Climate Protection in Urban Transport—Six Scenario Studies in Germany: More Climate Protection, Fewer Carbon Dioxide Emissions, Less Car Traffic

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Abstract: Six German scenario studies on urban passenger transport for Munich 2058, Wuppertal 2050, Eastern Ruhr Region 2030, Tuebingen 2030, Cologne 2020 and Hanover Region 2020 investigate the key question: With which strategies and on what kind of scale, is it possible to reduce the carbon dioxide emissions of urban passenger transport to accomplish the 2 °C climate protection goal with a consequently huge reduction of greenhouse gas emissions by 80% to 95% by 2050 in relation to the base year 1990? The scenarios show that the major challenge of a “climate-friendly city transport” can be achieved by appropriate measures (regarding direction and scale): in small and medium-sized cities, large cities, cities of over a million people, and metropolitan regions. The scenarios demonstrate the extent to which the considered measures contribute to the CO₂ reduction, and which gap to the achievement of the goal remains if that which is currently regarded as realistic in practice is really implemented in future. Thus, they illustrate the conflict between that which is necessary for climate protection and that which is currently considered feasible in politics. The scenarios show that it is essential to act quickly and appropriately, and not hesitantly or without conviction.

Key words: Climate protection, CO₂ reduction, urban transport, scenario studies, Germany.

1. Introduction

Urban transport planning in Germany was characterised for many years by the question of how to deal with growing motorized traffic as a consequence of economic, political, social and technological developments [1]. The question was ingrained in various models for urban planning (Fig. 1) [2, 3]. These reflected the changing attitudes towards means of transport and the urban environment. Prognoses and scenarios served to predict traffic levels, in order to develop concepts to cope with them. Forecasting scenarios were created to design strategies and measures, and, in multiple variations, reveal potential future conditions as a basis for political decision-making.

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In contrast, backcasting scenarios involve the determination of normative target values, e.g., with respect to the health, quality of life and mobility of the population, followed by the systematic search for appropriate paths to attain these values [4]. In relation to climate protection, such backcasting scenarios were first developed in Germany at the beginning of the 1990s, at federal level. More recently, further Germany-wide backcasting scenarios were developed within three studies: by Öko-Institut [5], by Öko-Institut and DLR-IVF [6], and in the FGSV (German Road and Transportation Research Association) [7].

Germany aims to reduce its total greenhouse gas emissions by 40% by 2020, and by 80%–95% by 2050 in relation to the baseline of 1990 (Fig. 2). And in fact, Germany is on its way to achieve these goals. But the transport sector misses these objectives so far. Within the transport sector, the carbon dioxide is the

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Fig. 1 Prognoses and scenarios in transport planning.

Source: Refs. [2, 3].

Fig. 2 Development of the percentage of greenhouse gas emissions in Germany in total and in the transport sector as well as reduction goals of the federal government (1990–2050).

Sources: *Umweltbundesamt* (Federal Environment Agency) (UBA) 2014: national trends charts for the German coverage of atmospheric emissions 1990–2012 (forthcoming; written advance information by Gniffken Patrick (UBA) of 06/03/2014); *Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit* (Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety) (BMUB), as of 01/05/2013: climate protection policy in Germany (accessed March 5, 2014. <http://www.bmub.bund.de/themen/klima-energie/klimaschutz/nationale-klimapolitik/>).

main important greenhouse gas. The transport sector, particularly road transport, causes about one-fifth of the total direct CO₂ emissions of Germany and has likewise to contribute to the politically decided GHG (greenhouse gas) reduction goals of Germany. Thereto, it is necessary to think backwards from the 2 °C limit and the necessity of relevant reduced GHG emissions, respectively, CO₂ emissions with adequate policies and measures regarding direction and scale. This is a challenging task for the national transport policy as well as the local transport policies of cities and regions.

Since 2006, the first climate protection scenarios at a specifically urban and metropolitan level have been developed. Six scenario studies for Munich 2058, Wuppertal 2050, Eastern Ruhr Region 2030, Tuebingen 2030, Cologne 2020 and Hanover Region 2020 investigate the central question: With which strategies and on what kind of scale, is it possible to reduce the carbon dioxide emissions of urban passenger traffic in such a way that this causative sector also contributes to the achievement of the climate protection goals?

2. Munich 2058

For Munich (1.3 million inhabitants, trend: growing population), two different scenarios for urban land-based passenger and freight traffic in the year 2058 (residence principle) were developed by the Wuppertal Institute in 2008, on behalf of Siemens AG, and compared with the 2008 benchmark case [8]. The aim was to show the technical feasibility of strategies for an extensive CO₂ neutrality.

In passenger traffic, the purely technology-oriented action scenario “bridge” (what will happen if...?) takes as a starting point of the highly efficient traffic engineering (combustion engines, electromobility, biofuels) in motorized individual transport and public transport. As a result, the absolute CO₂ emissions caused by transport will decline by 33% from an annual 1.1 million t in 2008 to an annual 750,000 t by

2058 in comparison to the 2008 benchmark case, declining by 42% if the total electricity used in traffic is produced on a renewable basis.

The more ambitious goal scenario “goal” (what do we need?), in addition to assuming the even more intensive application of technical improvements, makes optimistic assumptions about behavioural change, to demonstrate the path to an nearly CO₂-free future. Noticeable effects of traffic avoidance (reduction of transport volume by 10% per capita) and a distinct modal shift from motorized private transport to the environmentally friendly modes of transport (walking, cycling, public transport) mean that, in 2058, over 70% of all daily trips will be covered by the environmentally friendly modes of transport. This scenario also includes a substantially increased promotion of electric cars, thereby causing a reduction of absolute CO₂ emissions in transport of 52% to an annual 534,000 t in the timeframe 2008 to 2058, or even of 69% if additional reduction effects were developed for electricity consumption in transport by using renewable energies and combined heat and power. In conclusion, the efforts required for the goal scenario “goal” appear challenging but viable.

3. Wuppertal 2050

For Wuppertal (350,000 inhabitants, trend: declining population), two goal scenarios (what do we need?) were developed in an internal research project at the Wuppertal Institute for urban passenger transport in 2050 (residence principle) [9]. The extent to which the passenger transport of Wuppertal citizens would have to contribute to climate protection was investigated using this backcasting approach. The model calculations show that the CO₂ emissions of passenger transport in Wuppertal can be reduced by an absolute 85% by 2050, or by 78% per capita, in comparison to the base year 1990, provided that:

(1) One per mille of passenger kilometres per year is saved through traffic avoidance;

(2) With the modal shift as a central local politics field of action, a distinct modal shift from the car to the environmentally friendly modes of transport is achieved, meaning that the share of trips made by car is halved from 51% in 2002 to 26% in 2050 and the share of trips realised by environmentally friendly modes of transport increases from 49% in 2002 to 74% in 2050;

(3) In automotive engineering, the motor vehicle-specific CO₂ emissions of the car and of public transport, is, primarily through EU and federal policy measures, reduced by 2% per year, twice as much as in the existing trend development;

(4) With a decline in population of over 100,000 inhabitants by 2050, half of the associated conceivable CO₂ reduction potential is actually realised.

In conclusion, the necessary efforts for the –80% CO₂ goal scenario seem ambitious but manageable. A –95% CO₂ goal scenario (1990~2050) would necessitate extreme steps which are difficult to imagine at present: Wuppertal would have to be developed as a car-free city in which urban traffic is exclusively conducted by the environmentally friendly modes of transport with a highly efficient public transport system.

4. Eastern Ruhr Region 2030

For the Eastern Ruhr Region (extended Dortmund City Region, 2.6 million inhabitants, trend: declining population), a scientific action scenario study was carried out by the Office of Spiekermann & Wegener Urban and Regional Research for the European Union in 2006 [10]. Several action scenarios (what will happen if...?) for the land-based passenger traffic are elaborated therein for the year 2030 (residence principle) and compared with the 2005 benchmark case. With this, the long-term economic, social and environmental effects of possible fuel price increases and various policies and measures are evaluated; For the environmental effects, the development of CO₂ emissions is also investigated.

Three variations are examined as conceivable future annual fuel price increases: moderate: +1%; strong: +4% and extreme: +7%. With these three energy price scenarios, five different action scenarios are combined: a “do nothing scenario”, a “business as usual scenario”, a pure “technology investments scenario” (economical cars, alternative vehicles/fuels, public transport expansion and acceleration), a pure “demand regulation scenario” (raised petroleum tax, additional road tolls, more traffic calming, more carsharing, more telecommuting, polycentric or compact settlement structure planning and lower public transport tariffs), and an “integrated policies scenario” in which all measures are implemented simultaneously.

These action scenarios establish clear CO₂ reduction potentials. Rising fuel prices substantially intensify the CO₂ savings effects. The most pronounced reduction effect is shown in the integrated policies scenario. Here, the share of trips realised by public transport increases and the share of trips realised by car decreases. As a result, relative to the base year 2005, the daily CO₂ emissions per capita caused by transport are reduced particularly sharply: by between 60% in the case of a moderate petrol price increase and 80% in the case of an extreme petrol price increase. This effect is primarily due to the measures concerning influence on demand. However, the authors point out that, due to the high fuel price increases, this extreme scenario would be associated with a severe decline in wealth and quality of life, particularly for households with low income in less central locations.

Nonetheless, these scenarios demonstrate that, in the Eastern Ruhr Region, considerable CO₂ savings per capita in passenger traffic can be achieved through a transport policy oriented approach at metropolitan level. Fuel price increases, combined with transport-political measures, thus lead to serious changes in mobility behaviour and the traffic situation.

5. Tuebingen 2030

For Tuebingen (85,000 inhabitants, trend: stable population), a “BAU (business as usual) scenario” and a “sustainability scenario” as a backcasting scenario (what do we need?) for urban passenger transport (residence principle) were developed for the year 2030 by the Institute for Mobility and Transport of the University of Kaiserslautern on behalf of the City of Tuebingen and published as the scientific report *Mobilität Tübingen 2030 (Tuebingen Mobility 2030)* [11, 12].

The BAU scenario expects that, despite increasing travel distances and more car traffic, the absolute CO₂ emissions in urban passenger traffic will, on balance, decline by 25% by 2030 relative to the base year 2008, through technical efficiency enhancements in motorized vehicles. The sustainability scenario is aimed at achieving an additional 25% reduction of CO₂ through behavioural changes as the result of integrated city and transportation planning in Tuebingen. Therefore, the travel distances for Tuebingen inhabitants should be shortened by 10%, and 10% of the transport share of car traffic should be transferred to the environmentally friendly modes of transport; An efficiency enhancement accelerated by supplementary municipal measures (user benefits, incentives and purchase advice) should lead to 40% less CO₂ emissions per kilometers for the total vehicle fleet in Tuebingen.

In the sustainability scenario, 14 packages of measures in the action fields of settlement development, public transport and multimodality, urban space and traffic, and mobility management are developed in dialogue with an advisory body and in several workshops with local stakeholders. All packages of measures are described in profiles: goal, specific measures, benefits for traffic and urban planning, costs for the municipal household (investment costs and running costs in euro), estimation of the level of acceptance (from very low to very positive), expected CO₂ reduction potential (in

percentage), relevant stakeholders in the implementation and initial steps for the realisation. The effects on traffic and the resulting CO₂ reduction potential of the packages of measures are evaluated using a computer model on transport simulation.

The model calculations show that, with the sustainability scenario, the absolute CO₂ emissions in passenger traffic in Tuebingen can be roughly halved by 2030 in comparison to 2008 (–52,4%). The Tuebingen local council selected the overall plan *Tuebingen Mobility 2030* at the beginning of 2011 as the basis for further administrative action in Tuebingen. Since then, it has been implemented step by step.

6. Cologne 2020

For Cologne (1 million inhabitants, trend: growing population), based on a detailed traffic assessment for the year 2006 (territoriality principle, passenger and freight traffic, not including air traffic or transit traffic), two action scenarios (what will happen if...?) were developed in 2011 for the year 2020 by the Wuppertal Institute on behalf of the City of Cologne: a “reference scenario” and a “climate protection scenario”, which consider the conceivable developments in population, traffic density and motor vehicle technology [13, 14]. The scenarios aim to show the CO₂ reduction potential in transport, which can be opened by the City of Cologne. In the base year 2006, the CO₂ emissions of the traffic in Cologne, excluding air and transit traffic, were an absolute 1,598.1 kt/a, or respectively 1.6-t CO₂ per capita annually.

The reference Scenario 2020 considers the CO₂ reduction effect of all local climate protection measures in traffic which had taken effect by the end of 2006, as well as the CO₂ reduction effect of the measures at EU, national or federal state level. It sees the absolute CO₂ emissions of the traffic in Cologne decrease by 19% in relation to 2006 and by 21% in relation to 1990. This means that, in the reference scenario 2020, the CO₂ emissions of the traffic in Cologne (excluding air and transit traffic) are an

absolute 1,314.7 kt/a or respectively 1.3-t CO₂ per capita annually.

The climate protection scenario 2020 also considers the CO₂ reduction effect of a further 29 technical and non-technical reduction measures. These were developed within the framework of the climate protection concept in dialogue with local stakeholders, and recommended for implementation. They substantiate the fields of action of improved motor vehicle technology in new purchases, promotion of cycling, public transport development, organisation of economic trade and public relations. The CO₂ reduction effects were assessed quantitatively and the implementation costs (financial, organisational and time costs) were estimated qualitatively (high-medium-low). In addition, the period required for the development of the CO₂ reduction effects was estimated (short, medium or long term).

With the 29 additional climate protection measures, the absolute CO₂ emissions of the traffic in Cologne, which can be directly influenced by the policy of the City of Cologne, decrease until 2020 by 25% in relation to 2006 and by 28% in relation to 1990. This means that Cologne's commitment in the transport sector, made as a member of the *Klimabündnis* (Climate Alliance) of cities (to reduce the city's CO₂ emissions by 50% by 2030 and by 38% by 2020), cannot be fully achieved. In the climate protection scenario 2020, the CO₂ emissions of the traffic in Cologne (excluding air and transit traffic) are an absolute 1,204.3 kt/a or respectively 1.2-t CO₂ per capita annually, i.e., a saving of 0.1-t CO₂ per inhabitant per year compared to the reference scenario 2020, or a saving of 0.4-t CO₂ per inhabitant per year compared to the base year 2006.

The Cologne 2020 climate protection scenario shows that the suggested measures which can be realised by the city of Cologne can contribute considerably to the CO₂ reduction, but they alone are not adequate to achieve the climate protection goals in the urban transport sector.

7. Hanover Region 2020

For the Hanover Region (1.1 million inhabitants, of which 520,000 inhabitants in the federal state capital Hanover, trend: stable population), the Pro-climate TDP (Transport Development Plan) was created [15, 16]. The expert research for this was carried out by the Offices of Gertz-Gutsche-Rümenapp and Proloco on behalf of the Hanover Region. It was approved by the regional assembly on September 27, 2011.¹

In the Pro-climate TDP, the regional initial situation in 2010 was analysed firstly: From 1990 until 2010, the CO₂ emissions caused by traffic had increased from 2.0 to 2.3 million t per year (+11%). Consequently, the CO₂ emissions caused by traffic must be reduced by 51% between 2010 and 2020, in order to still achieve the regional policy reduction goal of 40% fewer CO₂ emissions in the period 1990 to 2020. An overall view of external effects as an assessment of trends 2010~2020 (vehicle efficiency, demography, petrol price and long distance traffic, especially lorries), on which the Hanover Region has no substantial influence, indicates that only a minimal reduction of the CO₂ emissions caused by traffic can be expected (−1%). The CO₂ reduction goals are thus not achieved through these external effects only.

For this reason, for the passenger transport in the Hanover Region for the year 2020 in a goal scenario (what do we need?), the CO₂ savings potential for 11 packages of measures in four fields of action (settlement development/local mobility; public transport; traffic management, road infrastructure and parking; mobility management) were evaluated with a traffic simulation model (residence principle). The

¹The Pro-climate Transport Development Plan of the Hanover Region was awarded the *Deutscher Verkehrsplanungspreis* (German Transport Planning Prize) 2012, which was presented by the *Vereinigung für SRL (Stadt-, Regional- und Landesplanung)* (German Association for City and Regional Planning) and the *Verkehrslub Deutschland* (VCD: a German transport association with a focus on ecology), for the best project in Germany on the topic "transport and climate protection".

catalogue of measures contains projects which can be realised by 2020. It is guided by the three-stage transport strategy: avoid traffic, modal shift and improve motorized traffic.

According to the results of the simulation calculations, there is a modal shift in traffic volume (all trips, weekdays) from 2002 to 2020: 11% of all the trips would be shifted. The share of trips made by car decreases from 51% to 40% and the share of trips made by environmentally friendly modes of transport increases from 49% to 60%. The measures open a theoretical absolute savings potential of 44% CO₂ emissions in regional passenger traffic by 2020, in relation to 1990. An absolute CO₂ reduction of 35% by 2020 in regional passenger traffic, in relation to 1990, is considered as true feasible savings potential. This means that the intended goal of an absolute CO₂ reduction of 40% by 2020 in relation to 1990 is not completely achieved.

In addition, so-called “visionary ideas” for new innovative forms of automobility were researched: area-wide carsharing, promotion of electromobility, privileging low CO₂ emission cars, solely urban redevelopment, consequent parking management, introduction of congestion charges for the city and region. In this way, considerable further contributions would be made to CO₂ reduction. Thus far, however, these approaches have been assessed unrealistic.

Following the political decision on the Pro-climate TDP, the administration was commissioned to implement the measures step by step. Since then, initial implementation projects have been realised: the priorities concern cycling traffic, the changeover of the city’s bus fleet to hybrid technology, the expansion of the regional rail service, and an offensive in the field of mobility management.

8. Conclusions

The six scenario studies show that it is possible for urban and/or metropolitan transportation concepts to be specifically guided by the politically desirable

climate protection goal: the 2 °C goal with a consequently huge reduction of greenhouse gas emissions by 80% to 95% by 2050 in relation to the base year 1990 [17]. The transport sector, too, which is responsible for around a fifth of CO₂ emissions in Germany, the most quantitatively significant greenhouse gas, can and should contribute to an effective climate protection. The scenarios show, with appropriate direction and adequate scale, that the major challenge of “climate-friendly city traffic” can be achieved: in small and medium-sized cities, large cities, cities of over a million people, and metropolitan regions (Table 1).

The particular focus of the concepts is on passenger transportation; Freight transportation is additionally addressed in two studies (Cologne 2020, Munich 2058). All concepts use the scenario technique to formulate “If A, then B” statements for planning and politics. The concepts with a short time horizon of 10–15 years (Cologne 2020, Hanover Region 2020) focus on implementation in their description of possible climate protection measures; The concepts with a long-term time horizon of 40–50 years (Munich 2058, Wuppertal 2050) outline the principal suitable climate protection strategies; The concepts with a medium-term time horizon (Tuebingen 2030, Eastern Ruhr Region 2030) use a combined approach.

The scenario assumptions concerning the achievable CO₂ reduction effect of the strategies and measures are based on expert assessments and literature reviews of empirical experiences from other cities. Inexactness is accepted due to a lack of better alternatives. The scenario studies use quantitative calculation models to evaluate the effects of various assumptions. For the most part, scenarios in growing or shrinking cities or regions consider not only the development of the transport-caused annual absolute CO₂ emissions, but also the CO₂ emissions per capita.

All concepts follow the traffic planning principles: “avoid-shift-improve”. Through a combined implementation of the generally well-known measures,

Table 1 Scenarios for climate-friendly transport in selected German cities and regions [8-11, 13, 15].

Scenario	Munich 2058	Wuppertal 2050	Tuebingen 2030	Ruhr District-East 2030	Cologne 2020	Hanover 2020
Type of city	City of population over a million, growing (population: 1.3 million)	Large town, shrinking (population: 350,000)	Medium-sized town, stable (population: 85,000)	Region of over a million, shrinking (population: 2.6 million)	City of a million, growing (population: 1 million)	Region of over a million, stable (population: 1.1 million)
Main scenario Technology and behaviour	Goal scenario: “goal”: backcasting approach: What do we need?	Goal scenario: “80% CO ₂ reduction goal”: backcasting approach: What do we need?	Goal scenario: “sustainability: 50% CO ₂ reduction goal”: backcasting approach: What do we need?	Action scenario: “integrative”: forecasting approach: What happens if...?	Action scenario: “climate protection”: forecasting approach: What happens if...?	Goal scenario: “pro-climate 40% CO ₂ reduction goal”: backcasting approach: What do we need?
Sub-scenarios for comparison	Action scenario “bridge”	Goal scenario “95% CO ₂ reduction goal”	Business as usual scenario	Action scenarios: “do nothing”: business as usual; technology investments; demand regulation	Reference scenario	Basic situation; External effects; Visionary ideas
Type of transport	Passenger and freight transport (land-based)	Passenger transport (land-based)	Passenger transport (land-based)	Passenger transport (land-based)	Passenger and freight transport (land-based); Excluding air traffic; Excluding transit traffic	Passenger transport (land-based)
Balancing principle	Residence principle	Residence principle	Residence principle	Residence principle	Territoriality principle	Residence principle
Balancing period	2058 versus 2008	2050 versus 1990	2030 versus 2008	2030 versus 2005	2020 versus 2006	2020 versus 2010 and 2020 versus 1990
Assumptions of the main scenarios (selection)						
Fuel price trend	-	-	-	Price increase variations per year: +1%, +4%, +7%	-	Demography and long distance traffic almost entirely offset CO ₂ savings effects through vehicle efficiency and fuel price increase; Balance: –1% CO ₂ emissions in 2020 compared with 2010
Population development and CO ₂	Increase: rising CO ₂ emissions	Decline: decreasing CO ₂ emissions	Constant	Decline; evaluated per capita	Increase: rising CO ₂ emissions	
Improvement in technology	Significant efficiency enhancements and electrification in public and motorized private transport; Biofuels: further reduction through renewable electricity generation and CHP (combined heat and power)	CO ₂ emissions of cars and public transport are reduced by two thirds primarily through EU and federal policy (2050 versus 1990)	Communal additional efforts for efficiency enhancement increase the efficiency enhancement in the BAU scenario from –35% to –40% CO ₂ emissions per kilometers	Eco-friendly vehicles and alternative fuels	Improved motor vehicle technology in new purchases	

(Table 1 continued)

Scenario	Munich 2058	Wuppertal 2050	Tuebingen 2030	Ruhr District-East 2030	Cologne 2020	Hanover 2020
Traffic avoidance	10% fewer passenger kilometres per capita 2058 versus 2008	1 per mille passenger kilometres saved per year	10% fewer passenger kilometres 2030 versus 2008	Raised fuel tax, additional road tolls, more telecommuting, polycentric or compact settlement structure planning, public transport expansion and acceleration, lower public transport tariffs, more traffic calming, more carsharing	29 technical and non-technical reduction measures in the fields of action: promotion of cycling; public transport development; organisation of economy transport; public relations	11 packages of measures in four fields of action: settlement development/local mobility; public transport; traffic management, road infrastructure and parking; mobility management from 2002 to 2020: environmentally friendly modes of transport: from 49% to 60%; Motorized private transport: from 51% to 40%
Redistribution of traffic (traffic share)	2058: over 70% of daily trips by the environmentally friendly modes of transport	From 2002 to 2050: walking: from 32% to 32% bicycle: from 1% to 10% public transport: from 16% to 32% motorized private transport: from 51% to 26%	From 2008 to 2030: 10% motorized private transport share transferred to the environmentally friendly modes of transport			
Results of the main scenarios						
CO ₂ emissions absolute	-69% (2058 versus 2008)	-85% (2050 versus 1990)	-52.4% (2030 versus 2008)	-	-25% (2020 versus 2006)	-35% (2020 versus 1990)
CO ₂ emissions per capita	-	-78% (2050 versus 1990)	-	Between -61% and -79% (2030 versus 2005), depending on fuel price increase	-0.4 t CO ₂ per year (2020 versus 2006)	-

Fig. 3 Decline vectors in the main scenarios [8-11, 13, 15].

substantial CO₂ emission reductions in urban passenger traffic can be achieved.

All concepts take significant technical efficiency enhancements in motor vehicles as their starting point, which are primarily initiated by the European Union and German federal policy and partially reinforced by local strategies. In addition, all concepts assume that measures for changing transportation behaviour are necessary and possible. Technology and behaviour should therefore work together.

Traffic avoidance through the development of a city of short routes and, more importantly, modal shift are considered important strategies for urban and regional action. Through consequent push & pull measures, a modal shift from motorised individual transport to the environmentally friendly modes of transport means of transport, should be achieved. An active local and/or regional modal shift policy is expected to affect substantial contributions to the reduction of CO₂ emissions of passenger traffic. For this to happen, considerable changes in mobility behaviour and in traffic are necessary. At the same time, the scenarios also reveal possible undesirable economic and social side effects, particularly for households with low income. It is important that this is considered and used for compromise in the concrete discussion of measures.

In conclusion, all scenarios demonstrate the extent to which the considered measures contribute to the CO₂ reduction (Fig. 3), and which gap to the achievement of the goal remains if that which is currently regarded as realistic in practice is really implemented in future.

Overall, the transport scenarios show that it is essential to act quickly and appropriately, and not hesitantly or without conviction. They act as a stimulus for an intensive discussion in theory and practice on a consequent urban transport, which is guided by climate protection and socially acceptable, too. They also illustrate the field of conflict between that which is necessary for climate protection and that which is currently considered feasible in politics.

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