



Bundesministerium  
für Verkehr, Bau  
und Stadtentwicklung

**Energie**  
für Deutschland

# The Mobility and Fuels Strategy of the German Government (MFS)

New pathways for energy





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# 1. Summary

## 1.1 Transport's changing energy world

- Germany needs a reliable, economical, affordable and environmentally friendly energy supply. Energy security, the careful use of resources and climate protection are also central action areas for the transport sector.
- The reorganisation of the German energy system as part of the *Energiewende* [literally: energy transformation or transition] represents the decision of the German government to phase out nuclear power, transition to renewable sources of energy whilst meeting its climate protection commitments] represents, with its many conditionalities, a significant challenge which can only be addressed with a systematic approach. This affects the transport sector to a notably high degree.
- For the transport sector too, the energy “system” is changing. The principle of transitioning away from oil, already well-established in the transport sector, has gained renewed importance as a result of the *Energiewende* and the German government's Energy Concept. Rail and passenger road transport are being more closely linked to climate targets and renewable energies. However, realistic, supportable, robust and sustainable future concepts must also be developed for other modes of transport that will, for technical reasons, be dependent on oil for a long time to come. The transport sector as a whole must make its contribution to the German government's climate targets.
- To make the “energy world” of transport future-proof, as well as economically, ecologically and socially compatible, policies need to be put in place in good time and with appropriate transition periods, so that the automotive industry, energy industry, transport companies and citizens can adapt, and investments can be made with a long-term perspective.

## 1.2 Focus of the Mobility and Fuels Strategy

- The MFS is not an overarching mobility strategy; rather, it is an initial, concrete contribution by the transport sector to achieving the targets set out in the German government's Energy Concept for the transport sector. It provides – for the first time in such depth – a comprehensive overview of the technologies and of the options for energy and fuel for the various modes of transport. In addition, it seeks to broaden the knowledge base on issues of energy and technology in the transport sector, to analyse the framework conditions and to prioritise targets. Ultimately, its purpose – as a “learning strategy” – is to identify ways in which the *Energiewende* can be implemented for transport in the future.

- The drafting of the MFS was preceded by a comprehensive participation process ([www.mks-dialog.de](http://www.mks-dialog.de)). Through the dialogue with the transport community and with citizens it has once again become clear that sustainable mobility and the issues at the heart of the MFS (drives/ fuels/ energy) are two sides of the same coin. For the long-term outlook, this fuels strategy should, therefore, be integrated into an overarching and comprehensive mobility strategy.
- The MFS aims to provide information and orientation on the current status, opportunities and challenges of alternative fuel options and innovative drives, as well as on the effect of energy issues on transport.
- The following key questions are addressed:
  - Which modes of transport make which demands when it comes to fuels, drives and fuel infrastructure?
  - What are the framework conditions and instruments (for sources of energy, efficiency and renewable energies) in Germany and Europe?
  - Can the challenges be met with the existing sets of rules and framework conditions, or are changes required?
- National developments cannot take place in isolation from those of our European neighbours and of the global situation. In the European context, this affects all modes of transport, and in the international context this holds particularly true for aviation and shipping. Here, the MFS seeks to contribute to the European and international debates.

## 1.3 Key messages

### Diversification of the energy sources in transport

- The transport sector must play its part in implementing the German government's Energy Concept. The lead target for the transport sector is the reduction of final energy consumption by some 10 percent by 2020, and by about 40 percent by 2050 (baseline = 2005). The key prerequisites for achieving the targets are the diversification of the energy sources for transport through alternative fuels, in conjunction with innovative drive technologies, further improvements in the energy efficiency of combustion engines and the optimisation of transport processes.
- For consumers and industry, the diversification of energy sources in transport and the introduction of innovative drive technologies will involve a transition period with many questions and uncertainties. Customers will ask which fuels to use in their vehicles, which drive systems are economical or particularly environmentally friendly and how much alternative vehicles will cost. At the moment, the proportion of vehicles with an alternative drivetrain is still low.

Because of the challenges relating to energy policy and for reasons of environmental protection, as well as to ensure its own competitiveness, the industry is called upon to pursue and develop a number of different technology concepts, which involve high investments in research and development. One thing is clear: in coming years, consumers will have to analyse their mobility needs in detail in order to determine which combination of fuel and drive is best suited for them.

- It is clear that greater diversity will prevail. One challenge here will be overcoming the evident barriers to market entry for highly efficient drives and alternative fuels. These these will be required in the future in order to reduce the environmental impact of passenger cars and commercial vehicles and the dependency of road-based traffic on petroleum.

#### Actively changing the system

- The step-by-step change of energy sources in transport and the increase in energy efficiency through innovative technologies must be organised and implemented now. The interfaces between transport and energy issues should be optimised, and the barriers to market entry eliminated. Measures to support the competitiveness of new market entrants, for example in the field of electromobility, must be developed in cooperation with companies.
- Clear changes in the field of fuels and drives will not be brought to the market before 2020 – in individual modes of transport, in public road transport and in private motor vehicle transport. The increased electrification of passenger car drivetrains and greater use of renewable energy sources offer higher potential for reducing CO<sub>2</sub> emissions and other pollutants between 2020 and 2030.
- New drive technologies will play an ever increasing role on the market. We currently find ourselves – despite the hopes of the general public – in a very difficult market preparation phase. Research and innnovation endeavours are currently, to an extent, still faced with high technological risks and economic barriers to market entry. This also holds for the infrastructure necessary for alternative fuels. Greater consideration must be given to how the system can be transformed more effectively and quickly, whilst not losing sight of economic factors.
- The structural change towards sustainable mobility must be in harmony with the principles of the social market economy and a market-based approach must therefore be adopted. To this end, clear and reliable framework conditions must be put in place for companies and consumers. For example, framework conditions advantageous to sustainable mobility must be specified for the automotive and petroleum industries, to enable them to switch to more environmentally friendly forms of transport on the one hand, whilst allowing them to maintain and increase their international competitiveness on increasingly global markets on the other.

For the purposes of a “learning strategy”, these developments cannot be viewed in isolation of the efforts in other regions of the global economy with which Germany is competing.

#### European and international context

- In addition to the developments at national level, those at international and European level are equally important for the drafting of the German government’s Mobility and Fuels Strategy. These developments give rise to both opportunities for action and challenges or constraints for the German economy, for research and for the interest groups affected.
- Germany can become the leading market for innovative technologies and sustainable mobility solutions, and the provider of energy-efficient products on the global market. With regard to transport technologies, it is important to extend the advantage that has already been gained. Particular attention should be paid here to the establishment of strategic alliances, for example in the areas of electromobility, hydrogen technology, LNG for shipping and, in particular, alternative fuels for the aviation industry. In addition, it is necessary to ensure that Germany continues to show a strong presence in the key international bodies (for example UNECE, ICAO, IMO, CCNT etc.).

#### Perspectives: modes of transport

- In the future, the greatest potential for CO<sub>2</sub> savings are probably to be found in passenger car and rail transport. Extensive decarbonisation of public road transport and private motor vehicle transport is technically possible in the long term through the increased use of electricity and hydrogen as well as battery and fuel cell technology and the use of renewable sources of energy, supplemented by measures on the vehicle. This development is indeed necessary in order to meet the German government’s energy and climate targets up to 2050.
- For decades, rail transport has been the traditional use case for electrical energy. A changeover to 100 percent renewable electricity by 2050 is firmly embedded in DB AG’s (German railway company) strategy. As in the case of electromobility on the roads, however, the economic factors for implementation and ensuring that additional renewable energy is actually produced are problems that still need to be addressed.
- In recent decades, road freight in Germany has continuously increased due to greater economic power and more extensive global trade integration, partly in connection with the EU expansion eastwards. Fuel savings can also be expected as a result of the further development of the conventional drive technologies currently used, in particular through further hybridisation. The introduction of “revolutionary” drive technology is not a short-term solution option for the commercial vehicle sector. Nevertheless, it would be unwise to shelve development of these technologies, particularly as light-duty vehicles are already able to achieve additional energy gains through electrification (hybrid technology). Furthermore,



manufacturers are currently preparing the market introduction of comparable technologies for heavy-duty vehicles. The commercial vehicle sector can benefit from the lessons learned from developing the technology for the passenger car. These synergies should also be exploited in the relevant research and development programmes. The extension of the fuel base for trucks from diesel to a gas drive should be systematically addressed as a new pillar of the programme. "Duel fuel" vehicles (combination of diesel and natural gas or liquified petroleum gas) could also contribute to a diversification of the energy supply and lead to a reduction in CO<sub>2</sub> in view of the option of including biomethane.

- The international aviation industry has set itself ambitious, far-reaching CO<sub>2</sub> reduction targets and German and European airlines, in particular, can boast substantial specific successes in the conservation of energy. Technology, management and infrastructure measures can help to conserve energy further. At the moment, the only conceivable fuel alternatives to fossil kerosene are biofuels (biokerosene). The use of biofuels is an alternative that has been shown to be technically feasible, but its implementation (availability of sustainable biomass, plant technology, costs etc.) is associated with great uncertainties and it therefore requires special attention both in the industry and from a political perspective. Global emissions trading is in principle probably the most effective and energy-efficient climate protection instrument in aviation at the moment. Irrespective of the continuation of emissions trading for air transport at EU level, it is important that every effort is made at international level to introduce a global market-based climate protection instrument in conjunction with a cap for emissions. The environment committee of the ICAO is currently working intensively on developing a CO<sub>2</sub> standard for aircraft. Adoption of the standard is scheduled for the end of 2015.
- In connection with European and international requirements in the area of pollutant reduction, maritime shipping has undergone a significant transformation with regard to the fuel base: from heavy oil to diesel and accompanied by the use of liquified natural gas (LNG) as an additional, parallel development. Because of a lack of technical alternatives, the combustion engine will remain the dominant form of propulsion in maritime shipping. In the MFS, particular attention will be paid here to a further reduction in emissions, for example through a market introduction strategy for LNG in shipping (including inland shipping). Effective climate and efficiency measures must be introduced in shipping in order to respond to shipping's increasing climate impact. In addition to efficiency thresholds, which have already been introduced for new vessels, the primary concern is to adopt effective market-based climate protection instruments.

#### Perspectives: Sources of energy fuels / problem of ILUC (indirect land use change)

- No profound changes in the energy sources for transport are expected until at least 2020. Oil-based fuels will continue to dominate the market in the medium term. Natural gas, liquified petroleum gas and biofuels are currently the only alternatives available on the market; in some cases, to a very low degree. In view of the diversification of the fuel base in transport, the German government will investigate whether measures can be considered (and if so, what these measures would be) to create sales potential for natural gas (CNG / LNG) and LPG beyond 2018, for example whether a conditioned extension of the energy tax relief, which ceases in 2018, is advisable, and if so with what prerequisites.
- Gas and renewable methane as a storage medium are also becoming more important (keyword: power-to-gas / hydrogen). The fact that methane does not have the mixing limits imposed on hydrogen is positive. In addition, the raw material base for biomethane is broader than for other biogenic fuels, which fosters the use of ILUC-free raw materials.
- Sustainable biofuels are one way of reducing greenhouse gas emissions in the transport sector. However, studies in recent years have shown that if ILUC potentially resulting from this is considered, this contribution would be compromised.
- On 17 October 2012, the European Commission submitted a proposal to change the Renewable Energy and Fuel Quality Directive. The aim is to avoid ILUC through the use of biofuels. The proposal is currently being negotiated in the Council and European Parliament in the codecision procedure.
- In Germany, the acceptance of biofuels is increasingly being questioned by the population. This is due to concerns regarding environmental and climate damage and discussions about the competition between food and fuel, or about cropland.
- The German government therefore welcomes the submission of a regulation proposal that aims to avoid the negative effects from ILUC when the use of biofuels is increased. The European Commission's proposal considers important aspects that have also been demanded by Germany in connection with indirect land use changes. The approach proposed by the Commission of setting an upper limit for the proportion of "conventional biofuels" is expressly supported by the German government.

- The use of biomass for energy or fuels is therefore contingent on clear criteria and requisite conditions that must form the basis for further areas in which biofuels can be used, for example in aviation. The opportunities and challenges as well as possible action recommendations for a future sustainable use of biofuels in the transport sector are discussed below. In the context of other options for energy efficiency and renewable alternatives, the role biofuels play in the various transport sectors should primarily be dictated by the potential for future climate protection efficiency and the availability of other alternatives for climate protection. A state-determined allocation of biofuels to particular modes of transport is not a viable solution at the moment.
- Another step towards reducing greenhouse gases is the transition from an energy-related biofuel quota to a greenhouse gas quota as of 2015. For the future, and with a view to the 2050 targets of the Energy Concept, an investigation is needed to determine the form in which the greenhouse gas quota applicable for biofuels as of 2015 could be continued. One possible discussion model would be an extension of the greenhouse gas quota to other fuels and forms of renewable energies in order to give the parties involved the necessary direction and planning security. However, developments at European level must be taken into consideration when defining targets.

#### Infrastructures for alternative fuels: solving the “chicken and egg problem”

- The subject of infrastructure development for alternative fuels must be more firmly anchored in the public awareness and the political agenda, both nationally and in a European context. The relationship between fuel, drive system and fuelling station (also in connection with the energy system) must be reinforced as an integrated approach in the various research, development and demonstration programmes, and with regard to market validation. In the participation process for the MFS, it was clear that private stakeholders, in particular the providers of infrastructure and vehicles, should not be absolved of their responsibility with regard to the infrastructure for alternative fuels, but that commitment is still required from the public sector in order to improve the framework conditions for the market preparation phase. Agreed targets between the industry and government for alternative fuel infrastructures can become real drivers on the alternative fuel markets, because a greater public presence and better access to alternative “fuelling stations” are one possible key to attracting consumers and increasing the market demand for these fuels. The German government will use the EU Commission’s proposal on the “Clean-Power-for-Transport” initiative to discuss with those stakeholders affected an overall framework for solutions to develop alternative fuel infrastructures in Europe, building on Germany’s extensive preparatory work.

### Developing targets further

- Following on from the work already conducted in the individual ministries, and taking account of the reorganisation of the energy system and the available budget funds, the German government will present an analysis and simulation instrument on the subject of “transport and energy / climate” that is as broadly accepted as possible and compatible with EU reporting obligations, and that also takes account of the complex regulations on greenhouse gas balancing of biofuels in existing legal regulations. This will be based on the 2030 future transport forecast, will consider the potential uses of biofuels and will further develop the policy of CO<sub>2</sub> reduction for road vehicles. A comprehensive instrument is required to enable the effects of developments and measures in the field of transport and energy to be estimated flexibly.
- Participants in the technical dialogue on the MFS proposed a CO<sub>2</sub> reduction target for the transport sector as a supplement to the final energy conservation target. The German government will evaluate whether the existing targets and instruments suffice to help renewable energies penetrate the market more effectively in the transport segment, or whether supplementary measures are required. Strategies coordinated with each other in the transport sector and aligned with those for the reorganisation of the energy system are therefore absolutely essential.

### Responsibility of the transport sector

- Businesses and the industry are required to consistently support and pursue the transition that has already begun from conventional energies and technologies to alternative and innovative solutions. This applies not just to the vehicle industry, which must also exploit the economic efficiency reserves of its products, but also to the energy and petroleum industry.
- An important demand made in the participation process to support energy and climate targets is that political measures must be transparent and predictable for the industry so that the financial risks for investments in new technologies are manageable. Another demand is that the Energiewende in transport must be organised in a socially acceptable manner. Mobility must remain affordable. New mobility solutions must be integrated, and the modal split improved. The German government will organise the transition to sustainable mobility so that the competitiveness of the German economy is preserved and strengthened. One of the German government’s central maxims is to enable mobility, not to impede it.
- Solid state finances are a fundamental prerequisite to establish framework conditions that are reliable over the long term for the required future investment, in the transport sector and elsewhere. The German government is pursuing a growth-oriented strategy of consolidation. All measures of this strategy that affect finances must therefore be included within the framework of the key values of the federal budget and financial plan.

## 1.4 The MFS as a “learning strategy”

- The concept underlying the MFS also involved a new type of participation in the political process. In the course of the participation process, networks between the stakeholders were created that did not previously exist in such a form. A constructive culture of dialogue should be sustained and enhanced.
- The MFS should therefore be continued as an ongoing “learning strategy” and as an instrument for implementing the Energiewende in transport in the spirit of a national sustainability strategy. It will be implemented within the framework of the ministry responsibilities. As a result, action recommendations can be investigated and future developments taken into account during implementation. With a view to an action horizon that extends until 2050, the launch of a “learning strategy” is very much in the interests of a sustainable and forward-looking policy.



# 2. The MFS – mission, goals and work process

## Requirements to be met by transport

Germany needs a reliable, economical, affordable and environmentally friendly energy supply. The supply of fuels and energy is a central action area for the transport sector alongside climate protection.

Today, transport is still more than 90 percent dependent on petroleum. While the global demand for petroleum is increasing, the exploitation of new reserves is becoming more complex and expensive. The central challenge is to start the changeover to new, safe, environmentally sound, reliable and affordable energy supply today. The German government has set the course for this with the 2010 Energy Concept and the 2011 Energiewende.

The energy sources for transport must also change step-by-step through to 2050, away from oil and towards more alternative fuels, and in particular towards more renewable energies. However, the best energy is that which is not consumed in the first place: particular attention must therefore be paid to the vehicles' energy efficiency.

## Responsibility of the transport sector: reliable targets and steps

In Germany, transport is currently responsible for around 30 percent of energy consumption and some 20 percent of CO<sub>2</sub> emissions. Because of its almost complete dependence on petroleum, the transport sector has hitherto enjoyed a certain autonomy, which it will not be possible to retain in the future following integration in the general energy system.

The transport sector, along with the electricity and heat sector, is therefore an important action area for the Energiewende in Germany. Without the contribution from the transport sector, it will not be possible to achieve the Energy Concept's ambitious targets:

- In the 2010 Energy Concept, the German government defined a reduction target for the transport sector: final energy consumption should be decreased by around 10 percent by 2020 and by 40 percent by 2050 (baseline = 2005).
- In addition, greenhouse gas emissions in Germany across all sectors are to be reduced by 40 percent by 2010 and at least 80 percent by 2050 (baseline = 1990). No sector-specific greenhouse gas reduction targets were set for the transport sector in the Energy Concept.
- The German government's 2010 Energy Concept specifies that renewable energies are to account for 18 percent of gross final energy consumption by 2020 and 60 percent by 2050 across all sectors.

In addition, regulations exist at EU level that have a significant impact on energy supply in the transport sector in Germany:

- The EU Fuel Quality Directive (FQD 98/70/EC) specifies a six percent reduction in the lifecycle greenhouse gas emissions of the fuel/energy source by 2020, compared with 2010.
- The EU Renewable Energy Directive (RED 2009/28/EC) specifies that renewable energies (RE) should account for at least 10 percent of the total final energy consumption by 2020 in the transport sector for all modes of transport (procurement of electricity, petrol/diesel/biofuels for road and rail transport).
- EU Ordinances 443/2009 and 510/2011 define CO<sub>2</sub> efficiency targets for passenger cars and light-duty vehicles that lead to considerable energy savings.

All the targets and measures point in the same direction. In view of the fact that further dynamic growth in traffic is forecast, a critical investigation and analysis is required into whether and how the initiated measures are having an impact and whether additional instruments and measures need to be developed or supplemented in order to achieve the targets.

#### Which energy will move us in the future?

The MFS provides a broad overview of measures, instruments, technologies and fuel options, and describes which development pathways are required to successfully implement the Energiewende – with the initial focus on drives and fuels.

The German government had already drafted a fuels strategy in 2004. However, this was only directed at the passenger car sector. As a result of the dynamic developments in drives and alternative fuels, the 2004 strategy is now less up-to-date or valid. The situation that has arisen since then has made it necessary to draft a comprehensive Mobility and Fuels Strategy.

#### Challenges facing the MFS

In the large energy production, industry and buildings sectors, clear, absolute energy savings and CO<sub>2</sub> reductions have been achieved, despite growth. Despite a clear increase in traffic activity, CO<sub>2</sub> emissions in the transport sector have also been reduced since 1990, though not to the same degree as in other sectors.

The dilemma facing the transport sector, and therefore one of its greatest challenges, is that efforts to achieve greater energy efficiency, and the resultant successes, have been negated by dynamic growth in transport, particularly in long-distance heavy goods transport and aviation.

In past decades, traffic in Germany has continuously increased. Traffic activity for private motor vehicles is now four times higher than in 1960.



“We are developing a broad and technologically open Mobility and Fuels Strategy that takes account of all alternative technologies and sources of energy.”

(Coalition contract “Growth, Education, Solidarity”, October 2009)



## Freight traffic – traffic activity 1960 to 2011

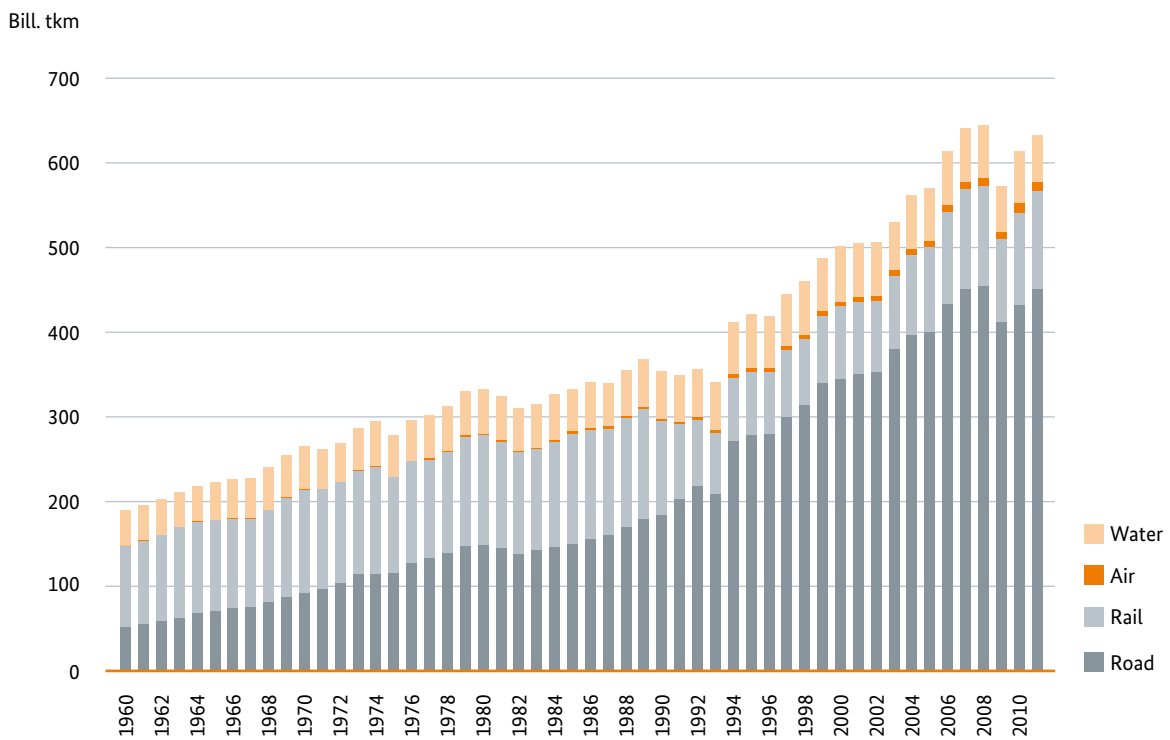


Figure 1: Traffic activity (excluding maritime shipping) in the Federal Republic and (up to 1990) from and to West Berlin. (Source: BMVBS (publisher): Verkehr in Zahlen [transport in figures])

## Passenger transport – traffic activity 1960 to 2011

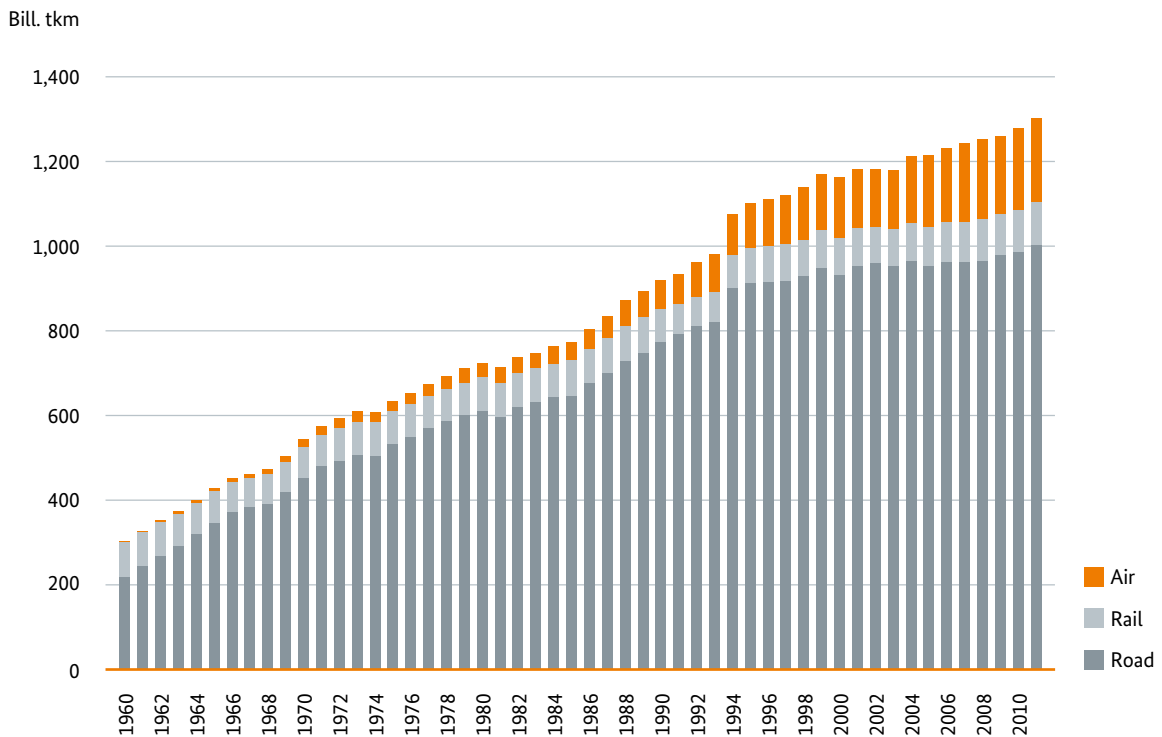


Figure 2: Traffic activity (excluding maritime shipping) in the Federal Republic and (up to 1990) from and to West Berlin. (Source: BMVBS (publisher): Verkehr in Zahlen [transport in figures])

Car ownership has risen from 71 cars per 1,000 residents in 1960 to 553 cars per 1,000 residents in 2010. Stagnation has only been seen in recent years. Air traffic has risen sharply in the recent past. Air traffic has increased 2.5-fold since 1990 (national air traffic activity has fallen in this period). In the same period, fuel consumption per passenger and 100 kilometres fell by 37 percent. Overall, the absolute CO<sub>2</sub> emissions from German domestic flights fell by 14 percent between 1990 and today. The central challenge however arises from the high growth forecast in air transport in the coming decades.

Based on these developments in freight and passenger transport, the key issues for the MFS are as follows with regard to the final energy target formulated in the Energy Concept:

- What does the energy reduction target mean for transport?
- Which drive and fuel options contribute to the achievement of the target?

### Final energy consumption in transport 1960 to 2011 (delimitation after energy balance)

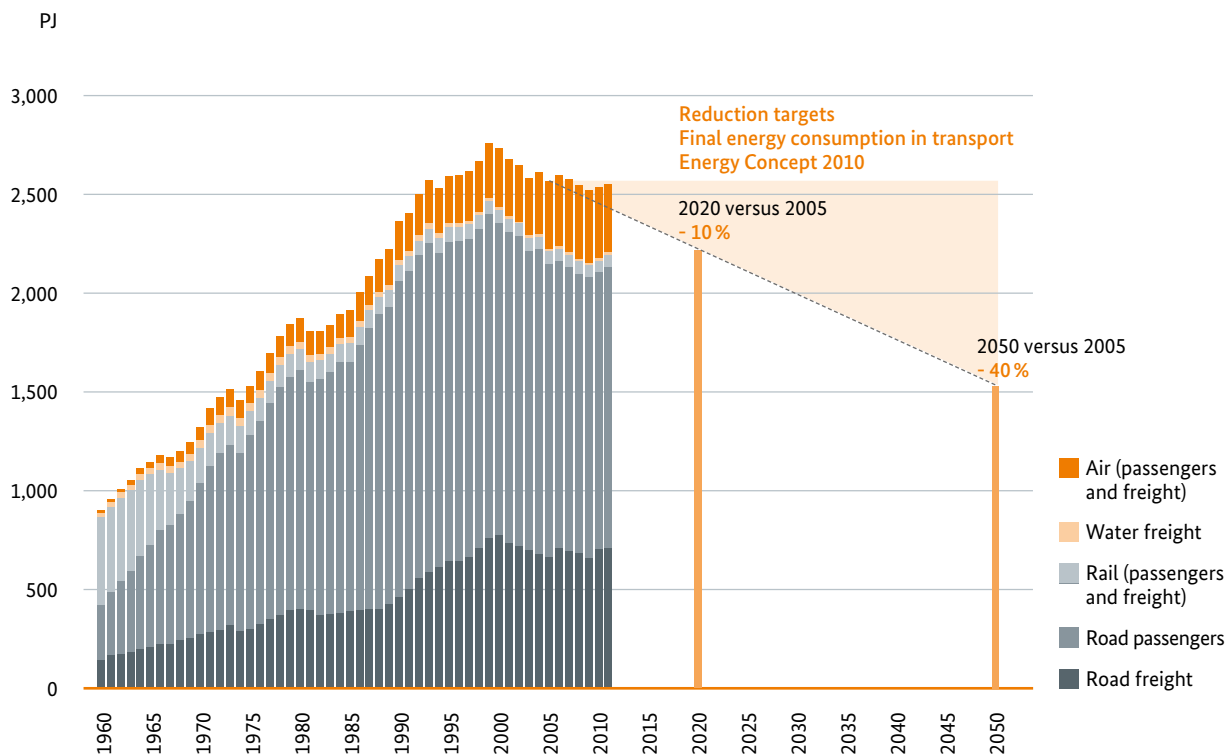


Figure 3: The diagram shows the energy consumption of the individual modes of transport, the current situation and the targets for 2020 and 2050. (Source: own diagram BMVBS / ifeu)

## Annual development of crude oil prices

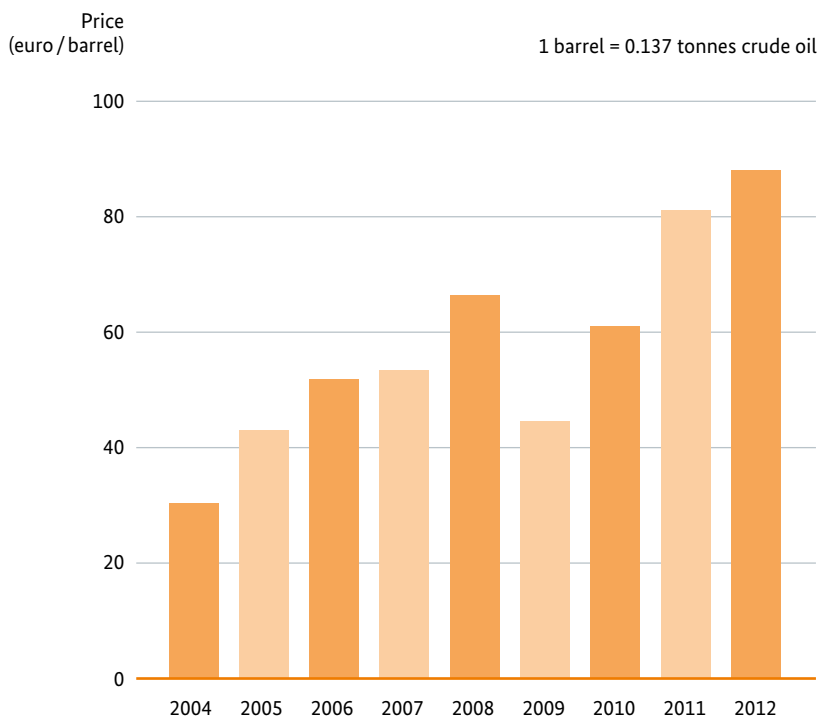


Figure 4: Cross-border price for crude oil Germany. (Own graphic BMVBS; source: BAFA, 2013)

### Making sure mobility is still affordable

A further challenge is the social dimension of an Energiewende in transport. In 2010, expenditure for mobility made up 14 percent of consumer spending in private households. The prices for crude oil have been constantly rising since 2000. In the past two years, crude oil prices have reached a historically high level, and this has been reflected in the prices for petrol and diesel. It is not possible to reliably predict the future development of prices for petroleum products and other sources of energy, or those for the new drive technologies.

However, the German government will make sure that mobility remains affordable. In addition, the EU legislation for increasing the efficiency of road vehicles will play a particularly important role: more efficient vehicles and alternative fuels could help to significantly reduce the fuel costs per kilometre travelled. This legislation is currently the most effective instrument for reducing energy consumption in the transport sector and it must be developed further.

Europe imports 84 percent of crude oil and had an annual “oil bill” of around 370 billion euros in 2011. Volatile prices also generate additional costs. A strategy in the transport sector to reduce dependence on oil will contribute to added-value effects in Europe and Germany.

### Participation process – involving the people affected

In accordance with the German government’s fundamental aim of improving citizen participation and involvement, the drafting of the MFS was preceded by a comprehensive dialogue process involving all the relevant sectors and interest groups. More than 300 stakeholders from industry and science, as well as societal interest groups, took part in almost 20 workshops. Here, the stakeholders had their first opportunity to discuss “transport and energy” on a cross-industry and cross-energy basis and weigh up and, where possible, reconcile conflicting interests.

A comprehensive overview can be found in the appendix and at: [www.mks-dialog.de](http://www.mks-dialog.de)

In the summer of 2012, the German government’s State Secretary Committee for Sustainable Development named the MFS as the 2012 lighthouse project for the national sustainability strategy. The central reason for this was the way (namely the multistage process) in which an understanding of the MFS was to be reached between government, industry and science in a participation process.



- Leuchtturmprojekt 2012 -

Each year, this title should be awarded to at least one government project that implements the sustainability targets and measures in practice. According to the resolution, a lighthouse project should be particularly designed to “give sufficient room to the interests of the various stakeholders in the participation process.”





# 3. The MFS – developing today what will drive us tomorrow

## 3.1 Cross-cutting issues

### 3.1.1 Forecasts and scenarios

#### Initial situation

In recent years, a number of forecasts and scenarios have been commissioned and drawn up on future energy requirements and the greenhouse gas emissions from traffic. All these forecasts and scenarios serve different purposes and thus have different analytical focal points and degrees of abstraction.

For transport development, data from the 2003 federal transport infrastructure plan and the 2025 forecast for the integration of transport networks was regularly used in the past. Because of the now outdated data basis and the economic consequences of the global financial and economic crisis, new assumptions have been formulated by various institutions. As a result, Prognos / ProgTrans defined their own traffic activity assumptions as part of its energy scenarios, as did DLR within the Renewability study (Institute for Applied Ecology).

The German government is currently drafting a new transport forecast for 2030 as part of the development of a new 2015 federal transport infrastructure plan, and the results of this forecast are likely to be available at the end of 2013.

From an energy point of view, the uncertainties surrounding the forecast and assumptions relate in particular to supply, demand and the potential for reducing greenhouse gases. Here, too, scientists commissioned by the German government are working on proposals for a future-proof use of bioenergy (Milestones 2030 project), the purpose of which is to evaluate the objectives of the 2010 Energy Concept in particular for the period after 2020.

The known forecasts and scenarios can be used as the general basis for a discussion of strategic long-term goals and for pathways for technology and sources of energy. However, they are not yet suitable as a sound basis for defining binding forecasts and scenarios specifically for different modes of transports or types of fuel, or further-reaching sector targets potentially derived from these.

## Opportunities and constraints

Because of the uncertainties described above, a broad range of opinions have been formed on the issue of whether the existing measures suffice to achieve the targets set out in the 2010 Energy Concept in the transport sector, and which additional measures may need to be initiated. The same is true of the discussion about the EU aim of using 10 percent renewable energies in transport, or achieving the greenhouse gas reduction targets by using biofuels, in view of the current reworking of the two related EU directives to take account of indirect land use changes (“ILUC effects”).

## Linking the transport sector and energy system more effectively

Up until now, energy supply for the transport sector has only been linked with the general energy system (electricity and heat market) to a small degree, particularly when it comes to future developments such as the use of bioenergy or electricity from renewable energy sources (RES-E) in the transport segment.

In an energy system based on renewable energies over the long term, the use of energy sources and the corresponding instruments must be better coordinated across the whole system. Particular attention must be paid to possible competition for energy use, as well as synergy effects between electricity, heat and mobility produced by the system. One noteworthy example here is the growing need for the transport sector to make a contribution to network stability (keyword: battery technology and hydrogen as a storage medium).

The public debate also involves a discussion on whether a supplementary CO<sub>2</sub> reduction target could be helpful in encouraging greater use of renewable energies (bioenergies, electricity, electricity-based fuels such as hydrogen or methane) in the transport sector. However, a supplementary target of this kind would also have to be backed up by suitable instruments and accompanied by a monitoring process. The discussions show that target-oriented CO<sub>2</sub> monitoring sets far higher demands than final energy monitoring. In principle, a sector target, mode of transport targets (where the energy conservation potentials of the individual modes of transport differ greatly) or indicator targets are conceivable. New scenarios would have to be developed for this. A final energy conservation target alone would be unsuitable, because this would preclude the transport sector from developing and using renewable energies, or at least hinder such efforts.

## Action areas

- The German government is committed to the final energy conservation targets of the 2010 Energy Concept as a target for the transport sector. The assumptions that formed the basis for the energy scenarios at that time must be developed further in line with current developments.
- The German government is developing an analysis and simulation instrument on the subject of “transport and energy / climate” that is as broadly accepted as possible and compatible with EU reporting obligations, and that can also be used as an analysis tool and guide for defining



energy conservation and climate protection measures in the transport sector. This will be based on the 2030 future transport forecast, will consider the potential uses of biofuels and will further develop of the policy of CO<sub>2</sub> reduction for road vehicles. The data basis for energy consumption, the environmental impact and the costs of the different modes of transport and technologies must be transparent, open and constantly updated. The complex regulations on greenhouse gas balancing of biofuels in existing legal regulations should be portrayed here. A “Facts and Matrix” database could perform this task. A database of this kind enables a specific, transparent “traffic and energy scenario” to be developed that, in view of the dynamic changes, should be updated regularly (at least every two to four years). The Renewability project, for example, can be jointly developed as an analysis instrument and basis for work.

- Once this specific “transport and energy scenario” is available, a decision is needed on which 10-year targets can be specified for a final energy conservation target for 2030 and 2040 in the transport sector.
- A critical check will then be necessary to determine whether and in what form a supplementary CO<sub>2</sub> conservation target for the transport sector (including interim targets) can be developed that supports in particular the use of environmentally friendly renewable energies in the transport sector.
- In all future decisions on the increased use of renewable energies, the German government will take account of the increasing permeability of system boundaries between use in the electricity, heat or transport market and look for suitable cross-system action strategies.
- However, this approach of linking up central uses of energy more intensively must also be established at European level in view of the decision-making powers located there. The German government will provide information about the Mobility and Fuels Strategy and in particular communicate its targets at European level. The various stakeholder groups from science, industry and civil society are also required to use the opportunities open to them to stress the growing importance of an integrated overall energy system that also includes transport.

### 3.1.2 Reliable framework conditions

#### Initial situation

Absolute energy consumption, the energy efficiency of transport technology and strategies to reduce greenhouse gases are influenced by numerous technological, economic and social framework conditions that are difficult to separate from each other. These include not only market-based, regulatory and tax controlling instruments, but also information policy and research.

## Indirect land use changes

Indirect land use changes (ILUC) arise when biomass for use as energy is produced on land that was previously used agriculturally, as a result of which the conventional usages are at least in part forced into areas with a high carbon content or with high biological diversity. Thus the use of bioenergy could cause indirect greenhouse gas emissions and threaten ecologically valuable areas (even if the biomass for this energy is not itself cultivated in ecologically sensitive areas).

On 17 October 2012, the European Commission submitted a proposal to change the Renewable Energy and Fuel Quality Directive. The aim is to avoid ILUC through the use of biofuels. The proposal is currently being negotiated in the Council and European Parliament in the codecision procedure.

While measures and instruments closely attuned to the transport and energy interface have been discussed and, in some cases, approved at European and national level in some areas (for example biofuels or European / international emissions trading in aviation), it is still necessary to adapt existing rulings and implement new ones in Germany in these and other areas (for example electromobility or the expansion of the required infrastructures).

In general, a state-determined framework that is open to new technologies can generate impetus for sustainable mobility, new drive technologies and alternative fuels, energy efficiency and the reduction in greenhouse gases. In view of the long development, market introduction and market penetration periods involved, the central interest of the transport and energy industries alike is to achieve planning certainty with regard to political decisions.

### Opportunities and constraints

From a German point of view, the decision-making powers divided between the European Union and nation states mean a particularly well-coordinated balance of interests is required. One particular challenge is the fact that the interests of the member states are shaped by the very different degrees to which they are affected in almost all issues relating to the transport and energy interface.

In countries in which the directives are implemented very promptly, for example, modifications and adjustments become necessary even though other member states have still not gathered any comparable implementation or market experiences. On the other hand, a certain amount of room for manoeuvre in the implementation of European directives, or decisions of member states that cannot be agreed upon, leads to competition for positive or negative “fostering” conditions, resulting in fuel tourism or buyer premiums for e-vehicles, for example.

The key elements of the European decarbonisation strategy are defined above all in the Fuel Quality Directive (FQD 98 / 70 / EC) and the Renewable Energy Directive (RED 2009 / 28 / EC). Key aspects of these directives were transferred into national law in the Federal Immission Control Act, the 36th Federal Immission Protection Ordinance (BImSchV) and the Biofuels Sustainability Ordinance. To increase coherence, the targets proposed for 2020 (transport target of the Renewable Energy Directive, greenhouse gas reduction target of the Fuel Quality Directive) must be better aligned with each other as part of the investigation planned for 2014.

The proposal of the European Commission for a directive to modify the RED and FQD with regard to biofuels and indirect land use changes is currently under discussion. Key elements of the proposal are:

- Limiting the “conventional” biofuels to a maximum of five percent of the energy content;
- Extending the multiple offsetting of certain biofuels (four-fold offsetting is also planned for the first time);
- Reporting on possible greenhouse gas emissions from ILUC based on calculations from a study conducted on behalf of the European Commission.

The two- and four-fold offsetting of certain biofuels against the EU target for renewable energies proposed by the Commission would in effect result in less biofuel being used to achieve the EU target.

With regard to the challenges for the transport and energy industry described in the MFS, the particular problem from the German government’s point of view is that existing price structures for mobility are changing. While the general price development (for example raw material prices, labour costs, inflation and capital costs), new technologies and product innovations lead to increasing costs, with individual mobility remaining constant or increasing slightly, the income from the energy tax and electricity tax is expected to fall as a result of the likely drop in sales of fuels and shifts in energy sources. The petroleum industry is also expecting a drop in sales figures for petroleum products over the medium to long term. The German government will therefore continue to monitor developments regarding energy and electricity tax income.

### Action areas

- The German government will investigate whether measures can be considered (and if so, what these measures would be) to create better sales potential for natural gas (CNG / LNG) and LPG beyond 2018, for example whether a conditioned extension of the energy tax relief, which ceases in 2018, is advisable, and if so with what prerequisites. If a continuation of tax relief beyond 2018 is considered, this should be done on a diminishing scale (declining and for a fixed period) and differentiate between natural gas and LPG.

In future, CNG should contain an increasing proportion of renewable methane (for example biomethane from biogas; biomethane from gasification and synthesis; renewable methane from hydrogen synthesised with CO<sub>2</sub>). The biofuel quota is an effective instrument for this that has proven its worth in practice. Additional tax benefits for biomethane after 2015 will therefore not be necessary. Because of the changeover to the greenhouse gas reduction quota as of 2015, the requisite conditions will also be put in place to ensure that biomethane, in particular, which has a particularly good greenhouse gas balance, will be used for fuels.

- From 2015, biofuels that have a particularly good greenhouse gas balance will count more heavily towards the greenhouse gas avoidance quota (greenhouse gas quota) that will apply as of then. If it transpires that certain particularly innovative biofuels require particular encouragement going beyond the general quota-based support, the German government will look into suitable measures.
- From 2017, the first series-produced fuel cell vehicles are expected on the market. The industry is currently also working on concepts to expand the hydrogen infrastructure in Germany. In view of this, the German government will investigate whether steps should be implemented to support the market introduction of hydrogen as a fuel used in fuel cell vehicles, and if so, what these steps should be.
- With regard to the amendment of the European Energy Tax Directive, the German government will continue to call for a fair EU-wide minimum taxation that limits fuel tourism and at the same time allows for a limited amount of national flexibility.
- To ensure competition and price transparency for fuel prices, the German government will continue on its course based on competition law. The prohibition of a margin squeeze and the establishment of market transparency units send important signals to industry and consumers.
- To strengthen rural areas and take account of factors relating to soil and water conservation, the German government will investigate how the framework conditions can be improved and market incentives created to encourage the use of pure biofuels in agricultural and forestry machines and possibly other offroad applications as well. This would therefore help the agricultural industry to cover large portions of the fuel it requires for food production itself.
- During the further development of instruments to promote renewable energies in the transport sector, as well as in the electricity and heat sector, the effects on the other sectors must be taken into account.

- In the government's research and development policy, the interfaces between the programmes for the transport and energy sectors should be better coordinated with each other. Research into the production of innovative biofuel close to the market and biorefinery concepts that particularly focus on lignocellulose and biogenic residues and waste should be extended. Research and development support for midsize enterprises is particularly important here. World-leading German research and development expertise must be consolidated and expanded in the field of fuels, as in the field of vehicle and transport technology. Just as important as the increase in support for research and development, however, is a stable political framework, without which said support for research and development would come to nothing.
- The German government will monitor and analyse the market for the production and use of algal biomass.
- When central energy supply structures are implemented at regional level, the area of transport should play an important role, for example in concepts / ideas for establishing regional value chains for energy and fuels. New residential areas could be planned in such a way that the modal split is systematically shifted towards environmentally friendly modes of transport.

### 3.1.3 Infrastructure for alternative fuels

#### Initial situation

In Germany, around 14,300 roadside fuelling stations are in operation serving almost 43 million passenger cars or almost 3,000 passenger cars per fuelling station, most of which are designed to distribute the fuels commonly used today. Since the peak number of fuelling stations, approximately 45,000, was reached in 1970, this figure has been permanently in decline.

Up until now, the majority of vehicles with an alternative drive have used CNG and LPG. In addition to 6,556 LPG fuelling stations for approximately 495,000 vehicles, there are around 900 CNG fuelling stations for approximately 96,000 vehicles. Across Germany, there are currently 15 fuelling stations for hydrogen for fuel supply, and a further 35 will be built by the end of 2015. At the moment, these primarily serve the fuel cell cars driven in a few high-population areas.

As battery-powered vehicles can in principle be charged at any socket, there is already an extensive infrastructure for this drive technology. Around 70 percent of passenger cars in Germany are plugged into a socket on private land and as a rule could also be connected with the electricity grid here. Only around 1,447 public charging points exist at the moment for car users who cannot park their cars on private land for long periods of time ("kerbside parkers"). Appropriate concepts must be developed for these users in the coming years. One solution could be to increase the number of quick-charging stations. This should be put to the test as part of the Schaufenster Elektromobilität [electromobility showcase] initiative.

Because they are blended with fossil fuels, biofuels do not generally require a separate infrastructure since in the case of biokerosene, for example, the biogenic proportions have the same specification as fossil kerosene and the existing fuelling facilities can be used.

In the future, the dominance of petroleum is expected to fall in favour of a diverse energy and fuel mix, with a corresponding impact on the supply situation. The fuel options range from conventional liquid fossil fuels (petrol/diesel) in various qualities (and with added quantities of biofuel), alternative liquid fuels such as liquified petroleum gas (LPG) or liquid natural gas (LNG) (for example in shipping), biodiesel, vegetable-oil fuel and ethanol fuel as well as the gaseous fuels natural gas, biomethane and hydrogen, through to the greater use of electricity in private motor vehicle transport.

The market development for alternative fuel options and innovative drive technologies in the transport sector means that the fuel infrastructure and charging infrastructures must be developed and constantly synchronised with the developments in drive technology and vehicles.

In the efforts to exploit alternative sources of energy for the transport sector, the focus to date has primarily been on developing alternative fuels and innovative drive technologies. However, with the discussions surrounding

## Fuelling stations in Germany

thousand

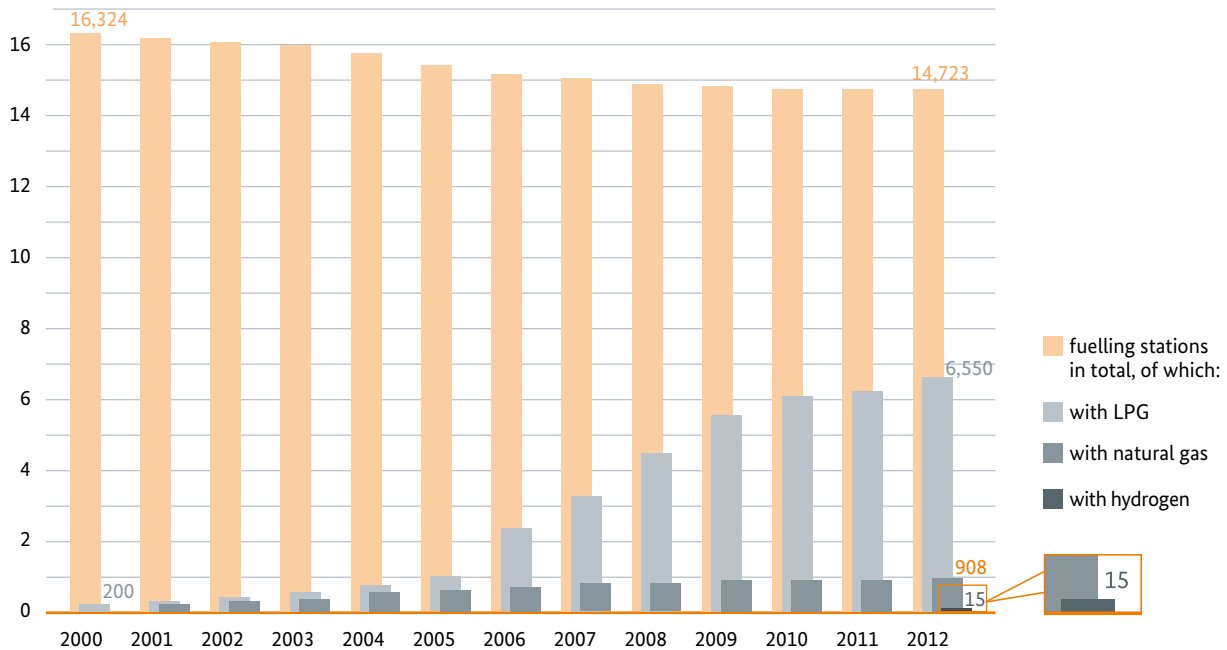


Figure 5: Number of CNG, LPG and hydrogen fuelling stations installed in Germany. (Source: dena 2012)

natural gas as a fuel and the issue of suitable charging and fuelling points for battery-operated electric vehicles and fuel cell vehicles (hydrogen), the public is becoming increasingly aware of the issue of infrastructure. The discussion is defined by the question of whether there is sufficient economic motivation on the part of private stakeholders to establish a demand-responsive fuelling station infrastructure to run in parallel with the vehicle developments and harmonised with this in terms of (safety) technology, or whether the present situation, in which the market for alternative fuels still needs to develop, also requires a stronger public sector role to generate impetus and moderate and steer events.

### Opportunities and constraints

The initial costs for opening up markets for alternative fuel infrastructures are high – due in part to the initial lack of returns to scale. In all cases, the setup of demand-responsive infrastructures for fuels that are not established on the mass markets entails risks for those who invest as “first movers”.

When alternative fuel infrastructures are developed, investments are in some cases required that are only amortised in the long term with vehicle ramp-up. In addition, the risks of market validation (use of non-established technologies with numbers of vehicles that are still low) disproportionately fall on those that first invested in the market development. This is particularly true for midsize enterprises. The burden of fixed costs per amount of energy sold is several orders of magnitude higher for new fuels entering the market than for established fuels. There is a risk that endeavours on the fuels or vehicle side could be hampered by the slower development on the infrastructure side due to a lack of business models and a lack of (EU-wide) harmonised standards, as well as a lack of approval procedures and so on (keyword: “chicken and egg problem”). It does not need to be especially emphasised that these considerations are also true in the opposite direction. The private stakeholders on both the fuel infrastructure side and the vehicle side must therefore be involved.

The example of the market introduction of natural gas vehicles shows that the comparatively complex and therefore expensive fuelling station infrastructure (as compared to liquified petroleum gas, for example), as well as fuelling station density, the lack of diversity in the cars on offer and the high premiums are a large obstacle to the establishment and customer acceptance of a new fuel.

From the participation process for the MFS, it was clear that private stakeholders should not be absolved of their responsibility with regard to the infrastructure for alternative fuels, but that commitment is still required from the public sector in order to improve the framework conditions for the market preparation phase.

## The challenge facing the public charging infrastructure – an example

For the development of a demand-responsive public charging infrastructure in Germany, the third current report of the National Platform for Electromobility (NPE), a German government advisory committee, estimates a maximum of 150,000 charging stations are needed, with at least half of these regarded as a forecasting uncertainty by the NPE. This number was estimated on the basis of the market penetration of the various drives predicted in the second report. It now seems likely that the proportion of plug-in hybrid electric vehicles (PHEV) will be higher than that of purely battery-powered electric vehicles (BEV). In view of the fact that PHEVs are not dependent on public charging opportunities to ensure mobility, the figures relating to public charging infrastructure requirements will be looked into once again.

One key task will be to use the information gained from the German government's *Schaufenster Elektromobilität* [electromobility showcases] and support programmes of the federal ministries in order to set appropriate standards. This relates for example to harmonised and unimpeded charging and settlement, as well as the interoperability of the systems. Appropriate technologies and the related legal frameworks are being developed for this. The

calculation of demand – i. e. the core question of how much charging infrastructure is needed, of what type and where? – can be determined and verified using various simulations. The current observations / assumptions are not generally valid here because of low vehicle availability.

The aim should be a concept coordinated between all the stakeholders (including at local authority level, in particular) and a timetable with consistent content for the future development of a demand-responsive public charging infrastructure. Overall, the local stakeholders, in particular the local authorities, should take on particular responsibility. Electromobility should be taken into consideration in local authority transport planning, local authority planning autonomy should be clearly stipulated and measures should be taken towards developing systematic knowledge management in the local authorities. This includes questions relating to the acquisition of the public fleet, as well as the granting of concessions for the charging infrastructure or concepts such as linking up electric vehicles and short-distance public transport.

Public-sector commitment in this area can only be justified through higher-level targets for security in the energy offering, in order to ensure a sustainable course of long-term decarbonisation. Agreed targets between the industry and government for alternative fuel infrastructures can become real drivers on the alternative fuel market because a greater public presence and better access to alternative fuelling stations are one key to attracting end consumers and increasing the market demand for these fuels. A reliable legal framework, in conjunction with the harmonisation of standards and support through innovative financial plans, will gradually lead to an optimum coverage of alternative fuelling stations.



## Action areas

The subject of infrastructure development for alternative fuels must be more firmly anchored in the public awareness and the political agenda, both nationally and in a European context. The relationship between fuel, drive and fuelling station (also in connection with the energy system) must be reinforced as an integrated approach in the various research, development and demonstration programmes, and with regard to market validation.

### Expansion of the infrastructure requires planning certainty in the private and public sector

A stable framework should be put in place that enables enterprises to push forward their business models successfully. With a European fuels strategy, the European Union is also striving to create this framework across Europe and to thus offer the market, consumers and developers not only initial impetus but also certainty for their planning. For reasons relating to technology and economic policy, Germany should continue to adopt a leading role in the issue of infrastructure for alternative fuel options in Europe (lead market function).

### The challenge facing the hydrogen infrastructure – an example

With regard to the development of the hydrogen infrastructure, the market and technology development, general suitability and development of the commercial hydrogen infrastructure are currently being analysed by stakeholders from various industry sectors within the H<sub>2</sub> Mobility industry initiative – in the long-term, a viable business model can be developed from this. It is also

important here that a European market is developed and models are found for how the investment risk resulting from the low utilisation of fuelling stations in the initial years can be reduced.

### “EU fuels strategy” targets

#### “Clean Power for Transport: A European Alternative Fuels Strategy”

On 24 January 2013, the EU Commission submitted the draft of a “fuels strategy for Europe”, which is currently being discussed. Its main objective is to tap the European domestic market, not least in the field of innovations and efficiency technologies in the transport sector. Objectives include:

- Developing an EU-wide minimum-coverage fuelling station infrastructure for the most important alternative fuels that are technologically feasible and offer market potential – to promote market introduction through economies of scale;
- Ensuring the implementation of harmonised standards for the most important alternative fuels.

The infrastructure costs in the later setup and expansion phase are lower as a result of economies of scale and technical progress. As a result, the lessons learned in practice from early market introduction are to be accompanied by applied research, development and demonstration in order to turn these into products fit for series production. This includes not only large demonstration projects such as in the Schaufenster Elektromobilität [electromobility showcases] initiatives, the model regions for battery-powered vehicles and charging infrastructure, or the Clean Energy Partnership (CEP) project for fuel cell vehicles and hydrogen fuelling stations, but also in particular the accompanying measures, which are concerned for example with (international) standardisation, approval processes and the regulatory framework, as well as raising public awareness. The progress in expanding the infrastructure should be regularly checked by independent, expert third parties to ensure the technical, economic and strategic expansion targets are being met.

For private investment to be forthcoming, a tangible development of the market and the vehicles on offer is required, along with reliable framework conditions in the investment period in order to ensure planning certainty for investors and to guarantee competitiveness with alternative investments. Cooperation models of private (various industry sectors) and public investors, perhaps outside of traditional PPP projects, would therefore seem to make sense (good examples: initiative for natural gas-based mobility, H<sub>2</sub> Mobility initiative).

The expansion of the LNG infrastructure poses great challenges (and not just in relation to safety and approval legislation). These should initially be overcome and implemented for the shipping sector (maritime and inland shipping). A national LNG infrastructure for the commercial vehicle sector should be postponed until empirical values have been gained from shipping, and then investigated in due course.

### Overview: use of electrical energy in long-distance freight transport

In the area of heavy-duty vehicles, the battery-powered electric drive is only a possibility for applications that do not require a high daily mileage, for example local authority vehicles or transport vehicles in ports. For long-distance road freight, electrical energy can be continuously supplied externally, as in rail transport. Because of the relatively high investments, the installation in this type of supply infrastructure would only make sense for those parts of the road network frequented by many vehicles with the potential for electrification. As a rule, this applies to heavily used sections of the motorway

network. The basic technical feasibility was verified on a test route as part of a government-supported research project. Issues relating to traffic safety, economic effectiveness, environmental impact and user acceptance are currently being investigated in detail. A qualified discussion on the possible introduction of the system can only take place once these investigations have been concluded.

Specific tasks:

- The German government will use the EU Commission's proposal on the "Clean-Power-for-Transport" initiative to discuss with those stakeholders affected an overall framework for solutions for the expansion of alternative fuel infrastructures in Europe, building on Germany's extensive preparatory work. Binding statements on standards and binding time-based targets, for example, should be approved here. The inclusion of LNG in freight transport will also be investigated in relation to this. In all respects, it will be necessary to make sure that this infrastructure can be operated profitably. A key element of such a development is an agreement on the economic parameters and the financing instruments and business models required for these.
- The infrastructure development for alternative fuels should also be anchored as an element in general infrastructure planning (keyword: trans-European networks).
- Investigation into the expansion of the natural gas infrastructure (for proposals see chapter "Gaseous fuels").
- Check uniform price display (for example by litre equivalent) for all fuel options at fuelling stations. This would make consumers more familiar with alternative fuels, increase acceptance of alternatives, make the different options comparable and promote competition.
- Check signage on motorways for fuelling options for alternative fuels (including charging and hydrogen infrastructure).
- "LNG action plan": develop joint LNG infrastructure programme for shipping (maritime stakeholders, energy and port industry and public sector). Reasons: harmonise safety standards and approval procedures; communication strategy for public acceptance; enable plannable investment decisions.
- Active national role in European initiatives. Build up infrastructure alliances with EU neighbours (relates in particular to the standardisation of the charging infrastructure, as well as natural gas and hydrogen for road transport, LNG infrastructure for shipping or supply issues for the possible production and use of biokerosene).

### 3.1.4 Mobility and logistics concepts as a contribution to energy efficiency and climate protection

#### Initial situation

In the first instance, the MFS is an initial concrete contribution by the transport sector towards achieving the targets set in the German government's Energy Concept for the transport sector. For the future, the issues focused on here should be integrated in a holistic, overarching mobility strategy and the goals and indicators of the national sustainability strategy should be taken into account and, if necessary, developed further. This should focus in particular on mobility and logistics concept issues as a contribution to energy efficiency and climate protection in transport.

The individual mobility requirements of citizens and the freight transport industry can be met with the help of different mobility and logistics concepts. The German government's aim is to enable mobility and support sustainable mobility and logistics concepts for passenger and freight transport by establishing suitable framework conditions. If this objective is to be achieved, more freight transport must be transferred to rail and waterways in order to relieve the pressure on the roads. Through transferring activity to rail and waterways, combined transport (CT) relieves the pressure on the road network and helps reduce emissions. The government is therefore supporting the building of new and the upgrading and expansion of existing terminal infrastructure based on the "directive on subsidising terminal Infrastructure for combined transport for of non-federal companies". Through CT, around 18.1 billion tonne-kilometres will be transferred and 1.2 million tonnes of CO<sub>2</sub> saved (baseline = 2008).

#### Contribution of mobility concepts to greater efficiency in transport

For decades, public passenger transport has been making a significant contribution to environmental and climate protection in the transport sector thanks to its efficiency and therefore relatively low CO<sub>2</sub> emissions per person-kilometre. Buses and trains are energy-efficient and already use renewable energies. More than 28 million passengers use short-distance public transport services daily and therefore spare society and the environment around 18 million car journeys per day. The already environmentally friendly short-distance public transport services offer considerable further potential with regard to air pollutants and noise as well as climate protection, since further improvements can be made in efficiency, for example through hybridisation concepts. This is one of the keys to the climate-compatible, environmentally friendly urban transport of the future.

Electricity has been used in short-distance public transport as a matter of course for more than 130 years: trams, underground trains, suburban trains and in some cases trolleybuses have been travelling through our cities for decades without emitting pollutants in these densely populated areas. Short-distance public transport also offers numerous advantages over private motor vehicle transport in terms of space requirements. Figures from the VDV (Verband Deutscher Verkehrsunternehmen, Association of German Transport Companies) document the importance of electricity in public transport:

- In Germany, 86 percent of rail passenger transport services are electric.
- 60 percent of public passenger transport services are provided by electric underground trains, suburban trains and trolleybuses.

In the future, new mobility concepts and offers will increasingly affect traditional transport behaviour. The overall services on offer will play a significant role, but another important factor will be the linking up of various offers, making it possible to exploit the advantages of the individual means of transport. The progress achieved in recent years in information and communication technology will be a key element in this development. This technology will enable providers on the mobility market to develop new offers, for example flexible car-sharing solutions that are not tied to stations, which customers can use easily and intuitively with mobile devices.

In recent years, a number of new offers have emerged – largely without state influence – in the area of car-sharing, which follow the trend of “use, not ownership” for the car. There are two different types of car-sharing service: the traditional, station-bound car-sharing systems, and the more recent “free-floating car-sharing” systems, which permit spontaneous one-way leasing in restricted geographical areas.

New kinds of bicycle transport services have also emerged in the recent past. In European cities such as Paris, Barcelona or London, a trend can be seen towards station-based, public bicycle rental systems, which have now also arrived in Germany (examples include the model initiative “Innovative public bicycle rental systems” in several towns and regions, in which the linking of the bicycle rental systems with short-distance public transport services is a central element; or the “StadtRad Hamburg” [city bike Hamburg] bicycle rental system).

In addition to the individual innovative transport services on offer, focus has shifted to the intermodal linking of modes of transports. The user-friendliness of this has increased hugely, driven by the advances in information and communication technology and the resulting networking. This linking opens up far-reaching options for increasing the attractiveness of public passenger services, in particular. Going the “last mile” with short-distance public transport services or the last section of the route with long-distance transport is often difficult and time-consuming. Here, systems that offer the short-term and flexible use of a bike or car are a way of effectively supplementing the existing public transport system.

#### **Contribution of logistics concepts to greater efficiency in transport**

For freight transport, additional though moderate growth is expected in Germany overall. The logistics concepts applied by industry, trade and the transport industry are relevant for the truck mileage resulting from this increase in traffic activity.

The following elements are primarily responsible for the further optimisation of transport logistics processes:

- Improvement in the capacity utilisation of vehicles through improved bundling of shipments and individual orders – optimised transport logistics processes;
- Reduction in empty trips;
- Use of telematic systems to control and monitor freight transport;
- Where appropriate, journeys should be transferred from road to rail or inland shipping.

The market structure is changing as a result of new demands placed on transport logistics. This includes for example stronger growth for the large logistics service providers compared to the mostly mid-sized haulage companies as a result of the globalisation of supplier relations in trade and industry and also the continuing trend towards smaller shipments caused by online trading. Logistics companies that operate on a trans-regional level and offer additional services can benefit from the growth opportunities of contract logistics.

### Laden and empty truck trips

Year	2003	2004	2005	2006	2007	2008	2009	2010
Laden trips (mill. km)	19,422	20,314	20,576	21,620	22,466	22,785	21,097	21,333
Empty trips (mill. km)	5,791	5,642	5,339	5,541	5,708	5,852	5,496	5,527
Proportion of laden trips (%)	77.0	78.3	79.4	79.6	79.7	79.6	79.3	79.4

Figure 6: Laden and empty trips by German trucks in million kilometres from 2003 to 2010. (Source: Federal Motor Transport Authority)

In the past, a trend emerged here that has, however, not continued since the introduction of the toll on lorries on 1 January 2005. It is necessary to bear in mind that the proportion of empty trips will not fall below a certain threshold. The following factors must be taken into consideration as the reasons for this:

- Journeys with special equipment, such as tankers, silo trucks and dump truck (building site traffic), for example, can in most cases only be carried out with alternating laden and empty trips, as the transport container must not be filled with another load that could be transported in the opposite direction.
- Within areas of high population, industrial production is being replaced by services. The daily supply of goods to the people living there means laden incoming lorries, but there are too few loads for the return journey, resulting in empty trips.
- Most laden trips will be followed by an empty trip, because it is usually not possible to load a vehicle again immediately and at the place where goods were just delivered. However, these empty trips usually last just a few kilometres.

### Boosting rail and inland shipping to relieve pressure on the roads

Improvements to the interfaces between land-based modes of transport make it possible to fully exploit the strengths of the respective modes of transport in national and European freight transport. The more easily forwarders and logistics services providers can access intermodal service offerings, the easier it is for stakeholders to organise competitive transport chains. As a result, freight traffic can be taken off the roads. If more transport is moved to rail and inland waterways are used, fewer air pollutants and greenhouse gases are emitted, while energy efficiency remains at the same high level.

## Opportunities and constraints

### Uncertainty regarding trends in individual mobility behaviour

At the moment, there are no comprehensive empirical values regarding the new mobility concepts in passenger transport described above. We are not yet sufficiently aware of the transport-related and geographical effects, in particular, and thus the environmental impact. The first comprehensive evaluation projects that look beyond specific individual cases have only just begun. Thus it is still unclear what impact car-sharing systems will have on the choice of a means of transport. Opposing effects can be expected here: on the one hand, a reduction can be expected in the proportion of private individuals owning cars, in particular in high-population areas, because private ownership appears less necessary due to use-dependent, flexible access to cars. On the other hand, the higher location-independent and spontaneous availability could lead to an increase in traffic and could compete with public transport.

So far, most of the new mobility concepts have emerged in urban areas, because of the higher population density there, and they have hardly played any role in less densely populated areas. It is likely that private motor vehicle transport will continue to dominate the transport situation for many journey purposes and distances over the long term.

### Action areas

- The German government will continually provide citizens with information about different services on offer and involve them in the discussions about suitable strategies and the derived instruments by means of suitable participation processes.
- In the coming decades, public transport will continue to be an important pillar in maintaining the mobility of broad sections of the population. Ensuring the financial basis for this is therefore of central importance. The powers for this lie primarily with the federal states. Within the framework of the constitutional rulings, the German government is striving for mutual understanding with the federal states regarding the future form that regionalisation funding will take. This also applies to the question of which compensatory measures (in accordance with the demerger act),

which have up to now been earmarked among other things for investments in the area of local authority transport financing, are appropriate and necessary for the period from 2014 to 2019 so that the federal states can fulfil their tasks. With their responsibility for short-distance public transport, the role of the federal states and local authorities will be instrumental in achieving energy and climate policy targets in the sphere of transport.

- In the future, the German government will continue to support the new mobility solutions within the framework of the available budget and with a variety of instruments (regulatory law, funding programmes etc.) with the aim of ensuring a broad, sustainable and affordable transport offering. Important goals of transport policy include the capability of mobility solutions to be integrated in the overall transport system and viable concepts that can also safeguard mobility in rural areas.
- In the short term, developments in transport in cities will primarily depend on how the cities deal with the road space: national urban development policy must therefore look more intensively at the transport-related use of public space. The allocation of space in the city must also be seen as an important means of controlling the modal split.
- The German government is committed to implementing and further developing the freight transport and logistics action plan. Important topics for its further development are already under discussion. Numerous measures of the action plan are helping to improve the environmental balance of freight transport.
- Support for the current trend towards “green logistics” should continue. Together with industry associations, a protected label can be created, using recognised calculation bases (EN 16258, Green Freight Europe Agreement), which is awarded after a certification process, to give customers and consumers an idea of which products or transport services can be classified as energy-efficient or environmentally sound, similar to the labels for vehicles and technical devices.
- The German government believes commercial car, truck and bus fleets are key initiators for the market introduction and implementation of new drives and fuels.



## 3.2 Modes of transport – drives

### 3.2.1 Road transport

#### Initial situation

In recent years, road traffic in Germany has undergone a rapid development as a result of increasing motorisation. On 1 January 2013, 52.4 million vehicles were registered in Germany. The number of passenger cars increased 1.3 percent on the previous year to 43.4 million vehicles. The average age of the car rose again from 8.5 to 8.7 years.

Worldwide, the trend of rising passenger car numbers will continue, particularly as a result of developments in newly industrialising countries.

#### Passenger transport

In road-based passenger transport in Germany, traffic activity rose from 899 billion person-kilometres to 968 billion person-kilometres between 1994 and 2008, an increase of eight percent. In 2008, around 87 percent of all transport took place on the road – 92 percent of this in private motor vehicles, eight percent in public road transport. Private motor vehicle transport therefore still plays a dominant role as the main means of transporting people. Since the start of the new millennium, however, the proportion of private motor vehicle transport has fallen slightly from 82.0 percent (1999) to 79.9 percent (2008) of overall passenger transport (see BMVBS 2011). Particularly in high-population areas, the drop in car use among younger age groups is countered by an increasing use of private motor vehicles in older age groups.

#### Short-distance public transport (land transport)

Around 28 million passengers daily travel by bus and train in Germany. The number of passengers is increasing. Short-distance public transport plays an important role in energy policy: not only does it have a lower impact on the environment, the transport offering is relevant for all population groups, including commuters, and provides a powerful infrastructure for Germany as an economic location. Bus transport currently almost exclusively uses diesel. Natural gas and hybrid applications and, in particular, the electrification of the bus drive system through battery and fuel cell solutions point to the future potential of low-emission urban mobility.

#### Road freight transport

In recent decades, road freight transport in Germany has continuously increased due to greater economic power and more extensive global trade integration. From 1994 to 2011, road freight transport rose from 273 billion tonne-kilometres to 469 billion tonne-kilometres, an increase of 72 percent. In this period, road freight transport rose from 64.5 to 71.8 percent of total freight transport. While efficiency has been increased for example through optimised round trips or new delivery concepts with greater pooling effects,

these have not been able to compensate for the increase in freight traffic and longer distances. Cross-enterprise cooperations such as city logistics concepts or cooperative trans-shipment transports are starting points for making supply streams more efficient. However, establishing them often entails permanent organisational effort, which has led to the failure of numerous projects in the past. Nevertheless, new opportunities for city logistics concepts can be developed by imposing vehicle entry restrictions, introducing environmental regulations and using new drive technologies.

#### Final energy consumption

The greatest proportion of energy is consumed in road transport, 82 percent of the energy required for transport as a whole. Since about the start of the new millennium, fuel consumption in road transport has fallen slightly. However, consumption has developed differently in passenger and freight transport. While fuel consumption in passenger transport fell by 7.0 percent from 1993 to 2008 as a result of a reduced specific fuel consumption, higher fuel prices and an invigorated public transport system, consumption in freight transport rose by 30.1 percent in the same period due to a rise in transport volume.

#### Fuel consumption and CO<sub>2</sub> emissions

In recent years, the CO<sub>2</sub> emissions of new car fleets in Germany have fallen continuously thanks to the efforts of vehicle manufacturers and their suppliers, and stood at an average of 141.8 grams/kilometres in 2012. This converts into fuel consumption of around 5.98 litres/100 kilometres (petrol).

### Opportunities and constraints

#### Diversification of energy sources in road transport

The differentiation of fuels on offer and of the drive technologies in road transport involves uncertainties for consumers and the industry. Vehicles with an alternative drive have been stagnating at a low level for years. Because of the challenges facing energy policy, for reasons of environmental protection and in the interests of ensuring its competitiveness, the industry is called upon to pursue and develop a number of different technology concepts. In some cases, this is associated with high investments in research and development. It seems likely that the variety will increase. The long-term trend for passenger cars is clearly towards the electrification of the drive-train. However, overcoming the barriers to market entry will remain the major challenge.

#### CO<sub>2</sub> fleet targets

For both passenger cars and light-duty vehicles (LDV), further efforts must be undertaken to help achieve the ambitious energy and cross-sector greenhouse gas reduction targets. The German automotive industry is well on its way towards achieving the applicable CO<sub>2</sub> emission targets of an average of 130 grams of CO<sub>2</sub> per kilometre for new cars and 175 grams of CO<sub>2</sub> per kilometre for new LDVs. The further optimisation of the combustion

## Development of new registrations with alternative drives

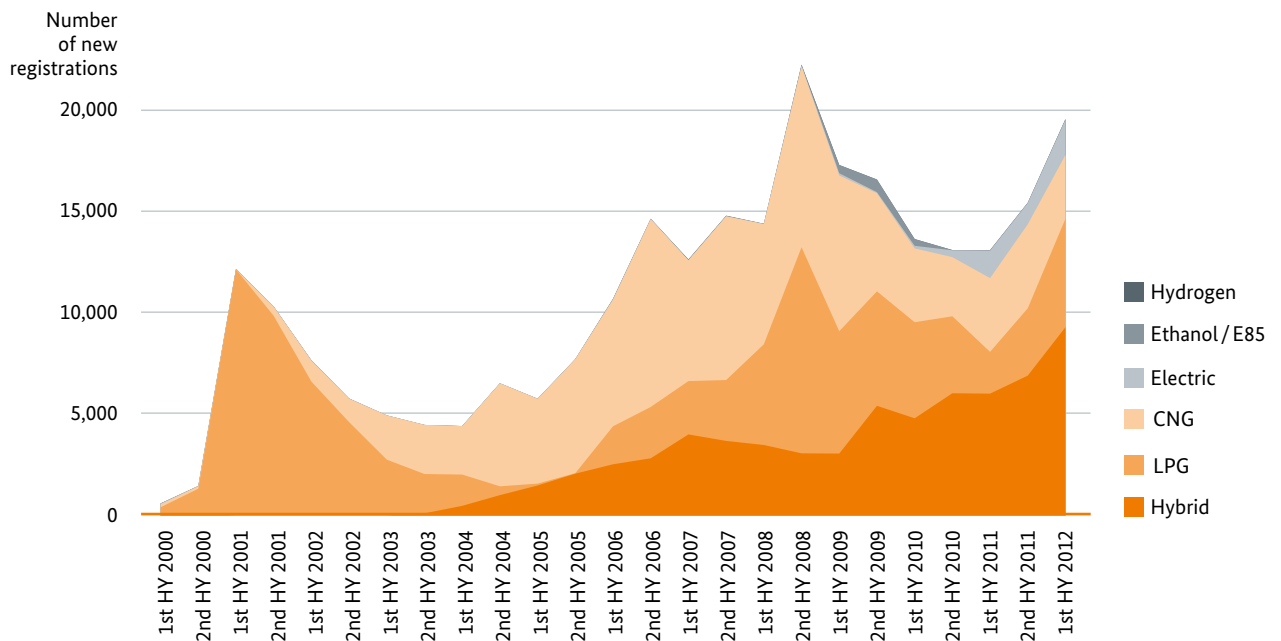


Figure 7: Development of new registrations of vehicles with alternative drives in the period 1st half year of 2000 to 1st half year of 2012. Graph from the German Energy Agency dena (2012) based on data from Adam Opel AG and the Federal Motor Transport Authority.

engine, downsizing measures, new vehicle designs and light-duty design concepts and innovative vehicle and drive technologies are playing a decisive role here. The CO<sub>2</sub> emissions of new German vehicles are already constantly falling. The CO<sub>2</sub> target for new cars in 2020 (95 grams of CO<sub>2</sub> per kilometre) – which is also supported by sections of the industry – can be achieved if the framework conditions are suitable and through appropriate efficiency measures, hybrid vehicles and the greater use of zero-emissions vehicles (electrification of vehicles with battery and fuel cell).

In public passenger transport, bus fleets have slowly started to be redesigned in recent years with the advent of hybridisation. Several manufacturers now offer series-ready vehicles. As yet, it is unclear how quickly and to what extent greater electrification of the bus fleets will be possible. Here, we must await the results of current demonstration initiatives, for example for electric buses.

After 2020, the ambitious CO<sub>2</sub> reduction pathway for cars and LDVs will be sustained. Ambitious CO<sub>2</sub> targets, coupled with energy efficiency improvements on the vehicle, can also benefit the consumer with regard to fuel savings and fuel costs, if the higher acquisition price for a low-emission vehicle is amortised over time. The electrification of the drivetrain will also have a positive impact on pollutant reduction and – at low speeds – lead to qualitative improvements in noise pollution.

### Efficiency potential of the passenger car

In the future, the passenger car will become an “energy saver” in the transport system, particularly because of the technical (efficiency) options that are available. Improvements to the engine and emission control (particle filter, SCR systems) will further reduce the air pollution from diesel cars. Downsizing concepts, lightweight design and alternative fuel options (for example natural gas in conjunction with biomethane), and in particular the technical option of electrifying the drivetrain and thus using renewable electricity, can lead to great gains in efficiency and a paradigm shift in car mobility in the long term. The goal is substantial decarbonisation in car transport through battery and fuel cell technology and the use of renewable energy resources.

### Efficiency potential of the truck

Following a long phase of development and optimisation, the conventional diesel engine in a truck is already very efficient. Here too, though, efficiency improvements can be made. At the moment, particular attention is being paid to measures relating to the efficiency of the drivetrain, vehicle body, weight reduction, aerodynamics and the interplay between the individual vehicle components. The large German manufacturers are also preparing hybridisation concepts for heavy-duty vehicles, which promise the biggest potential savings over the medium term. However, there is reason to fear that gains in truck efficiency will be cancelled out by a further increase in truck traffic.

Alternative fuel options and / or innovative drive technologies (keyword: electrification) will not be available in the short and medium term, or only to a limited degree. For the time being, diesel will remain the dominant fuel.

For heavy trucks (7.5 t and over), biofuels with a high energy density in the blend and the use of natural gas in compressed or liquid form (keyword: LNG) will in practice be available in the long term as alternatives to diesel. Dual-fuel vehicles (combination of diesel and natural gas or liquified petroleum gas) are another option, particularly for the transition phase. Slightly lower levels of pollutant emissions and greenhouse gases than those from purely diesel vehicles can thus be achieved with more or less identical engine efficiency.

### Action areas

The European CO<sub>2</sub> targets are the key instrument for the efficiency pathway for the passenger car and light-duty vehicle. The German government will therefore work to ensure that framework conditions exist, including for the period after 2020, that enable CO<sub>2</sub> emissions to be reduced further and keep the automotive industry globally competitive. This includes systematically developing the CO<sub>2</sub> targets after 2020. These framework conditions can make a significant contribution to conserving energy in road transport and achieving technological advances. At the same time, the competitive opportunities for German industry on the global markets must be safeguarded. Low-emission vehicles with new technologies offer particular opportunities here.

The market introduction and market penetration of innovative vehicle technologies will undoubtedly require patience and will not gain ground until the coming decade. The complete renewal of an existing vehicle fleet takes more than 10 years. Here, it is necessary for industry, government and science to jointly establish the right framework to help these future technologies break through.

Further gains in efficiency and thus successes in reducing CO<sub>2</sub> in road transport will emerge through to 2020 as a result of the legal specifications for passenger cars and LDVs, and must then be upheld for the period after 2020. Specifications must also be set here for heavy-duty vehicles.

New types of drive technology, for example vehicle electrification or fuel cell technology, are only a realistic alternative to the diesel motor in the longer term. Nevertheless, it would be unwise to shelve development of these technologies, particularly as light-duty vehicles are already able to achieve additional energy gains through electrification (hybrid technology). The commercial vehicle sector can benefit from the lessons learned from developing the technology for the passenger car. These synergies should also be exploited more fully in the application-oriented research and development programmes for electromobility and hydrogen/fuel cell. The expansion of the fuel base for trucks from diesel to alternative fuels, in particular the gas drive, should be systematically addressed as a new pillar of the programme (technical prerequisites and rulings, logistics/supply infrastructure, European dimension). Dual-fuel vehicles (combination of diesel and natural gas or liquified petroleum gas) are an additional fuel option.

The use of biodiesel with the current B7 blend must be discussed in connection with more general issues relating to bioenergy and the use of biofuels. A biodiesel strategy, for example the introduction of a special truck B30 fuel pathway, is currently not a feasible option because of the technical challenges.

Short-distance public transport services on road and rail are important drivers for technical and organisational innovations and a “backbone” for reducing energy and greenhouse gas emissions for transport. New technologies will find particularly good framework conditions here for rapid testing. Starting with the use of hybrid buses, which are already deployed in regular services in many local authorities with improvements in efficiency of up to 20 percent, electric buses are likely to already be in use in the medium term. Battery-powered and fuel cell buses are already being tested today. As a result, the bus can become a pillar of sustainable and largely emission-free mobility in cities and urban areas. However, technical improvements and extensive trials are still needed here.

To enable these technologies to be introduced, the German government will systematically continue its support, which began with the programme for the market introduction of diesel hybrid buses as well as research and development projects.

Specific tasks for the passenger car:

- Analyse the effect and success of the current CO<sub>2</sub> fleet targets and ambitiously develop them in an EU context after 2020;
- Develop and promptly introduce a realistic type test;
- Formulate EU regulations to measure CO<sub>2</sub> emissions in the short term to more closely reflect reality and introduce the regulations for increasing the efficiency of air conditioning systems across Europe;
- Check the support measures based on efficiency criteria and develop these if necessary. The available CO<sub>2</sub> data basis must be taken into account accordingly here;
- Further implement the comprehensive public acquisition programme (government) for energy-efficient vehicles.

Specific tasks for the truck:

- Set up the “Zukunft Lkw” [truck future] innovation initiative. Focal points include possible development pathways for the truck with the aim of safeguarding energy sources over the long term through alternative fuels/innovative drives as a supplement to the diesel engine, as well as improved vehicle design (including analyses (technical/ economic/ infrastructure) for the use of CNG, LNG, dual fuels and long-term options for electrification/hydrogen).
- Support for development of the European strategy for commercial vehicles, including measurement procedures for the various commercial vehicle concepts and the legal definition of measures to increase the efficiency of the vehicles.
- Revenue-neutral toll spread favouring the low-emission, efficient and climate-friendly truck: it is necessary to check whether, in addition to the differentiation of the toll based on pollutant classes, the further development of which has been exhausted with the introduction of the EURO VI standards, a further CO<sub>2</sub>-based differentiation of the toll could provide incentives encouraging the acquisition of low-emission, energy-efficient vehicles. A check of this kind would need to be conducted after completion of the work for an EU methodology for measuring CO<sub>2</sub> in commercial vehicles. The current version of the Eurovignette Directive, however, does not allow for a CO<sub>2</sub>-dependent differentiation of the toll, so the EU directive would have to be amended.
- Continue to investigate “mega trucks” in terms of energy and environmental impact. In addition, the German government will provide constructive support for the proposal of the EU Commission on defining the maximum permitted dimensions for certain road vehicles, which deals in particular with the efficiency improvements achieved by aerodynamic designs.

Specific tasks for short-distance public transport/bus:

- Continuation of support for market introduction of hybrid buses and plug-in hybrid buses;
- Development of a strategy in the joint working group for alternative drives in road-based short-distance public transport;

- Look into the “electric bus” campaign after successful execution of the test runs. The aim is to develop challenges and conditions for the electrification of buses together with manufacturers, transport companies and local authorities (hybrid / fuel cell options);
- Investigate tender modalities for the acquisition of efficient buses.

### 3.2.2 Air transport

#### Initial situation

Globally, air traffic is the mode of transport with the strongest growth, and competition is international to a particularly high degree. Growth rates in traffic activity of five percent per year are forecast globally for the next two decades. However, this increase, which is welcome from an economic point of view, will mean a significant rise in absolute CO<sub>2</sub> emissions can also be expected in air transport.

Considerable technical optimisation has already been achieved in air transport. As a result, the specific fuel consumption per passenger and 100 kilometres has been reduced by 37 percent since 1990. The fall per year is around one to two percent. Further improvements can currently be expected through the selection and enhancement of materials, the geometry of both the components and the aircraft as a whole, the enhancement of drive units (optimised noise properties and efficiency) and optimisation of flight operations themselves.

The A320neo (neo: new engine option), for example, which Airbus will be supplying to airlines as of 2016, will significantly help to reduce energy consumption in air transport. Through the combination of the new wingtips (sharklets) and the new high-efficiency engines, fuel consumption of the neo models should be up to 15 percent lower than for the current A320 series. This would be equivalent to an annual reduction in CO<sub>2</sub> emissions of 3,600 tonnes per aircraft.

The targets and milestones for further technical development of European air transport are defined in particular in the “Flight Path 2050” policy paper developed jointly by the EU Commission and the aviation industry. According to this, CO<sub>2</sub> emissions should be reduced by 75 percent and NO<sub>x</sub> emissions by 90 percent by 2050 (baseline = 2000). This policy paper also provides the basis for the “Strategic Research and Innovation Agenda” in Europe, the aim of which is to draw up technological solutions for the entire system with aircraft, flight guidance and airports.

The aircraft operators affiliated in the umbrella organisation for airline companies, the International Air Transport Association (IATA), have also agreed to reduce specific fuel consumption by 1.5 percent per year up to 2020 and to halve the CO<sub>2</sub> emissions by 2050 compared to the 2005 value. The International Civil Aviation Organization (ICAO) also approved similar tasks in the 2010 Resolution A37-19 (two percent CO<sub>2</sub> reduction by 2050), which will be backed in a binding manner by the ICAO member states.

With final energy consumption of around 360 petajoules per year, air traffic makes up around 14 percent of the total transport sector (Germany, 2010). With regard to the required kerosene qualities, the biofuel alternatives are limited to hydroprocessed oils and fats (HVO / HEFA) over the short and medium term. EU-wide, the current capacity is approximately 43 petajoules per year. With a hypothetical switch to kerosene and if only German air

traffic were supplied, this would be about 11 percent of the aforementioned 360 petajoules per year. This means all the (suitable) biofuels currently produced in the European Union would correspond to 11 percent of the kerosene consumption by German air traffic.

### Alternative fuels

Biokerosene (as a “drop-in” fuel) is currently the only available fuel alternative for air transport and has already been successfully tested in aviation, in particular as a blend. The IATA has set its members the target of using 10 percent of the total required kerosene from alternative fuel sources by 2017. The German government will carefully monitor whether this target can be achieved.

### European emissions trading system (ETS)

Air transport has been included in the EU emissions trading system (ETS) since 2012.

Originally, the system was supposed to include all the aircraft operators taking off and landing in the European Union. However, because of opposition from important third countries and in view of the progress in the International Civil Aviation Organization (ICAO) in drawing up a global, market-based measure, the European Commission submitted a resolution proposal at the end of November 2012 according to which sanctions for airline companies from third countries relating to commitments from 2010, 2011 and 2012 would be suspended until the ICAO Assembly in 2013. If the ICAO Assembly does not amend the directive in the autumn of 2013, the commitments for 2013 and subsequent years will be enforced as originally planned.

### Air transport tax and kerosene tax

On 1 January 2011, mobility taxation was extended to cover air transport – taking account of the burden from emissions trading – in the area of passage through the imposition of an air transport tax. The air transport tax was expressly introduced as an alternative to the international taxation of kerosene in commercial air transport, which could not have been realistically implemented in the short or medium term.



## Opportunities and constraints

One challenge facing the climate and energy targets and the measures required for this in air transport is the very interwoven nature of the international market. The MFS can provide food for thought here with regard to developments and, in particular, initiatives at EU level. It would not be expedient to implement specific measures at German level only.

The achievement of CO<sub>2</sub> targets presents the aviation industry with huge challenges, despite the great success that has been achieved in reducing specific energy consumption. Discussions within the participation process revealed that these self-defined targets – CO<sub>2</sub>-neutral growth as of 2020 and a reduction in CO<sub>2</sub> emissions of 50 percent by 2050 compared to 2005 – are not safeguarded or based on tangible instruments. The gap between climate protection targets, energy targets and growth targets is still wide.

Measures relating to technology (efficiency increases), management (optimised flight planning) and infrastructures can be instrumental in achieving the targets. However, the significant proportion of the reduction in CO<sub>2</sub> cannot be achieved simply by introducing a global market-based instrument. For the foreseeable future, air transport will not be able to achieve sufficient reductions in its own sector. In this context, however, it is necessary to ascertain the extent to which sustainably produced, alternative fuels can help achieve a reduction over the medium and long term, be this in the form of biofuels (biokerosene) or new technologies (longer-term options such as electricity-to-kerosene or hydrogen). However, these are options that are currently very uncertain and involve economic and environmental risks (energy security of sustainable biomass, costs etc.).

The aviation industry, unlike other modes of transport, also requires fuels with a high energy density (bioethanol is out of the question, for example). The challenge for the aviation industry is to have kerosene-appropriate biomass raw materials that not only meet the sustainability requirements but also enable fuels to be produced that meet the strict fuel quality requirements in air transport.

Efficiency measures are extremely important for the industry: 33 percent of costs in air transport are generated by energy / fuel costs alone, and the trend is set to rise. The IATA is also aware that effective global mechanisms are needed if it is to meet its self-imposed targets. The timeframe for this is not open-ended. Without an effective market-based measure, the risk is high that climate-neutral air transport (including with regard to the longevity of the fleet) will have to be achieved in other sectors without compensation through emission reductions.

## Action areas

### Developments in air transport require foresight – and a flight plan to stay on course

The air transport sector is characterised by long development cycles and lifecycles. The process from development, approval, diffusion, and operation through to decommissioning of an aircraft generation takes about 50 years. In particular, the implementation of long-term technology targets (IATA) in the fleet takes many years. Additional options that go beyond technical efficiency improvements and the use of biokerosene must therefore be analysed and strategically integrated. For the seamless transition to new technology generations, an early definition of targets for 2050 and the definition of development increments (2040, 2030, 2020) is necessary so that new technology options are available in time. Regarding the question of the aircraft engine of the future, biomass from agricultural and forestry sources (in the form of “drop-in” fuels) will facilitate the transition to longer-term options such as algae fuel, electricity-to-kerosene and, looking forward, hydrogen.

Because of the current lack of alternative fuel options, the aviation industry is reclaiming the use of biofuels. However, a “biostrategy” for air transport is associated with great uncertainties and obstacles. Both the qualitative prerequisites for biokerosene fuel and the quantitative prerequisites (quantity availability) must be met. Because of the high technical requirements and the global or at least trans-regional supply requirements of the airports, air transport faces particular challenges in this respect. Good examples from practice and the air transport industry’s willingness to pay will determine whether sustainable supply concepts, for example the cultivation of special cultures on degraded land, can also be established to supply air transport. Targeted support for the first concepts of this type is recommended, for example through a “10,000 t biokerosene” programme (with sufficiently comprehensive sustainability and quality requirements along the entire supply chain).

Specific tasks:

- Development and implementation of a “national development plan for sustainable alternative aviation fuels” by the industry (“10,000 t biokerosene programme”); further optimisation of existing technologies and operational processes (SES / air traffic concepts);
- Commitment to the ETS-pushed introduction of an effective and binding market-based climate protection instrument at international level; use of income from EU-ETS for climate protection and energy efficiency, including in aviation;
- Investigation into and further development of aviation research (for example alternative fuels / technologies; procedural research);
- The German government will monitor and analyse the market for the production and use of algal biomass;
- Analysis of the technical and economic potential of electricity-to-liquid fuel as a “drop-in” option in the air transport sector.

## 3.2.3 Shipping

### Initial situation

#### Maritime shipping

The maritime transport of goods is the backbone of international trade and thus the global economy. In 2010, the volume of goods arriving at and departing from German ports alone was 1,742 billion tonne-kilometres, which is around four times the volume of freight transported by road.

The number of ships in the global trade fleet increased by around 70 percent between 1970 and 2001. Before the financial and economic crisis, the international trade in goods increased twice as much as global production as a result of processes and production that are increasingly based on a division of labour. Maritime traffic will continue to increase as a result of progressive globalisation and the division of labour in goods production and the growth in global trade.

In 2011, the volume of seaborne cargo handled at German ports was around 296 million tonnes. At around 82 percent, the majority of this was handled at Germany's five most important seaports, Hamburg (with a particularly high share of around 38 percent), Bremen / Bremerhaven, Wilhelmshaven, Rostock and Lübeck.

Seaborne cargo is in principle transported with a high level of energy efficiency. However, the large volume of goods transported usually over great distances means that maritime shipping consumes a high volume of fuel. In addition, the heavy oil still predominantly used today causes high specific emissions of carbon dioxide, nitrogen oxides, sulphur dioxide, particulate matter and heavy metals.

At the moment, the means of propulsion in maritime and inland shipping focuses on the combustion engine – and this will continue to be the case for the foreseeable future. With the current state of the art, the diesel engine is the most efficient technology for this purpose (not just for ship propulsion).

#### Overview: fuel costs

Each day, a container ship consumes up to 140 tonnes of maritime diesel. Fuel prices have become a significant cost factor for shipping companies. In recent years, the fuel costs in maritime shipping have increased enormously (2004: one tonne of bunker fuel cost around 150 US

dollars, 2012: one tonne around 660 US dollars). As a result of price pressures, shipping companies have already undertaken a large number of measures (for example reducing speed) to cut fuel consumption.

Possible technical measures to increase efficiency in maritime shipping relate to the drive units, the use of alternative energies, ship geometry and (operational) management (for example freight management, reduction in speed / slow steaming; energy management in auxiliary units, port approach rules, shore-side electricity supply, turbo-charging etc.). Many of these efficiency measures are already being implemented.

Liquefied natural gas (LNG) is regarded in general as a very promising alternative fuel in maritime and inland shipping. In theory, biofuels are also available as an alternative. However, potential quantities, competition for resources, storage stability and costs are arguments against their use in maritime shipping (see also chapter “Biofuels”).

The use of fuel cells is being tested not as a means of propulsion (with the exception of ferries) but as an efficiency measure and to cover the power required “on board” (see German website on fuel cells in maritime applications). With regard to the release of local air pollutants, the creation of energy by means of fuel cells is a notable improvement over the generation of electricity using the conventional fossil-based generators of today, and can therefore help keep the air in the ports clean.

#### **IMO as international regulator**

The International Maritime Organization (IMO) is responsible for regulating international maritime shipping. This organisation has now approved measures that should lead to improvements in energy efficiency and a reduction in pollutant emissions in the years to come:

- Introduction of an “Energy Efficiency Design Index” (EEDI), which since January 2013 has enabled the energy efficiency of new vessels to be calculated and compared per tonne-kilometre, creating incentives for energy-efficient ship-building.
- Gradual and region-dependent limiting of the sulphur content in marine fuel to 0.1 percent by 2015 in emission control areas (ECA) and to 0.5 percent in all other waters by 2020. The implementation of this ruling means that heavy oil will be out of the question as a fuel in the medium term, as without the use of approved equivalent alternatives (such as exhaust gas aftertreatment systems), this reduction can only be achieved with middle distillates (marine diesel, marine gasoil).

Furthermore, there are voluntary initiatives on the part of individual stakeholders around the world, for example the World Ports Climate Initiative (WPCI), an affiliation of various ports that aims to improve the environmental performance of shipping in ports and at sea. An Environmental Ship Index (ESI) has been created for this, which records vessels that are particularly environmentally friendly and grants them special conditions in the participating ports, for example for demurrage.

The current activities will help to improve energy efficiency and reduce maritime shipping's impact on the environment and climate. Because ships have a long life, however, efficiency improvements from new ships will take time to emerge.

These developments will herald the switch from heavy oil to diesel fuel / gasoil in maritime shipping. Over the medium term, LNG will also play an important role as a fuel alternative to oil. This will impact the international fuel markets and affect the prices for petroleum products.

### **Inland shipping**

In German inland shipping, the volume has grown only slightly in recent decades. The current freight volume transported by inland shipping of 96 billion tonne-kilometres (2008) has only risen slightly since 1994, while at the same time the amount of goods transported by inland shipping as a proportion of total freight transport has constantly fallen because of the reduction in the proportion of bulk goods: the share has fallen by a third, from 14.6 percent (in 1994) to 9.8 percent in 2008 (see BMVBS 2011 – Verkehr in Zahlen [transport in figures] 2009/2010). At the same time, the importance of container transport is growing within inland shipping. In 2010, the transport volume in this segment was 21.8 million tonnes, or almost 2.2 million TEU (see Federal Statistical Office periodical "Wirtschaft und Statistik" [economy and statistics], July 2011). This development has been encouraged through financial support from the government for the building and upgrading of private terminal infrastructure, has helped to shift traffic from roads to inland waterways and contributed to a reduction in emissions. In 2008, around 2.2 billion tonne-kilometres were switched as a result of combined transport, and more than 137,000 tonnes of greenhouse gas emissions saved (survey on the evaluation of the funding programme for terminal infrastructure for combined transport, March 2011).

### **Inland shipping is an energy-efficient mode of transport**

Inland shipping plays an important role in the transport of goods in Germany, in particular, making up 10 percent of total transport volume, as well as in the other countries bordering the Rhine. The traffic is distributed very differently: in Germany, 80 percent is on the Rhine (main network of around 5,100 kilometres) and its tributaries. In cargo handling, the Ruhr region, including tributaries, clearly dominates: at almost 13 million tonnes, by far the most goods are handled here.

The only fuel used in inland shipping (gasoil or diesel) has lower soot, sulphur and nitrogen emissions than the heavy oil commonly used in maritime shipping. There is very low potential for developing the drive technology of inland vessels.

### Example from practice:

LNG is also becoming a more interesting option for inland shipping: since the start of 2011 or thereabouts, the CCNR has been looking into developing conditions for the approval of LNG as a fuel for inland vessels. The first inland vessel powered by LNG was given the go-ahead to use LNG as a fuel in January 2012, and three

further projects with designs differing from the first vessel are under way, approval by the CCNR was also granted in 2012. All four vessels are new tankers from the Netherlands.

### The CCNR as international regulator for Rhine shipping

In its plenary session in the autumn of 2012, the Central Commission for the Navigation of the Rhine (CCNR) approved a strategy to reduce fuel consumption and greenhouse gas emissions for shipping on the Rhine. This strategy is based on a comprehensive report on fundamentals, which describes in detail the action areas for inland shipping.

This report discusses the objectives, as well as the basic strategies for reducing greenhouse gas emissions from traffic and the options of reducing fuel consumption and CO<sub>2</sub> emissions in inland shipping. It also looks at alternative fuels and sources of energy for inland shipping, as well as accompanying measures and the additional benefits of reducing greenhouse gas emissions. The CCNR's aim is to reduce greenhouse gas emissions by 60 percent by 2050, in accordance with the specifications of the European Union.

### Opportunities and constraints

The longevity / period of depreciation for vessels (around 30 years for maritime and coastal vessels, sometimes far more than 40 years for inland vessels; sources: IMO, CCNR) results in low replacement / modernisation rates. Efficiency improvements in new vessels therefore take effect in the medium and long term. In domestic shipping, the installation of energy-efficient engines is supported by the German government through the engine funding programme.

With rising crude oil prices and new statutory emission specifications, a further increase in operating costs can be expected in shipping. However, the comparative advantage over other modes of transport will remain.

With regard to the development of LNG supply in the area of shipping, the challenges are to provide and develop the supply and storage capacities for LNG both in the ports concerned and on board.

## Action areas

### Maritime shipping action area: international harmonisation of framework conditions

Regulatory instruments for climate and efficiency measures should if possible be coordinated on a global level. Particular attention should be paid here to ensuring the approval of binding emission reduction targets that are in line with the 2-degree target. With market-based measures (MBM), the IMO is counting on the indirect impact of market incentives. Germany will continue to work towards bringing this process to a positive conclusion. Emissions trading in shipping would be particularly effective from a German point of view, and a duty on fuels could be considered if this could lead to the same reduction targets. The advantages and disadvantages of this and other instruments are currently being discussed intensively in the IMO committees. The market-based measures can accelerate the development of high-efficiency technologies and create incentives for further innovations.

A long-term market introduction strategy for LNG as an alternative to heavy oil should be developed now, for example on the basis of regional pilot projects. Consumers' sense of safety must be given due consideration here. The development of a "manual" on gas handling in port operations, binding for Germany and Europe, could be useful here. This would ensure planning certainty and clarify responsibilities (for example in port operations). Binding standards for gaseous fuels (comparable with ISO 8217 for bunker oils) must be drawn up (use best practice examples from other European countries here). As a result of the amendment to the energy tax law on 1 January 2013, LNG will be sold tax-free to commercial shipping. It is also important here to avoid adverse effects, for example additional methane emissions (methane slip).

One other decisive factor for protecting air quality is the use of effective exhaust gas aftertreatment technologies in the first instance. Over the medium term, improvements can be achieved here by employing SCR and particle filters. The use of shore-side electricity, for container energy supply at the port among other things, necessitates a frequency conversion from mains electricity (50 hertz) to on-board electricity (60 hertz) and requires investments in the infrastructure. Fuel cells for emission-free on-board supply of electricity are a possible alternative, which should be promoted more intensively in the research and development programmes, particularly in view of the domestic creation of value in ship-building (for example within the national innovation programme for hydrogen and fuel cell technology (NIP)).

To increase the modernisation rate for vessels and implement new ship concepts (for example with hybrid or fuel cell drive for ferry operation), the existing funding programmes for (inland) shipping should be expanded and developed subject to the available budget (among other things the "low-emission diesel engines" funding programme).

### Inland shipping action area

Measures for inland shipping should primarily be geared towards optimising the transport processes on the existing waterways, on which future-relevant transport streams are also to be expected, and thus make these more efficient and economically competitive. The following are under discussion as promising measures here:

- Infrastructure: development of available capacities for larger and therefore more efficient vessels (in particular the elongation of locks) where the traffic requires this.
- Energy efficiency: new forms of vessel offer greater potential for reductions. Above all, though, improvements to logistics processes (avoidance of empty trips, creation of barge trains) offer the potential for savings here.
- Pollutant emissions: over the long term, the pollutant caps of the CCNR and European Union can lead to a reduction in emissions. Because of vessels' long life of several decades – between 10 and 50 years for ship engines, depending on the type and driving profile – fast reductions cannot be expected, however. Effective measures in the short term are the reintroduction of the engine replacement programme or the installation of emission control systems, which will however only be implemented if there is sufficient support or regulation.
- Fuels: as in maritime shipping, LNG is a promising fuel for inland shipping. Biofuels (including vegetable oil, biodiesel) may be of interest for selected areas. In the long term, hydrogen based on the existing renewable energy potentials could be used, possibly in the form of liquified hydrogen for large vessels, as well as with compressed gaseous hydrogen.

## 3.2.4 Rail transport

### Initial situation

The volume of rail transport fell between the 1950s and 1990s in Germany. However, the past 10 years or so have seen a reversal of this trend. In passenger transport in particular, but also in freight transport, rail transport is growing, both in terms of absolute volume and as a percentage compared to road transport.

### Passenger transport

The proportion of passenger transport (excluding non-motorised transport) covered by rail passenger transport rose from 6.6 to 7.5 percent between 1994 and 2008 while traffic volume as a whole rose only slightly and is currently almost stagnant. In 2011, rail traffic was around 85 billion person-kilometres, 58 percent of which was short-distance and 42 percent long-distance rail transport.

### Freight transport

While passenger transport has only experienced very slight growth rates in the past 20 years, freight transport has seen a strong growth in activity overall.



Rail freight transport is also experiencing growth. In 2008 – before the financial and economic crisis – 115.7 billion tonne-kilometres were handled by rail freight transport, which corresponds to a 64 percent increase since 1994 (by way of comparison 1994: 70.7 billion tonne-kilometres). As a result, the proportion of freight transported by rail rose from the low of 15.5 percent in 1999 to 17.6 percent in 2008.

#### Short-distance rail transport

There are no good statistics on the proportion of short-distance rail transport: the data is not available in aggregated form. The statistics are simply based on information from federal states and transport associations. Nevertheless, the available figures indicate that around two thirds of traffic is covered by short-distance services (including trams) (2010), so this area clearly dominates over long-distance transport.

#### Technical options / energy supply for rail transport

Although around 40 percent of the Deutsche Bahn AG (DB) network is not yet electrified, 92 percent of operating services of all locomotives were run with electric traction in 2011, and only eight percent with a diesel drive. As a result, Germany's rail transport has a very high degree of electrification, compared with the rest of Europe and, particularly, with the rest of the world. However, it should be noted that railway companies use diesel locomotives even on longer electrified routes.

At the moment, electrical power to run trains via the 7,754 kilometre traction power network is provided by DB Energie GmbH. While the frequency in the public grid is 50 hertz, the nominal frequency for rail is 16.7 hertz. The suburban train networks in Berlin and Hamburg, as well as underground trains, use direct current. Electricity from the public grid can therefore only be supplied using converters and transformers, which transform the electrical mains current to the rail frequency. More than 25,000 passenger and freight trains per day are supplied with traction current from the railway's own high-voltage network on an electrified rail network that is around 19,000 kilometres long.

The electric locomotives currently in service already offer a high level of performance. Further increases in efficiency are possible through greater recovery of braking energy, which can be achieved by modernising the traction vehicles and providing the appropriate equipment in new vehicles. To date, hybrid technology is hardly used in rail transport. This is of particular interest for the non-electrified routes. Research and demonstration projects are looking into the hybridisation of diesel traction and are also assessing battery (keyword: Battery Tender) and fuel cell technology (keyword: hydrogen locomotive) as other technology options for the future.

## Example: Deutsche Bahn AG

Targets or statements on the proportion of renewable energy and emissions (greenhouse gases and pollutants) are only available from Deutsche Bahn AG (DB). DB has set itself the target of increasing the proportion of renewable energies for traction current to 35 percent by 2020. DB is striving for completely CO<sub>2</sub>-free rail transport by 2050.

In 2011 the proportion of renewable energy was 21.8 percent, approximately the same as the average for electricity supply in Germany. The specific CO<sub>2</sub> emissions should be reduced by 20 percent across all fields of business by 2020, compared with 2006.

### Traction current mix 2011\* (figures in percent)

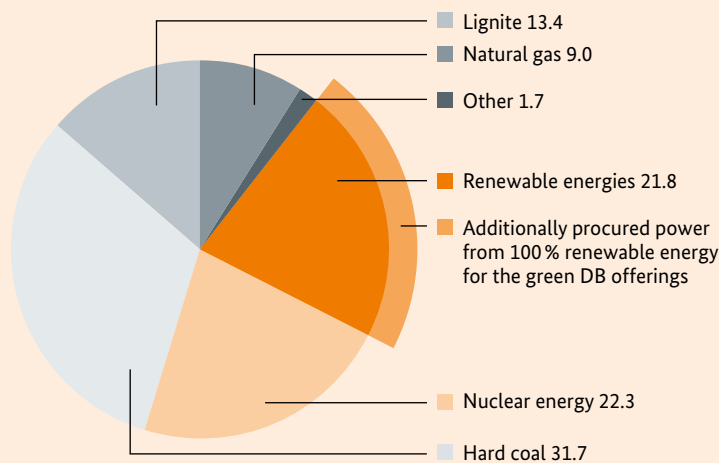


Figure 8: Key figures and facts on sustainability 2011. (Source: Deutsche Bahn, 2012)

\* provisional values with regard to final reporting in accordance with § 42 EnWG [energy economy act]

## Opportunities and constraints

Rail transport is essentially the traditional use case for electromobility. For rail as a mode of transport, the use of electricity, increasingly from renewable resources as a result of the Energiewende, means independence (for the most part) from oil and high specific energy efficiency as a result of the technology used. Consequently, rail transport can contribute to a reduction in greenhouse gases for the transport sector.

The expected development in rail transport activity depends to a high degree on the transport development scenarios on which various assumptions relating to socio-economic structure data, transport offering and the demand for transport are based.

The obstacles to a greater increase in rail traffic include the lack of development capacities in the rail infrastructure and high investment costs. Regarding development of the rail infrastructure, attention must be paid to the problem of increased noise and factors relating to operating procedures (for example higher requirements regarding flexibility (just in time), higher demand for smaller shipment sizes).

The problem of noise leads to problems of acceptance of rail transport among the general population. The main sources of rail noise are the sound of rolling wheels as well as engines, ventilators and other units. More extensive noise prevention measures lead to higher investment costs. It is therefore important to reduce the noise directly at source through quieter vehicles and braking systems.

## Action areas

### Standardisation

To increase the competitiveness of the rail system, the German rail sector needs functioning, stable and efficient stipulations and processes for the production and approval of new and converted railway vehicles, from tendering through to commissioning. A current “railway vehicles manual” aims to help clearly describe in detail the roles, obligations and responsibilities of the stakeholders.

### Energy

Rail is a key mode of transport in the Energiewende, as a switch to 100 percent renewable energy sources (electricity) is possible. Efficient driving and the recovery of electricity back to the network are further important elements. DB’s self-appointed targets are in tune with the German government’s efforts. Other railway companies should set themselves similarly ambitious targets.

In rail transport, the aim is to extend the proportion of renewable electricity to 100 percent by 2050, taking account of cost-efficiency; high investments by railway infrastructure companies are needed here with regard to long-term framework conditions that still have to be developed. In parallel over the short and medium term, all options that can help increase the energy efficiency of rail transport must be investigated (examples: the Eco Rail Innovation platform ERI and the ECORails EU project).

### Question: How can DB AG’s renewable energy target be achieved?

A Greenpeace study (arrhenius 2010) deals with the question of whether and how DB can cover its power requirements from renewable energies by as early as 2030. The study arrives at the conclusion that, to obtain all its power from renewable sources, DB would require an annual capacity of 500 megawatts from wind power.

By way of comparison: at the moment, around 27 gigawatts of wind power plants are installed, and further planning (average value from various studies) defines an increase to around 64 gigawatts by 2030. According to

expert opinion, if 80 percent or more of the traction current were obtained from wind power, synthetic methane (methanised hydrogen) would also need to be used as a temporary store. Consequently, DB could supply all energy from renewable sources through:

- An installed wind power capacity of 10 gigawatts
- A methane synthesis capacity of 2.5 gigawatt hours and
- A storage capacity of 2,000 gigawatt hours (thermal)

The question of whether the existing traction power network could also be used for the transport of electric current (keyword: network development), and if so under what conditions, must not be addressed on the basis of technical parameters alone. Risk estimates should also take account of requirements relating to economic efficiency and the impact on the preservation and operation of rail transport and the rail infrastructure. In all cases, a decision is dependent on the overarching developments and analyses on the need for additional power lines (also relevant: the role and capacity of other storage systems as well as regional electricity concepts) in Germany.

Specific tasks:

- Railway companies (DB and others) must adhere to their strategy and gradually increase the proportion of renewable energy in the traction power network (part of the corporate strategy, including timetables);
- Look into retaining the particular compensation scheme for rail in the amendment of the Renewable Energies Act;
- Look into systems of incentives for the use of energy-efficient vehicles as well as renewable energy and fuels;
- Use railway vehicles as power stations / push forward acquisition of vehicles in which energy can be recovered and ensure fair offsetting for recovered energy; systematic consideration of energy efficiency criteria in procurement (lifecycle costing (LCC));
- The rail industry should expand its innovation and research activities and if possible link them with similar research and development projects / programmes by the German government. The following should be investigated in this comprehensive research and development approach:
  - New mobility concepts that facilitate better intermodal transport;
  - How the use of alternative fuels in non-electrified railway vehicles can be achieved with comparable conditions for all modes of transport;
  - Improvement in the efficiency of existing technologies.
- Continue the national rail noise prevention programme and use it for a “rail innovation strategy”;
- Expand the mobility offering (road – rail / public transport), including (e-)car-sharing, bicycle hire, etc.

## 3.3 Sources of energy – fuels

### 3.3.1 Oil-based fossil fuels

#### Initial situation

According to the World Energy Outlook from the International Energy Agency (IEA 2012), a further rise in the demand for / production of oil can be expected worldwide up to 2035. This rise is due to the additional demand from the transport sector in newly industrialising countries. According to the IEA estimates, around 40 percent of this increased demand will be attributable to road traffic alone. This means that there will be a higher demand for diesel fuel, in particular.

Almost all the crude oil used in Germany is imported, with domestic production covering only around three percent of demand. The origin and transport routes for imported crude oil are well diversified. Germany has the highest processing capacities in Europe. Crude oil is processed in refineries to create various petroleum products (gases, petrols, middle distillates, heavy heating oil and feedstocks for the chemical industry).

#### Importance of petroleum for the transport sector

Petroleum, as a fossil, liquid source of energy, is the dominant source of energy in the transport sector. In the medium term, petroleum will remain the most important fuel option in the transport sector, though in some segments – for example passenger cars – its importance will decline gradually, albeit slowly. In the coming decades, oil-based fossil fuels will continue to prevail in the commercial vehicle sector as well as for aviation and shipping. Radical changes in technologies for fuels and drives are only expected here in the long term.

The oil-based fuels available at the moment on the German market are the petrol types Super (RON 95), Superplus (RON 98), diesel and LPG (liquified petroleum gas). In the petrol segment, there are also two types with a higher octane number and a premium diesel.

#### “Designer” fuels

More relevant further into the future are the (liquid) XTL “designer” fuels (GTL, gas-to-liquid, BTL, bio-mass-to-liquid, and in theory also CTL, coal-to-liquid). They offer a way of aligning engine development and fuel properties more closely with each other and thus achieving more efficient combustion. These fuels can be

used either as pure fuel or as a blend (via the currently established infrastructure).

The questions relating to greenhouse gas emissions and greenhouse gas balance must be clarified.

Gasoil and diesel are primarily used in inland shipping, heavy oil and maritime diesel in maritime shipping, and kerosene in air transport. Diesel is also used (to a small degree) in rail transport.

#### **Falling petroleum consumption in Germany**

According to a forecast from the Association of the German Petroleum Industry (MWV), Germany will see another clear drop in the sale of petroleum products up to 2025. Based on petroleum sales of 106 million tonnes in 2010, an initial fall of eight percent to 97.5 million tonnes is expected by 2020. After 2020, this reduction in sales will continue, falling by another five percent to 92 million tonnes by 2025.

As crude oil processing involves combined production, there is a limit to how far the proportion of petroleum products generated can be varied. There is already an incongruity between the demand for petroleum products in Germany and the structure of Germany's refinery output. This is balanced out by international petroleum trading with the export of "surplus" petrol fuels and the net import of medium distillates, which include diesel fuel and light heating oil. The extent to which this incongruity will grow in the future depends on how far domestic sales of light heating oils will fall and how far diesel fuels will be replaced by alternative fuels.

### **Opportunities and constraints**

#### **Energy security of petroleum**

Drive systems and suitable fuel supply infrastructures in the transport sector have been optimised over many decades through the use of refinery products (in particular petrol and diesel). This has had far-reaching effects on the shaping of settlement structures and the organisation of our everyday life. A change (keyword "away from oil") is a Herculean task that must not be rushed, but must be implemented incrementally and continuously.

The supply of affordable, high-quality fuels must be guaranteed. There are concerns that the number of refineries in Germany is continuing to fall and dependence on imported petroleum products is increasing. With regard to fuel types, the production of diesel fuel is regarded as a growing challenge in the future. Diesel sales in Germany and worldwide are increasing (keyword: dieselisation) while demand for petrol is simultaneously falling, with consequences for the economic efficiency of refinery processes. The switch from heavy oil to middle distillates in shipping will further exacerbate the general shortage of diesel and similar refinery products.

#### **Energiewende in transport – opportunity for regional value creation**

In 2012, Germany imported crude oil and natural gas worth a total of 90 billion euros. With a switch to renewable energies, particularly the rural regions of Germany and Europe can contribute to the supply of renewable fuel and thus add value in the country. In transport, there is high technical potential for this in wind and solar power in combination with electric drive systems.

### Example: German armed forces

The structural peculiarities of the various users are something else that must be borne in mind. For example, the German armed forces' task is particularly mission-oriented. They require material that ensures they can fulfil their task under very different regional and climatic conditions. Despite every openness to innovative approaches and climate protection, the need to ensure

mobility means the most simple and robust supply chain possible is required, in which even fuels of low quality is used – with the corresponding requirements this places on the drive units.

### Air quality

In Germany, high air pollution usually occurs close to roads in urban areas or in the vicinity of airports, seaports and large inland ports. The exhaust gas emissions from motor vehicles, in particular particulate matter (PM) and nitrogen oxides (NOx), play an important role here. The problem can be reduced through introduction of emissions standard Euro 6 for passenger cars and light-duty vehicles, and Euro VI for heavy-duty vehicles. Major technical challenges must be overcome here, in particular with regard to diesel engines, and costs are involved (for example inclusion of an additional AdBlue service fluid).

### Action areas

The introduction of new fuel types with a higher admixture of “conventional” biofuels is currently not foreseeable, particular in view of the technical quality requirements. There are biofuels (principle of “drop-in” fuels) that would allow higher admixture amounts because of their physical properties, though they are subject to the same sustainability requirements as all other biofuels.

### Sources of energy – relaunch of the fuels and drives matrix

The creation of a fuels and drives matrix has proved its worth as an important instrument for assessing the sustainability and cost efficiency of fuel supply pathways to the tank (Well-to-Tank – WtT) or wheel (Well-to-Wheel – WtW). This matrix can be used to depict and arrange technology and cost data clearly, which supports environmental evaluations and consensus-building processes. This enables a specific, transparent “traffic and energy scenario” to be developed that, in view of the dynamic changes, should be updated regularly. The Renewability project, for example, can be jointly developed as an analysis instrument and basis for work.

The fuels matrix should be embedded in an analysis landscape that can be used to answer important questions about the development of the infrastructure for alternative fuels, including their economic viability and environmental impact. Thus the focus of the matrix will gradually be adapted to include not only road traffic but also other modes of transport (shipping, air transport, rail), individual processes or drives.

In addition to transport-specific processes, the matrix also implicitly contains a number of stationary energy transformation processes or other technical processes, which are needed for an analysis of complete energy or value-added chains. The complex regulations on greenhouse gas balancing of biofuels in existing legal regulations should also be depicted.

The fuels and drives matrix has long been established as a tool, for example in the Transport Energy Strategy (VES, since 1998), the European harmonisation efforts for (alternative) fuels and drive systems for road transport (EU Joint Research Center, EUCAR, CONCAWE, since 2005) and many projects for the industry.

The purpose of the fuels and drives matrix is to provide a neutral data platform and the corresponding instruments to analyse technical feasibility, resource efficiency, sustainability and economic effectiveness of energy options for the transport sector. The accessible database will be set up by the end of 2013.

### 3.3.2 Gaseous fuels

#### Initial situation

88 percent of German natural gas consumption comes from imports. The most important countries of origin are Russia, Norway and the Netherlands. Around 12 percent of German consumption volume is supplied domestically.

Liquified petroleum gas (LPG – in chemical terms a mixture of propane and butane) and natural gas (CNG – chemically methane) are the most common alternative fuels worldwide. Both fuels are used in modified petrol engines. Series vehicles powered by natural gas have been available on the German market since the mid 90s. LPG has been used in the Netherlands, Italy and Poland for longer; in Germany, the volume has increased sharply in the past 10 years. Both drive concepts can be regarded as technically well-developed.

As a fuel, natural gas / biogas has the advantage of a higher anti-knock rating compared to petrol, but a lower energy density, which makes compression to around 200 bar in the vehicle necessary. In the case of LPG, on the other hand, only a low compression is required. As a result of this compression, the fuel can be stored in liquid form at a pressure of <10 bar.

#### Vehicles

In 2013, there are approximately 96,000 natural gas vehicles in Germany, around 20 percent of which are commercial vehicles. At 495,000, the



## Natural gas and biomethane

Natural gas supplies are estimated to last longer than crude oil, and the extraction areas are spread across more countries than those for petroleum. The effects of fracking technology must be analysed in detail here.

In 2010, natural gas and gaseous hydrocarbons made up around 0.4 percent in the transport sector, with a final energy consumption of around 10 petajoules per year (of this, around six percent biomethane within and outside the quota). Biomethane could be an important driver in developing CNG as well as power-to-gas and hydrogen in the transport sector.

More than 80 percent of the biogas plants currently in operation in Germany use renewable raw materials, which at the moment means primarily maize, vegetable and, to some extent, animal waste such as liquid manure. Only a few companies serve primarily the transport sector, with a current capacity of 60 megawatts or 130 megawatts in 2014 based on residues from bioethanol

production. Biogas from renewable raw materials is primarily used in the electricity and heat sector within the framework of the Renewable Energies Act. Because of the support framework (in particular the dual weighting), biomethane from residues and waste is primarily used in the transport sector. Offsetting (including subsequently as a result of transfer) against the biofuel quota is only possible in connection with a corresponding proof of sustainability. The Biofuels Sustainability Ordinance does not yet contain a standard value for biomethane from energy crops (a prompt extension to the list of standard values has been announced by the European Commission), so in this case, a separate calculation of the greenhouse gas balance should be carried out based on the method contained in the biofuel sustainability ordinance. In addition, since 2011 biomethane volumes produced from residues and waste count twice towards the fulfilment of the quota.

number of LPG vehicles was far higher, with 98 percent of these passenger cars. Most of these are upgraded petrol-driven cars. In the past three years, the number of LPG vehicles newly registered each year has fallen by 56 percent to below 5,000 vehicles. At the same time, upgrading has increased slightly, so the increase in LPG vehicles with a proportion of upgrading of 95 percent remained constant in 2011. For CNG, the picture is vague. Recently, the number of newly registered vehicles rose slightly (almost 6,300 vehicles in 2011). However, in past years, the number of new registrations fell overall. Because the number of decommissioned vehicles increase as gas-powered vehicles age, the total number grew only slowly.

### Climate protection

If greenhouse gas emissions from LPG and CNG are to be compared with those from diesel and petrol fuels, we need to look at the entire chain from the well to the tank (WtT) and from the tank to the wheel (TtW). This data is provided on page 66 for a current medium-sized passenger car.

The influence of the places of origin and the pathways is apparent for CNG and LPG. For the sources currently typical for Germany, namely CNG from natural gas and LPG largely from crude oil, CNG has the largest greenhouse gas reduction compared to petrol, at 15 percent, followed by diesel at 13 percent and LPG at nine percent. LPG is created as a by-product during

petroleum and natural gas supply and crude oil refining. LPG could potentially achieve a greenhouse gas balance comparable to CNG if it were obtained primarily from natural gas supply rather than from crude oil.

However, CNG vehicles can already be powered by biogas. As a result, the greenhouse gas emissions (in the case of biogas from residues and waste) can be significantly reduced compared to those of fossil fuels. In future, synthetic methane from thermochemical biomass gasification or electrolytic hydrogen with subsequent methanisation can further extend the portfolio of renewable sources for methane. On the other hand, it is necessary to determine whether the increased supply of natural gas from unconventional sources would result in higher specific greenhouse gas emissions. These developments should continue to be monitored.

At the moment, the majority of greenhouse gas emissions are released from the combustion of fuels in the engine. Natural gas has up to 20 percent lower CO<sub>2</sub> emissions per energy provided compared with petrol, whilst the emissions for LPG are around 10 percent lower. In addition, natural gas can be used in the engine more efficiently than liquid fuels. On the other hand, tank and engine are heavier. Thus the energy consumption of an optimised CNG car stands at around the same level as a petrol-driven car; the most efficient diesel vehicles currently have a slight advantage. Hybrid petrol cars are currently already available in larger numbers on the market and thus offer great efficiency benefits. At the moment, they generate the lowest greenhouse gas emissions.

### WtW greenhouse gas emissions – passenger car 2012

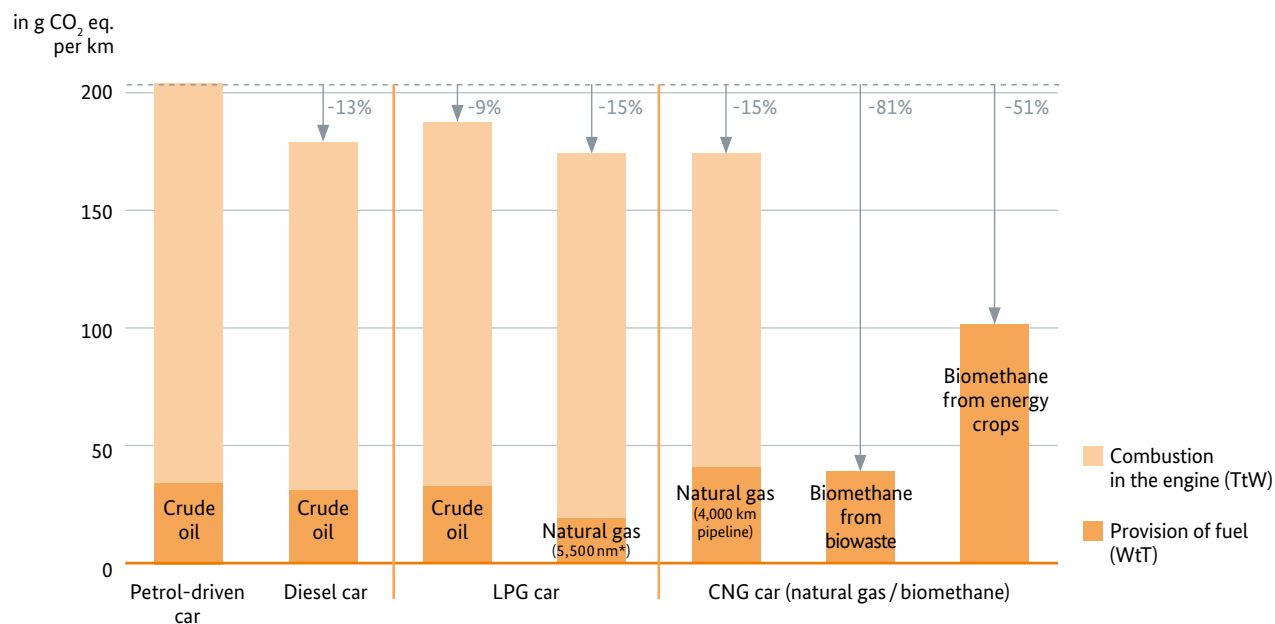


Figure 9: Example of WtW greenhouse gas emissions of a medium-sized passenger car from the German fleet in 2012 and typical pathways for fuel provision. (Source: own diagram BMVBS / ifeu) \*Explanation: LPG from natural gas transported by ship (corresponds to 10,186 km)

All drive improvements are offset by non-optimised upgraded vehicles, which are available above all on the market for LPG. For retrofitted vehicles in which the engine is not optimised for gas propulsion, some of the material advantage is lost, so in these cases, only low reductions in greenhouse gas emissions can be expected.

### Opportunities and constraints

For reasons relating to the environmental advantages, reduction in import dependencies and diversification of fuels, many countries are implementing measures to increase the use of gas fuels in the transport sector. The infrastructure developed for CNG is still seen to pave the way for the integration of renewable energies in the transport sector.

### Expansion of the range of models

The range of CNG vehicles on offer is currently relatively small. In April 2013, 15 CNG vehicle models could be ordered as new vehicles in Germany in the passenger car segment, and by 2014, this will increase to at least 22 models. Eight CNG models are available as light-duty vehicles up to 3.5 tonnes. Equipment options or selection options are not usually available. Most of the cars on offer are in the light-duty vehicle segment or are vans / high-roof estate cars or small / compact cars. As today's passenger car market is characterised by maximum possible individualisation based on numerous body and equipment options, the small range of gas-powered vehicles on offer is regarded as an obstacle to their further growth. In addition, the manufacturers' different pricing policies, as well as the different costs of the options depending on engine type and size, makes a cost comparison of the drive types difficult for buyers of new vehicles.

Neither the competitiveness with respect to total costs nor the upgrading options explain the slow development for gas-powered vehicle numbers. The available infrastructure and the vehicle offering, as well as user-friendliness and the level of information, are other areas in which action is required.

### Gas-powered trucks

The use of gaseous fuels is also an alternative for heavy-duty vehicles with a total permitted weight of more than 3.5 tonnes, and can be used as a transitional technology, prior to the use of pure natural gas, for example in liquid form as liquified natural gas (LNG), or purely electric drives. One problem with the pure use of gaseous fuels in commercial vehicles is that the distances that can be covered on a full tank are too low to make their use economically feasible for a company. It is therefore necessary to investigate the extent to which a combination of diesel and gaseous fuels (for example CNG) in a combustion engine can offer a solution that reduces emissions and the dependency on diesel while still retaining the high efficiency of the diesel engine.

### Air quality

CNG drives can be an environmentally friendly alternative to diesel, combining a better CO<sub>2</sub> balance with lower pollutant emissions. Urban bus fleets, local authority commercial vehicles or gas-powered fork-lift trucks used in warehouses are providing good practical experiences, for example. Additional costs for exhaust gas aftertreatment technology could therefore alternatively be invested in the acquisition and development of CNG drives. The optimised LPG engine produces just as few emissions as CNG and petrol, but is tending to replace the petrol engines that are already cleaner. In some cases, retrofitted LPG vehicles perform worse than their petrol-based predecessors with regard to NO<sub>x</sub> and PM emissions.

### Recommended actions

Concrete proposals for market participants:

Expand range of vehicles:

- Increase choice of vehicles: manufacturers / automotive industry;
- Communicate range of natural gas vehicles more intensively: automotive industry / dealers;
- Push forward use of commercial vehicles powered by natural gas, including in public passenger transport or for local authority tasks: manufacturers / local authorities.

Infrastructure:

- Increase number of natural gas fuelling stations from currently 900 to 1,300, or 10 percent of the German fuelling station network: energy industry;
- Where possible, include natural gas fuel pumps in highly frequented fuelling stations;
- Where necessary, further expand the fuel card systems for vehicle fleets.

Politicians should also look into the following aspects:

- Standardise natural gas / CNG labelling;
- Harmonise interface between fuelling stations and vehicle across the EU;
- Consider discounts for grid charges for natural gas as a fuel;
- Consider the additional weight of vehicles with alternative fuels / drive technologies in EU driving licence categories and EU weight policies.

Consumer information as a joint task for all stakeholders:

- Introduce standardised energy pricing to enable consumers to compare for example indication of fuel consumption and fuel prices by petrol equivalent or energy content;
- Check signage on motorways for fuelling options for alternative fuels;
- Integrate fuelling stations with alternative fuels in navigation systems (including filter function for example for CNG, LPG or hydrogen).

Fuel tax: see information in chapter 3.1.2.

### **Increase the proportion of biomethane / regeneratively produced methane**

Gas-powered vehicles have a particularly low greenhouse gas balance across the entire chain if biomethane from residues or waste, or regeneratively produced methane, is used.

- The German government welcomes the industry's target of increasing the proportion of renewable methane (in particular from residues and waste) in natural gas fuel in Germany to at least 20 percent on average by 2020. The legally defined funding measures provide a good framework for achieving this target.
- In view of this, it is necessary to determine whether measures should be taken to supplement the biomethane currently available with more biomethane produced abroad, and if so, what these measures should be.

### **3.3.3 Biogenic liquid fuels (including blends)**

#### **Initial situation**

At the moment, biofuels are undergoing a reevaluation in Europe and Germany, resulting in uncertainty with regard to future usage pathways and framework conditions. In addition, biofuels are struggling with problems of acceptance among the general public.

At the same time, the demand for biofuels is expected to rise in the medium term, in particular for modes of transport that do not have realistic fuel alternatives to diesel or kerosene. In this context, the aviation industry gives preference to biofuels.

The demand for biomass for use as material and energy is growing. The additional competition for biomass as fuel or food / feed must also be taken into account. Feeding the population takes priority over other biomass uses.

Overall, there is a global market for biomass. The effects of a higher demand for biomass should be investigated with an eye to developing countries. Trading with biomass only provides opportunities for developing countries and in the fight against poverty if ecologically and socially sustainable means of production are observed, food security is guaranteed and local added value and employment effects are incorporated.

#### **Use of biofuel in transport**

For reasons of energy supply and climate protection policy, and to support rural regions, the promotion of biofuels in the transport sector is a political decision (national / EU).

At the same time, it is clear (this was one of the main topics of discussion in the participation process) that it would be better to structure the framework conditions in Germany and the European Union in such a way as to enable the objectives (energy savings / climate protection) to be met.

Because of the current revaluation and realignment of the use of biofuels, basic considerations are outlined below and overarching action recommendations provided, the specific purpose of which is to provide a reliable basis for the use of sustainable biofuels in transportation.

#### Changes relating to biofuels

In recent years, changes have arisen in the area of biofuels that must be taken into consideration for the future use of these fuels. These changes include:

- Delays and setbacks in the development and deployment of technology for supplying substantial amounts of liquid biofuels, for example from lignocellulose (in particular from thermochemical provisioning procedures such as BtL fuels, innovative biorefinery concepts with biofuels as a product);
- Obstacles in the area of facility investments (biorefinery);
- Development of capacities for the provision of biomethane as a gaseous source of energy for the transport sector have been more rapid than expected (currently supply outweighs demand).

#### Action areas

Sustainable biofuels are one way of reducing greenhouse gas emissions in transport. Within the context of other options for energy efficiency and renewable alternatives, the roles biofuels play in the various transport sectors should primarily be dictated by the reduction in greenhouse gases that can be achieved in the future. The “Milestones 2030” project, which is supported by the German government, is important in relation to this. Initial results will be available in 2014.

On 17 October 2012, the European Commission submitted a proposal to change the Renewable Energy and Fuel Quality Directive. The aim is to avoid ILUC through the use of biofuels. The proposal is currently being negotiated in the Council and European Parliament in the codecision procedure. In Germany, the acceptance of biofuels among the population has also fallen sharply. This is due to concerns regarding environmental and climate damage and discussions about the competition between food and fuel, or about cropland. The German government therefore welcomes the submission of a regulation proposal that aims to avoid the negative effects from ILUC when the use of biofuels is increased. The European Commission’s proposal considers important aspects that have also been demanded by Germany in connection with indirect land use changes. The approach proposed by the Commission of setting an upper limit for the proportion of “conventional biofuels” is expressly supported by the German government.

#### Further development of the greenhouse gas quota

One important step towards climate protection is the system change from an energy-related biofuel quota to a greenhouse gas quota as of 2015 as the national implementation of the FQD (98/70/EC) via §§ 37a ff. BImSchG [Federal Immission Control Act].

The sustainability requirements placed on biofuels are laid down in the biofuel sustainability ordinance. Companies in the petroleum industry are obliged to meet this quota, either themselves or by means of a third party (quota trading). Fines are to be levied if the quotas are not met.

Decisions on further increasing the proportion of biofuels, taking account of the technical framework conditions for renewable energy targets in transport, should only be made when new biofuel options and sufficiently sustainable biomass sources have been established / tapped and the additional costs associated with this for the transport sector can thus be foreseen.

For the future, and with a view to the 2050 targets of the Energy Concept, an investigation is needed to determine the form in which the greenhouse gas quota applicable for biofuels as of 2015 could be continued. One possible discussion model would be an extension of the greenhouse gas quota to all renewable sources of energy / energy carriers and fuels, i. e. to electricity or hydrogen as well as renewable sources, in order to give the stakeholders the necessary direction and planning certainty. However, developments at European level must be taken into consideration when defining targets.

In view of biomass availability for the future use of biofuels, prioritising biokerosene is therefore something that should not be considered at the moment.

#### Advanced biofuels

In the past, it has been seen time and again that the expectations regarding the commercial feasibility of the production of advanced biofuels (“2nd or 3rd generation biofuels”) have had to be adapted to the existing challenges. In view of this, the establishment and development of capacities for producing sufficient quantities of future biofuel options (for example based on lignocellulose, bioethanol, BtL fuels with the focus on diesel and kerosene, biomethane via SNG, hydrogen or algae fuels) cannot be expected until after 2020. With a view to resource-efficient use, biorefinery concepts provide particularly promising starting points as part of a bioeconomy based on renewable raw materials, not least with regard to the greater flexibility between different products (for example biomethane / bioethanol as fuels and / or base chemicals). The challenges still to be overcome include successful demonstrations (currently still pending), the results of which need to be incorporated into the deployment of commercial series systems, plus the technical and economic risks for investors in these new technologies. In view of this, the German government will continue its involvement in research and development.

### 3.3.4 Electrical energy in transport

#### 3.3.4.1 Importance of electricity and electric drive systems for tomorrow's transport

At the moment, the transport sector is almost exclusively dependent on liquid fossil sources of energy, and currently has only very few interactions with the electricity sector. However, this situation will change in the future; interfaces between the various energy sectors will increase and become more closely linked with each other. One good example is the “Effizienzhaus Plus” [efficient house plus]: the energy generated by the house is made available to the heating circuit and can also be stored in suitable high-performance batteries, which in turn can be used to charge up an electric car.

The use of new energy sources is particularly viable for road transport. There are essentially two pathways for using electricity from renewable energy sources to a greater extent in the future for transport: electricity is either stored in a battery directly from the electricity grid, or it is converted to hydrogen through electrolysis in stationary plants. This hydrogen can then be used for a variety of transport applications.

The availability of electricity from renewable energy sources for the transport sector depends on progress being made in the switch to a generally more sustainable energy system.

The reorganisation of the energy supply with a high proportion of fluctuating infeed from wind and sun will also require new storage systems in the future to balance the energy offering through renewable energies against consumer demand. The battery systems in vehicles (a more short-term store with the option of recovery in the vehicle) and hydrogen (also commercial seasonal store; no option of recovery when used in a vehicle) may become important as storage technologies here in terms of energy policy. In addition, up to a certain percentage of hydrogen can also be added to natural gas and transported directly to end consumers via the natural gas grid (keyword: “Power-to-Gas”).

In principle, electric drive systems offer the potential for high energy efficiency, regardless of whether the electricity is taken from the grid and temporarily stored in batteries or is generated on board from the energy carriers, such as hydrogen, also carried on board.

In local terms, the running of an electric vehicle can be regarded as practically emission-free; neither greenhouse gases nor air pollutants are released. Another factor in road transport, at least at low speeds, is the reduction in noise emissions, as there are no engine noises typical of the combustion engine.

Current efforts relating to the use of electrical energy in road transport cover passenger cars and motorbikes, light-duty vehicles and urban buses. Electrical energy has already been in use in rail transport for many decades.



The market development for electric drive systems will take a long time. The gradual replacement of a system that has been perfected over decades, that is important from an industrial policy point of view and is familiar to consumers, that is based on crude-oil fuels and the combustion engine, requires endeavours to win over the population, as well as resoluteness, investments and patience on the part of those concerned. The stakeholders here have frequently called for (planning) certainty for the instruments (in particular with regard to support for research and development) and consistency with regard to the framework conditions.

#### Opportunities and constraints

The gradual diversification of energy sources in road transport to include electrical energy entails a technological paradigm shift that affects the vehicle, drive, energy source and required infrastructure.

The Energiewende in transport, and the targets associated with this, require a political and economic framework that facilitates the necessary decision-making for the establishment and development of electric drive systems, in particular in road transport, and the investments related to this. For the energy system, one decisive factor is that the effects of developments in the transport system are taken into consideration to a greater extent in the future.

#### 3.3.4.2 Battery-powered electric drive technologies

With its “Electromobility” programme, the German government has placed particular importance on battery-powered electric drives. Comprehensive measures for research, development and market preparation have been initiated and implemented, together with the stakeholders, on the NPE (“National Platform for Electromobility”). The specific technology support for this field, which is very important for the mobility of the future, is a key element for implementing the Energiewende in transport.

The market development for electric vehicles is taking shape. Numerous passenger cars and motorbikes with an electric drive are currently available on the market. German manufacturers have announced the market introduction of 15 vehicle models by 2014. It seems that the plug-in hybrid drive will be the dominant form of propulsion for externally chargeable vehicles in the coming years. Several vehicle manufacturers have announced they will be offering the plug-in hybrid drive as an option in numerous models.

#### Opportunities and constraints

The battery of an electric or plug-in hybrid vehicle can be charged from a normal socket. As 70 percent of passenger cars in Germany are parked on private property overnight, extensive charging opportunities already exist, since electric vehicles can as a rule be charged up easily from the 11 million plus single-family homes in Germany. As charging can take place overnight over a long period of time, the available electric installations are for the most part already sufficiently dimensioned. When it comes to operating costs, running a vehicle on electrical energy rather than fuel is less expensive for users.

Nor do the plug-in hybrid vehicles lead to any restrictions in use compared to conventional cars. One obstacle to rapid market introduction, however, is the high vehicle price. Targeted support for research and development could lead to further cost reductions here.

#### 3.3.4.3 Fuel cell technology

In fuel cell vehicles, the fuel (usually hydrogen) stored in a tank is converted into electrical energy (fuel cell electric vehicles, FCEV), which is fed to the electric motor or stored in the battery. To improve efficiency, fuel cell systems are usually designed as hybrid systems, meaning they are supplemented with a smaller battery.

Research and development efforts for fuel cell vehicles have had concrete success. Large automobile manufacturers have announced that the first series-produced car with fuel cells will be launched in the coming years (as of 2017). The relevant activities by government, science and industry are gathered together under the umbrella of the “national innovation programme for hydrogen and fuel cell technology” (NIP).

#### Opportunities and constraints

As hydrogen is a secondary energy carrier, there can be a relatively long period of time between its creation and use. This fact also makes hydrogen an interesting option for long-term storage. If hydrogen is used in compressed or liquified form in a car, distances of 400 kilometres and more are possible.

Development of the fuelling infrastructure is needed to ensure the widespread availability of hydrogen. Renowned companies have come together here to set up an industry initiative to analyse the conditions for developing the hydrogen infrastructure in Germany and define development concepts (“H<sub>2</sub> Mobility” initiative). The aim of this initiative is to create a network of around 1,000 hydrogen fuelling stations by 2030. The promotion of research and development is a prerequisite for achieving further cost reductions in the production and fuelling infrastructure and for the vehicles. On the way to the customer and the market, market introduction concepts and ideas are also decisive in positioning these vehicles as a competitive alternative to conventional cars.

## Action areas

- Cross-industry collaboration between industry and government, as characterised by the NPE and NIP, sets an example. The activities and the successes achieved here would therefore suggest that these initiatives should be continued and developed.
- The specific support for research and development in the field of battery-powered electric drives will be upheld whilst maintaining existing ministry responsibilities. Support for marketing activities for battery-powered electric vehicles and forms of mobility should be increased as a focal point of joint initiatives between government and industry.
- Together with science and industry, the German government will continue the innovation and research activities in the field of hydrogen and fuel cell technology in Germany and support this within the framework of the NIP. Particular attention will be paid to market activation here.
- To support market preparation and ensure competitiveness with other alternatives, the German government will investigate whether steps should be implemented to support the market introduction of hydrogen as a fuel used in fuel cell vehicles, and if so, what these steps should be.
- The German government will further stabilise its research activities in the field of energy stores in Germany and support corresponding measures by science and industry.



## 4. The MFS as a “learning strategy”

The fuels strategy in 2004 was a milestone project of the national sustainability strategy: it described the most important alternative fuel options at that time for passenger cars. However, the strategy’s focus on cars was too restricted, and it was not subsequently developed. As a result of these experiences, the MFS is taking account of all modes of transport, all drive concepts and all energy and fuel options.

Because of the long development cycles involved, it is necessary to take a longer-term view of the development of climate-friendly technologies, changes in transport and in mobility behaviour. In addition, not only the technologies but also the political framework conditions at national and international level will change in the decades to come.

There are several advantages to continuing the MFS as a “learning strategy”. The preliminary study for the MFS describes the need for a “learning strategy” that checks the assumptions made at the start, and the related strategy targets, and makes adjustments where necessary. As a result, not only will the implementation of its action recommendations be reviewed, future innovations and developments can also be taken into consideration. With a view to an action horizon that extends until 2050, the launch of a “learning strategy” is very much in the interests of a sustainable and forward-looking policy.

One key element in drafting the Mobility and Fuels Strategy was a comprehensive participation process (technical dialogue) throughout 2012, which brought together more than 300 stakeholders from industry, politics, science and society for a constructive exchange of views in a variety of events and technical forums. In the course of this technical dialogue, networks between the stakeholders were created that did not previously exist in that form. During the technical dialogue, this network has stabilised into a constructive culture of dialogue. The “learning structure” can make use of and expand on this.

The dialogue not only acted as an important instrument for jointly clarifying facts, it also revealed the opinions and positions of the parties involved. This ultimately resulted in a shared knowledge base, which can be updated within the framework of a “learning strategy” and is the basis for adapting action areas within the MFS to new requirements, for example:

- Picking up on new technological developments and scientific findings and adapting the framework conditions where necessary, while preserving the existing ministry responsibilities
- Different stakeholder constellations and different interests
- Leveraging the dynamism of the markets
- Identifying cross-cutting issues and integrating them compatibly with strategies from other ministries

#### Instruments for implementing the Energiewende in transport

Essentially, the MFS as a “learning strategy” of the German government should serve as an instrument for implementing the change to energy sources in the transport sector.

#### Flexibility not institutionalisation

The aim of the “learning” MFS is not to create new processes or structures. Rather, it seeks remain flexible so that existing committee work can be used, events relating to the MSF as a discussion platform for fuels and mobility topics can be included, or existing or expected communication opportunities can be exploited, for example. To achieve this aim, the details of the learning strategy, and its implementation, relate to three elements:

**Process:** even after conclusion of the technical dialogue, the MFS remains a process with numerous different stakeholders whose actions must be monitored, evaluated and coordinated. The participation of these stakeholders will continue to be needed, albeit in a framework other than the technical dialogue. This is particularly true with regard to coordination and the joint exchange of information with the ministries responsible for the topics, and with the representatives of the federal states.

**Knowledge and content:** action requirements are usually specified in documents. In the “learning” MFS, digitally managed documents will play a more important role than traditional offline documents. The prerequisites for this have been put in place with the project home page – a decision must be made on an extension or modification in line with new requirements. The documents should include: action programmes or plans of measures, progress reports and information for public relations work.

**Strategic capacity:** in addition to the knowledge base and network, the strategic capacity includes communication and the shaping of the process. It will be necessary to integrate more deeply the scientific support and the network of participants from the technical dialogue.

### Fields of work

In practice, four fields of work can be defined for the learning MFS:

- Monitoring of technology, sources of energy and cross-cutting issues
- Achievement / adjustment of targets in the transport sector with regard to energy savings and climate protection
- Implementation of proposed actions and measures
- Contribution of the MFS to an overarching mobility strategy

These topic areas and fields of work can be taken up and discussed in the following forums and platforms, for example:

- MFS annual conference – network meeting
- Dialogue between German government and the federal states
- European / international exchange of information in technical meetings
- Interministerial working group
- Parliamentary committee for sustainable development
- Practical dialogue – involve citizens
- Public relations work

### The elements of the MFS as a “learning strategy”

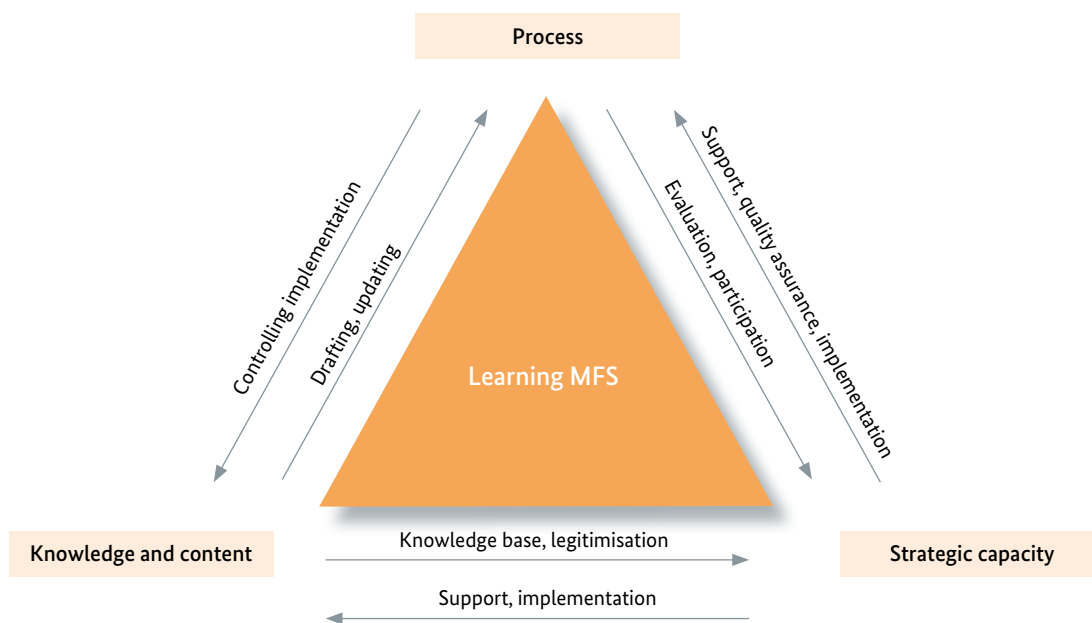


Figure 10: Elements of the learning strategy. (Source: own diagram BMVBS / IFOK)





# Appendix

## Energy and fuel pathways – schematic overview

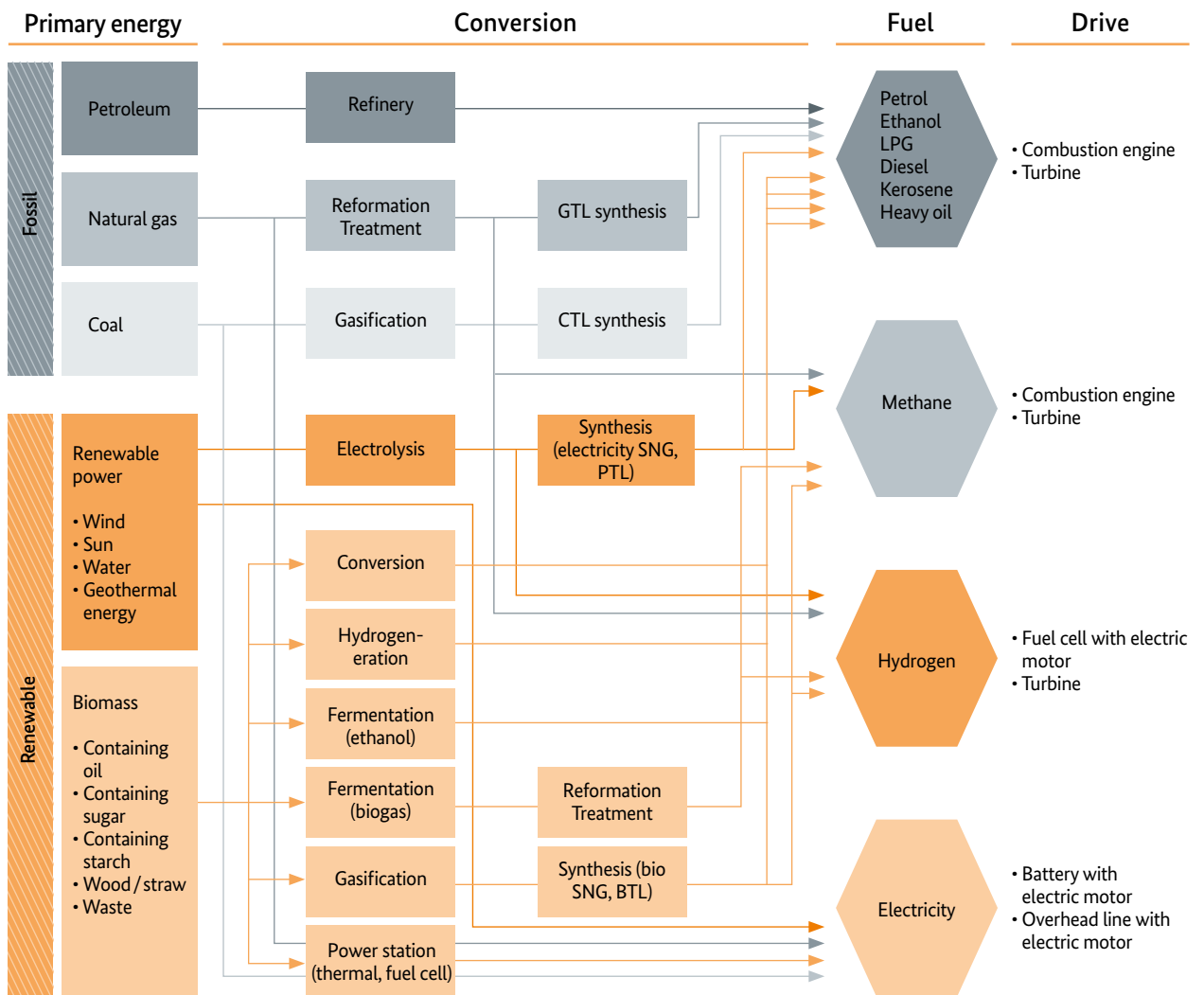


Figure 11: MFS: simplified energy-drive matrix. (Source: own diagram BMVBS / LBST)

## MFS participation process

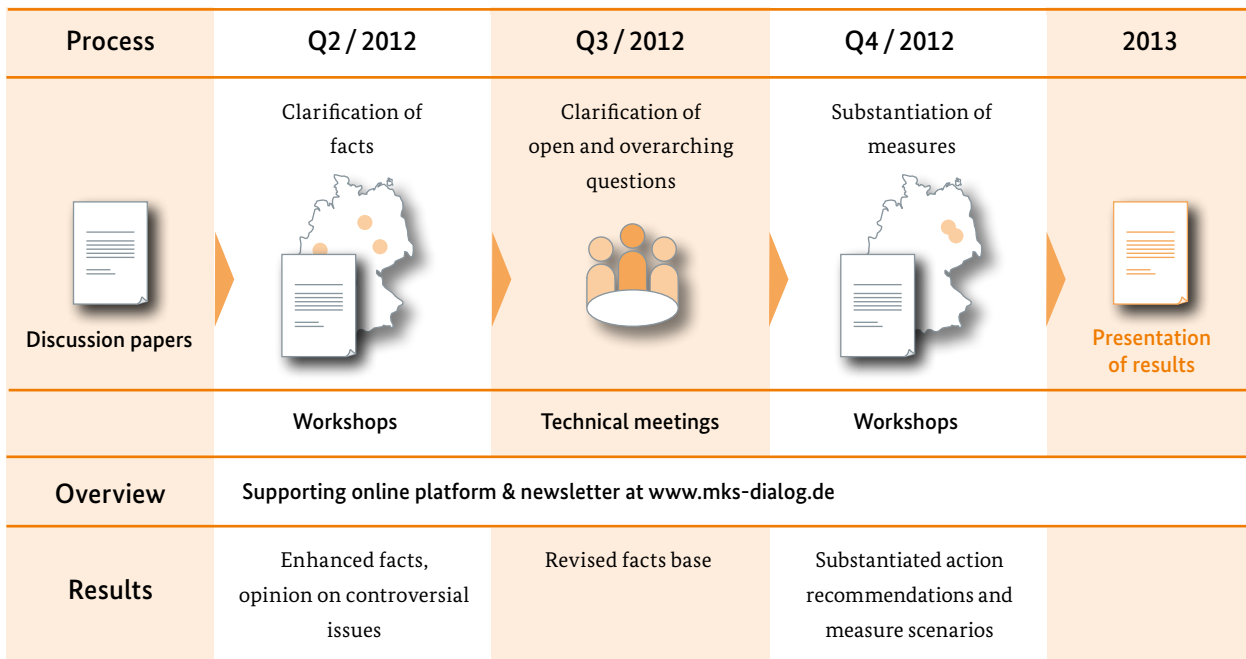


Figure 12: Schematic overview of the participation process / technical dialogue. (Source: own diagram BMVBS / IFOK)

### Complete overview of participants in the MFS technical dialogue (see: [www.mks-dialog.de](http://www.mks-dialog.de))

Participants in all events, cumulated:	780
People involved:	331
Institutions involved:	186
Submitted action recommendations:	282

### Overview of MFS dialogue events

#### Phase 1: Workshops to clarify the facts

**Aim:** Gathering enhanced facts, opinions and controversial issues on various MFS action areas.

**Participants:** 236 participants (cumulated) from industry, science, society and politics.

#### Events:

Workshop: MFS in the mirror of international and European developments	16.03.2012, Berlin
Workshop: Fossil fuels	19.04.2012, Hamburg
Workshop: Biogenic fuels	25.04.2012, Düsseldorf
Workshop: New energies as fuels	09.05.2012, Leipzig
Workshop: Drives – road transport	15.05.2012, Frankfurt
Workshop: Drives – shipping	12.06.2012, Bonn
Workshop: Drives – air transport	15.06.2012, Berlin
Workshop: Drives – rail transport	28.06.2012, Berlin

**Result:** Identification of particularly relevant topic blocks and related issues for drafting of the MFS.

## Phase 2: Technical meetings

**Aim:** Targeted exchange of information with experts on topic blocks particularly relevant from a technical-scientific and social point of view for drafting of the MFS. Discussion of controversial and trenchant issues and action recommendations.

**Participants:** 354 participants (cumulated) from industry, science, society and politics.

### Events:

Framework conditions for bioenergy in transport	12.07.2012, Berlin
Importance of the different savings targets in transport	17.07.2012, Berlin
Infrastructure development for alternative fuels	12.09.2012, Berlin
Mobility and logistics concepts	25.09.2012, Berlin
Framework conditions	17.10.2012, Berlin

**Result:** First concrete statements and results for particularly relevant MFS topics.

## Phase 3: Workshops to draft action recommendations

**Aim:** Discussion of concrete issues and action recommendations derived from the results of the events to date.

**Participants:** 250 participants (cumulated) from industry, science, society and politics.

### Events:

Workshop 1: Sources of energy	24.10.2012, Berlin
Workshop 2: Modes of transport	06.11.2012, Berlin
Workshop 3: Cross-cutting issues	20.11.2012, Berlin
Event to check consistency	04.12.2012, Berlin

**Result:** Discussion of concrete action recommendations and measure options for drafting of the MFS.

## Other events

### Practical dialogue – mobility and fuels on 6 and 7 October 2012 in Berlin

**Aim:** Comparison and commenting of the discussed technical content from a user perspective through a discussion on expectations, fears and wishes in relation to future developments in the areas of mobility, fuels and drives.

**Participants:** 79 citizens from across Germany.

**Result:** Drafting of an opinion report on the discussed topic areas that reveals what is expected of government, industry, research and the users themselves.

### **Federal states dialogue forum on 11 October 2012 in Berlin**

**Aim:** Provision of information to the responsible technical representatives from the transport ministries of the federal states about the MFS process, the current situation and future planning. The representatives at federal state level can present their expectations and information that should be taken into consideration during creation of the MFS.

**Participants:** Representatives of the transport ministries and subordinated authorities of some federal states.

**Result:** Exchange of opinions and information.

### **Results of the dialogue process:**

#### **Predictability – coherence – consistency**

It is necessary to bear in mind that a representative opinion was not formed in the participation process and no decisions could be made on individual issues in the work meetings. Rather, in addition to the various stakeholders' vested interests, the participants' technical expertise and criticisms were incorporated by means of the dialogue process.

Overall, the results of the dialogue process form the guiding framework for formulation of the MFS by the German government. There was criticism above all regarding the lack of content consistency of the instruments in the area of “transport – fuels – energy – drives / infrastructure” and a lack of coherence between the many different political instruments and measures. Again and again, the demand was made for planning certainty and a complete research and development programme.

The stakeholders also stressed that the transport sector must be able to formulate its contribution to the Energiewende itself. In this context, the work on the MFS and the open participation process were seen as positive.

### **Practical and citizen dialogues**

On 6 and 7 October 2012, 80 participants from throughout Germany were invited to Berlin to share their everyday experiences in the “Mobility and Fuels” practical dialogue. New developments in the transport sector are dependent on them being accepted and used in day-to-day life. The focus was therefore on the role of the participants as “experts from everyday life”.

In August and September 2012, four one-day regional citizen dialogue events entitled “New Pathways for Energy” were held on the issues relating to the Mobility and Fuels Strategy. The citizen dialogues took place in the north, south, east and west of Germany: in the cities of Frankfurt am Main and Dresden and in Passau and Stade.

On 14 December 2012, the participants officially handed the results over to the BMVBS. All discussions and results of these citizen dialogues are published in full on the following website:

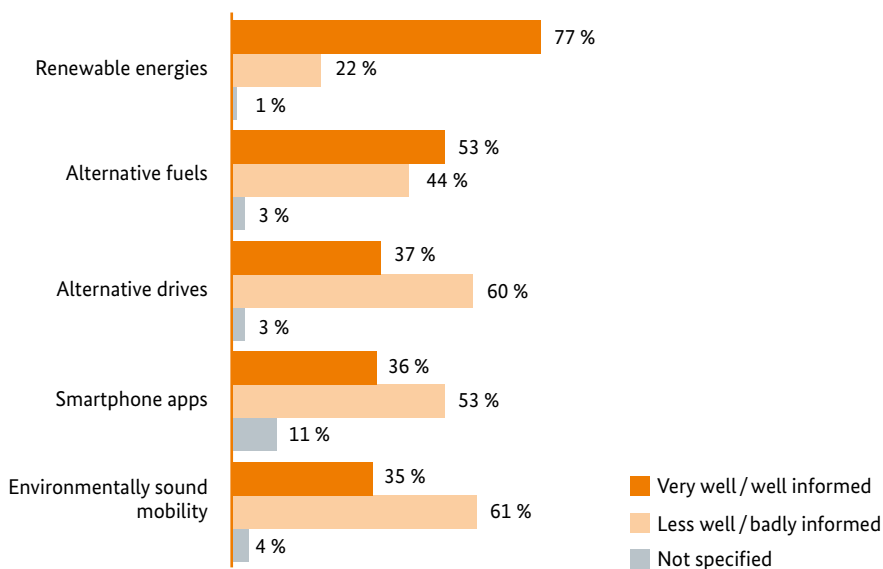
[www.dialog-verkehr.de](http://www.dialog-verkehr.de)

## Representative survey on the MFS

From 6 to 10 November 2012, TNS Infratest Bielefeld (transport research project area), on behalf of the Federal Ministry of Transport, Building and Urban Development (BMVBS), surveyed 1,000 people across Germany regarding their general knowledge about the MFS, alternative fuels and drives, their own transport behaviour and the type of information and involvement they would like.

### Selection of results:

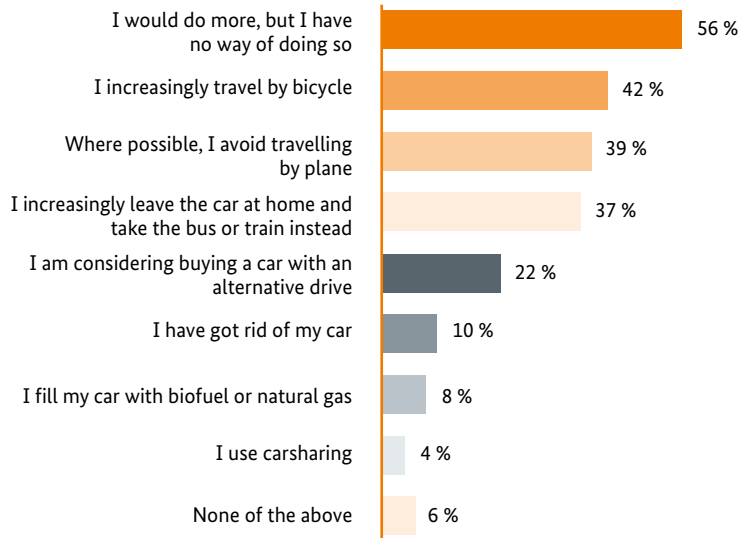
How well informed do you feel you are on the following subjects? For each of the subjects I name, please tell me whether you feel very well informed, well informed, less well informed or badly informed:



(Quelle: eigene Darstellung BMVBS / fischerAppelt)

Most of those taking part in the survey would like to do more to take account of environmental protection in transport. However, they see no way of doing so. To accommodate environmental concerns in their mobility behaviour, around 40 percent of those surveyed often travel by bicycle or try to avoid flying.

How do you take account of environmental protection in transport? Which statements apply to you personally?

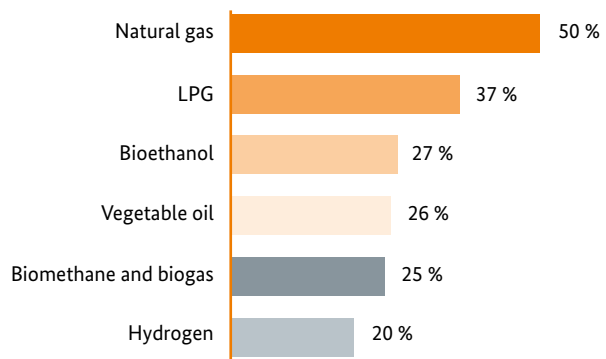


(Source: own diagram BMVBS / fischerAppelt)

The population is less well informed about alternative fuels, with the exception of natural gas. However, men are in general better informed than women.

How well informed do you feel about the fuels that I will name?

The following answered with “very well informed” or “well informed”:



(Source: own diagram BMVBS / fischerAppelt)

## List of abbreviations

AdBlue	Aqueous urea solution for the treatment of exhaust gases in diesel engines
B 30	Diesel containing 30 percent biodiesel
B 7	Diesel containing up to seven percent biodiesel
bar	Physical unit for pressure
BMVBS	German Federal Ministry for Transport, Building and Urban Development
BTL	Biomass-to-liquid
CNG	Compressed natural gas
CO <sub>2</sub>	Carbon dioxide
CONCAWE	CONservation of Clean Air and Water in Europe
CTL	Coal-to-liquid
DB AG	Deutsche Bahn Aktiengesellschaft [German rail company]
DENA	German Energy Agency
DLR	German Aerospace Center
E 85	Petrol with 85 percent ethanol
RE	Renewable energies
EEG	Renewable Energies Act
EC	European Community
ETS	Emissions trading system
EU	European Union
EUCAR	European Council for Automotive R&D
FAME	Fatty acid methyl ester
FQD	Fuel Quality Directive
GTL	Gas-to-liquid
GW	Gigawatt
H <sub>2</sub>	Hydrogen
HVO/HEFA	Hydrotreated vegetable oil / hydroprocessed esters and fatty acids
i. e.	id est; that is
IATA	International Air Transport Association
IEA	International Energy Agency
IFEU	Institute for Energy and Environmental Research
IFOK	Institute for Organisational Communication
ILUC	Indirect land use change
IMO	International Maritime Organization
ISO	International Organization for Standardization
KBA	Federal Motor Transport Authority
Lkw	Truck
LDV	Light-duty vehicle
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
PMVT	Private motor vehicle transport
MJ	Megajoule
MW	Megawatt
RRM	Renewable raw materials
NIP	National innovation programme for hydrogen and fuel cell technology
NO <sub>x</sub>	Nitrogen oxides
NPE	National Platform for Electromobility
SDPT	Short-distance public transport
PT	Public transport
PHEV	Plug-in hybrid electric vehicle
PJ	Petajoule

Pkm	Person-kilometre
Pkw	Passenger car
PM	Particulate matter
RED	Renewable Energy Directive
RON	Research octane number
SCR systems	Systems for the selective catalyst reduction of nitrogen oxides in exhaust gases
SNG	Synthetic natural gas
SDRT	Short-distance rail transport
t	Tonne
GG	Greenhouse gas
tkm	Tonne-kilometre
TtW	Tank-to-wheel
UNECE	United Nations Economic Commission for Europe
WtT	Well-to-tank
WtW	Well-to-wheel
CCNR	Central Commission for the Navigation of the Rhine



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