly increasing importance of ICT is a key driver for the changing mobility behaviour of younger people. Internet and mobile phones are getting more important, social networks increasingly come in virtual form (Facebook, Twitter etc.). Access to public transport is getting much easier since all the required information is available nearly at all times and at any place. Furthermore, "gadgets" such as smart phones, MP3 players, or laptops are becoming symbols associated with identity, self-image, or social recognition.

In this project, group interviews with younger people in urban areas (at Budapest, Copenhagen and Karlsruhe) were conducted to learn more about younger people's attitudes and perceptions on urban mobility. The results are described in DEL IV of the project and summarised in the report at hand. An interesting finding is that, in general, environmental concerns were not an important factor for the daily modal choice of the young urban citizens. Mostly pragmatic reasons such as being faster, or travelling cheaper, or the non-availability of a car that made them choose cycling, public transport, or walking. However, in questions and discussions not directly related to factual daily transport behaviour, environmental issues were ranked higher. The interview meetings underpin that it is not enough to promote sustainable modes of transport by pointing only at their environmental friendliness.

It can be argued that sustainable transport should not be that much framed in context of fears and threats related to negative environmental impacts. A sustainable transport system has to be better and has to signal to be more "fun" than its alternatives (see Urry 2010). In order to meet these requirements, innovations need to offer more than new technologies, they likewise need to offer new forms of organisation and business models that are well interconnected. Policies that provide framework conditions favouring such developments are needed.

Transport policies: The high density in urban areas offers a broad variety in policy approaches for the facilitation of a transition towards a more sustainable transport system. All the four areas described in the previous chapter interact with and can be influenced by transport policy. In a more indirect way, the paradigms are setting the broader framework by which concrete policies are motivated and legitimised. The influence on technologies, business models, and transport related behaviour can be much more direct. Not only one but all political levels are of relevance. Urban transport policy is a mixture of regional/urban, national, and European policies. Nevertheless, the urban level is of particular importance since it is closest to the citizens and users of the transport system. Public authorities have the challenging task to provide an environment in which the elements of the transport system co-evolve in a more sustainable way than today. It is crucial to facilitate large scale field trials and showcase activities on new approaches in a highly integrative manner.

Conclusions: A transition towards a more sustainable urban transport in Europe depends on a broad variety of rather different factors. The mixture of relevant technical and non-technical factors is getting extremely dense in urban areas where human activities as well as the supporting technology infrastructure accumulate to a dense and interdependent network. For understanding successful pathways to sustainable urban transport it is essential to take this interplay of different elements into account which makes integrative approaches necessary. In this report it is illustrated that changes with regard to all of these elements are taking place. In respect of transport policies, it is essential to be aware of the changes and dynamics in the system and to make use of them. All of the five elements offer approaches for pathways to sustainable urban transport. Successful pathways do not only require new developments in one of the described elements but in all of them, synchronously. Integrated policies need to consider technical as well as non-technical factors and developments. Even if it is widely acknowledged that policies stipulated in isolation do not lead to satisfying results, there is still a lack in integrated perspectives in transport policy making. Long-term political acceptance is curial since a transition to a sustainable urban transport system takes longer. Infrastructures are long-lasting elements of urban landscapes, therefore, long-term commitment is needed. It is quite clear that a transition of complex urban transport systems cannot be fully planned or developed at the drawing board. There are too many factors and interrelations involved inbetween the individual factors. Against this background, it is of utmost importance that policy making is understood as a process of learning (see Voß et al. 2008). The facilitation of learning opportunities is crucial. Innovations need "spaces" to be tested and demonstrated.

Contents

General Information

Urban transport is related to a wide range of unsolved problems and challenges that need to be tackled in order to guarantee a high quality of life in European cities and to make the transport system an even more efficient pillar of the European economies. More information is needed—especially on the potential of future or emerging technological developments and organizational innovations. To aid understanding and to ensure that such potential is achieved, it is important to get a better idea not only of technologies, but also of the relationship between these technologies and concepts and the different actors that are important for their successful development and implementation. In this context, the STOA project on urban transport considers technologies from an innovation-oriented perspective. The overall aim is to highlight promising innovation pathways to a more sustainable urban transport system. In order to do so, different technical and non-technical elements of the transport system will be analyzed, as well as the interrelations between them. The present report is Deliverable V of the project. It is a summary of the previous phases and the respective deliverables:

DEL I: This scoping report is giving a rough overview on the research field

DEL II describes technology options and mobility services, which are, or might become, relevant for urban transport systems and, thus, will become relevant to a transition to more sustainable urban transport. In doing so, it is putting the focus on the supply side of the transport system.

DEL III looks at the socio-economic context in which innovative technologies and concepts are, or will be, implemented. It deals with paradigms and visions, with mobility patterns, user behaviour, attitudes and perceptions, with policy measures as well as with barriers and success factors for the implementation of promising approaches.

DEL IV summarises the results of the citizen's consultation conducted in the project.

Based on the work documented in these deliverables, this final report highlights relevant aspects and pathways for a transition to a more sustainable urban transport system.

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1. Introduction

1.1. A need for sustainable urban transport

Good approaches and successful examples for promoting sustainable urban transport can be observed in many European cities. Recently, the Danish capital, Copenhagen, further improved its already advanced cycling scheme; carmakers are promoting electric vehicles and starting to connect them to new business models such as car sharing; advanced approaches to integrated ticketing are appearing; in many cities, information on public transport is available all the time and everywhere via smartphone; pedestrian infrastructures are being improved in many urban areas; congestion charging has become an accepted tool for reducing volumes in car transport and for promoting cleaner cars in cities such as London, Stockholm and recently also Milan.

Still, the big breakthrough, the striking trend breaks, seem to be missing if one looks at the general developments in the urban transport system in Europe. As outlined in the previous deliverables of this project, the European transport system is still suffering from congestion and from the emission of harmful substances; there is still a strong tendency to use private cars, cycling is not at the level where it could be and public transport systems are not fully efficient in many urban areas. These challenges are quantitatively expressed in transport activities, modal choice, energy intensity and carbon intensity. A look at related figures reveals that there is still much to be done. A transition towards sustainable urban transport systems would mean changing these figures considerably. On the other hand, it can be observed that sustainable development is high on the agendas of most of the urban areas and cites in Europe. It is now crucial to turn these visions into reality.

The central thesis of this project, which will be summarized and further developed in this final report, is that successful pathways to a sustainable urban transport system require an integrative perspective that incorporates both technical and non-technical elements of the transport system. Furthermore, it will be illustrated that the transport system is not static, but subject to permanent change that is related not only to technologies but to other areas as well. These existing dynamics need to be better understood in order to be able to influence them and to make use of them in terms of sustainable transport.

As a final report, this document is heavily based on the previous deliverables of the urban transport project. In these deliverables, it has been shown that a more holistic view is needed in order to understand and govern the transport system. Such a systemic approach should be able to clarify the interrelations between different elements of the system and to help align these elements and related activities with the long-term goals of the transport system. A key element in such a systemic perspective on the transport sector is its strong focus on the interplay between mobility patterns, on the one hand, and the technologies and infrastructures that are summarized as transport supply and related services, on the other.

Urban areas play a special role in this context. More than 70% of European citizens live in urban areas, and this share is expected to continue to grow. There is an extremely high density of population—of people that need transport for their daily activities, such as going to work, shopping, meeting friends and leisure. For most of these activities, people need to travel, and this is the source of transport demand. Taking a closer look at this allegedly simple situation reveals a much greater complexity.

The choice of a specific activity or destination, for example, shopping at a particular store, might depend on the opportunities offered by the transport system and on the time and money that needs to be invested in order to reach the destination where the activity can be carried out. Thus, the availability of transport options influences the development of demand patterns. This simple example illustrates that there is a mutual relationship between demand and supply in the transport system. The term coevolution is used to describe this kind of interplay between technology-infrastructure systems and—to put it simply—non-technical factors. Habits and routines that may be shaped by the use of existing technologies play a significant role in the acceptance of new developments. Kemp (1994, 1032) points out that consumer preferences and habits are influenced by the adoption and use of past technologies. Accordingly, technological change and socioeconomic trends coevolve and interact. Mechanisms of habituation and endogenous taste formation play a role. Kemp (1994, 1032) argues: “The fact that people are used to having a car with a certain mileage and speed may obscure the development of a car with totally different characteristics (for instance, an electric vehicle with a relatively low speed and range and long loading time).” This notion of co-evolution supports what has been claimed by many authors (see, for example, Banister et al. 2011, STOA 2008, Urry 2010): A holistic view of the transport system is needed as regards research activities, but also for the enabling of integrated planning approaches and implementation strategies. The issue of sustainable urban transport demands a broader view, one that goes beyond innovations, in order to permit a successful implementation of such innovation—that is, to permit the efficient, effective and acceptable governance of urban transport systems.

1.2. Elements of urban transport

Thus, as outlined above, a holistic view is needed to identify relevant innovations and related pathways towards sustainable urban transport. Such a holistic view needs to integrate the different factors and developments that have or might have an influence on technology-infrastructure systems and travel patterns in urban areas. Since the transport system as a whole is shaped by the interplay between its elements, it is rather difficult to isolate single elements from that whole (Schwanen et al. 2011; Urry 2010).

However, although a holistic perspective is required, a structure is needed to help frame both scientific work and the practical implementation of policies. For this project, the structure that is shown in figure 1.1 was applied. The elements shown here were dealt with in the course of the project. But still, they were not treated in an isolated way: Their relationships to other elements were looked at as well. The selected elements are essential for the functioning of the system: They provide opportunities to influence the system, and they are, to a certain extent, observable and measurable. In addition, there is a relatively broad body of literature related to these elements, which is important for a project like this. The transport system could be structured or clustered in different ways; however, for the purposes of this project, the chosen structure has proven helpful. The actors, who are shown in the middle of the figure, are able to influence the five elements. In contrast, actors in the transport system are not able to exert direct influence on external factors, such as developments in oil prices, GDP, climate change or societal trends, such as aging.

The identified elements include the supply side, as a sort of dynamic basis of the transport system, encompassing technology-infrastructure combinations and business models. A third element is represented by mobility patterns: These are what we can actually observe or even measure in the form of transport volume, number of trips and modal share. They are related to the demand side and include research on behavior and factors influencing transport demand. Of course, transport policy is also important for the development in the transport sector. But, based on research conducted during the project, it has become obvious that paradigms and visions are of striking importance. Therefore, these have been framed as an independent "element" of the transport system.

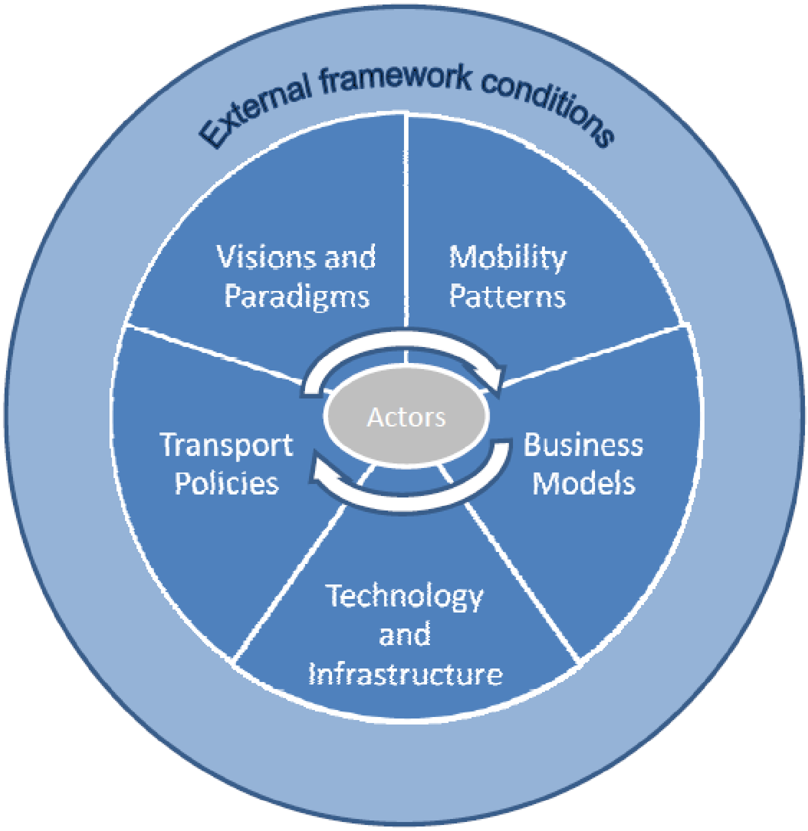
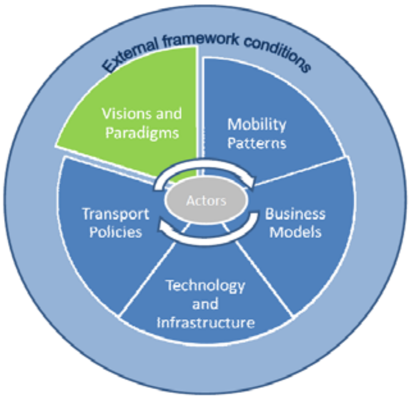


Figure 1.1: Structure of the transport system used for this project

In the following chapters, the summary of the work conducted during the project will be organized on the basis of these elements. Conclusions will be drawn in relation to pathways towards sustainable urban transport.

It is not easy to say which of these elements comes first in terms of influencing the others. New technologies or changed mobility patterns can both be the first factor to influence the formulation of a new paradigm or the structure of urban space. The different elements of the system not only have a mutual relationship, they can simultaneously be seen as effective approaches for changing the transport system.

2. Visions and paradigms in transport policy



There is evidence that paradigms, visions and "guiding principles" can exert significant influence on the development of socio-technological systems such as the transport system. They are of great importance for the technology-infrastructure combinations that are implemented in urban areas and, thus, a factor to be considered when it comes to the identification of pathways towards sustainable urban transport systems. A paradigm, or guiding principle, basically refers to how people think about problems and how they develop solutions to overcome these problems.[2] Policy paradigms, like Kuhn's concept of scientific paradigms, are described by Hall (1993) as a framework of visions and standards that not only specify the goals of policy making and the tools used to achieve these goals, but "also the very nature of the problems they are meant to be addressing."[3] Along the same lines, Dosi (1982) describes a technological paradigm as "a dominant technological style whose common sense and rules of thumb affect the whole economy."[4]

If this concept is applied to the transport sector, it becomes obvious that paradigms matter—and that paradigms change over time. For example, in many European countries in the 1960s and—to some extent—in the 1970s, the leading paradigm for urban transport was to create a city optimized for motorized individual transport, with broad roads and parking spaces. Public transport was considered old fashioned and, in many cities, tramway lines were removed. "Predict and provide" was the dominant planning approach of this period: This consisted of predicting demands and building the required infrastructure as quickly as possible.[5] Since strong growth in car transport was predicted, corresponding infrastructures were built. The guiding vision was that of a car-dominated transport future – obviously that paradigm or vision materialized and became reality in the course of time. It was undoubtedly a highly formative paradigm; however, it can be questioned whether it was also successful, since many cities attracted so many cars that the attractiveness of car transport was reduced by congestion or a lack of parking spaces. In the 1970s, there were calls for integrated transport solutions, whereas in the 1980s, deregulation and liberalization of access to the markets became important issues.[6]

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[2] The term "scientific paradigm" was initially coined by Thomas S. Kuhn (1962) to describe a set of practices that define relevant problems as well as the specific knowledge related to their solutions; a scientific paradigm determines the field of inquiry, the problems, the procedures and the tasks.

[3] Hall, P.A. (1993).

[4] Dosi, G. (1982).

[5] Bertolini, L. et al. (2008).

[6] See Viegas, J.M. (2003).

Figure 2-1: Visions of a future transport system from 1959 and 1961.
Source: Bürgle, K. (1959).

Figure 2-2: Perspective of Malmö's future transport system as an example of a sustainable transport vision.
Source: Ljungberg, C. (2010).

In the meantime, the paradigm of "sustainable transport" has become a well-established key concept that is deeply embedded in the scientific literature as well as in implementation-oriented planning documents at different political levels.[7] For example, in most European cities' transport plans and urban development plans, sustainable transport plays a crucial role. The visions of sustainable transport are clearly different from 1960s visions of a car-friendly urban future (see figures 2.1 and 2.2).

In general, this paradigm places strong emphasis on an attractive public transport system and, thus, on technologies conducive to this goal. It further emphasizes a stronger integration of transport planning and land-use planning to reduce transport demand in urban areas. Many authors emphasize various aspects of sustainable transport (see Banister 2008), whereby one key element is surely to simultaneously take economic and social as well as environmental aspects into account. For example, the Commission's 2001 White Paper states at the very beginning that "a modern transport system must be sustainable from an economic and social as well as an environmental viewpoint."[8] The 1960s and 1970s paradigm of the car-friendly city certainly materialized, and there are many facts indicating that the paradigms of sustainable urban transport have been exerting influence on the urban design of many European cities. Many such indicators can be found in this final report and in the deliverables of the urban transport project.

Thus, paradigms matter: They change and they seem to be changeable by actors in the transport system—at least to a certain extent. Accordingly, it is worth fostering the paradigm of sustainable transport through policies at different political levels. However, the world is not a static but a dynamic system and, therefore, paradigms must be adapted to upcoming trends and challenges in order to be accepted and, thus, effective. The challenges that are currently emerging for the next decades will certainly impact transport paradigms and their materialization in future subsystems, technologies, economic settings and demand patterns. Potential examples might be a new framing of safety and security measures in keeping with upcoming societal problems, such as the changing needs of an aging population and the threat of international terrorism.

Recently, it seems as though economic aspects have gained importance in terms of transport-relevant paradigms. It has always been emphasized that a functioning transport system is of the utmost importance for economic growth in European countries. But in the meantime, the international competitiveness of transport technologies and services has gained in importance. The notion of competitiveness is becoming more and more linked to the paradigm of sustainable transport. Various examples can be found to support this thesis. The Commission's new White Paper on transport points to this notion in its title, "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system."

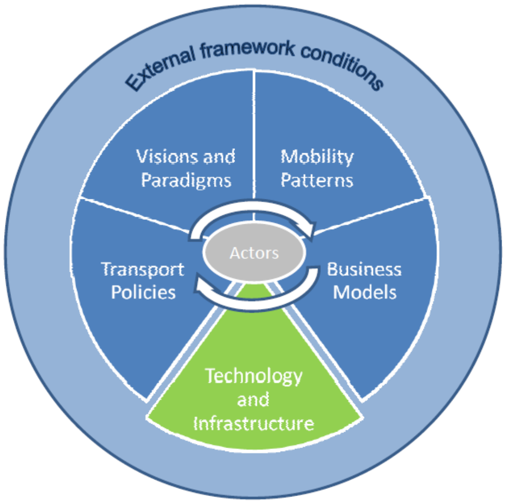
The economic crises and the growing competition between the EU and industries in emerging countries will surely increase the need to include the requirements of global competitiveness in transport-related concepts and visions. It is widely acknowledged that Europe can only compete with low-cost locations and keep up its economic strength by pushing the development of highly sophisticated technologies forward. Thus, this notion of integrating international competitiveness in transport-related paradigms is sure to have a technological focus.

[7] See Banister, D. (2008).

[8] CEC (2001); the term "sustainable transport" was already featured in the title of the 1992 White Paper on transport (CEC 1992).

However, when translated into policies for sustainable urban transport, it is important to demonstrate how innovative technologies and also concepts can be implemented in urban areas in a way that they will be accepted by the public and, at the same time, foster sustainability. It can be argued that innovative concepts that support both sustainable transport and economic growth in Europe should be able to find strong and long-lasting support from many different stakeholder groups.

3. Technologies and infrastructures



It goes without saying that advanced technologies and infrastructures are essential for enabling modern mobility patterns. DEL 2 of this project highlights a broad range of technological options for sustainable urban transport. Some of them are already available, some are emerging and others are of a more visionary character. It is argued that, recently and with respect to technologies, major contributors to anticipated as well as already observable changes have been provided by developments in two fields of technology:

1. Technologies that affect oil-dependency, efficiency and emissions of vehicles, which can be generally labeled as alternative fuel and propulsion systems and
2. Technologies that affect the way transport modes are used, which can be generally labeled as information and communication technologies (ICT).

Relevant trends and developments in these fields will be briefly summarized in this chapter. In addition, the relevance of longer-lasting infrastructures and urban design will be emphasized in a further section. Finally, a brief outlook on emerging technologies is given in an "out-of-the-box" section.

3.1. Fuel and propulsion systems

One important strategy for improving the sustainability of urban transport systems is to reduce energy consumption and emissions from vehicles. Basically, this means replacing existing vehicles with cleaner ones; however, it should be noted that there might be effects on travel patterns as well—for example, if people were to travel more because increasing efficiency reduces the cost of travel. In addition to environmental topics, such as climate change and air quality in urban areas, there are other substantial drivers changing fuel and propulsion systems—mainly in road transport but also for other modes of transport. Oil is a finite resource and oil prices are expected to rise in the future. Furthermore, economic competitiveness is a trigger pushing new transport technologies forward.

The modern internal combustion engine (ICE) is a highly advanced technology and is still subject to improvements in terms of efficiency and emissions. Several alternatives to the conventional, oil-based ICE are currently being discussed. Regarding alternative approaches, various options exist — some of them are already on the market, while others are still in pilot and development stages.

Biofuels are surely the most advanced: in Brazil, for example, they have achieved high market shares, but so-called flex-fuel cars, which are able to run on blends of conventional and biomass-based gasoline, are also widespread in some European countries, such as Sweden. In Germany, however, the recent introduction of a 10% blend of ethanol (E10) did not find full acceptance among users. But fundamentally, in terms of infrastructure and usability, biofuels are a quite convenient solution, since the existing infrastructure can be used and they require no significant changes in the daily routines of users. Biofuels offer one solution to reduce CO_2 emissions and dependency on fossil fuels. In 2006, biofuels' share of the total energy used in road transport in Europe was 2%. In 2008, EU leaders reached an agreement on a new renewable energy directive that requires all member states to reach the mandatory target of a 10% share of biofuels in transport gasoline and diesel consumption by 2020. Biofuels derive from biomass feedstock, which has led to growing concerns about the effects of a large-scale implementation on food prices. Therefore, recent growth rates (the global biofuel supply achieved a 37% increase in 2006) are not expected to continue.[9] Furthermore, there are controversies related to the environmental impacts of large-scale biomass production, for example, when virgin forest is converted into monocultures for producing palm oil. Also, the overall balance of GHG-emissions depends on how the biomass is produced and processed and is not necessarily particularly advantageous. Up to now, so-called first-generation biofuels are only able to use the oil or the sugar from certain parts of the plant. Technological progress is moving towards second-generation biofuels. These are able to use most parts of the plants for fuel production and, thus, to significantly increase the amount of fuel per hectare as well as the variability in feedstock. The technology is not too far away from commercialization and is expected to bring benefits in terms of well-to-wheel energy and GHG balance. An alternative might be the cultivation of biofuels with the help of algae. However, it still remains uncertain whether significant amounts can be produced at reasonable costs. In addition, biomass could also be used for the production of power and heat. Thus, biofuels are an alternative, but it is not certain that they will ever reach significant shares in urban transport.

Gaseous fuels are another alternative. Compressed natural gas (CNG) is often promoted as a convenient alternative and is already on the market and ready for use. It brings environmental benefits, however, it remains a fossil-based fuel—unless the gas is produced from biomass. This is theoretically possible, however, the use of biogas is also an interesting option for the stationary production of power and heat on the basis of renewable energies. CNG would not require infrastructures, ranges and loading times to be changed extensively. But the density of CNG fueling stations is still far too low in many European regions.

Electric drivers are considered by many observers to be the most promising alternative to conventional ICEs, and they dominate political and scientific debates about future mobility concepts. In terms of technologies, it is not the propulsion itself that is the most crucial issue, but the efficient generation and storage of electrical power. Two fundamentally different concepts exist: the storage of energy in batteries and the storage of energy in the form of hydrogen. Both concepts have their pros and cons and their related challenges in terms of technological development. A further electrification of road transport would entail striking changes under several aspects.

[9] See IEA (2009).

Electric mobility covers a whole range of already-existing and new vehicles. Besides electric cars, public transport — such as electric trams, suburban trains and trolley buses — as well as light electric vehicles — such as pedelecs,[10] e-bikes and Segways — are all a part of this variety. Electric drive trains offer an opportunity to reduce (local) emissions[11] and the oil dependency of the sector, and might also correspond to changing transport habits due to new transport modes that are entering the market (i.e., pedelecs) and changed technological settings (i.e., limited range of e-cars).

Battery electric vehicle (BEV)	Drivable solely through electric motors, without the need for an internal combustion engine.
Hybrid electric vehicle (HEV)	Incorporate both an electric and a combustion engine. Electric machines are used to provide power to the wheels and to charge battery packs.
Plug-in electric vehicle (PHEV)	Can use conventional fuel or electricity, both rechargeable from external sources. In order to recharge the battery, the car is simply plugged into a normal power grid.

In many countries, the development of battery electric vehicles comprises the core of current efforts to push electric mobility forward; electric cars are often treated as synonymous with electric mobility. All over Europe and beyond, various tests and projects have been put into place — although electric cars are still a niche product and mass-market introduction has not yet occurred. Nonetheless, many interesting approaches can be observed: These range from rather conventional car models to new concepts, such as small and light cars that are particularly interesting for urban areas.

However, considerable technical, economic and social barriers still need to be overcome. One major challenge is to reduce the purchase cost of battery electric vehicles, including the battery, which is still the most cost-intensive part. Additionally, even modern lithium-ion batteries only have a limited range of about 100–200 km, and their charging time is relatively long (about 8.5 hours for a 30 kWh battery; faster options are available, but also have disadvantages). Furthermore, an infrastructure for charging needs to be put in place—particularly in urban areas, where many citizens do not have a private garage and park their cars in public areas.

If electric cars are expected to fully substitute conventional ICE cars, substantial improvements need to be realized in order to bring costs, range and charging times closer to current standards of individual mobility. However, the extent to which users might get used to the lower ranges and longer loading times remains an open question.[12] For example, tests in pilots show that users adapt to loading times and ranges by loading the car whenever possible[13]. For these pilot users, fueling is not a singular event, as in the case of conventional cars, but is embedded in daily routines. This is a good example of the mutual relationship between technologies and mobility patterns.

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[10] A pedelec (pedal electric cycle) is a bicycle that requires the user to pedal in order to activate electrical assistance.

[11] While there is agreement about the fact that electric cars are locally emission free, the question of whether or not they can help to reduce CO_2 emissions in terms of the entire life cycle of a car is the subject of controversy.

[12] See Schippl, J. (2010); Kaiser, O. et al. (2011).

[13] See Fraunhofer IAO and PwC (2010).

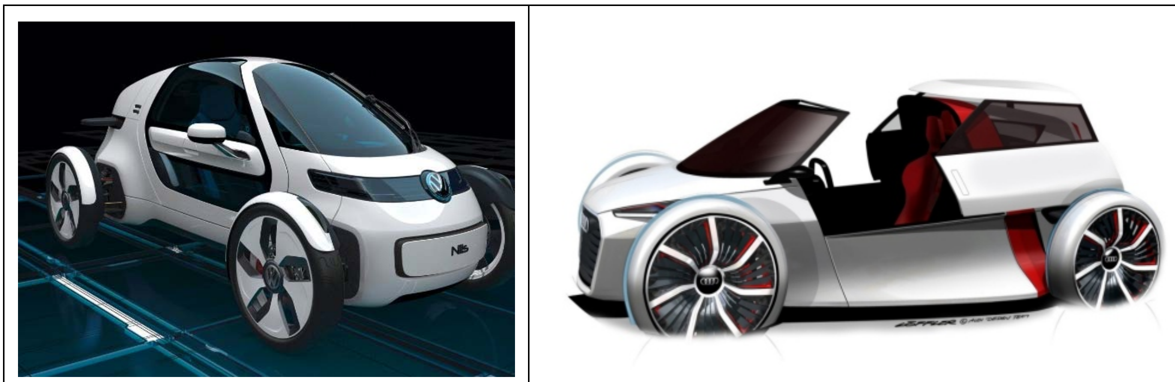

Figure 3.1: Electric concept cars address short-trip and commuter passenger needs: the one-seater "Nils" by VW (left) and the two-seater "Urban Concept" by Audi (right).

Source: Volkswagen (n.s.) and Audi (n.s.)

Another approach to onboard energy storage and power generation is offered by the combination of hydrogen and fuel cells. The hydrogen is used to generate electric power in a fuel cell, and this electric power is then used in an electric engine. Such vehicles are technically feasible and are already running as prototypes and in pilot projects. Costs are still too high for broader commercialization. A hydrogen infrastructure would be required, which would also be expensive but feasible, as many examples illustrate. If hydrogen is produced with renewable energy, fuel cell hydrogen vehicles do, in fact, emit low to zero emissions on a well-to-wheel basis. Still, the production of hydrogen remains a controversially debated issue, since electric energy needs to be converted into hydrogen first and then hydrogen needs to be reconverted into electric energy again. This considerable reduction in overall efficiency is discussed critically by many experts. The obvious advantage is that this technology offers ranges of around 400 km and more, as well as short loading times. A proper assessment of the pros and cons of hydrogen needs to consider its potential role in future energy systems. The striking advantage of hydrogen is that it is able to "store" electric power, even if this goes along with a reduction in efficiency. The importance in storage facilities will gain in importance when the share of fluctuating renewable energies (wind and solar) will increase in future. Also the batteries in cars need to be discussed in such a broader context. Many experts argue that batteries in cars could be used a "buffers" in renewable energy systems. What seems be clear, is that the transport system is becoming more and more merged with the energy system.

It is not yet clear whether battery electric vehicles or hydrogen fuel cell vehicles will be the dominant propulsion technology in the urban areas of the future. As figure 3.2 illustrates, it has been discussed that both approaches might enter into an era of coexistence, where battery electric vehicles are used predominantly for shorter distances and hydrogen fuel cell vehicles for longer distances.

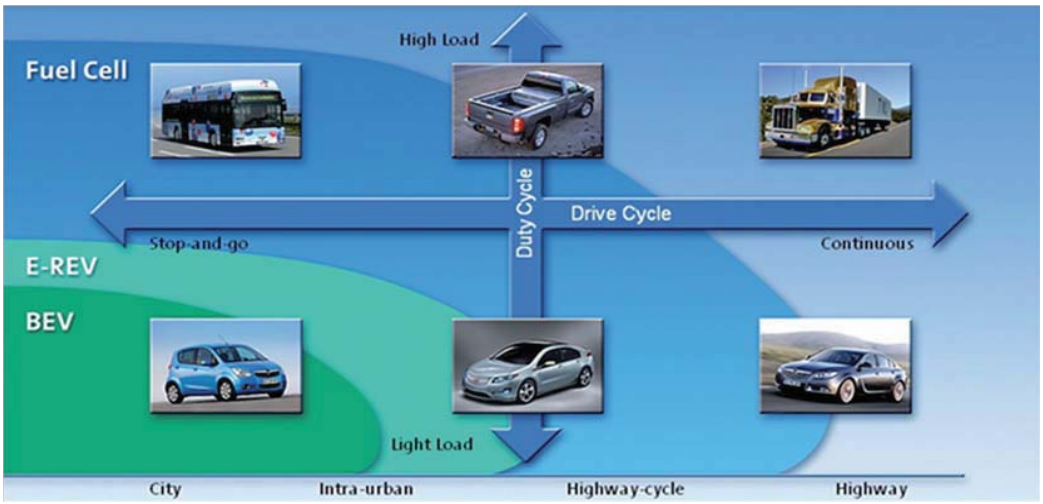

Figure 3.2: Potential applications for BEV and Fuel Cells.

Source: adapted from Eberle, U. and von Helmolt, R. (2010).

Here, it can only be briefly mentioned that innovative fuel and propulsion technologies for urban areas do not have to be restricted to cars. A light electric vehicle (LEV) is a two- or three-wheeled vehicle that typically weighs less than 100 kg and has either a battery or fuel cell or is hybrid powered. Electric bicycles (e-bikes or pedelecs) are the most common LEVs and are a promising solution for individual urban mobility. In 2009, one in seven bicycles sold were battery assisted. An e-bike is a bicycle with an electric motor; the battery is usually detachable so that it can be recharged at home. A pedelec is a bicycle that requires the user to pedal in order to activate electrical assistance. Steep topographies can easily be tackled or luggage transported. The range of a Li-ion pedelec is about 30–70 km.

Figure 3.3: Trolley Bus.

Source: Trolleymotion (n.s.).

Also in public transport promising approaches can be observed to extend the usage of electric drives. In recent years, the number of trolley buses, which run on electric power trains, has continued to increase (see figure 3.3). Worldwide, around 350 cities have more than 40,000 trolley buses in use. Between 2000 and 2008, 5,300 new buses were ordered or put into operation. In several European cities, trolley buses have revitalized systems that had previously been shut down (e.g., Rome); other European cities are developing Bus Rapid Transport (BRT) systems (e.g., Castellón, Spain, or Lyon, France) with trolley buses. In total, 156 European cities have at least one trolley bus in operation — most of them in Switzerland. The electric propulsion system is especially advantageous in cities with a steep topography. To avoid obstacles, the buses are also equipped with a diesel engine or a battery-supplied engine. Purchase prices of trolley buses are higher than conventional diesel buses, but they have a longer durability.[14]

Also hydrogen and fuel cells could play a more important role in urban public transport. The introduction of hydrogen-powered buses is currently taking place in selected demonstration sites worldwide. Due to the support of the European Commission and its hydrogen bus demonstration projects, CUTE and HyFLEET:CUTE, the development of hydrogen in public transport in Europe has made major advances toward proving the reliability of fuel-cell technology.

3.2. Information and communication technologies

Whereas various external triggers have been pushing technological developments in the field of fuel and propulsion technologies, in the ICT sector, it is the sheer progress and diffusion of new technologies that has been changing the transport sector, particularly in urban areas. ICT is an integrative and enabling technology in nearly all areas of daily life and also affect urban transport in various ways. ICT offers solutions for substituting virtual mobility for physical travel as well as applications that help to better organize transport flows. Relevant applications for the transport sector range from electronic communication via e-mail to highly intelligent applications for traffic management and control systems.[15] User-friendly interfaces and better information on travel options, possible delays or congested networks help to better plan and execute trips—beforehand or when already underway. ICT applications may be implemented in different areas of urban transport.

For car transport, the primary objectives of ICT are basically to better organize transport (by steering traffic flows), to optimize the use of infrastructure capacities, to improve road safety and to enhance environmental performance. Intelligent cooperative systems enable vehicles to communicate wirelessly with one another (vehicle-to-vehicle communication - V2V) or with roadside infrastructure (V2I). It is seen as the next crucial step in automotive electronics and an important component of the envisioned Intelligent Transport Systems (ITS).[16] Cooperative Systems enable the driver of one vehicle to communicate with other drivers (or their vehicles) even if they are out of sight. It is expected that the gathered qualitative and quantitative real-time data can be used to improve traffic management and road safety.[17] Also in this area, the potential benefits and effects on the transport system are difficult to predict.

[14] See VCÖ (2009).

[15] See Black, W. et al. (2006).

[16] See Kompfner, P. and Reinhardt, W. (2008).

[17] See Luo, J. and Hubaux, J. (2004).

Whilst Polis[18] comes to the conclusion that benefits will only be vital when enough vehicles are equipped with on-board devices[19], Kompfner and Reinhardt state that even "an equipment rate of only 20% could lead to fewer traffic jams on selected highways [...]".[20]

ICT is especially important for battery electric vehicles: It is crucial to know where the next option for reloading can be found. Furthermore, ICT enables the convenient use of new business models, such as car sharing (see chapter 5).

Efficient logistics are based on communication, organisation and co-ordination; ICT clearly is of utmost importance for such activities.Further developments include technical concepts to substitute contact-based technologies, such as magnetic-stripe cards, by contactless technologies in order to alleviate multimodal transportation for freight transport. Promising technology in this field is Radio Frequency Identification (RFID) or Near-Field-Communication (NFC). The function of RFID systems is primarily the same that barcodes perform today: to store and provide information or data about products. They are, however, far superior to barcodes, as they can also process data or communicate with other RFID tags and are thereby compatible with existing contactless infrastructure.21 Real-time indication of processes and flow of goods is fundamental for freight transport and a basis for process improvement.22 A move towards embedding RFID technology into a mobile device is NFC, which is a composite technology of RFID and contactless infrastructure.

The public transport system also profits strongly from ICT applications, since they enable easier access to vehicles (through mobile ticketing), and easier access to information (through mobile Internet)—at least for those societal groups that are familiar with mobile phones and the Internet. Customers want to be mobile without having to put too much effort into finding out about routes, fares and timetables, and they desire flexibility.[23]

The central element of the upcoming e-ticketing solution is a check-in/check-out process, whereby customers begin their trip by using a mobile phone, irrespective if one or several means of transportation are being used. Once a customer enters a bus, tram or train, he/she either uses a mobile phone or a smart card to check-in. As soon as the destination is reached he/she checks-out again (either through a phone call, or by holding a RFID smart card or NFC device against a reader). In doing so, the customer is located at origin, destination and during the trip at defined time intervals. [24] The reconstructed route is then the basis for pricing and thus a pre-selection of tickets is not applicable anymore. Furthermore, ICT is essential for organizing the public transport system.

ICT applications are also seen as a means to reduce traffic volumes by avoiding trips, for example, through virtual mobility. However, several authors cite a number of rebound effects that may reduce the advantages of virtual mobility. According to Banister et al. (2004), it is not necessarily true that ICT applications will reduce passenger transport in general, as it is still possible that additional trips will be made instead.

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18 Polis is the European cities and regions network for innovative transport solutions.

19 See Polis Position Paper (2010).

20 Kompfner, P. and Reinhardt, W. (2008).

21 See International Organization for Standardization (2004).

22 See Baranek, M. et al. (2010).

23 See Maertins, C. and Schmöe, H. (2008).

24 See Böhm, A. (2008).

3.3. Infrastructures and urban design

This section is more related to longer-lasting infrastructures than to more easily alterable technologies. Urban design is closely related to the transport system, since it can either reduce or increase the need and the distance to travel. Transport between suburbs has increased particularly strongly in European cities; such journeys are usually too long for walking or cycling and do no generate sufficient travel volumes to make public transport economically feasible. Thus, suburbanization has increased the use and necessity of the car.[25]

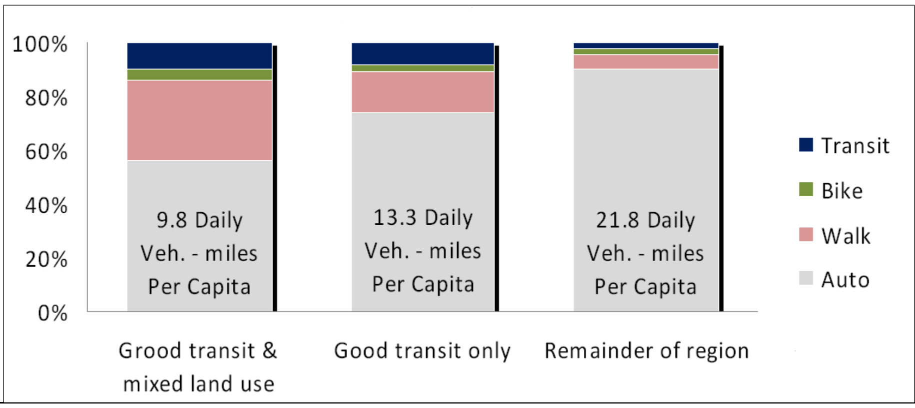


Figure 3.4: Urban design and mode share

Source: Ohland, G. and Poticha, S. (2006).

The implication that urban sprawl induces more transport means it can be assumed that changes in the built environment have a considerable effect on mobility patterns. According to Banister (2008) it should be "the intention to build sustainable mobility into the patterns of urban forms and layouts, which in turn may lead to a switch to green modes of transport." In particular, mixed-use and dense areas can reduce the need to travel and increase the attractiveness and efficiency of public transport, cycling and walking. "Land use patterns affect accessibility, which refers to people's general ability to reach desired goods, services and activities, and therefore affects mobility, the amount and type of travel activity that occurs in an area."[26]

According to T. Litman (2010), people who live and work in an urban environment that offers suitable public transport services within walking or cycling distance tend to drive 20–40% less than residents of rural locations. Planning for an accessible urban area is essential in realizing sustainable transport, as land use often determines travel behavior for many years. Walkable streets and a good and convenient cycling infrastructure are the most direct means to foster access to most local destinations, such as schools, work, transit stations and suppliers of everyday goods and services. Furthermore, encouraging a mixed land use that integrates residential, commercial, institutional and recreational use tends to reduce distances and, thus, increase the relative efficiency of alternative transport modes.

[25] See Pucher, J. and Lefèvre, C. (1996).

[26] Litman, T. (2010).

3.4. Out of the box

The transport system has always been subject to changes in its technology-infrastructure basis and in its service concepts, and it is likely that this will continue to be the case in the future. Technologies might emerge that are currently considered unrealistic or have not yet even been envisioned. Some technological options that might be elements of future transport systems are described in Deliverable 2 of this project. Two examples are briefly mentioned here: one for the passenger and one for the freight sector in urban areas.

Figure 3.5: PRT vehicles at London Heathrow Airport.

Source: PRT Consulting (2009).

Personal Rapid Transport (PRT) is a new transport method that runs on a track system. It provides on-demand services for individuals or for small groups traveling together by choice. PRT is structured much like an elevator: Passengers push a button to call for a vehicle and then another to select their destination. The service combines the advantages of individual mobility (flexibility, convenience, privacy) with those of public transport (sustainability, cost-effectiveness) by offering a direct origin-to-destination service in a podcar, without making intermediate stops along the way.[27] The system consists of a network of fully automated electric vehicles, which operate 24 hours a day, 7 days a week. A network of stations is connected by a track that passes by all stations in the system. Electric vehicles travel along these tracks, which are exclusively for their use. As soon as a vehicle reaches its destination, it can leave the track, in order to allow other vehicles to continue on. A central computer controls the system. The pods travel along paved paths equipped with magnets placed every five meters.[28] The first large-scale testing site has been operating at London Heathrow Airport since 2009. There are plans for PRT to be the primary means of transportation in Masdar City in Abu Dhabi.

[27] See Jeffery, D. (n.d.).

[28] See Bullis, K. (2009).

Figure 3.6: CargoCap underground pipelines (left) and loading ramp (right).

Source: CargoCap (n.s.).

CargoCap is designed for freight transport in urban agglomerations and for long-distance and regional traffic of up to 150 km.[29] The idea is that so-called caps would travel 24 hours a day in underground pipelines with a diameter of two meters: each would be loaded with two euro-pallets (see figure 3.6). Among the goods intended for transport are consumer and investment items, bulk goods, cargo production components, building materials, parcels and express freight as well as food and related products. Pipelines would be of a design similar to that of sewage drains and would be installed in public streets — next to, under or above preexisting supply and disposal lines, electric cables, subway crossings and other underground structures. As a general rule, the depth would be six to eight meters. Transport pipelines would be equipped with tracks for the caps as well as contact–free, energy-supply information technology and also RFID transponders to locate the caps.[30] Caps would be locally emission free as they travel electrically on rails through the underground pipeline system. At their final destination, caps would arrange themselves automatically into stations to be reloaded or unloaded. The stations could be located above or below ground and would serve as reloading points.

[29] See CargoCap (n.d.).

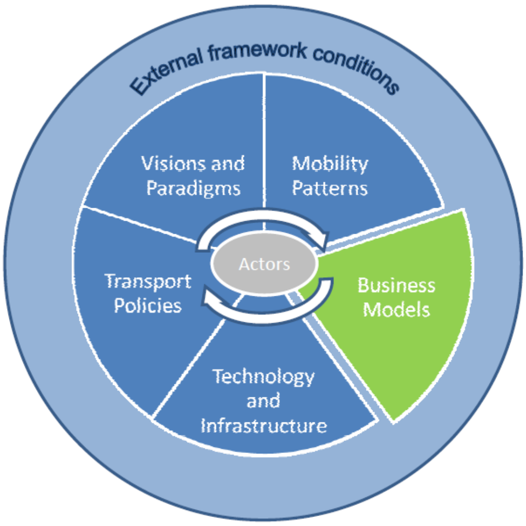
[30] See Kersting, M. et al. (2004).

These reloading points could be hubs on the outskirts of urban areas, where palletized goods would be reloaded to conventional modes of transport, such as trucks, in order to bring goods to their final destination.[31] The theoretical and development work of CargoCap is based on the specific conditions of an 80 km track through the Ruhr district. A test track has been developed, permitting the examination of electrical and automation engineering.[32]

[31] Ibid.

[32] See Stein, D. (2002).

4. Business models



Business models and organizational innovations develop together with technology-infrastructure systems, on the one hand, and transport demand, on the other. These two elements are linked and "co-evolve". Different business models can be observed in the transport sector: cars have traditionally been sold to the user, so private ownership is the standard business model. The same is true of bicycles. The use of a car might be integrated into other business models, such as toll systems on highways or congestion charging in urban areas. Other modes, such as airplanes, trains, buses or also taxis, are not bought – they usually are used by buying a ticket. In such cases, fare structures and marketing strategies establish the link to the customer. In the freight sector, the situation can be more complicated. Modern supply-chain management, for example, can be a complex system integrating various actors with individual functions. However, the management of freight transport remains a crucial issue in terms of sustainable urban transport. In both sectors, freight and passenger, the business models and organizational concepts are not static, but change over time.

Obviously, business models play a decisive role in the development of the transport system and, thus, also in the sustainability of urban transport. In the passenger sector, the car is the dominant vehicle: It is embedded in a matrix of services (garages, signals, stations, etc.) that contribute significantly to the attractiveness of its usage. Other modes have to compete with the convenience and flexibility of cars.

In recent decades, a variety of interesting approaches from changing business models have occurred; these can only be described briefly here (see DEL 2). In relation to public transport, it can be observed that access to the system has been greatly improved, whereby ICT is of the utmost importance for such progress. Access to information and a clear and comprehensible fare structure are highly important to the success of an urban transport system. Interview meetings with young citizens revealed that, even in a smaller city such as Karlsruhe, difficulties in understanding the fare system and buying the right ticket can still form an obstacle to using public transport (see DEL 4). It should be emphasized that these young people were well-educated and familiar with the use of ICT. In the meantime, integrated ticketing is much discussed as a promising approach to increasing the attractiveness of public transport. It enables access and makes transfers between different public transport services easier. Furthermore, the booking and use of tickets has become much more convenient, with e-tickets or mobile tickets as the latest development (see figure 4.1).

Figure 4.1: Ticketing is changing.

Source: Handyticket Deutschland (n.s.)

These concepts do not necessarily change the existing technology-infrastructure systems, but they make the use of the system much easier and bring it closer to the idea of the "seamless door-to-door mobility" that is supported by the new White Paper of the European Commission.[33] For example, the Irish Rail Procurement Agency is promoting integrated ticketing in a rather enthusiastic way: "Integrated Ticketing Scheme will completely change the way you view public transport across Ireland. It will have such a profound impact that it will be hard to imagine travelling without an ITS card."[34] Figure 4.2 gives another example for a concept encompassing even more mobility services.

The city of Hannover has introduced a smartcard, called Hannover mobile, that permits the use of public transport, including German railways (Deutsche Bahn), and provides for other services, such as the use of the local car-sharing scheme or a discount on taxis. Other cities, such as Freiburg (regiomobilcard), have had positive experiences with similar projects.

Figure 4.2: Integrated ticketing beyond buses and trains.

Source: GVH (n.s.).

Another key topic in relation to business models for passenger transport is car sharing. In the field of individual motorized transport, it is interesting to observe that the credo of ownership seems to have become somewhat weaker over the last decades. Leasing is becoming more popular in many countries, and there are also concepts for the sharing of cars and also bicycles. Most of these concepts are mainly applied in urban areas. Car sharing is particularly impressive, with its high growth rates in recent years—even if this growth is coming from a rather low basis. Whereas car sharing has "traditionally" been organized by small, environmentally oriented organizations operating within a single city, the spectrum of car sharing has become broader in recent years. In the traditional form, which became widespread in Switzerland and Germany during the 1990s, clients chose and booked a vehicle in advance and for a specific period of time; after use, they brought it back to the initial parking lot.

[33] See CEC (2011).

[34] Railway Procurement Agency (n.s.).

Usually, the customers became members of the organization operating the car fleet. Customers paid the fleet manager for the allocated service, mostly on the basis of time and mileage. While in the early days of car sharing, users as well as operators were primarily ecologically motivated, users now tend to be much more milieu-indifferent. In Germany, as well as in other countries, the number of car-sharing users has been growing continuously over the last two decades. Currently, car sharing is present in nearly all German cities with more than 200,000 inhabitants and also in most of the cities with between 100,000 and 200,000 inhabitants. In 2009, nearly 160,000 people in Germany were using this system. For Europe, the number of users is estimated to be around 500,000 and steady growth rates can be observed.[35]

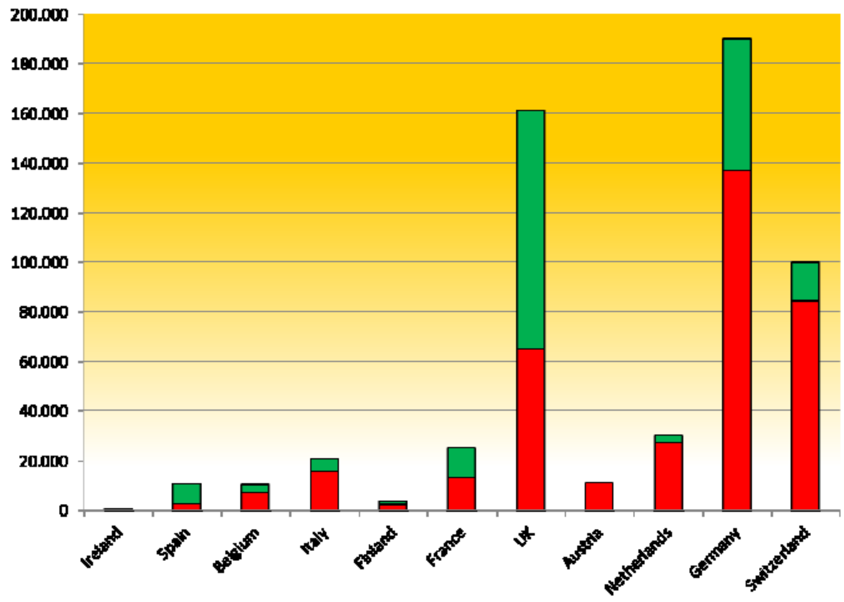


Figure 4.3 Car-sharing customers in European countries in 2009 (red) and 2011 (red + green).

Source: Loose, W. (2011).

According to several car-sharing surveys, the impacts on transport and environment are large.[36] Effects can especially be seen in:

- CO_2 reduction: many car-sharing providers already meet EU-established standards, even though they will not be binding until 2015;
- The strengthening of modes of transport with no or low emissions (bus, tram, bicycle, walking, etc.), as the fee structure encourages the combination of different modes;
- The diffusion of more eco-efficient vehicles, as car-sharing vehicles are, on average, newer than personal cars and thus benefit from improved engine technology, fuel efficiency and emission levels.

[35] Frost & Sullivan (2010).

[36] See Bundesverband CarSharing (2009).

Car sharing could be an interesting niche market for alternative fuel and propulsion technologies, since it makes it possible to choose between different types of vehicles according to the purpose or distance of the journey. Battery electric vehicles could be used for trips in urban areas; for longer trips, a car with a range extender or a conventional ICE might be chosen.

Car2Go by Daimler

Since March 2009, 200 "Smart fortwo" cars available in the City of Ulm, Germany

Access to cars by RFID chip on license of registered users

Price: € 0.19/minute (incl. mileage, tax, insurance, fuel, parking)

More than 20,000 users (60% aged 18–35)

700–1,000 trips per day

Also in other cities, such as Hamburg and Amsterdam (with electric vehicles)

Similar project in Austin, Texas

Other automakers also starting innovative projects (e.g., Mu by Peugeot)

Figure 4.4: Car2go as an example of the variety in car-sharing schemes.

Source: Car2Go (n.s.).

In recent years, new car-sharing schemes have emerged: These deviate from the traditional form described above. Germany is the source of two prominent examples. First, there is the car-sharing scheme that is run by German railways, which links rail services with car rental. Secondly, with the car2go scheme, operated by Daimler, a "conventional" car company has introduced an unconventional approach to car sharing. Since 2008, in the German city of Ulm, 200 "Smart fortwo" cars have been available for every registered person to use and then leave for the next person. The cars can either be picked up spontaneously or reserved. Registered users receive a small RFID chip on their license, which they then simply need to hold up to a card reader on the windshield.[37] After use, the car can either be parked at any downtown destination or at one of 130 parking lots that are exclusively reserved for Car2go. The scheme has become surprisingly successful (see figure 4.4). Car2go resembles the modern bike-sharing schemes that have become widespread in European cities within a relatively short time. Once again, ICT provides the backbone of these bike-sharing schemes (see figure 4.5). In Paris, the successful bike-sharing scheme Vélib' has inspired a car-sharing system for electric vehicles, which is called Autolib'. The system plans to operate more than 3,000 electric vehicles. More than 1,000 pick-up and return stations are projected for Paris and surrounding municipalities.

[37] Users have to register in the city hall and online.

The concept in Ulm has recently been extended to an online ride-sharing service called "car2gether". Via PC or mobile phone, registered drivers and passengers can send offers and requests regarding routes. Starting location, destination and time are then transmitted in real time between suitable partners. In addition, all offers and requests are posted every 15 seconds on a live ticker. The data of potential drivers and passengers traveling in the same direction is then transmitted mutually among both. Even if it is not clear whether the idea will develop successfully or not, it is a good illustration of the fact that—mainly driven by the new options offered by ICT — there is room for new and innovative business models for mobility in urban areas.

Bike sharing

Different generations of bike-sharing systems:

First and second generation failed due to a lack of control mechanisms and theft

Third generation: advanced technology for reservation, pick-up/drop-off procedures and information services

Upcoming fourth generation: improvements expected in more flexible docking stations, the use of intermodal smartcards, GPS tracking, touch screen kiosks and the use of electric bicycles

Figure 4.5: Bike sharing schemes are becoming a part of urban transport systems.

Source: JCDecaux (2007).

Thus, car sharing seems to be a business model that might become a sort of "enabler" for electric mobility. The background and motivation are the disadvantages of battery electric vehicles, such as long loading times, limited ranges and the extremely high cost of batteries, which are not proven to be fully reliable over longer periods.

There seems to be a general tendency to compensate for technological disadvantages by designing new business models that are suitable for battery electric vehicles. For example, electric cars that have come on the market are often sold to customers without the battery, which is only leased (e.g., 70 Euro/month for the e-smart). One prominent approach in this context is called Better Place. The overall idea of Better Place is that suppliers own the battery themselves and sell usage (miles, kilometers or kWh) to the customers at a lower cost than the average gasoline price in the given country.[38] This idea was adopted from the mobile phone sector: initial costs of electric vehicles are subsidized by the ongoing per-distance revenue contract, just as mobile handset purchases are subsidized by per-minute mobile service contracts. The project's main partner is the French car manufacturer Renault, which will provide mass-market electric vehicles with switchable batteries.[39] Again, this is a concept that would be unimaginable without advanced ICT (see figure 4.6).

[38] See Better Place (2012).

[39] See Renault (2010).

The concept of Better Place relies on two axes: a dense network of charging stations and a thinner network of battery-switching stations. The latter offer the possibility of exchanging depleted batteries for full ones in under a minute. A cohesive network will be developed with cars that: (1) are virtually connected to the main control unit, (2) have in-car software that constantly monitors the charging status and calculates the range of the battery until recharging is necessary and (3) feature a navigation system that shows the closest switching or charging stations.[40]

Figure 4.6: Better Place station for switching batteries[41]

Source: Betterplace (n.s.).

These examples prove that a strong dynamic can be observed in terms of new business models for urban transport in the passenger sector. The freight sector also displays developments related to new business models. First of all, it should be emphasized that the delivery of goods in urban areas might be an interesting market for battery electric vehicles, since, in this context, shorter ranges are often sufficient and charging can be done in periods when the cars are not in use. This could be overnight, as long as goods are delivered during the day time. It could also be interesting, and is suggested as an option in the Commission's recent White Paper on transport, for more goods to be delivered at night. This would have the advantage that the roads are usually not crowded. In this way, free capacities in the network could be utilized, and travel volumes during peak hours could be reduced. Silently running electric vehicles are an important element in such concepts. The obvious disadvantage is that working during the night would be an unfavorable condition for the drivers. There are many more examples of new approaches, two of which are briefly described in figures 4.7 and 4.8.

DHL Smart Truck

Three-month DHL pilot project in Berlin to increase efficiency

Technological innovation (ICT-based):

Use of RFID tags to permanently screen loading condition of the truck

Receives input from GPS signals of 500 taxis in Berlin to change routes dynamically

> Saves energy, emissions, time and costs

Figure 4.7: DHL Smart Truck.

Source: Deutsche Post (2009).

[40] See Engel, R. (2009).

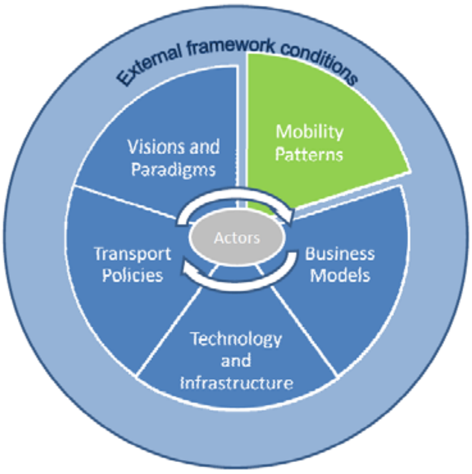
[41] See Agassi, S. (2009).

The freight tramcar in Dresden, Germany, uses a tram for goods transport. The CarGo Tram project involves a cooperation between DVB (local cargo enterprise), Volkswagen and local authorities. VW wanted a competitive solution (compared to road transport) for bringing prefabricated parts just-in-time from one point in the city to another, using existing tramway tracks. The main key to the viability of the project is the length of the tram (60 m) and its capacity of three trucks (maximum load 60 tons, with a load space of 214 m^3)

Figure 4.8: CarGo Tram in Dresden

Source: Rail for the Valley (2010).

5. Mobility patterns and behavioral aspects



The behavior, attitudes and perceptions of the users of the transport system are of the utmost importance for the successful implementation of innovations. In this chapter, the project's findings in relation to the dynamics of transport behavior are summarized and supplemented by the results of interview meetings with younger citizens in three European metropolitan areas.

5.1. On the dynamics of transport behavior

The reports for this project have emphasized that there is a mutual relationship—or a coevolution—between the development of technical and organizational innovations, on the one hand, and mobility behavior and related mobility patterns, on the other. Therefore, in order to understand the potential for innovation in sustainable urban transport, it is crucial to understand the factors and motivations that influence transport behavior, particularly non-technical factors and their dynamics.

Transport behavior becomes visible in the form of mobility patterns, which are measurable in the form of modal split, transport volumes and number of trips. It is worthwhile to take a brief look at some significant parameters of travel patterns in Europe. The share of total passenger travel undertaken in the EU-27 grew steadily from 1995 to 2006. Some 6.4 trillion passenger kilometers, or an average of more than 13,000 km per person, were undertaken by Europeans in 2006. This represents an increase of 1.7% per year since 1995.[42] During this period, the share of travel undertaken by public transport was relatively stable at around 9–10% since 1995.[43] Walking also has a reasonable share of total trips in some European countries. Even though data is not available on a European basis, Bassett Jr. et al. (2008) have provided some exemplary numbers. According to their study, numbers vary between 13% in Ireland and 35% in Spain. Nevertheless, the main means of transport — the car — accounts for almost three quarters (73%) of the total performance.[44] These numbers have to be changed if a modal shift or a reduction in transport volumes is to be achieved.

[42] See CEC (2009a).

[43] These numbers vary depending on the country. According to Bassett Jr. et al. (2008), Germany, Finland and Denmark, for example, have a mode share of public transport of 8%, the UK 9%, Sweden 11%, Switzerland and Spain 12%, and Latvia 32%.

[44] See CEC (2009a).

Everett M. Rogers (2003), one of the most influential researchers of the diffusion of innovations, illustrated that "rational" economic factors are only one factor in individuals' adoption or rejection of an innovation. Users' attitudes, perceptions, norms and values are quite often important, and these can hardly be translated into economic yardsticks. Many studies acknowledge that perceptions and attitudes are also of the utmost importance for transport-related decisions, such as the wish to travel, the choice of destinations, the selection of mode and the route chosen as well as for the decision about which car to buy. The latter is highly relevant in the context of the discussion about the potentials of battery electric vehicles and other alternative fuel and propulsion technologies.

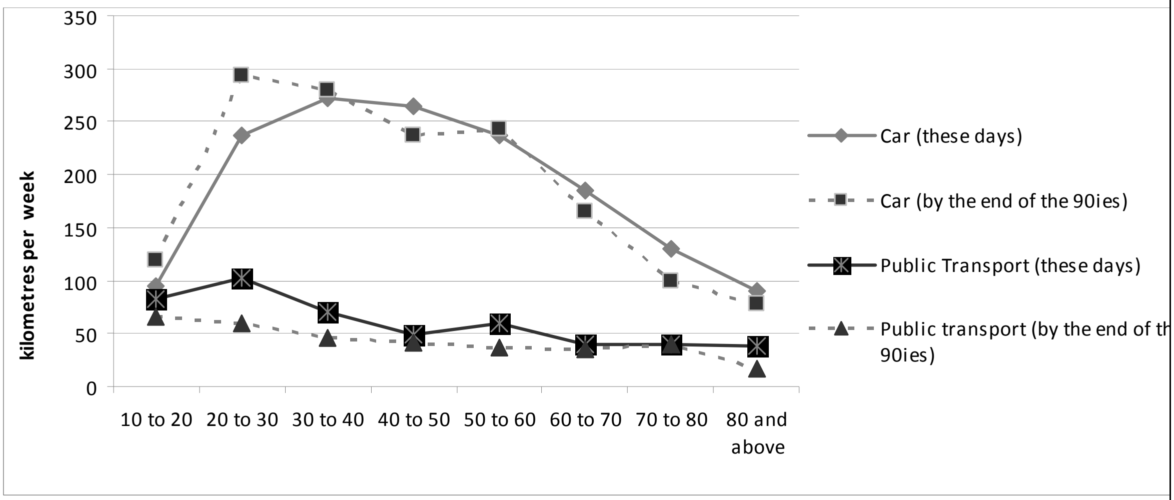


Figure 5.1: Changing mobility patterns in Germany.

Source: KIT (2010)

Age Groups: 10-20 years old; 20-30 years old; etc.

One survey that should be mentioned here is a large-scale evidence review of more than 3000 studies focusing on attitudes toward important aspects of transport policy.[45] One of the key findings of this review is that "just as transport and travel choices are rooted in the structure of activities undertaken by individuals and families, it follows sensibly that attitudes to transport must also be rooted in deeper values and aspirations of how people want to lead their lives."[46] It is further concluded that economic motivations (costs, allocation of time and participation in employment) are important, but so are influences such as stress, tranquility, feelings of control and independence, social obligations and desires for both excitement and calm. The study also points to the fact that there is a lack of evidence regarding how individual attitudes change over time.

[45] Goodwin, P. and Lyons, G. (2010).

[46] ibid.

It is further argued that transport behavior is a matter of habitual behavioral patterns: This means that, under ordinary circumstances, these patterns repeat themselves on a daily basis. Such behavioral patterns stem from learning processes and routines that develop over longer periods of time and are difficult to break. According to Schlag and Schade (2007), behavior is performed almost automatically and with a minimum of cognitive effort.[47] It is quite often assumed that transport-related behavior is something rather static; however, data from different countries illustrates that changes are ongoing and that further changes can be expected for the future. In Germany, for example, there is data illustrating different trends for younger and for older people (see figure 5.1). People over 60 use cars more than the same group did about 10 years ago. The reasons are quite obvious and surely also of international relevance: People are more healthy, their income is higher (so that they can afford a car), they are used to a car-oriented lifestyle and — last but not least — the number of women with a driver's license has increased significantly in this group.

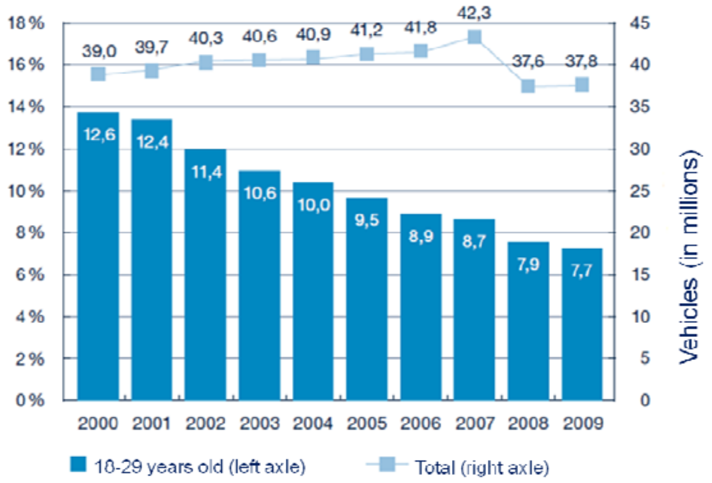


Figure 5.2: Share of 18- to 29-year-olds among total vehicle owners in Germany.

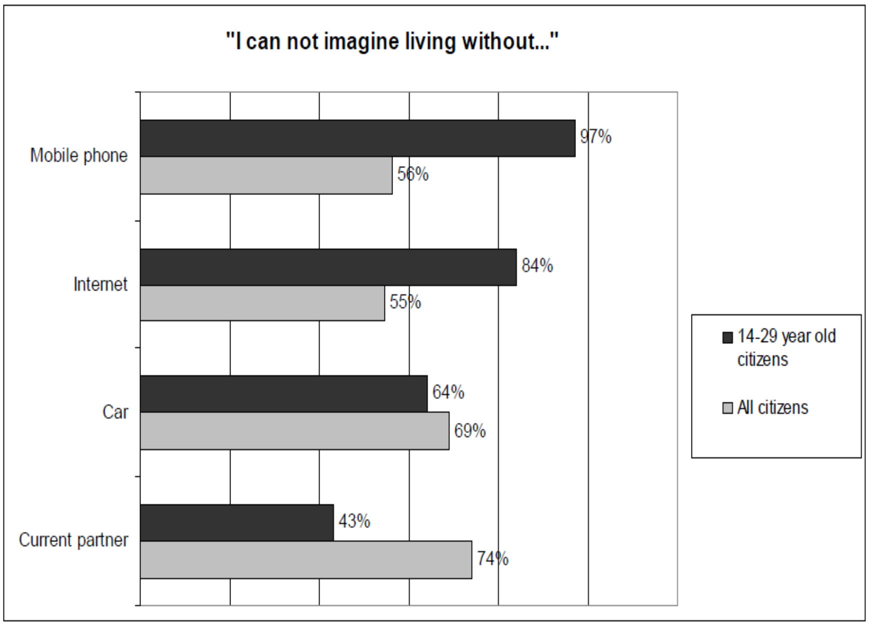
Source: Fraunhofer IAO and PwC (2010).

The same figure illustrates that younger people are using cars less than the same age group did about ten years ago. Several empirical studies prove that there is a growing group of younger people with rather pragmatic attitudes towards car ownership and transport (FHDW 2010). According to a (non-representative) survey, 22% of young people between 18 and 25 stated that the car is nothing more to them than a means of transportation, and 20% of them can imagine living without a car. For many young people, however, the car is still something important. Still, other studies support the impression that the car is losing importance among younger people in urban areas.[48] Young people in urban areas are the most flexible group in terms of using different modes of transport, and they are comparatively flexible in regard to their travel patterns. Figure 5.2 shows the decrease in the share of total car ownership among 18- to 29-year-olds, which supports the thesis introduced above. Data for other countries, mainly from Sweden and Norway, reveals a similar development.

[47] See Schlag, B. and Schade, J. (2007).

[48] See Fraunhofer IAO and PwC; infas and DLR 2010; tfactory (2008).

It is assumed that the greatly increasing importance of ICT is a key driver for the changing mobility behavior of younger people. Internet and mobile phones are becoming more important for younger people. Social networks are more and more often of a virtual form (Facebook, Twitter, etc.). ICT are needed to gain access to these networks. At the same time, it could be assumed that the physical accessibility of friends and events might lose relevance. The growing relevance of ICT is supported by results of a survey which are are presented in figure 5.3. Another reason for such changes might be that access to public transport is becoming much easier, since all the required information is available all the time and at any place. It is easy to get used to public transport and to perceive it as something flexible, at least in urban areas with a dense public transport network. Furthermore, "gadgets" such as smartphones, MP3 players and laptops are becoming symbols linked to identity, self-image and social recognition. Nevertheless, it is unclear whether this group will change its behavior when it enters a new phase of life (e.g., having children, finding a first job, moving to another place). However, the group does seem to be disposed to using different modes of transport — if these modes are "feasible and handy."



According to this survey, a considerable share of young people cannot imagine living without a car. But, nearly all young people cannot imagine living without a mobile phone. Particularly in relation to mobile phones and the Internet, the figures for "young people" differ from those of "all citizens."

Figure 5.3: Results of the Bitkom Study "Webciety."

Source: Scheer, A.-W. (2009).

Somewhat similar data is available for Nordic countries. Ruud and Nordbakke (2005) make reference to a decrease in driver's license rates among young people between 18 and 24 in Sweden and Norway. As possible explanations, the authors mention urbanization and the fact that more young people are attaining a higher education, resulting in many young Swedes having children later. Even if these people might start driving cars as soon as they have children, the observable lower rate of possession of a license is seen as a good opportunity for public transport. It has also been reported that, for young people, time is the most important issue in daily transport. This finding is supported by the results of the interview meetings conducted with young citizens during this project (see section 5.2). Young people are more "impulsive travelers" than older groups.

Within the context of the fact that cars are usually associated with freedom, Ruud and Nordbakke (2005) suggest that future transport planning should try to communicate the freedom offered by public transport, for example: freedom from responsibility, freedom to make constructive use of travel time, freedom from having to return back to the same point.

Several surveys illustrate that environmental issues are often regarded as very important, but for daily transport-related choices, they seem to be of minor importance. J. Anable et al. (2006) argue that, at the individual level, knowledge and awareness of climate change is only weakly linked to travel behavior. Another relevant study deals with the travel behavior of young people in the context of climate change (see Line et al. 2010). A series of discussion groups were undertaken with young people aged 11–18 who live in the suburbs around the city of Bristol. The results show that the participants' travel-behavior intentions are dominated by a desire to drive. Key influences are values related to identity, self-image and social recognition (at the expense of individuals' environmental values) as well as individuals' affective attitudes towards transport modes. The participants' understanding of the link between transport and climate change is weak. Their values are related to their positive attitudes towards cars and driving; favoring this mode is rated more highly than more environmentally friendly modes. The authors conclude that one answer to this situation may be "to promote cycling as a signal of success and being 'cool' rather than promoting the health and environmental benefits of this behavior."[49] Although young people express some support for transport policies aimed at reducing the impact of transport on the environment, they are generally protective of their right to retain their use of the car. However, another interesting finding is that there is some acceptance of the idea of enforced travel-behavior change—away from the use of cars and towards more environmentally friendly modes. "This acceptance was in part due to their belief that such action would remove the influence of the 'social dilemma', where their own efforts to tackle climate change may be rendered worthless by the inaction of others."[50]

So, values are important: Image and self-identification can influence the development of mobility patterns. The findings of the interview meetings with young citizens underpin the position that it is not enough to promote sustainable modes of transport by pointing only at their environmental friendliness. It can be argued that sustainable transport should not be so strongly framed in the context of fears and threats related to negative environmental impacts. In this sense (and to come back to the diffusion of innovations), Urry (2010) states that innovations require "consumer communities" that highlight, advocate and develop them and declare them to be fashionable. He sees consumer fashion as the trigger for behavior change. A sustainable transport system has to be better and to signal that it is more fun. In order to meet these requirements, innovations need to offer more than new technologies: They also need to offer new forms of organization and business models that are well connected. Therefore, policies are needed that provide framework conditions favoring such developments.

5.2. Interview meetings with younger urban citizens

In this project, group interviews with younger people in urban areas were conducted in order to learn more about younger people's attitudes and perceptions regarding urban mobility. For this purpose, interview meetings were conducted in Budapest, Copenhagen and Karlsruhe (see box X and annex 3 of DEL 4 for more information). The three cities can be quickly characterized as follows:

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[49] Line, T. et al. (2010).

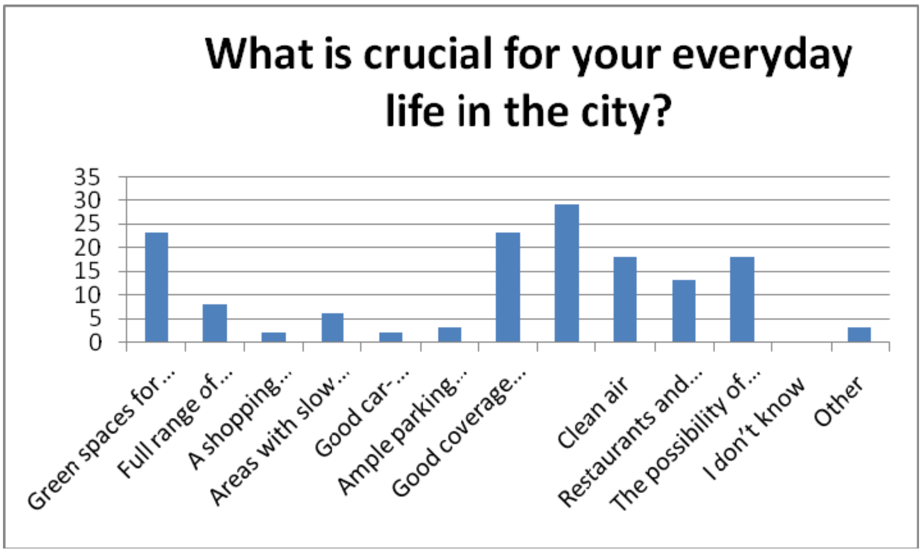
[50] ibid.

- **Budapes**t is the Hungarian capital; it has 1.7 million inhabitants and is divided by the Danube river. Urban transport in Budapest had been a very hot topic for several months prior to and also at the time of the citizen meeting. Although the country has received extensive EU funding for infrastructural investments in its cities, the news about urban transport is often related to examples of corruption and misuse of taxpayers' money. The average age of a bus in Budapest is 16 years, and one out of three buses breaks down every day. Prices for using public transport are high, and monthly tickets for a family of two adults and two children cost 20% of the average monthly salary. In the nineteenth century, Budapest had the first metro line on the Continent, and it now has the longest tram vehicle in Europe (only on one tram line). Still, the volume of car traffic is rather high. City leaders have implemented some measures to limit negative effects, such as separate bus lanes, car-free areas and an improved bicycle and pedestrian infrastructure in the downtown area. The number of cyclists is increasing in Budapest, but in most parts of the city, cyclists have to drive alongside cars or pedestrians, rather than in separate bike lanes. (See Report form Hungary.)
- **Copenhagen** has been the capital of Denmark since the early sixteenth century; today, about 650,000 people live in the municipalities of Copenhagen and Frederiksberg. Copenhagen is a seaport city characterized by bridges, wharfs, canals, etc. The central area of the city is old and filled with narrow, crisscrossing streets. Newer buildings and wider streets can be found further away from the center. Copenhageners have access to various forms of public transport, including buses, trains and a relatively new subway system, whose limited network is currently being expanded. Today, 36% of all travel to and from work or school in Copenhagen is by bike, and in its 'Bicycle Strategy 2011–2025,' the city plans to increase this share to as much as 50%. In addition, 28% of this category of traffic is handled by public transit services and 29% takes place by car.
- **Karlsruhe** is a city in southwestern Germany with a total population of around 290,000 inhabitants; the city is home to eight universities and more than 30,000 students. Like most other European cities in the 1970s, Karlsruhe's urban planners were eager to optimize the city for motorized transport. Today the transport system is characterized by the co-existence of different transport modes. The public transport network includes 226 tram and bus lines, spread over an expanse of 3,500 square kilometers. This ensures fast connections from the suburban regions into the downtown area; at most intersections, the tram is prioritized and has the right of way, which enables even faster connections. In recent years, cycling has gained increasing political importance. The city has set itself the goal of becoming cycling-city number one in Southern Germany by 2015 (and hence it has to "beat" Freiburg, which has a cycling mode share of 28%). Special roads around the downtown area have been identified as primarily designated to cyclists, and a bike-sharing scheme (DB "Call a Bike") has been implemented in Karlsruhe, currently with 350 bicycles. In addition, Karlsruhe has a well-developed car-sharing system. At 135 stations, the privately owned company Stadtmobil provides a total of more than 471 vehicles of various sizes to its 7,356 customers.

A brief overview of the main results is given in a separate box in this chapter. More detailed results can be found in DEL 4 of the project. Some aspects will be highlighted below, since they are of special importance in the context of pathways towards more sustainable transport systems in urban areas.

Between one third and one half of the participants in the three cities expect to drive a car more in the future than they do today. This is not astonishing given the fact that many of the interviewees were still students and not earning a full salary. Furthermore, most of them did not yet have children. Having children or starting a job are always factors that can influence travel habits. A majority of the young people in all three cities expected to earn more money in the future.

There are striking differences among opinions on the transport systems and the quality of life in the respective cities. In Budapest, the interviewees had rather critical attitudes towards urban planning and the infrastructures of their city. Most of the young people interviewed use public transport more out of necessity than as a preferred means of transport. In this group, there was strong interest in using cars—for practical reasons, but also because it symbolizes a certain economic and social status. However, primarily for economic reasons, cars were not available. Cycling was not considered to be an alternative, because it was perceived as being too dangerous.



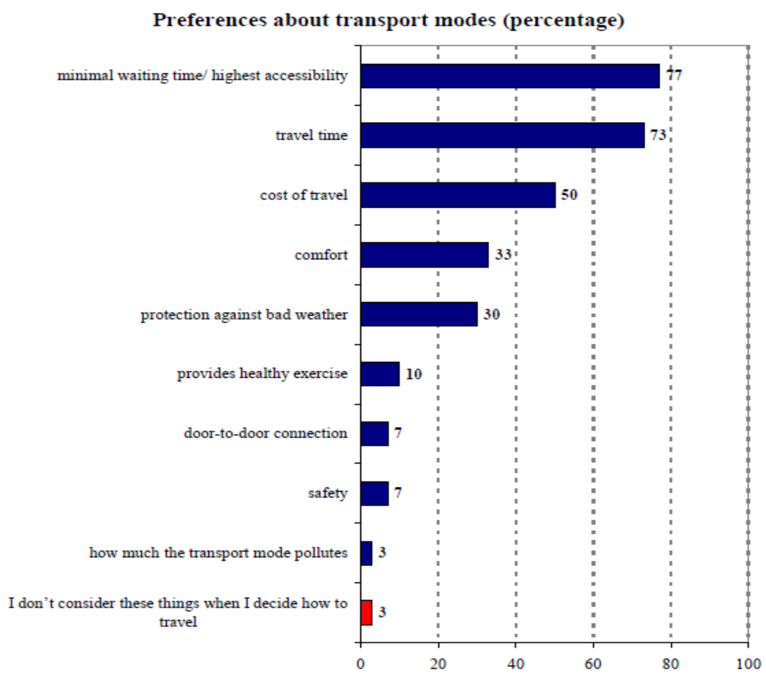
Results attest to the great importance of cycling for the interviewees in the Danish capital of Copenhagen. Green space and good public transport coverage are also of great importance. Good accessibility for cars seems not to be an important aspect for the interviewed group.

Figure 5.4: Answers from interviews in Copenhagen.

Source: STOA (2011).

This contrasts clearly with Karlsruhe and Copenhagen, where a high degree of satisfaction with the transport system and the quality of life became apparent. People in Karlsruhe use public transport relatively often, and the young people interviewed in Copenhagen mainly cycle. This corresponds well with the good reputation of the transport system in Karlsruhe and the good reputation of Copenhagen as a cycling city. The results from all three cities show that interviewees had a high preference for clean air and green spaces in their cities. But, transport-related issues were also of great importance. Figure 5.4 illustrates the example of Copenhagen.

One remarkable phenomenon is that people in Karlsruhe and Copenhagen like public transport and cycling, have a strong preference for green and clean urban environments and they do not rank car-related issues and measures as high priorities. Nonetheless, many of the interviewees assume that they will have to use a car more in the years to come. The question might be raised, whether these positive attitudes towards many factors that would be better achieved through a city with less cars rather than more could not provide a sound basis for an even better public transport and cycling system. New, better and more integrated forms of supply could make use of these positive attitudes. Particularly the young people in Karlsruhe and Copenhagen seem to be very open to alternatives to car transport—as long as these are attractive, convenient and affordable.



Travel time and accessibility are most important, with a significant gap between these and cost of travel and comfort (whereby protection against bad weather could be considered a subcategory of "comfort"). Interestingly, safety is of little concern. Environment-related issues such as "how much the transport mode pollutes" seem to be even less important.

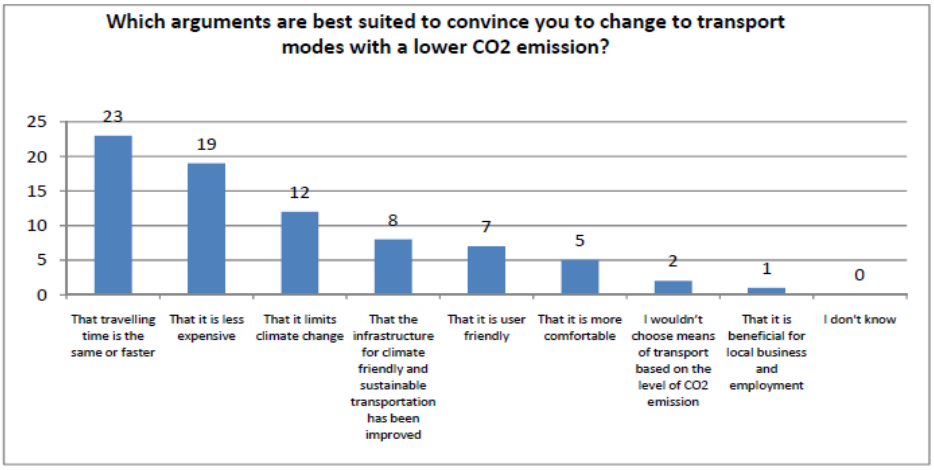
Figure 5.5: Answers from Budapest on reasons for choosing a mode of transport.

Source: STOA (2011).

It is interesting to note the readily apparent finding that, in general, environmental concerns were not an important factor in the daily modal choice of the young urban citizens (see, for example, the answers from Budapest in figure 5.5). It was mostly pragmatic reasons — such as being faster, traveling more cheaply or the unavailability of a car — that made them choose cycling, public transport or walking. However, environmental issues were ranked higher in the context of questions and discussions not directly related to factual daily transport behavior. This is fully in keeping with other studies mentioned in section 5.1.

One question included was: "Which arguments are best suited to convince you to change to transport modes with lower CO_2 emissions?" The results show that pragmatic reasons, such as costs and travel time, are generally ranked high. Interestingly, in Budapest, "that it limits climate change" was ranked as the second most important argument—behind "that travel time is the same or faster," but before "that it is less expensive." Figure 5.6 shows the distribution of answers from Karlsruhe to this question.

109: Arguments suited to convince to change transport modes



Comfort seems not to matter that much. Environmental issues are often mentioned, but time and costs are by far the most important arguments. It should be taken into account that many of the interviewees in Karlsruhe were already using transport modes with low CO_2 emissions.

Figure 5.6: Answers from Karlsruhe related to arguments for changing transport modes.

Source: STOA (2011).

Regarding the different levels of policy making, most of the interviewees considered the local level to be the most relevant. The importance of local knowledge for local decisions was emphasized. The role of the EU was mostly seen in relation to setting objectives and standards or a "common course." Regarding policy measures, there was strong support in all three cities for policies promoting public transport and cycling.

Summary of the interview meetings with young adults in Budapest, Copenhagen and Karlsruhe (excerpt from DEL 4, STOA 2011: Engberg and Leisner)

In June and July 2011, three so-called *interview meetings* were held, in Budapest, Copenhagen and Karlsruhe, with randomly selected participants that were between 20 and 30 years old. The main purpose of the meetings was to take a closer look at the attitudes and perceptions of younger citizens in European cities as far as urban transport is concerned. The hosts were Medián Opinion and Market Research, the Danish Board of Technology and the Karlsruhe Institute of Technology respectively. In each country around 30 participants heard a presentation on the theme of urban transport, filled out a questionnaire and debated a number of issues in relation to the existing and the future transport system in their city. The interview meetings took place in the evening and lasted 3 hours. They began with a short welcome and an introduction to the theme. The main focus during the presentation was urgent trends and challenges in the transport sector as well as fictive stories that had been sent to the participants prior to the meeting. After a short break, the participants were asked to form groups to carry out the debates. Groups were built in advance by the moderators seeking to establish the best possible equal distribution in sex, age and professional background. The group discussions were recorded and transcribed afterwards.

When looking at the results, it can be concluded that there is a great agreement among the participants when it comes to the basic principles that determine their everyday transport patterns and their views on a future urban transport system. However, the actual urban transport realities that their cities offer are quite different and this has a big influence on how their transport patterns materialize and also on what tools they consider best fit to improve transport systems and take their city in a more liveable direction in the future.

Most of the interviewees have a relatively low income, and the international economic crisis has had a considerable effect, especially on the lives of the participating young Hungarians. A majority in all three cities, however, expect to earn more in the future. The participants in the three cities have in common that they generally walk often and drive a car rarely. The German participants use public transport and bicycle quite often, the Danish participants choose the bicycle much more often than public transport, and the Hungarian participants hardly ever bicycle but use public transport often. The participants in all three cities generally enjoy the many services and possibilities offered by their city and transport naturally plays a big role in their everyday life. The participants agree that urban transport, more than anything else, must be as fast and convenient as possible.

The participants are not blind to the environmental consequences of motoring, and basically they are very much in favour of making their cities more liveable by reducing CO_2 emissions, noise and air pollution. They support prioritizing environmental concerns in future urban planning, but if they themselves are to change behaviour towards using more eco-friendly means of transport the new transport means must have other advantages than being green – preferably they must be just as quick or quicker, cheaper and/or easier to use than their current choice of transport.

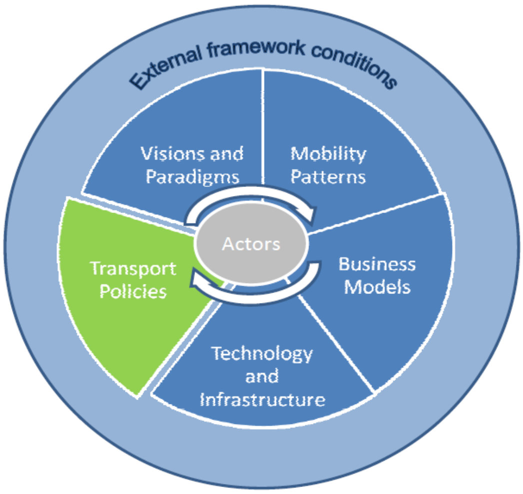
As far as behavioural changes are concerned, the participants in all three cities generally prefer the idea of positive interventions that motivate the commuters to change their traffic behaviour in a more sustainable direction – the 'carrot' method, so to speak. When asked about actual technologies and policy measures, however, particularly the German and Danish participants support actions that make especially car travelling in their cities more expensive, slower and more vexatious. However, a majority of the participants in all three cities feel that it makes the most sense to strengthen the possibilities of bicycling and public transport.

Many of the participants in all three cities think that they possibly or probably will move away from their city and many (especially Danish participants and Hungarians) also expect that they will come to drive a car more than they do now. For the German and Danish participants this mostly seems to rest on an assessment that the car will be the most convenient means of transport in the future, whereas the Hungarians rather seem to connect this expectation to a desired social status lift associated with driving a car.

A majority of the participants in Karlsruhe, Copenhagen and Budapest find that it is important to consider equality when promoting new ways to move about in the city. Mobility is seen as a basic right.

When the participants are asked to place the responsibility for leading urban transport in a more sustainable direction, the participants generally seem to agree that it is shared. The individual citizen, the city councils, the country, the EU and businesses/industry are all assigned a role and expected to contribute to the funding and promotion of more sustainable solutions. Agreement is not so clear, however, when it comes to saying who should carry the most responsibility. Individuals are seen as more responsible by the Hungarian participants than by the German and especially the Danish. The opinion is expressed in all three cities that the EU can play an important role by designating a common course for all member-states; however, this must unfold as a flexible framework that the individual member-states and municipalities can adapt to their specific situation.

6. Transport policies



The high density of urban areas offers a broad range of policy approaches for enabling a transition towards more sustainable transport. All four of the areas described in the previous chapter interact with and can be influenced by transport policy. In a more indirect way, paradigms determine the broader framework within which concrete polices are motivated and legitimized. The influence of policy measures on technologies, business models and transport-related behavior is much more direct. Not just one, but all political levels are relevant. Urban transport policy is a mixture of regional/municipal, national and European policies. Nevertheless, the municipal level is of particular importance since it is close to the citizens and users of the transport system.

Public authorities are faced with the challenging task of providing an environment in which the elements of the transport system coevolve in a more sustainable way than today. Decision makers should therefore keep all components in mind. They should simultaneously question various aspects of travel decisions, look at alternatives to travel and encourage greater efficiency in the transport sector. Three basic strategies for achieving sustainable transport can be distinguished:

1. changing the specific carbon intensity of the different transport modes,
2. changing the modal split and
3. reducing the need to travel/decoupling transport growth from economic growth.

All of the innovative technologies presented in this project do, in fact, exert influence on at least one of these strategies – otherwise they would not contribute to sustainable urban transport. In the first category, it is possible for improvements to occur without affecting the behavior of users. For example, the introduction of catalytic converters or the phase-in of small shares of biofuels need not have an influence on mobility patterns. For the other two strategies, inducing a modal shift and reducing volumes, changes in mobility patterns are definitely required. However, for the enabling of pathways to sustainable transport systems, changes in all these categories are needed. This makes an integrated perspective necessary, because the interplay between these measures has to be taken into account. For example, the introduction of electric mobility might change mobility patterns – on account of longer loading times and limited ranges.

To give another example: The reduction in fuel consumption could lead to an increase in transport volumes, since the improvements would make traveling cheaper and, thus, more attractive. Many studies have shown that policy considered in isolation might not lead to the intended effects.[51]

Deliverable 3 gives an overview of policy measures. The available instruments can be divided into the following five families:[52]

1) *Regulation and control:* rights to limit the scale of pollution, to restrict access to certain areas, to enforce technical standards, etc.

2) *Economic instruments:* fuel taxes and road charges, subsidies for efficient vehicles, etc.

3) *Infrastructure and spatial policy:* mixed-use developments, road layout, calming of traffic flows, primary construction of walking and cycling infrastructure, etc.

4) *Information to raise awareness:* information campaigns, promotion of local destinations, training courses for transport planners and local actors, etc.

5) *Research and development activities:* fleet tests and demonstration projects, research and development, etc.

In an annex to DEL III, different measures are allocated to these categories, and the relevance of the different political levels is indicated. Obviously, the measures of the categories 1, 4 and 5 are most important at the European level. The EU can also exert influence on economic instruments, but direct influence on infrastructure and spatial policy is surely limited. Emission standards for vehicles are among the genuinely powerful "European" instruments for influencing urban transport. Such standards have triggered the diffusion of innovations and, thus, clearly contributed to a better air quality in European cities. Another powerful measure is research policy, which opens up opportunities for research on new technologies and concepts as well as demonstration activities. Innovative approaches to urban transport have been tested in numerous European projects during the last two decades.

However, the responsibility for urban transport policies lies primarily with local, regional and national authorities, even though the Green Paper "Towards a new culture for urban mobility" states that "Europe has a capacity for reflection proposal-making and mobilising for the formulation of policies that are decided and implemented locally."[53] In other words, Europe has the capacity to initiate and guide a paradigm shift in transport policy, which is to be realized at a local level.

From a global perspective, the EU should take the lead in promoting and supporting sustainable transport, meaning that it should serve as an example to other countries. Through its White Papers, the EU possesses a guiding instrument to contribute to solutions for existing problems and to influence underlying policy objectives. A White Paper can help to set clear goals for reducing emissions and noise, encouraging modal shift and promoting the possibilities of substitution of travel. In its 2011 White Paper the European Commission set the goal to halve the use of 'conventionally-fuelled' cars in urban transport by 2030, to phase them out in cities by 2050 and to achieve essentially CO2-free city logistics in major urban centres by 2030.54

[51] see optic.toi.no

[52] A detailed list of available instruments can be found in Deliverable 3 of this project.

[53] CEC (2007b).

[54] CEC (2011).

In addition, directives and the planning for the Trans-European Networks have a strong influence on the aims of infrastructure planning processes within the EU. It is the role of the EU to organize a debate on transport among all relevant stakeholders (e.g., social groups, users of transport, employers and employees, economic groups, urban transport organizations and industry, national as well as regional and local authorities, stakeholder representatives and relevant associations).

The EU is already actively promoting sustainable urban transport: In 2009, the Commission agreed to implement a strategy for promoting sustainable urban mobility. The plan proposes 20 actions; the main areas of contribution include:[55]

- promoting the use of collective and non-motorized modes, especially through the provision of mutual-learning platforms for local authorities and through information and awareness-raising campaigns for users;
- promoting the market penetration of zero and lower emission vehicles, especially through research and demonstration projects;
- stimulating the development of technology for urban mobility (e.g., ITS), especially by setting common and harmonized standards that are interoperable and user-friendly as well as through the provision of financial support;
- fostering integrated, intermodal freight and passenger transport policies, e.g., through the support of local authorities in developing sustainable urban mobility plans;
- improving accessibility and travel information, especially by strengthening passenger rights and facilitating the exchange of information;
- completing the market-opening process by building up an appropriate EU legal framework, including the simplification and adoption of new legislation.

[55] See CEC (2009b) as well as CEC (2009c).

7. Conclusions

This project and the present report illustrate that a transition towards more sustainable urban transport systems in Europe is dependent upon a broad variety of rather diverse factors. The mixture of relevant technical and non-technical factors is becoming extremely dense in urban areas, where human activity as well as the technology-infrastructure systems that support it have accumulated into a dense and interdependent network. Most Europeans live in urban areas, and many of those who do not live there have a place of work within an urban agglomeration. This high degree of human activity leads to a high and diverse demand for transport.

Innovations are crucial for dealing with the negative consequences of transport and for enabling sustainable transport. Innovations are also of the utmost importance for the global competitiveness of the European economies and, also, for the global competitiveness of the European transport sector. However, technologies are a necessary but not a sufficient requirement for a transition to a sustainable transport system. This project has highlighted that not only technologies, but also non-technical factors, are important for the governing and accelerating of the diffusion of innovations. The transport system must be understood as a socio-technical system. It has been illustrated that there is a mutual relationship between innovations and mobility patterns. The term co-evolution has become established for the framing of the interplay between technical and non-technical elements in socio-technical systems. In order to understand successful pathways to sustainable urban transport, it is essential to take this interplay of different elements into account, which makes a rather holistic perspective necessary.

For this project, a structure was chosen that is intended to be able to provide such a holistic perspective and to cope with the notion of co-evolution. The transport system has been analyzed in terms of elements of rather different character: Paradigms and visions, technologies and infrastructures, business models, mobility patterns, transport behavior and, last but not least, transport policies. It is argued that all of these areas are relevant for the development of pathways towards a more sustainable urban transport. Changes in only one of these elements are not capable of redirecting the development of the transport system in a longer-lasting way. For example, the substitution of cleaner technologies for oil-based fuels will help to reduce negative environmental impacts, but will still not help to solve problems such as congestion or land consumption. Much activity can be observed in the field of new technologies and infrastructures, but these innovations need to be adopted by users in order to become effective. Paradigms, in the sense of the term used here, are also of importance. For example, Rogers (2003) clearly illustrated that the alignment of innovations with prevailing norms and values is crucial for their success.

This report has illustrated that changes in all of these elements are taking place. Not only are technologies and infrastructures changing, but new business models are also emerging, such as car sharing and bike sharing. The vision of the car-friendly city is no longer the leading paradigm for urban transport planning, and the preferences and attitudes of the system's users are changing. It is crucial for transport policy makers to be aware of these changes and of the dynamics of the system and to make use of them.

All five of these elements offer approaches for the identification of pathways towards sustainability. The relevance of paradigms and visions has been shown: It is important that the idea of sustainable transport be deeply rooted in related plans and documents. The general cultural context, in which the transport system is embedded, is also a crucial factor for sustainable urban transport. In order to achieve long-term acceptance, not only do environmental benefits need to be communicated, but also economic potentials and more general aspects of quality of life in urban areas. The interview meetings carried out during this project illustrate that issues such as green spaces and clean air are of great importance. An attractive urban environment must also be considered in terms of a local competitive advantage in an economic sense. Integrating aspects of economic competitiveness into the paradigm of sustainable transport also seems important when considering the recent economic crisis in Europe. It is likely that economic aspects will become a more dominant element in public discussions. Linking economic aspects with the notions of green lead markets and competitiveness is likely to become essential to the achievement of a high level of acceptance for measures leading to sustainable urban transport. Urbanization is a global trend. The link between competitiveness and sustainable mobility is clearly envisioned in the Commission's new White Paper on transport, which is entitled "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system."[56]

Regarding technologies and infrastructures, research agendas and demonstration activities are crucial approaches for securing a pathway towards sustainable urban transport. Again, an integrative perspective that better covers the interplay between technologies and behavioral aspects, in the sense of a coevolution, is needed and must be applied to research programs. For example, the development of electric vehicles needs to reflect potential changes in mobility behavior and innovative business models. More integrative perspectives are also needed for demonstration activities.

The great importance of such integrative demonstration activities is well expressed by the concept of "niches." This concept offers highly interesting pathways towards sustainable urban transport. It is rooted in the so-called multi-level perspective on socio-technical transitions and strongly related to concepts subsumed under the term "transition management." The concept of transition management and its particular relevance for urban transport were described in DEL 3 of this project. In short: The multi-level perspective was originally developed by Rip and Kemp (1998) and then refined by Geels (2004). The latter understands transitions as the "outcomes of multi-dimensional interactions" between three different levels: the micro level (or niches), the meso level (or regimes) and the macro level (or socio-technical landscape). The *macro level* relates to the slow-changing, exogenous environment that influences niche and regime dynamics: This level is characterized by overarching paradigms, macroeconomy, material infrastructure, environment and demographics. The *meso level* refers to socio-technical regimes, such as the dominant culture, practices and rules that guide private action and public policy. The *micro level* relates to niches, such as individual or social actors, technologies and local practices, which differ from the incumbent regime. At the micro level, novelties emerge in small markets, usually protected from mainstream markets.[57]

[56] CEC (2011).

[57] See Rotmans, J. et al. (2001).

Several authors refer to examples from the transport sector in this context.[58] Transitions are striking changes, also radical changes, accompanied by some incremental developments. Therefore, such strategies involving integrated policies must incorporate the fostering of various approaches that have the potential to become future building blocks of sustainable urban transport systems. In regard to an integrative perspective on innovations, it is important to enable the development of such niches. This approach is also referred to as "strategic niche management" (Hoogma 2002). This can be done in the form of large-scale field trials — for example, of electric mobility or of integrated ticketing schemes — that incorporate new business models, such as car sharing, as well as social and behavioral aspects. For example, the increasing flexibility in the mobility patterns of younger people could be understood as a window of opportunity in this context.[59] This trend might be used for trials with new business models. DEL II of this project describes a broad range of promising technologies and concepts. Many of these have already been tested in demonstration activities — quite often in the context of projects funded by the European Commission. However, the concept of niches should be applied in an even more intensive and integrative manner.

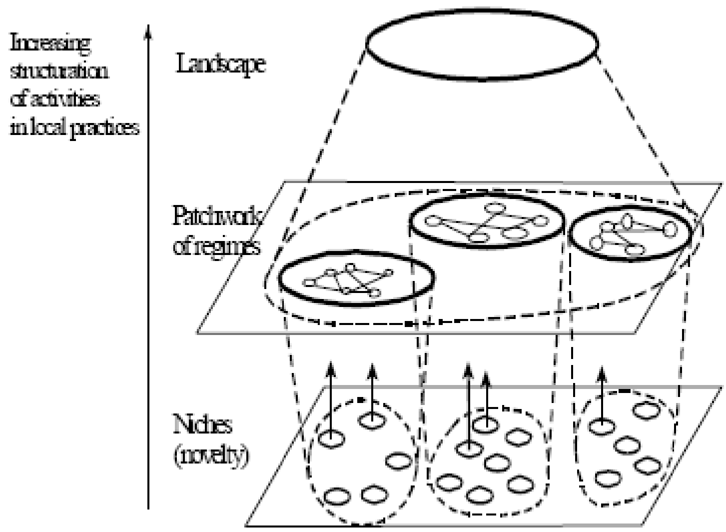


Figure 7.1: Multi-level perspective.

Source: Geels, F. (2005)

It has further been illustrated that mobility patterns are not static, but changing. Again, this offers approaches for pathways to more sustainability. For example, communication and marketing strategies could be more strongly targeted to the perceptions and attitudes of younger people in urban areas, who seem to be rather interested in different mobility concepts — as long as these concepts are flexible, fast and affordable. Instead of framing public transport within contexts such as health and the environment, these modes' freedom and flexibility (no parking required, online information available, possible to write e-mails or SMS on the bus, etc.) should be communicated—given that an attractive public transport and cycling infrastructure exists. As many surveys, and also the interview meetings conducted during this project, prove: It is not just economic aspects that are relevant for the quality of life in an urban area.

[58] see Hoogma, R. et al. (2002); Geels, F.W. (2005).

[59] see Hoogma, R. et al. (2002).

Last, but not least, the process of policy making itself is—of course—crucial for pathways to sustainable urban transport. Again, it is necessary that policy making is integrative: Integrated policies need to consider technical as well as non-technical factors and developments in the transport system. Even if it is widely acknowledged that policies implemented in isolation do not lead to satisfying results, integrated approaches, or "policy packages"[60], are still often lacking in transport policy making. This can be particularly problematic in urban areas, where a great number of interests and demands have to be considered when shaping transport policies. Long-term political acceptance is crucial, since the transition to a sustainable urban transport system takes a long time; infrastructures are long-lasting elements of urban landscapes, and so, long-term commitment is needed.

In the meantime, the problem of fragmented decision making is a subject that is often discussed in the literature[61], and a broad range of practical examples for integrated polices can already be observed. A "simple" example for a policy package combining organizational measures with supply-side improvements is offered by the Stockholm congestion charge: Here, acceptance has been increased by using the revenue for improved public transport. However, many policies still take a rather isolated form and either fail to meet the intended targets or lead to adverse effects or side effects. Recently, the EU project OPTIC listed and systemized a range of examples of such unintended effects stemming from transport policies.[62]

It has been illustrated that many factors influence the development of urban transport systems. It is quite clear that a transition in complex urban transport systems cannot be fully planned or developed on the drawing board. Too many factors, and interrelations between those factors, are involved. In this context, it is of the utmost importance that policy making is understood — to a certain extent—as a learning process (see, for example, Voß et al. 2009). Making greater use of approaches such as strategic niche management could improve the process of political learning. Something that seems genuinely promising is to make European agglomerations into a sort of series of urban laboratories, as envisioned in the Commission's action plan on urban mobility: "Urban areas are becoming laboratories for technological and organisational innovation, changing patterns of mobility and new funding solutions."[63] This idea needs support from all political levels in Europe: In this context, the European Parliament as well as the Commission will play a special role by promoting and supporting societal support.

[60] see Institute of Transport Economics et al. (2011).

[61] see Banister, D. et al. (2011).

[62] see Institute of Transport Economics et al. (2011).

[63] CEC (2009a).

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