



Federal Ministry  
of Transport and  
Digital Infrastructure

Energie **wende**  
Switch to the Future



# New Pathways for Energy

Recent developments in the Federal Government's  
Mobility and Fuels Strategy (MFS)





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# Mobility 4.0 – We can do it!

In the next ten years, mobility will experience more change than it has done over many previous decades. Automated driving is just around the corner. Transport is becoming interconnected – from traffic lights through signal boxes to shipping containers. And drivetrain technology is starting to head in a new direction towards alternative fuels.

The innovations of Mobility 4.0 will be key to tackling a huge challenge. On the one hand, they will enable us to meet our ambitious climate change targets and improve the quality of air in our towns and cities. On the other hand, they will simultaneously enable us to satisfy the legitimate requirements of the people and businesses in our country for more mobility. Automated and connected driving and alternative drivetrains will make mobility safer, cleaner, more accessible and more efficient.

My objective is that we use these opportunities and create more mobility but with fewer emissions. We have set out a clear road map for this in the form of the Federal Government's Mobility and Fuels Strategy (MFS). We now have to evolve this road map and consistently focus it on the innovations in the sphere of mobility.

Our action is guided by two principles. First, we do not favour any specific technology when providing financial assistance and are investing in, among other things, electric batteries, hydrogen and fuel cell technology and LNG. And second, we are not playing the different modes of transport off against one another for ideological reasons. Rather, the roads, railways, waterways and aviation enjoy equal status when it comes to funding.

We have already achieved a great deal in our journey along this road. The present brochure provides an overview of the success stories of the MFS to date and the wide range of measures we are taking to roll it forward.

I have no doubt whatsoever that with this strategy, Germany will remain a successful mobility country and a world leader in technological innovations. And it will have the unique opportunity to make products and strategies for clean air and low emissions a worldwide export hit. Our motto is: mobile and digital – mobile and clean.

I hope you enjoy reading this brochure.

**Yours, Andreas Scheuer, MdB**

Federal Minister of Transport and Digital Infrastructure





# The Federal Government's Mobility and Fuels Strategy (MFS)

The Federal Government's Mobility and Fuels Strategy (MFS) is the key instrument for shaping the transformation of the energy system in the transport sector and thus for achieving the Federal Government's energy and climate change policy objectives. The MFS was developed in 2013 on the basis of a broad dialogue with experts and adopted by the Federal Cabinet. The Federal Ministry of Transport and Digital Infrastructure has thus created a platform for a cross-modal information and reference framework on technologies, energy and fuel options plus innovative and modern approaches to mobility and modal shift. It consolidates the knowledge that exists and actively progresses the generation of new knowledge.

## Key parameters of the MFS

In Germany, the transport sector currently accounts for around 30 percent of total final energy consumption and is responsible for around one fifth of domestic greenhouse gas (GHG) emissions.

The Federal Government's 2010 Energy Strategy sets out the basic energy and climate policy objectives of the Federal Government. According to this document, GHG emissions are to be reduced by 40 percent by 2020 and by 80 to 95 percent by 2050 (against 1990 levels) across all sectors. Furthermore, in the transport sector, final energy consumption is to be reduced by around 10 percent by 2020 and by around 40 percent by 2050 against 2005 levels.

In the December 2015 Paris Agreement, the international community undertook to limit global warming to significantly below 2° C above pre-industrial levels and – if possible – to limit it to just 1.5° C. To achieve the long-term temperature objective, greenhouse gas neutrality is to be established in the second half of the century.

The 2050 Climate Action Plan, which was adopted by the Federal Government in November 2016, confirms and fleshes out the existing national climate change targets in the light of the outcome of the Paris Climate Change Conference. In the 2050 Climate Action Plan, the national greenhouse gas reduction target for 2030 (reduce GHG emissions by 55 percent against 1990 levels) is allocated to the action areas addressed. Accordingly, GHG emissions from the transport sector are to be reduced by 40 to 42 percent by 2030 against 1990 levels. The measures necessary to achieve this are to be designed such that they have an impact as quickly as possible and have become fully effective by 2030. In addition, action is to be taken today to progress developments that will help to almost totally decarbonize transport by 2050.

With the MFS plus the “2020 Climate Action Programme” and the “National Energy Efficiency Action Plan”, the Federal Government has already adopted measures for meeting the 2020 target. In addition, within the scope of the 2050 Climate Action Plan, specific options for action are currently being

## [The Federal Government's Mobility and Fuels Strategy \(2013\)](#)



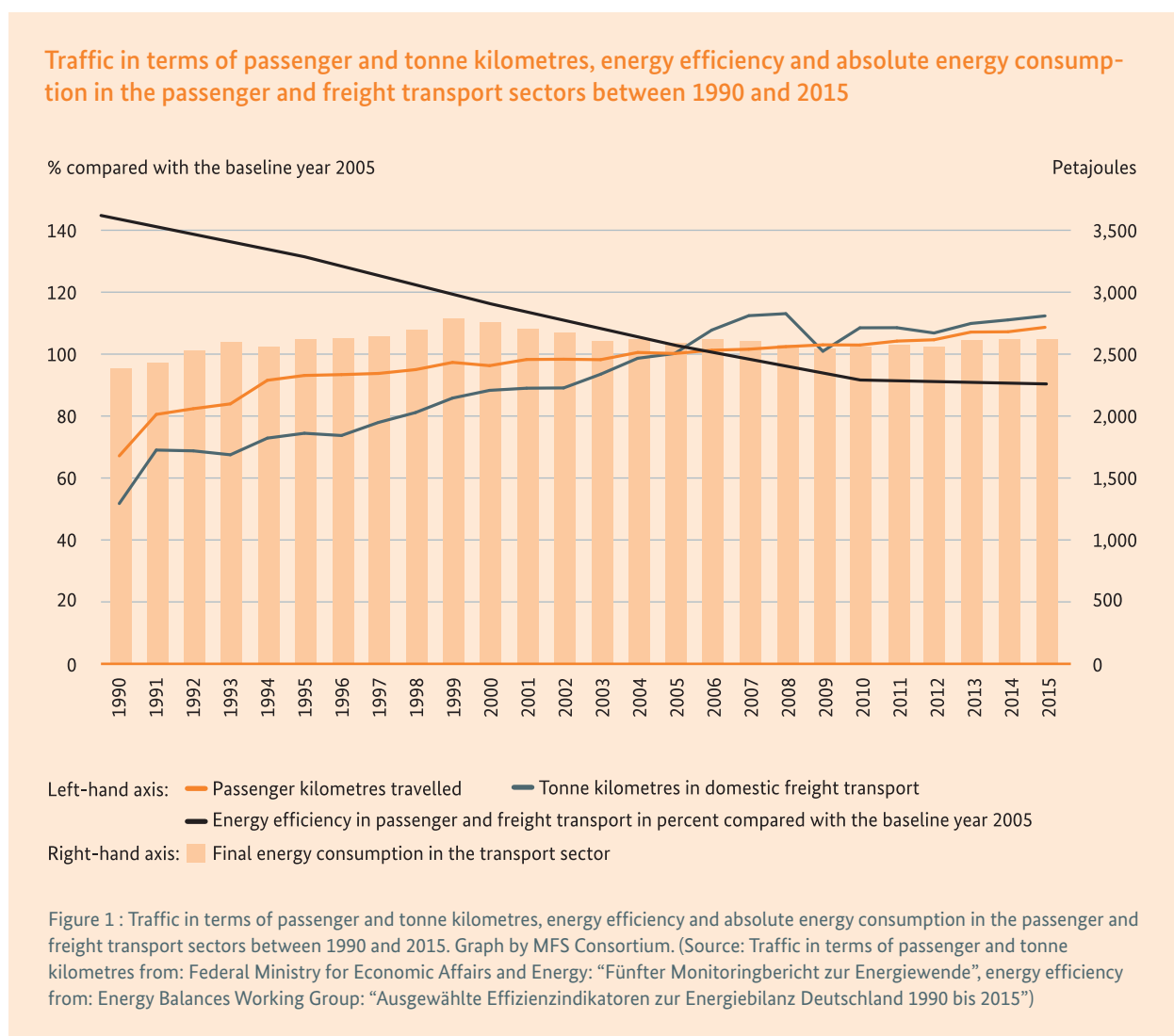
## [Documentation of the expert dialogue on the development of the MFS \(2013\) \(in German\)](#)



identified. By 2018, a programme of action is to be developed that is designed to ensure that the 2030 target is met.

### Trends in the transport sector

Specific final energy consumption in the passenger and freight transport sectors is continuously declining. In other words, the energy consumed per passenger or tonne kilometre is falling as a result of efficiency improvements. Over the period from 2005 to 2015, specific energy consumption dropped by around 10 percent, and the figure for the period since 1990 is just under 40 percent (in MJ/100 pkm). Fuel consumption per passenger kilometre fell on a similar scale.



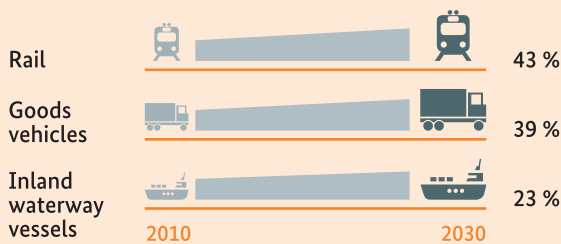
## Traffic forecast used for the 2030 Federal Transport Infrastructure Plan

The volume of freight moved is likely to increase by 38 percent by 2030 against 2010 levels. The highest growth is forecast for rail transport (+43 percent), which is already largely electrified, but road transport (+39 percent) and inland waterway transport (+23 percent) will also see a sharp increase [figures in tonne kilometres]. In the passenger transport sector, it is assumed that there will be total

growth of 13 percent over the same period. Whereas private motorized transport (+10 percent) and rail transport (+19 percent) will grow at a moderate rate, an especially sharp rise (+65 percent) is forecast for air transport. In the same period, road-based public transport is likely to increase by 6 percent [figures in passenger kilometres].

### Freight transport

Tonne kilometres



### Passenger transport

Passenger kilometres

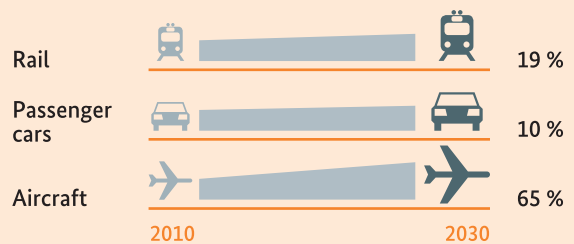


Figure 2: The Federal Government's 2030 Forecast of Transport Interconnectivity (Source: Federal Ministry of Transport and Digital Infrastructure)

However, total final transport energy consumption rose slightly by 1.3 percent to 2,619 PJ over the period from 2005 to 2015. One of the major reasons for this trend is the increase in traffic in terms of passenger and tonne kilometres. Between 2005 and 2015, the number of passenger kilometres travelled rose by 7.3 percent and the volume of freight moved rose by as much as 12.1 percent. The significant increase in traffic in terms of passenger and tonne kilometres thus slightly exceeds the improvements achieved in energy efficiency. In 2015, greenhouse gas emissions from transport totalled an estimated 164 million tonnes CO<sub>2</sub> equivalents. The level of emissions has thus remained virtually unchanged since 1990.

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### Priority areas of the MFS

Traffic trends to date show that further measures are required to achieve the national energy and climate change objectives.

The identification of suitable measures within the scope of the MFS is premised on technological neutrality. It considers, for the modes of transport, what technological developments and innovations will enable more efficient drivetrains and alternative energy sources (fuels) to be used and how the required infrastructure can be deployed. This involves examining, for each mode and for individual use cases, what options can make contributions in the short, medium and long term and what these contributions are.

Another priority area of the MFS is the shifting of traffic flows to modes of transport with lower greenhouse gas emissions and energy consumption. The scope of the necessary shift depends on the pace and extent of the progress made by road transport in reducing pollutants and climate change gases. This also looks at the interaction between individual modes of transport in multi-modal freight transport operations and journeys.

The MFS is currently focusing in particular on how to reduce the climate change impact of freight transport. The reason for this is that growth in this sector, which has so far comprised mainly diesel goods vehicles operating on the roads, is forecast to continue at a high rate. Here, it is thus imperative that drivetrains and the energy supply mix be optimized and changed and that freight be shifted to the railways, which are already largely electrified, and to the inland waterways.

Where there are especially promising approaches, the Federal Ministry of Transport and Digital Infrastructure launches pilot projects within the scope of the MFS, thereby making it possible to apply and test new technological solutions and ideas in a real-world setting. In addition, technologies that have already reached commercial maturity but are not yet competitive because of their development phase are assisted by various funding programmes to support their market ramp-up.

An integrated approach to the electricity and transport sectors (under the generic term “sector coupling”) is becoming increasingly important. This can produce important synergies for both sectors. Thus, for the transport sector, electric mobility makes efficiency gains possible and, if renewable energy sources are used, also helps to decarbonize transport. At the same time, the electricity sector can benefit if batteries are used as additional (intermediate) storage devices or electricity is also used for the production of hydrogen and/or synthetic fuels. This will relieve the pressure on power grids.

Complementing the national developments, the European perspective is also always considered. In addition, air and maritime transport have to be considered in an international context. Measures to promote sustainable transport are usually linked to corresponding standards, such as those set out in EU directives. Of particular relevance to the MFS, for instance, is the transposition of Directive 2014/94/EU on the deployment of alternative fuels infrastructure (AFID).

### **The MFS as a learning strategy.**

The parameters and findings in the transport, mobility and energy sectors and in the digital revolution are constantly evolving. In addition, the constellations of the players are continuously changing. The Federal Government has thus decided to roll forward the MFS as a “learning strategy”.

To analyse individual thematic fields, the MFS monitoring consortium is conducting studies on measures and technologies that can help to reduce final energy consumption and greenhouse gas emissions. Within the scope of interviews and targeted expert workshops, the practical perspectives of the key players from industry, academia and society are included to answer the research questions. In this way, the relevant developments can be taken into consideration at an early stage and the findings can be seamlessly transferred to an implementation phase.

One example of good practice of this process is in the field of hybrid trolley buses which, thanks to new technological developments, can also run on batteries for parts of their route. To analyse the potential created as a result, a study was conducted within the scope of the MFS to compare them with battery electric and fuel cell powered buses. Two workshops were held, at which the knowledge of expert players was included. Building on the findings of the study, the Federal Ministry of Transport and Digital Infrastructure is now funding a pilot project in Solingen and is conducting a feasibility study to explore further options for deploying this bus technology (cf. page 35).



# Key thematic areas

The lessons learned from the MFS are to be taken as a starting point for further studies, pilot projects and financial assistance programmes. In this way, the MFS is constantly being adapted to the changing circumstances and incorporating new parameters, thereby following the idea of a “learning strategy”. This brochure presents activities of the Federal Ministry of Transport and Digital Infrastructure to promote sustainable passenger and freight transport. The MFS is making a major contribution to this in all transport sectors.

## Alternative drivetrains, fuels and their infrastructure

Technological developments and innovations are an important lever for achieving the energy and climate policy objectives in the transport sector. Within the scope of the MFS, innovative drivetrains and alternative fuels are thus being studied and funding is being provided to establish them on the market. This also includes the deployment of corresponding infrastructure. To this end, the European Union has adopted a Europe-wide framework for corresponding measures – Directive 2014/94/EU on the deployment of alternative fuels infrastructure (AFID). To transpose this Directive into national law, the Federal Cabinet adopted a National Policy Framework in 2016 setting out the key objectives and measures for the deployment of infrastructure.

**Road transport** has by far the largest share of the modal split. The roads account for 70.8 percent of tonne kilometres and 87 percent of passenger kilometres. Fuels from fossil sources dominate here. Road transport is thus also responsible for the bulk of the GHG emissions from the transport sector. To reduce them, it is imperative that drivetrains be progressively electrified and that the electricity required for this purpose be increasingly generated from renewable energy sources. Alongside direct electrification, hydrogen and electricity-based fuels can make major contributions. The fuels will also play a major role in the future with regard to the question of the long-term storage of electricity. Second and third generation biofuels can make a (limited) contribution to the diversification of the energy supply mix.

Which drivetrain or fuel is to be used in each of the vehicle sectors also depends on the requirements in any given case. In the **passenger car sector**, battery electric and hybrid models, and increasingly hydrogen fuel cell vehicles, are already available. Since 2016, the Federal Government has been promoting the market penetration of electric mobility by providing a financial incentive for the purchase of electric vehicles and additional tax breaks. In addition, the Federal Government is pursuing the objective of deploying a nationwide electric vehicle charging infrastructure comprising both normal power charging points and high power charging posts. Within the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP), the Federal Ministry of Transport and Digital Infrastructure is also promoting the development of a basic network of hydrogen refuelling points.

There is also a continuous increase in the number of battery, hybrid and fuel cell powered buses in the **public (bus) transport sector**. The Federal Government is promoting the procurement of electric buses with various charging systems within the scope of the Electric Mobility Funding Guidelines. Investment grants for fuel cell powered buses can also be provided via the second phase of the NIP (NIP II). For the electrification of bus services, the Federal Ministry of Transport and Digital Infrastructure is also studying the use of hybrid trolley buses. These can operate on parts of their route in battery-only mode without an overhead line, enabling additional range and flexibility. Moreover, by means of bidirectional connection with the upstream electricity grid, the transport and energy sectors can be coupled.

In the case of smaller **goods vehicles**, it is already possible today to replace the internal combustion engine by battery electric and hybrid technologies on shorter journeys, for instance in logistics in urban areas. On the other hand, in the case of long-distance journeys and heavy goods vehicles, there are especially demanding requirements to be met by the performance of the drivetrain and the vehicles' range. Within the scope of the MFS, studies are thus being conducted to determine how hydrogen and fuel cell technology can replace diesel engines in the future. In addition, the potential inherent in hybrid overhead line systems is being studied. The use of longer goods vehicles can also reduce GHG emissions, as a five-year field trial has demonstrated.

Natural gas can contribute to a short- to medium-term reduction of GHG and pollutant emissions. In the long run, it will be possible to achieve further reductions by the admixture of methane generated from renewable energy sources or biomass. Natural gas is interesting for use in both passenger cars and buses as well as ships. In the form of CNG, it is already a much-used option in the passenger car sector and in the goods vehicle sector for delivery and distribution operations with smaller vehicles and ranges. For heavy goods vehicle traffic, and here especially for long distances, the Federal Ministry of Transport and Digital Infrastructure is promoting the use of liquefied natural gas (LNG) powered goods vehicles.

To support the use of natural gas because of the environmental impact, it has been decided to extend the tax relief to 2026. Whereas natural gas fuels in the form of CNG and bio natural gas can be distributed via the existing natural gas grid and CNG refuelling points, LNG requires a separate refuelling infrastructure, because the fuel has to be stored in special tanks. Because of its high energy density, LNG is interesting for both heavy goods vehicles and shipping alike. For this reason, possible synergies should be exploited when deploying the infrastructure. Coupling the rising demand in the two sectors can make investment in LNG refuelling points represent value for money.

To reflect the special role played by road haulage, the Federal Ministry of Transport and Digital Infrastructure has launched the **Climate-Friendly Road Haulage Initiative**. Within this framework, it has joined forces with representatives from industry and academia to discuss the opportunities and challenges of individual technologies that can make a contribution towards achieving the energy and climate policy objectives. The outcome is a set of three road-maps with specific recommendations for action and measures for supporting the use of LNG (from renewable sources), hydrogen and electricity-based fuels in the heavy road haulage sector.

**Rail transport**, which accounts for 7.7 percent of all passenger kilometres travelled and 18 percent of all freight moved (2015 figures), is responsible for only around 3 percent of GHG emissions. One of the key objectives of the MFS is thus to shift traffic to the railways. But potential for further decarbonization is also inherent in the rail sector itself. For this to happen, the share of renewable energy sources in the traction current mix has to be increased. Activities are being undertaken within the scope of the MFS to identify the lines on which further electrification would be worthwhile and where the use of alternative drivetrains has to be stepped up. Great potential for the substitution of diesel locomotives on non-electrified lines is currently offered by, in particular, hydrogen fuel cell technology and battery electric powered railcars. The Federal Ministry of Transport and Digital Infrastructure is funding initial pilot projects on both options.

The rolling stock used in rail freight has frequently been in use for many decades. Retrofitting these wagons could achieve further energy savings, for instance by using innovative regenerative braking and automatic couplings.

In the **aviation sector**, there are already especially demanding requirements to be met by the provision of energy and the safety of the propulsion systems used. The long development cycles resulting from this mean that innovative drivetrain technologies have so far hardly been used in aviation. Initial pilot projects on solar, hydrogen and fuel cell technology are still a long way from reaching commercial maturity for civil aviation. However, the use of hydrogen and fuel cell technology already offers potential for the on-board supply of electricity for all non-flight relevant loads (e.g. galleys and in-flight entertainment) and for the supply of electricity at airports using mobile generators. Renewable kerosene – from biogenic sources or synthetically produced – can make a crucial contribution towards achieving the energy and climate policy objectives in the aviation sector. Building on two MFS baseline studies, a research and demonstration project is currently being carried out at Leipzig/Halle Airport to investigate the use of multi-kerosene blends in real world conditions.

There is a similar situation in the **shipping sector** where, because of the long design life of the ships, technological innovations tend to take a long time to prevail. The fuels used today in maritime transport thus still entail high levels of emissions. LNG can make a major contribution towards making maritime shipping more sustainable. The Federal Ministry of Transport and Digital Infrastructure is thus supporting pilot projects to convert various ships to LNG or dual-fuel propulsion. Initial state-owned ships are being equipped with LNG propulsion, such as the Federal Maritime and Hydrographic Agency's research vessel, the "Atair".

Hitherto, these ships have been refuelled from trucks in Germany. For the supply of the LNG-fuelled ships, the Federal Ministry of Transport and Digital Infrastructure has joined forces with the Maritime LNG Platform and is championing the deployment of separate infrastructure. In addition, studies into the commercial maturity of natural gas engines in inland waterway transport and maritime shipping are being conducted within the scope of the MFS. In the medium to long term, hydrogen and fuel cell technology also represents an option for ship propulsion. Within the NIP, the use of fuel cells is being developed in the e4Ships project and is being trialled in both the inland waterway transport and maritime shipping sectors. For inland waterway transport, the use of battery electric powered ships also represents a propulsion option if they only sail short distances and have an opportunity to recharge at regular intervals. If this is not the case, hybrid propulsion systems with an internal combustion engine and a battery or fuel cell are conceivable.

Irrespective of the type of propulsion, it is already possible today to largely decarbonize the supply of energy in ports. Instead of using oil-based engines to generate on-board power during layovers, on-board power supply is already being successfully provided by LNG barges/generators or hydrogen fuel cells. Another option for the supply of energy to ships berthed in ports is supply via a shore-side electricity connection, such as that already being used at the Port of Hamburg. In the inland waterway transport sector, there are already several shore-side electricity connections for day-to-day use. In May 2017, the CCNR created the possibility for local authorities to install signs at ports making it mandatory for boatmasters to connect to the shore-side electricity network.

## Modal shift, mobility and logistics strategies

Because the individual modes of transport produce highly differing levels of emissions and thus have very different climate change impacts, the MFS seeks to shift traffic to the less polluting rail and waterway modes. In doing so, it bears in mind that a climate-friendly development in the road sector will have a direct impact on the modal shift requirements. In this regard, the 2030 Federal Transport Infrastructure Plan (FTIP) makes a significant contribution. Thus, structural maintenance and, to a lesser degree, the construction of new and the upgrading of existing railway and waterway infrastructure account for over one half of the 296.6 billion euros provided by the FTIP.

Alongside the rail network proper, further infrastructure capacity is to be created, especially for shifting traffic to the railways. Possible restrictions in this regard and measures to overcome them have been studied within the scope of the MFS. In the **freight transport** sector, the capacity of handling facilities, for instance, plays a significant role. The Federal Ministry of Transport and Digital Infrastructure uses various funding instruments to provide financial assistance to combined transport and the construction of the necessary terminals. In addition, the modal shift to rail is supported via the Guidelines on Funding for the Construction, Upgrading and Reactivation of Private Sidings. The continuing modernization of combined transport (CT) terminals can further enhance the attractiveness of rail freight. For this reason, the MFS has examined the extent to which the deployment of information and communications technologies provides options for optimizing cargo handling. The modal shift to more environmentally friendly modes of transport also involves making greater use of inland waterway transport for freight traffic, which is why this option is being explored by the Federal Ministry of Transport and Digital Infrastructure in various projects.

Alongside modal shift, addressing logistics operations and the development of emission-reducing logistics strategies is a major component of the decarbonization of freight transport.

One of the objectives in the **passenger transport** sector is to shift passenger flows from private motorized transport to ecomobility. The attractiveness of walking, cycling and local public transport will be enhanced by improving the quality of the services offered and interlinking the range of mobility services. Information and communications technologies play a key role in linking up the individual ecomobility services. To improve the cycling situation, the Federal Ministry of Transport and Digital Infrastructure has launched a financial assistance programme within the scope of the National Cycling Plan. Since 2017, this programme has also been used to fund cycle superhighways built by the federal states and local authorities. In addition, the Federal Ministry of Transport and Digital Infrastructure is exploring whether extending

clockface timetabling beyond the long-distance passenger sector can increase the railways' share as a whole. The plan is to address in greater depth the changes in mobility patterns towards ride and car sharing approaches, which can be supported by new technologies, information systems and mobility strategies.

## Automated and connected vehicles

Automated and connected road vehicles also play a major role in shaping sustainable transport. With the “Strategy for Automated and Connected Driving (ACD Strategy)”, the Federal Government has adopted guidelines on how to exploit the opportunities for growth and prosperity inherent in the mobility of the future. National and international activities in the key thematic areas of infrastructure, law, innovation, connectivity, cyber security and data protection plus societal dialogue will create an optimum framework for the development, trialling and introduction of ACD technologies. Examples of this include the most recent amendment to the Road Traffic Act, the construction of digital test beds for road vehicles and the establishment of research programmes. A study being conducted within the scope of the MFS addresses the potential for GHG reduction inherent in automated and connected driving.

The deployment of information and communications technologies also plays a major role in enhancing the attractiveness of rail transport. In the passenger sector, they make it possible to offer attractive and easily accessible ranges of mobility services. For the deployment of digital technologies in public transport, the “Roadmap for Digital Connectivity in Public Transport” has been developed. In the freight sector, the use of innovative technologies enhances productivity and efficiency along the entire value chain. In addition, digitalization and automation on the railways can enhance the capacity and attractiveness of local and long distance passenger services and rail freight. The Federal Government is providing an impetus here with its “Five-Point Strategy for Digital Railways”. In addition, the impact of introducing a systematic and widened deployment of the European Train Control System (ETCS) on the final energy consumption of the rail mode is being studied within the scope of the MFS.

## International cooperation to promote climate-friendly transport

The Federal Ministry of Transport and Digital Infrastructure is involved in international collaborative projects to establish climate-friendly transport systems. A Sino-German dialogue is designed to develop a mobility and fuels strategy for China by 2019 with German support. The Federal Ministry of Transport and Digital Infrastructure is also cooperating with the Chinese Ministry of Science and Technology in the field of electric mobility. The Federal Ministry of Transport and Digital Infrastructure is championing the establishment of hydrogen and fuel cell technology as part of its activities in the “International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)”. In addition, Japan’s endeavours to promote hydrogen and fuel cell technology are being supported in an exchange of ideas and experience between the “National Organization for Hydrogen and Fuel Cell Technology (NOW)” and the Japanese “New Energy and Industrial Technology Development Organization (NEDO)”. Within the scope of a German-Israeli dialogue on electric mobility, the exchange of knowledge between companies, especially start-ups, in the mobility sector from both countries is being supported. Last but not least, the Franco-German Initiative on Electric and Digital Mobility is committed to intensified cooperation between the two countries in the field of electric mobility and automated driving.



# Knowledge combats climate change: questions and answers on the MFS's supporting scientific research

In evolving the MFS, the Federal Ministry of Transport and Digital Infrastructure is assisted by an academic consortium comprising five institutions.

- Fraunhofer Institute for Systems and Innovation Research (ISI)
- Fraunhofer Institute for Material Flow and Logistics (IML)
- M-Five GmbH Mobility, Futures, Innovation, Economics
- PTV Group: PTV Transport Consult GmbH und PTV Planung Transport Verkehr AG
- Hamburg University of Technology (TUHH): Institute of Transport Planning and Logistics (VPL) and Institute of Environmental Technology and Energy Economics (IUE).

Representatives from two of these institutions – Dr Michael Krail (Fraunhofer Institute for Systems and Innovation Research) and Dr Wolfgang Schade (M-Five GmbH Mobility, Futures, Innovation, Economics) – answer the most important questions about their work.

## What are the tasks of the supporting scientific research for the evolution of the MKS?

Dr Michael Krail (MK): The supporting scientific research provides the Federal Ministry of Transport and Digital Infrastructure with professional advice on ongoing developments in tackling the climate change impacts of the transport sector. The studies focus on the question as to how final energy consumption and GHG emissions in the transport sector can be progressively reduced further. This involves calculating the impacts of possible measures on the basis of modelling and scenarios so that it is possible, for instance, to illustrate the costs of reducing CO<sub>2</sub> emissions by one tonne.

## How do you arrive at the questions you study?

Dr Wolfgang Schade (WS): The ideas for our studies are born in different ways, in keeping with the principle of a “learning strategy”. Many issues arise from ongoing technological and political developments and the associated professional advice. In addition, we receive proposals from a very wide range of stakeholders from industry, academia and society. Many further ideas and suggestions are contributed by the expert dialogue on the MFS and the Project Office.

## In your opinion, what are currently the greatest challenges facing the decarbonization of transport.

MK: Routines determine the trends in traffic and the growth in its GHG emissions. This is resulting in a continuing rise in the volume of traffic in our increasingly mobile society. Approaches pursued hitherto have not been sufficient. Thus, the success achieved in reducing specific energy consumption has so far been offset by the simultaneous rise in traffic in terms of passenger and tonne kilometres. As a result, the GHG emissions from transport in



Dr Michael Krail, Fraunhofer ISI

Germany are still at 1990 levels. By promoting technological developments, stepping up incentives to innovate and developing new mobility and logistics strategies, the aim is to reduce direct GHG emissions from transport by 40 to 42 percent by 2030, despite the continuing rise in the demand for transport. This is equivalent to a reduction of just over 65 to 68 million tonnes of CO<sub>2</sub> equivalents by 2030 or an annual reduction of 3.4 percent over the period from 2016 to 2030.

WS: Another challenge is that European and frequently even global contexts and interests always have to be taken into account. Thus, for instance, the introduction of technologies is rarely conceivable as an isolated solution. In land-based transport, account has to be taken at the very least of our European neighbours, whereas aviation and maritime transport have to be considered in intercontinental terms.

#### How do you systematically approach meeting the climate change target set by the Federal Government.

MK: The target set for the transport sector is ambitious, but it can be met if the right mixture of measures is chosen. For the future, this means that the development of innovative and alternative drivetrain technologies has to be continuously pursued. At the same time, targeted approaches are required to organize existing traffic more efficiently and shift it to more environmentally friendly modes of transport.

WS: We are thus looking at four building blocks for meeting the climate change target:

- improving the efficiency of conventional drivetrains;
- electrification of the transport system and decarbonization of fuels;
- a modal shift to more climate-friendly means of transport;
- improving the organization of transport.

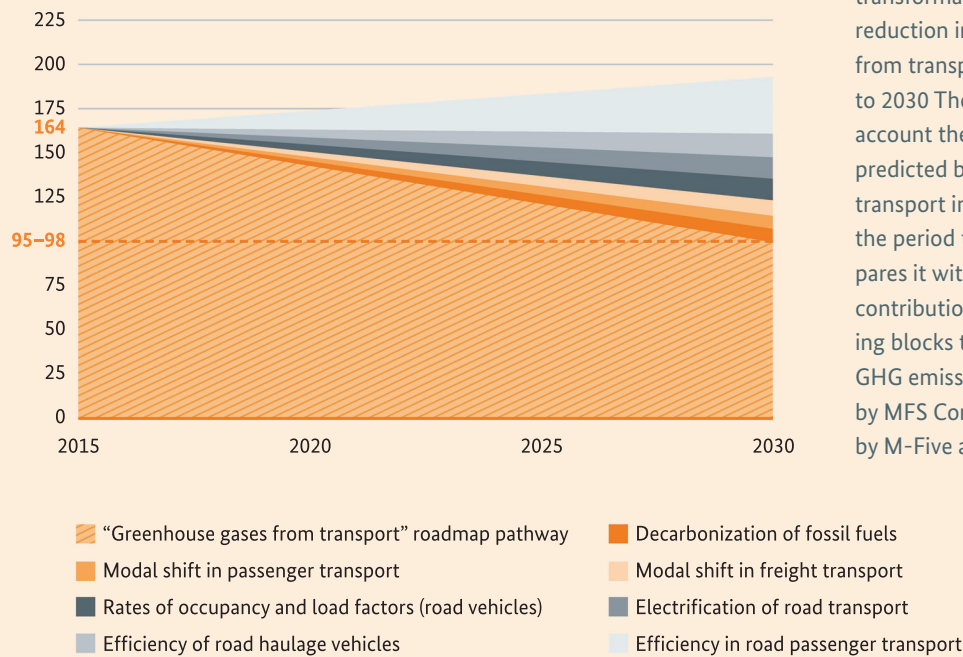


Dr Wolfgang Schade, M-FIVE

Figure 3 illustrates that GHG emissions from transport would continue to significantly rise over the period to 2030 in a business as usual scenario [top line]. At the same time, the transformation pathway, defined as an objective, for reducing direct GHG emissions [in CO<sub>2</sub> equivalents] over the period to 2030 is shown [bottom line]. Between them are the building blocks with which a corresponding contribution to a reduction in GHG emissions from transport can be achieved. The more important building blocks with the greatest contributions to a reduction are at the top. Further down are building blocks with smaller contributions. The graph does not include international maritime and air transport. The specific and absolute emissions from rail and inland waterway transport are low and thus of only minor importance in terms of efficiency improvements. They are thus not shown separately in on the graph.

## Building blocks of the transformation pathway in the transport sector in Germany

Million tonnes of CO<sub>2</sub>e



Looking at this, it is apparent that the annual GHG reductions get larger over the years. What is the reason for this?

WS: Many of the measures launched today will only have an impact over the course of time, as is the case with a modal shift. Because of this time lag, it is necessary to start the process of innovation well in advance. In addition, it is of course always better to start working towards a goal as early and continuously as possible rather than being dependent on more stringent solutions later on. This is especially true of those means of transport with very long-term investment cycles, such as shipping and aviation. It is thus cost-effective to start trialling new technologies at an early stage. This is especially important in the deployment of infrastructure. These lofty GHG targets suggest that it is believed there are technological possibilities for actually meeting them. Ambitious targets are thus a very good sign.

What are the links between individual measures to reduce the climate change impact of transport?

MK: There are very close links between the individual measures. This can be illustrated very graphically by the interaction between efficiency and modal shift. If greater progress is made in developing the efficiency of road vehicles, less effort is required when it comes to the shift to more environmentally friendly means of transport. Conversely, if more traffic is shifted from the roads to the railways, there is less pressure to improve the efficiency of road vehicles.

WS: There is also dependency like this between measures in the passenger and freight transport sectors. If the efforts to harness the potential for efficiency and modal shift are especially successful in one of the two sectors, there will

be less pressure in the other sector. These interconnections must be closely observed and must not result in responsibility being shifted to the other sector.

**What particular scope for reduction is there, for instance in passenger transport?**

MK: As the illustration shows, it could be possible to deliver roughly one third of the total decarbonization target in the passenger transport sector through an enhancement of vehicle efficiency alone. Thus, in 2030, the passenger car fleet on German roads could be 30 percent more energy efficient than in 2015 by means of technological improvements to engines and vehicles. In addition, the modal shift to ecomobility will play a major role. Here, the digital revolution, the increasing use of new multimodal mobility strategies and adapted incentives could result in the shares of public transport, walking and cycling rising by 5 to 10 percentage points by 2030. In addition, new technological and organizational solutions can better consolidate the remaining journeys made by private motorized transport, so that the occupancy rate of passenger cars will rise by 10 percent over the medium to long term. Thus, one sixth of the decarbonization required for meeting the climate change targets can be achieved by modal shift and improved use of the means of transport. On this reduction pathway, the passenger transport sector will reduce its final energy consumption by 3.1 percent each year over the period to 2030.

**What scope for action do you see in the freight transport sector? What levers have to be activated to reduce its climate change impact?**

WS: According to the transformation pathways we have calculated, around one seventh of the decarbonization can be achieved by improving efficiency in road haulage. In addition, modal shift and the improved organization of transport will play a significant role in the freight transport sector. By 2030, around ten percentage points of the modal share of road haulage are to be shifted – especially to the railways and waterways. At the same time, load factors are to be increased by 10 percent. This can be achieved by improved logistics strategies and adapted production systems, accompanied by appropriate measures to incentivize innovation. This will achieve an annual rate of reduction of final energy consumption in the freight transport sector of 1.4 percent over the period to 2030.

**What overarching measures are likely to make an effective contribution to decarbonization in all transport sectors?**

WS: First and foremost the electrification of vehicles through the use of electricity by means of battery technology, fuel cells or overhead lines. With a simultaneous increase in the share of renewable energy sources in the supply of electricity, this can achieve around one seventh of the necessary decarbonization over the period to 2030. In addition, fossil fuels can be replaced by the use of biomass and electricity-based fuels produced using renewable energy sources, especially in the aviation and maritime transport sectors.

MK: In addition, the MFS contains various building blocks that can make a cross-sectoral contribution to the decarbonization of the transport sector in Germany. From an academic perspective, this includes not only expediting technological progress in general but also providing adapted incentivization structures for companies and private users. Another aim is to make appropriate and intelligent alternative fuels infrastructure available.

**What do you think will be the key themes that the MFS addresses in the future?**

MK: Because of rising levels of traffic, one of the key issues will be implementing strategies for climate-friendly road haulage. Another issue will be considering the option of importing electricity-based fuels from renewable energy sources. The digitalization and connectivity of transport will also play an increasingly important role. The evolution of automated and connected vehicles and an assessment of their impact on future road user behaviour will be a major subject of studies.

WS: Another important theme is developing and promoting a situation in which society and industry are aware of the consequences of their mobility behaviour. This is a significant lever for meeting the climate change targets in the transport sector, and we believe that it should be backed up by appropriate incentivization structures.



# Alternative drivetrains, fuels and their infrastructure

If the transport sector is to be able to play its part in meeting the climate change targets, petroleum-based fuels will have to be progressively replaced by climate-friendly alternatives. In the medium to long term, it is imperative that electricity from renewable energy sources be developed into the dominant transport fuel. Technological developments and innovations in the field of alternative drivetrains are a key building block here.

The most efficient system is the direct use of electricity, for example via overhead lines. The most efficient form of indirect electricity use can be found in battery electric vehicles. As an alternative, fuel cell technology, which uses hydrogen produced from renewable energy sources, can also be used for electrification. In addition, biogenic and electricity-based fuels can be used without having to modify the existing drivetrains. In the short to medium term, natural gas (CNG or LNG) offers an option for decarbonization, especially if there is a further enhancement of efficiency in engine technologies. Blending biogenic or synthetic methane into conventional fuels can also further reduce GHG emissions.

Beyond the development of new drivetrain technologies, the supply of alternative fuels must also be ensured. Some alternative fuels require separate infrastructure, for instance hydrogen. Liquefied natural gas (LNG), which represents a suitable option in heavy goods vehicles and ships, also requires separate distribution and refuelling infrastructure. On the other hand, natural gas and biogenic and synthetic methane in the form of CNG can already be distributed nationwide via the existing natural gas grid. Some biogenic and synthetic liquid fuels can even be provided as drop-in fuels via conventional refuelling infrastructure. For the aviation sector, this option is being studied on the basis of a pilot project.

To promote the broad-based development of the market for alternative fuels, the European Union adopted Directive 2014/94/EU on the deployment of alternative fuels infrastructure (AFID) within the scope of its “Clean Power for Transport” initiative (CPT initiative). This requires all EU Member States to deploy appropriate refuelling and charging infrastructure. To transpose the Directive, Member States were requested to develop a National Policy Framework for the deployment of alternative fuels infrastructure. The Federal Cabinet adopted the German policy framework in November 2016. It provides a comprehensive overview of the current state of play regarding the charging and refuelling infrastructure for battery electric and natural gas powered vehicles and vehicles powered by hydrogen fuel cells in the road and maritime transport sectors and sets out key objectives and measures for establishing infrastructure that provides universal coverage.

The objectives of the National Policy Framework are guided by the needs of passenger and freight transport. This is done on the one hand by demand-side

[National Policy Framework to Support the Deployment of Alternative Fuels Infrastructure \(in German\)](#)



measures, i.e. the provision of targeted financial assistance for the procurement of vehicles, and on the other hand by infrastructure-related measures, i.e. capital grants for refuelling and charging infrastructure. As far as refuelling points are concerned, both refuelling points that are accessible to the public (such as the LNG refuelling point near Berlin that was opened in 2017) and refuelling and charging infrastructure installed at company premises as part of demonstration projects and only available for use by the company (e.g. charging station for battery powered buses in the “Sustainable Bus Systems of the Future” project in Hamburg) are funded. By providing financial assistance, the Federal Ministry of Transport and Digital Infrastructure ensures, on the one hand, that the refuelling and charging infrastructure is deployed and, on the other hand, that this infrastructure can also be operated economically in the long term, because the market ramp-up of the technologies is supported in parallel, thereby creating demand.

The following graph illustrates that the financial assistance provided by the Federal Government is having an impact. Refuelling points for LPG, natural gas and hydrogen plus charging points for battery electric vehicles are already in place in varying quantities. The LNG refuelling points are not included here because most of them have so far been located on private property and are thus not accessible to the public.

In creating the infrastructure conditions for the transformation of the energy system in the transport sector, the integration of the electricity supply and

### Alternative fuel refuelling and charging points accessible to the public in Germany

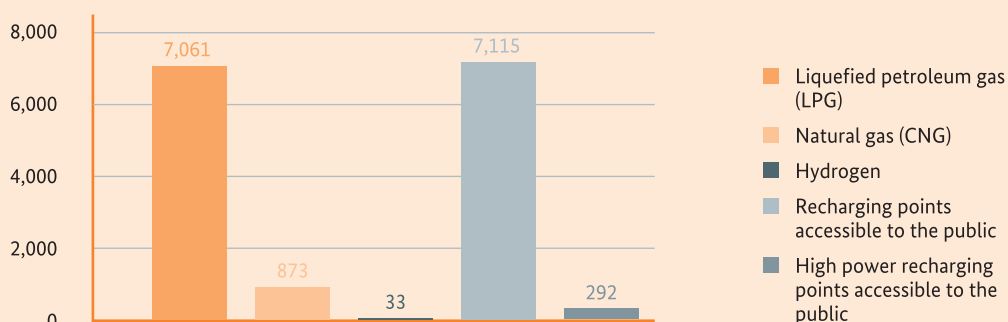


Figure 4 : Number of refuelling points for alternative fuels, including LPG, natural gas and hydrogen plus recharging points for electricity for road vehicles in Germany in 2016/2017 (Source: DVFG, Erdgas Mobil, NOW GmbH, BDEW)

transport sectors is playing an increasingly important role. Sector coupling can help to achieve good capacity utilization of the power grids in times of fluctuating electricity generation from solar and wind energy. To this end, the transport sector's future demand for renewable electricity must be considered now by the new direction in energy policy. Thus, within the scope of the MFS, an "Analysis of Challenges and Potential Synergies in the Interaction between the Transport and Electricity Supply Sectors" has been carried out and a range of actions needed for sector coupling has been identified.

The use of alternative fuels has to be viewed from a cross-modal perspective and the best option has to be chosen in any given case. In the case of electricity-based fuels, the challenge is that sufficient quantities of renewable electricity have to be generated for their production. The production costs are currently still much higher than those of fossil fuels. A reduction in fuel costs is thus the most important lever for the market integration of electricity-based fuels. Studies have thus been conducted within the scope of the MFS to explore what scope for efficiency enhancement in the production of electricity-based fuels can be leveraged. One of the key thematic areas of subsequent activities will be the evolution of electrolyzer technology. New findings from materials and surface engineering research can help to increase the efficiency of electrolyzers, thereby reducing production costs.

A cross-modal approach is also necessary to the use of biogenic fuels. The contribution they can make to a reduction in emissions from the transport sector is basically limited, because the availability of sustainable biomass is limited. In addition, competing uses for foodstuff on the one hand and as materials, for instance in the chemical industry, on the other hand have to be taken into account. Last but not least, social and ecological sustainability have to be considered in the production of biomass. Large capacities of the second or third generation, such as algae-based fuels and the like, are not likely to be available until after 2025. Consequently, biogenic fuels have to be seen as one of several options for diversification in the fuels sector. In particular, they should be used where there will be no fuel alternative to diesel or kerosene for the foreseeable future. The greenhouse gas reductions that can be achieved by using biogenic fuels should also determine the fields in which they are actually used.

[Analysis of Challenges and Potential Synergies in the Interaction between the Transport and Electricity Supply Sectors \(in German\)](#)

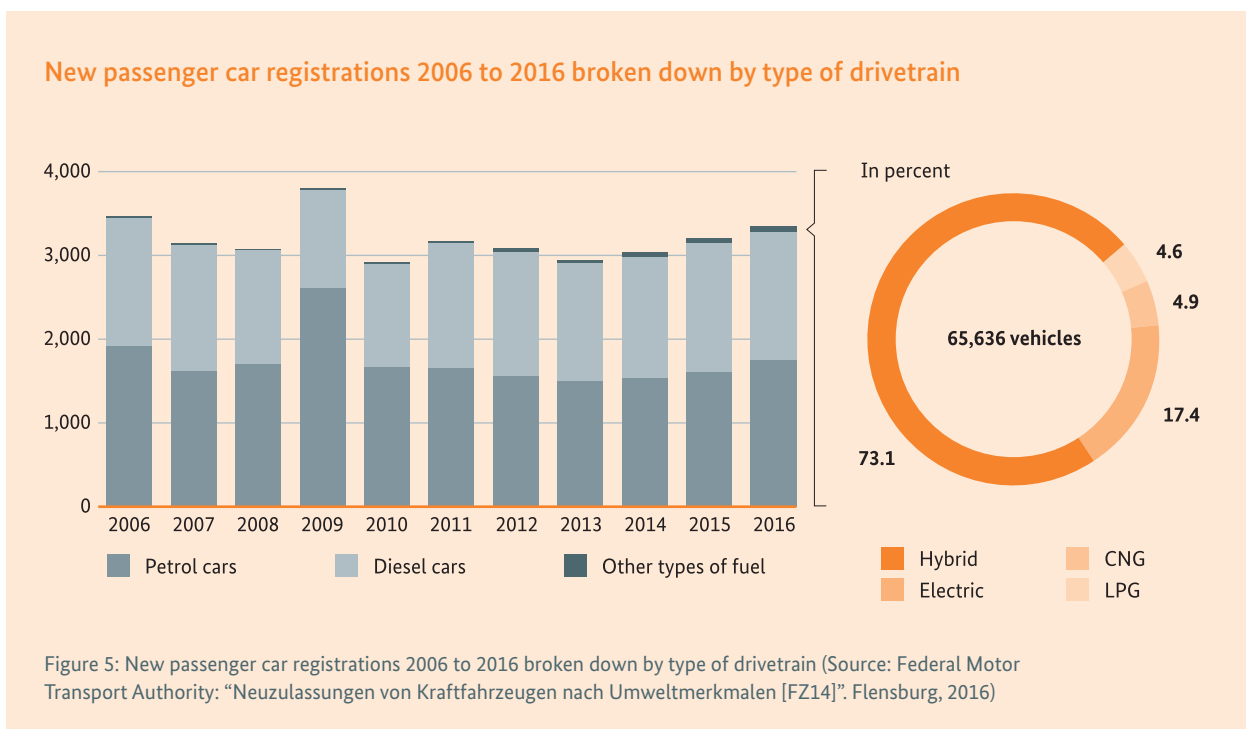


## Road transport

Over the past few decades, there has been a continuous rise in the number of motor vehicles registered in Germany. In 2016, the Federal Motor Transport Authority recorded 3.4 million new passenger car registrations. At the beginning of 2017, a total of 45.8 million passenger cars were registered – 1.6 percent more than at the beginning of the previous year. The total number of commercial vehicles registered rose by 2.8 percent to 5.5 million in 2016.

The consequence of the growing number of motor vehicles and their increasing mileage is a higher demand for energy and the rising levels of emissions this entails. This is to be countered by means of a greater market penetration of efficient alternative drivetrains and fuels. Alternative drivetrains are indeed exhibiting significant growth rates, especially hybrid and electric vehicles, even though petrol and diesel engines continue to dominate the car market.

The following illustration shows the trends in the registrations of new passenger cars, broken down by the drivetrain system installed.



## Alternative drivetrains and technological innovations in road transport

The decarbonization of road transport is being pursued via various options and without favouring a specific technology. The approaches suitable for each use become apparent on the basis of the requirements of the respective vehicles. Thus, the direct use of electricity from renewable energy sources in an electric motor – with intermediate storage in batteries, for instance – represents basically the most efficient way of powering a vehicle. In addition, in cases where electrification does not represent an option because of the great requirements in terms of engine power and range, hydrogen plus biogenic and electricity-based (synthetic) liquid fuels and gaseous fuels can make appropriate contributions.

### Private motorized transport

As the greatest emitter of CO<sub>2</sub> from road transport, the passenger car is frequently at the centre of public debate. Alongside European legislation, under which, starting in 2020, passenger cars registered for the time must not emit more than 95 g of CO<sub>2</sub>/km on average, the MFS focuses on studying and leveraging the efficiency potential inherent in passenger cars to reduce greenhouse gas emissions.

The increasing discrepancy between the emission values determined within the scope of type approval and the actual values occurring in normal vehicle operation prompted a fundamental revision and augmentation of the European type approval legislation. With regard to the non-representative fuel consumption figures (CO<sub>2</sub> emissions), a new “Worldwide Harmonized Light Duty Vehicles Test Procedure” (WLTP) was developed by the United Nations Economic Commission for Europe (UNECE) and incorporated into the European type approval legislation. As of September 2017, this procedure will be mandatory for approvals of new vehicles in the EU.

The electrification of passenger cars offers a particularly efficient option for decarbonizing private motorized transport. The Federal Government is supporting market penetration by means of numerous funding and networking initiatives relating to all aspects of charging infrastructure and vehicle procurement.

Back in 2009, as part of the Second Economic Stimulus Package, the Federal Ministry of Transport and Digital Infrastructure (or Federal Ministry of Transport, Building and Urban Development as it was called at the time) launched the financial assistance programme entitled “Electric Mobility in Pilot Regions”, which involved close cooperation between government, industry and academia. Over the period to the end of 2011, a broad spectrum of electric vehicles was deployed in eight pilot regions in a wide range of

different projects. The aim was to make electric mobility part of people's everyday lives. In 2012, the Federal Government launched the "electric mobility showcases", which complemented the "electric mobility pilot regions" by implementing stand-alone projects, academic studies and collaboration formats.

To establish electric vehicles on the market, the Federal Ministry of Transport and Digital Infrastructure issued the Electric Mobility Funding Guidelines in 2015, with which it has stepped up the support it provides to local authority and commercial fleet operators for the procurement of electric vehicles and the preparation of electric mobility strategies. Since 2016, the purchase of electric vehicles by both commercial enterprises and private individuals has been encouraged by the payment of an environmental bonus. A grant of €4,000 is provided to purchasers of battery electric or hydrogen fuel cell powered passenger cars and €3,000 to purchasers of plug-in hybrid electric vehicles (PHEVs). One half of the grant is paid by the Federal Government, and the purchaser receives the other half from the automotive manufacturer. In addition, all-electric vehicles are exempt from motor vehicle tax for ten years, with PHEVs being taxed on the basis of their CO<sub>2</sub> emissions.

In 2017, the Market Activation Funding Guidelines were issued within the scope of the NIP II. For the first time, financial assistance is now provided to the procurement of fuel cell powered vehicles in commercial fleets and local public transport. Investment is subsidized when three or more vehicles are purchased.

For vehicles marked accordingly ("E" at the end of their registration number or a sticker for vehicles registered abroad), the Electric Mobility Act has created not only the possibility of reserving parking spaces but also further privileges when these vehicles use the road. These concern options for granting concessions in the charging of parking fees, authorizations to exempt electric vehicles from access restrictions and allowing them to use bus lanes. This is designed to increase the acceptance and attractiveness of electric mobility. The measures are implemented by the (authorities of the) federal states.

In addition to electric mobility, alternative fuels can also help to reduce emissions from private motorized transport. Natural gas (CNG) and liquefied petroleum gas (LPG) are the most widespread of these. Today, greenhouse gas emissions from the use of CNG are already lower than from the use of LPG and established fuels. They can be reduced even further by blending CNG with synthetic or biomethane.

### **Road-based public transport**

Providing the population with sufficient local public transport services is part of the task of providing services of general interest which, in keeping with the federal structures in Germany, is the responsibility of the federal states and local authorities. For all sections of the population, and especially for commuters,

who now make up 60 percent of all employees, local public transport offers a key range of transport services, which have not only a social dimension but also a significant economic and ecological significance. Compared with private transport, public transport can carry more people while requiring less space and causing fewer emissions. With corresponding occupancy rates, its energy consumption and pollutant emissions per passenger are significantly lower than in private transport. Shifting passenger traffic to public transport is thus an important factor for the reduction of emissions from the transport sector.

Bus transport is currently based almost exclusively on the use of diesel powered vehicles. Thus, irrespective of the modal shift impact, switching to different types of drivetrain in public transport can play an important part in tackling climate change. Natural gas and hybrid applications, and in particular the electrification of the bus drivetrain via overhead lines, battery and fuel cell solutions, can be the basis of low-emission mobility. Since the revenue from local public transport is rarely sufficient for operators to break even and they thus have to rely on additional public funding, the costly establishment of innovative financial technologies confronts many local public transport operators with further financial challenges.

The Federal Government is thus promoting the evolution and procurement of electric buses with various charging systems within the scope of the Ministry's 2015 Electric Mobility Funding Guidelines. The findings and lessons learned from the approximately 31 regional financial assistance projects are being systematically recorded and appraised by a working group entitled "Innovative Drivetrains for Road-Based Local Public Transport", which has been chaired jointly by the Federal Ministry of Transport and Digital Infrastructure and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety since 2012.

The aim of this working group, which has an interdisciplinary composition, is to support sustainable commercialization through hybrid buses and speed up preparation of the market for innovative drivetrain technologies (electric buses). Alongside the federal ministries providing the funding, 34 public transport operators, ten industry partners on the vehicles and technology manufacturing side and eleven organizations from academia and the research community participate in the working group. The working group links up the regional stand-alone projects in which the practical viability, operational maturity, energy efficiency, ecological and climate change impact, value for money and acceptance of more than 200 vehicles, of which 79 are hybrid diesel buses, 25 electric buses and twelve fuel cell powered buses, are evaluated and documented. The working group has conducted a comprehensive analysis of the real-world operation of buses with innovative drivetrains in urban traffic, the findings of which are incorporated into an extensive database on real-life technology assessment.

The key findings regarding the operation of **hybrid diesel buses** are that they have high levels of availability (> 90 percent), consume up to 20 percent less fuel on suitable routes and exhibit great scope for a reduction in pollutant and noise emissions (especially in electric only mode) compared with diesel. **Battery powered buses** are currently at an early development/technology deployment phase. They have been operated in the context of research and development projects. This has involved different types of drivetrains and recharging (conductive/inductive, overnight charging at the depot or opportunity charging at points along their route or at their terminus). Battery powered buses tend to have mean availabilities of 75 percent. These are comparable to the values achieved initially when hybrid diesel bus technology was introduced. The installation of and interaction with the charging infrastructure is of great importance. As far as energy requirements are concerned, there were seasonal effects, which means that the need for heating and air conditioning had a great impact on the range.

[Conversion of bus depots for electric fleets \(in German\)](#)



Given that battery powered bus projects have thus far been limited to only few vehicles and bus routes, two bus depots in Hamburg will now be equipped to provide for an entirely battery-electric powered bus fleet. A new bus depot from the Hamburger Hochbahn AG will be built, and another already existing bus depot from the Verkehrsbetriebe Hamburger-Holstein will be upgraded. For this upgrade, a battery storage system from used vehicle batteries (second-life battery use) will be utilised. This is necessary, as so-called “overnight-chargers” will be used that can only charge at night and will pull their total daily charge from this time. The Federal Ministry of Transport and Digital Infrastructure funds both projects in the context of the MFS with a total of 8,6 million euros.

As part of the “Clean Energy Partnership (CEP)”, hydrogen fuel cell buses have been trialled in regular operations in Hamburg, Stuttgart, Cologne and Karlsruhe within the scope of pilot projects. Since March 2017, it has been possible to receive capital grants for the procurement of fuel cell powered buses via the Market Activation Funding Guidelines within the scope of the NIP II.

In 2016, the cities of Berlin and Hamburg adopted a joint procurement initiative for zero-emission regular service buses used in local public transport. In the interests of environmentally sound local transport, up to 200 zero-emission buses are to be procured and deployed each year by the federal state-owned transport operators without favouring a specific technology.

An alternative drivetrain system for public transport buses is also the (hybrid) trolley bus. Today, trolley buses operate in only three German towns: Solingen, Esslingen and Eberswalde. Currently, the main focus is on the hybrid application where, in addition to the pantograph, the buses are also fitted with batteries that are charged below the contact wire and by regenerative braking. This means that the buses can be powered by electricity on non-electrified sections

as well. In this way, overhead lines do not have to be installed on especially sensitive sections (for instance near listed buildings) or in areas that are expensive or require a high level of maintenance (for instance intersections).

The study entitled “Potential Inherent in Hybrid Trolley Buses as an Efficient Option for the Use of Renewable Energy Sources in Local Public Transport”, which was conducted within the scope of the MFS, identifies present-day and future fields of application for hybrid trolley buses. According to this study, it makes most sense to deploy them on especially demanding routes (long diagrams, short dwell times, high passenger volumes, difficult topography) that cannot be served by all-battery electric buses. In addition, the extra costs of providing the infrastructure can be offset by lower running costs.

Building on the findings of the study and specialist workshops, the Federal Ministry of Transport and Digital Infrastructure launched a research project to explore more precisely the technologies and options for an automatic connection with the overhead line. Currently, this is mainly possible at stops. In the future, however, the vehicles are to be able to raise their trolley poles while in motion.

In addition, feasibility studies are currently being conducted into the introduction of hybrid trolley buses on potentially suitable lines in Marburg and Trier. In Solingen, funding provided by the Federal Ministry of Transport and Digital Infrastructure is being used to convert the existing overhead line network on one route. In the future, a route previously operated by diesel buses will be operated by hybrid trolley buses.

#### **Towards emission-free local public transport with the battery-powered trolley bus and smart charging infrastructure.**

In Solingen, 50 of the total of 99 buses are currently powered by electricity supplied via an overhead contact line. The project will now make it possible to operate complete routes with electric traction that were previously only partially electrified or operated by diesel buses. To this end, the battery-powered trolley bus is fitted with batteries and can recharge dynamically via the overhead line while in motion. The conversion of the vehicles also requires modifications to the infrastructure. In this way, the overhead lines in Solingen will be converted into smart charging infrastructure. This smart trolleybus system (STS) will allow optimum use to be made of the charging infrastructure. The connection to stationary storage devices, photovoltaics systems and charging posts for electric passenger cars and pedelecs will minimize transmission losses and enhance the energy efficiency of electric local public transport as a whole. At the same time, this is addressing the key prerequisite for implementing electric mobility strategies – the sector coupling of the energy and transport sectors in order to provide

[Potential Inherent in Hybrid Trolley Buses as an Efficient Option for the Use of Renewable Energy Sources in Local Public Transport \(in German\)](#)



sufficient electricity from renewable energy sources for the transport sector. In this way, the STS is to become the central distribution network for electric mobility. The battery-powered trolley bus and STS will become a mobile incubator of innovation, testing the practical deployment of hybrid trolley buses and trialling the sector coupling of transport and energy and energy distribution on a smart network.

### Road haulage

Road haulage plays a crucial role in the reduction of emissions and energy consumption in the transport sector. The Federal Ministry of Transport and Digital Infrastructure's 2030 forecast of transport interconnectivity predicts that freight moved in the road haulage sector will rise by 39 percent against 2010 levels. In addition, the dominant type of drivetrain in the entire commercial vehicle sector is the diesel engine. It is true that, after a long development and optimization phase, it is very efficient in goods vehicles. Nevertheless, there is also further scope for development here.

With the existing and planned financial assistance programmes plus pilot and demonstration projects, the Federal Government is making numerous efforts to leverage further efficiency gains in drivetrain technology, vehicle bodies and the interaction between individual components and to explore fuel alternatives to diesel. An appropriate framework is also being created at EU level. Directive (EU) 2015/719 amending Council Directive 96/53/EC will, in the future, allow vehicles equipped with alternative drivetrain technologies to have a higher maximum permissible weight and, if their energy efficiency is improved by means of aerodynamic design or devices, to exceed the maximum permissible length for certain vehicles.

One promising option for a diesel substitute that has already been trialled is **natural gas**. Its use can significantly reduce pollutant emissions and the noise emissions caused by the drivetrain. The use of biogas or synthetic methane produced from (renewable) electricity could even make the drivetrain completely carbon-neutral.

The 2013 MFS recommended that the addition of alternative fuels to the range of transport fuels for goods vehicles be examined. This has been done in a wide range of ways. Thus, for instance, the MFS study entitled "Identifying Obstacles to the Use of LNG and CNG in Goods Vehicles and Ways of Overcoming Them" sheds light on the various fields of application of CNG (compressed natural gas) and LNG (liquefied natural gas). According to this study, LNG is an option particularly for heavy goods vehicles, which also require a long range, whereas CNG is more suitable for regional transport because of the lower amount with which vehicles can be refuelled. The key obstacles to the use of LNG and CNG that were identified were, in particular,

[Identifying Obstacles to the Use of LNG and CNG in Goods Vehicles and Ways of Overcoming Them \(in German\)](#)



the fact that procurement costs are still too high, the engine technology has not yet matured and insufficient infrastructure has been deployed. To kick start the technology, targeted financial assistance is being provided to the use of natural gas in the road haulage sector, for instance by the deployment of suitable refuelling infrastructure and appropriate pilot projects to examine practicability. Other accompanying measures include linking up stakeholders along the value chain and establishing an appropriate information and networking platform.

Another analysis within the scope of the MFS addresses “LNG as an Alternative Fuel for the Operation of Ships and Heavy-Duty Vehicles.” It studies the options offered by LNG for covering the energy needs of maritime shipping, inland waterway transport and heavy goods vehicle traffic while at the same time reducing pollutant and greenhouse gas emissions. To this end, it looked at all modes of transport with regard to relevant technical components for vehicles, supply and infrastructure. From this it derived introduction scenarios, in which the quantities of a future demand for LNG and the associated scope for a reduction in greenhouse gas emissions were estimated. For heavy goods vehicles, it recommends that, as the refuelling infrastructure is deployed along the main corridors, synergies with inland waterway transport be examined. To establish this fuel on the market, it is also important that the fuel costs are calculable in the long term; the use of costly renewable methane could cause them to rise.

To promote the use of LNG in the transport sector, the Federal Ministry of Transport and Digital Infrastructure has assumed the patronage of the **LNG Task Force**, an association of key market players formed to progress the introduction of LNG as a fuel in the road haulage sector. Its declared aim is to continuously identify obstacles and the need for new technical standards, to define suitable safety standards and fill information gaps.

#### **Funding of LNG-powered HGVs**

In a demonstration project, the Federal Ministry of Transport and Digital Infrastructure is providing financial assistance for the purchase of 20 LNG-powered HGVs for deployment by a logistics operator. The operator will use the IVECO Stralis NP HGVs in Berlin for temperature controlled logistics and food distribution. Provisional calculations show that it will be possible to reduce CO<sub>2</sub> emissions by around 50,000 kg per vehicle in five years. The first vehicle of the fleet was commissioned in 2016. Complementing this, the first LNG refuelling point accessible to the public has been funded via the Blue Corridor Project. It opened in April 2017 and is located on the eastern section of the Berlin orbital motorway. It is the first refuelling point that is open to other users who have LNG vehicles. The purpose of the project is to put LNG into practical use as a fuel on German roads and to trial its environmental sustainability and commercial viability.

[LNG as an Alternative Fuel for the Operation of Ships and Heavy-Duty Vehicles.](#)



[Feasibility Study to Identify the Potential Inherent in Hybrid Trolley Trucks \(in German\)](#)



**Electrification** also presents opportunities for the decarbonization of transport in the road haulage sector. Electrical and hybrid approaches are already available on the market for light-duty commercial vehicles and collection and distribution operations. In the medium term, there is not likely to be any electrification of heavy goods vehicles with high mileages, because the batteries available today do not yet exhibit sufficient energy density for the necessary transport weight. The demand for higher engine power in heavy goods vehicles, which has been growing for years, additionally impedes the substitution of battery electric options for internal combustion engines. Studies conducted within the scope of the MFS are thus examining the use of hydrogen and fuel cell technology and the deployment of an overhead line system for the direct supply of electricity to HGVs.

So far, **hydrogen and fuel cell technology** has been used in HGVs only for additional power generation in auxiliary units for on-board electricity, for instance to reduce noise and pollutants at the point of use. However, as a drivetrain technology – still little researched in HGVs – it does offer considerable scope for the low-emission freight transport of the future if the hydrogen used to fuel the vehicles comes from renewable sources.

The MFS study entitled “Fuel Cell Powered HGVs: Critical Development Obstacles, Research Needs and Market Potential” illustrates that although the technological lessons learned from the passenger car sector can provide pointers to the use of the technology in HGVs, they should not be overestimated, because the requirements of an HGV are different. With regard to a market launch in the medium to long term, it is apparent that the the fuel costs’ share of the total cost of ownership is very high in the HGV sector. For this reason, the high original cost of innovative drivetrains of this nature cannot be recouped unless the drivetrains are combined with low operating costs. At the current point in time, it is difficult to estimate how the cost of hydrogen will develop. It is heavily dependent on demand and on the surplus production of electricity from fluctuating renewable energy sources. The way in which the taxes levied on fuel develop will also play a role.

One potential disadvantage of the technology is, in some cases, considered to be the reduced range. Whereas a conventionally powered 40 tonne HGV has a range of around 2,500 kilometres, a hydrogen and fuel cell powered HGV with the same tank capacity would have to refuel after as little as 300 to 400 kilometres. Taking into account the derogation for fuel cell powered vehicles (EU Directive 2015/719), which permits a higher weight and a greater length of HGVs if they result in reductions in pollutant emissions, plus a higher energy density and a larger tank, the range on a full tank could be increased to 800 to 1,000 kilometres. The acceptance of this range has to be examined, as do the options for enhancing the efficiency of auxiliary units and hybrid systems comprising a fuel cell and a battery.

In the future, the MFS will look more closely at import options for electricity-based fuels. These can make an important contribution to decarbonization in transport sectors in which electrification will not be possible for the foreseeable future. Since the nature and time of the electrification of HGV transport are still unknown, the use of these fuels is a possible option. Here, the unanswered questions have to be resolved, for instance with regard to demand trends, production costs and the countries suitable for production.

For reasons of emissions and noise mitigation, **battery electric commercial and delivery vehicles** are becoming increasingly important, especially in urban freight transport.

In urban commercial transport, electric vehicles are already fit for everyday use and, if used in suitable settings, also economically viable. In the funding projects of the Federal Ministry of Transport and Digital Infrastructure, the greater use of electric delivery vehicles in local authority or private sector fleets and the integration of appropriate logistics strategies into local authority transport planning thus take centre stage.

As part of its efforts to promote electric mobility, the Federal Ministry of Transport and Digital Infrastructure has funded a nationwide series of research projects on electric commercial transport. A total of around 600 commercial vehicles with all-electric or hybrid drivetrains have been tested in field trials over the last few years.

To evolve the electrification of HGVs, the **Federal Government's Electric Mobility Programme** continues to support, among other things, the hybridization of HGVs, the enhancement of the efficiency of auxiliary units plus the basic user take-up of electric vehicles and the deployment of appropriate charging infrastructure. In addition, research into and the development of the use of fuel cells in HGVs is being funded within the scope of the **NIP**.

Within the scope of the Federal Ministry of Transport and Digital Infrastructure's Electric Mobility Pilot Regions, various applications for electric drivetrains in freight transport are being studied. In one of the projects being funded, a haulage company is operating a battery-powered HGV within its fleet and testing it in real-life conditions. The vehicle has a range of around 300 kilometres and consumes around 40,000 kilowatt hours per year (instead of 12,000 litres of diesel for the same mileage). The haulage and logistics industries expect the operating costs to be around 30 percent lower than for a conventional HGV and the maintenance costs to be around 75 percent lower.

[Fuel Cell Powered HGVs: Critical Development Obstacles, Research Needs and Market Potential \(in German\)](#)



### Climate-Friendly Road Haulage Initiative (in German)



#### **The Climate-Friendly Road Haulage Initiative**

The aim of the Climate-Friendly Road Haulage Initiative was to develop options for sustainable road haulage. From November 2016 to March 2017, stakeholders from industry, trade associations and academia formed three working groups to jointly develop possible next steps to promote the use of electricity-based liquid fuels, (renewable) LNG and hydrogen in heavy goods vehicles. The proposed measures cover the period to 2030, looking ahead to 2050, and are divided into three areas: research and development; pilot and demonstration projects; and policy and regulations. They also comprise the deployment of infrastructure and the development and trialling of new engine technologies. The findings of the work informed a roadmap for climate-friendly road haulage, which was adopted by the initiative in April 2017. Within the scope of the MFS and the NIP, it is now possible to fund pilot projects and demonstration projects and resolve unanswered questions within the context of academic studies.

The MFS defined the study of “longer goods vehicles” in terms of the energy and environmental impact as a task. On this basis, the Federal Ministry of Transport and Digital Infrastructure launched a five-year field trial to study the climate change impact of these vehicles. The test phase showed that two trips by longer goods vehicles replace three trips by conventional goods vehicles. The efficiency gains and fuel savings are between 15 and 25 percent. The trial did not reveal any higher need for structural maintenance of the infrastructure or an undesirable modal shift from the railways to the roads. Thus, in early 2017, the Federal Ministry of Transport and Digital Infrastructure put the majority of the longer goods vehicles into permanent operation. The Regulations allow longer goods vehicles to permanently operate on specified routes, known as the “approved network”. There are exceptions for just two types of longer goods vehicle: a time limit was set for the continuing operation of longer articulated vehicles (a further seven years) and articulated vehicles with a centre axle trailer (one year). The federal states are responsible for reviewing the roads suitable for the network. The approved network currently has a length of around 11,600 kilometres.

## **Alternative fuels infrastructure in road transport**

### **Charging infrastructure for battery electric and plug-in hybrid vehicles**

For the market ramp-up of electric vehicles, it is essential that it be accompanied by the deployment and expansion of charging infrastructure which, in terms of quantity and quality, meets current and future requirements, provides universal coverage and is user friendly.

In recent years, the Federal Government has invested considerable funds in numerous pilot projects to deploy basic facilities for the charging infrastructure. In the field of normal power charging infrastructure (recharging with alternating current up to 22 kW), numerous research and development projects have been carried out, commissioned primarily by the Federal Ministry of Transport and Digital Infrastructure, and around 2,500 charging stations with a total of around 6,000 recharging points have been installed.

However, in the market ramp-up phase that has now begun, the deployment and operation of charging infrastructure is still scarcely feasible on a purely commercial basis. Government assistance will therefore be necessary in the years ahead. The reduction in the costs of installing charging infrastructure will create the necessary incentive to invest in this sphere. In turn, as charging infrastructure that meets the demands of the market becomes increasingly available and accessible and as charging times are reduced, vehicle users will be encouraged to purchase electric vehicles rather than conventionally powered ones.

The Federal Government has defined the target of having a total of 43,000 recharging points – of which 7,000 are to be high power recharging points – in place throughout Germany by 2020. So far, electric mobility has primarily been funded within the scope of demonstration projects in pilot regions and in “electric mobility showcases”, which has already created a high density of charging stations in Stuttgart, Berlin, Bremen and Hamburg. The Funding Guidelines for Electric Vehicle Charging Infrastructure in Germany support the deployment of appropriate (high power) charging infrastructure in conurbations, along the key transport arteries and in rural areas. Under these Guidelines, the Federal Ministry of Transport and Digital Infrastructure is currently providing funding of 300 million euros for 15,000 charging stations. Of this funding, 100 million euros is earmarked for normal power charging and 200 million for high power charging. Applications can be submitted by private sector investors, towns and cities.

These Funding Guidelines are designed to launch a user-friendly charging infrastructure network that provides universal coverage and meets the requirements of the market so that users of electric vehicles can recharge them quickly and easily anywhere in Germany, depending on their driving and parking patterns. Another objective of this financial assistance programme is that, in the years ahead, properly functioning and broad-based competition should be established between providers of charging infrastructure, thereby preventing one company from enjoying a local dominant market position.

To complement the financial assistance programme for the deployment of appropriate (high power) charging infrastructure, Autobahn Tank & Rast GmbH, following an initiative of the Federal Ministry of Transport and Digital

Infrastructure and within the scope of existing concession agreements, is equipping the motorway service areas at around 400 locations with high power recharging stations. This measure, co-funded by the Federal Ministry of Transport and Digital Infrastructure on a pro rata basis, will create the first nationwide network of electric filling stations.

The European Union has also given a kick-start to the funding of the deployment of charging infrastructure via the “Trans-European Transport Network (TEN-T)” programme.

To ensure that the infrastructure deployed can actually be used by all electric vehicles, the Federal Ministry for Economic Affairs and Energy’s Charging Post Regulations transposes the AFID’s technical standards for charging infrastructure and the requirements relating to ad hoc charging. In particular, the Regulations define uniform standards for plugs and access, in order to ensure that all charging posts can be used by all vehicles, thereby further boosting the market ramp-up. Through this harmonization, the Charging Post Regulations are making an active contribution to implementation of the MFS.

[Funding Guidelines for Electric Vehicle Charging Infrastructure in Germany \(in German\)](#)



### **Hydrogen refuelling points for fuel cell powered vehicles**

The AFID states that sufficient hydrogen refuelling points must be in place by 2025 to enable the movement of corresponding vehicles across borders on the TEN-T if appropriate. To this end, the Federal Government is funding, within the scope of the NIP, the deployment of a basic network of 50 hydrogen refuelling points in the metropolitan regions of Berlin, Hamburg, Düsseldorf, Frankfurt, Stuttgart and Munich and along the motorways linking them. The Federal Government’s next objective is to have basic coverage of Germany by 2020 with around 100 hydrogen refuelling points. Around 400 refuelling points are to be created by 2025, depending on the market penetration of hydrogen powered vehicles. The infrastructure is to be deployed principally by H2MOBILITY, a cross-sectoral joint venture.

In 2016, the decision was taken to continue the programme until 2026 in order to continue the provision of targeted financial assistance to electric mobility using hydrogen and fuel cell technology.

[NIP II Funding Guidelines: Research, Development and Innovation \(in German\)](#)



### **National Hydrogen and Fuel Cell Technology Innovation Programme, Phase II (NIP)**

The aim of the Federal Ministry of Transport and Digital Infrastructure’s measures within the scope of the NIP is to establish competitive mobility using hydrogen and fuel cells on the market in the next ten years. This includes in-vehicle technologies and systems as well as the refuelling infrastructure required in any given case. In the first phase (2006 to 2016), funding totalling 1.4 billion euros was provided to support the development of hydrogen and fuel cell technology

products until they reached commercial maturity. One half of this funding came from the Federal Government and the other half from the industry stakeholders. The second phase (2016 to 2016) now involves supporting the introduction of technologically mature products in competition with one another. For this purpose, the Federal Ministry of Transport and Digital Infrastructure is providing – initially until 2019 – additional funding totalling 250 million euros. The funding is provided in two pillars – one of them for research, development and innovation, and the other one for direct market activation by providing capital grants, for instance for fuel cell powered vehicles or electrolysis systems for the generation of green hydrogen.

#### **The Clean Energy Partnership (CEP) & H2 MOBILITY**

From 2002 to 2016, the CEP was one of the NIP's key lighthouse projects. This project involved 20 industry stakeholders from various sectors joining forces to develop the systems capability of vehicles, refuelling points and logistics in the field of hydrogen and fuel cell technology.

The Federal Ministry of Transport and Digital Infrastructure provided a total of 118 million euros to support the CEP's activities, thereby enabling it to achieve considerable success. Fuel cell powered buses are now in operation on public transport services, and since 2016 the first passenger cars ready for mass production have been available in Germany. The deployment of a basic network of hydrogen refuelling points funded by the Federal Ministry of Transport and Digital Infrastructure is to be continued by H2 MOBILITY Deutschland, a joint venture comprising companies from the automotive, gas and petroleum industries. The first 100 refuelling points are to be completed by 2018/2019. Subsequent further deployment will be based on the numbers of fuel cell powered vehicles registered. With 400 refuelling points, a nationwide hydrogen refuelling infrastructure could have been installed in Germany by 2023.

#### **Infrastructure for natural gas in road transport**

Alongside electrification and the use of hydrogen and electricity-based fuels, natural gas also represents a major alternative to diesel and petrol. On the basis of the requirements set out in the AFID, an appropriate number of CNG and LNG refuelling stations are also to be installed in all European countries.

The MFS study entitled “The Development of Packages of Measures to Promote CNG/LNG to Support the CPT Initiative” represents the state of play of the supply of CNG/LNG in Germany and identifies, on the basis of future requirements, a recommendation for the appropriate supply of CNG and LNG for

[\*NIP II Funding Guidelines:  
Market Activation \(in German\)\*](#)



[\*The Development of Packages  
of Measures to Promote CNG/LNG  
to Support the CPT Initiative  
\(in German\)\*](#)



road and maritime transport. For CNG, there is currently already a basic infrastructure in Germany, so that the main focus here is on stabilizing the market.

To meet the requirement set out in the AFID that the maximum distance between refuelling points along the TEN-T Core Network should be 400 kilometres, a total of fewer than ten LNG refuelling points are necessary in Germany. Given that it is possible to blend sustainably produced methane into LNG, the deployment of further LNG infrastructure could, in the long term, prove ecologically beneficial and economically viable. To speed up the market launch of LNG in the heavy goods vehicle sector, the Federal Ministry of Transport and Digital Infrastructure is creating demand-side incentives. The Ministry has assumed patronage of the **LNG Taskforce**, thereby providing further support to the development of a market for LNG.

## Rail transport

In 2015, rail transport accounted for 7.7 percent of all passenger kilometres travelled and 18 percent of all freight moved. It is of particular importance for reducing the climate change impact of transport. The reason for this is the high degree of electrification of the relevant route network. Throughout Germany, around 60 percent of all lines are electrified, albeit with significant regional differences. Of the total traffic in terms of passenger and tonne kilometres in the transport sector, electrically powered freight services account for 93 percent and passenger services for 88 percent.

Electrified services are being decarbonized by the continuous adaptation of the traction current mix, with an increase in electricity from renewable sources. 42 percent of the mix of traction current supplied by DB Energie is already from renewable energy sources. Back in 2011, this share was only 21.8 percent. DB Energie's aim is to increase renewables' share of the traction current mix to 45 percent by 2020 and, by 2050, to completely decarbonize all services operated by railway undertakings that are supplied by DB Energie.

## Alternative drivetrains and technological innovations in rail transport

Whereas long-distance passenger rail services are already completely electrified (with a few exceptions), diesel locomotives are frequently still in operation on many local lines and freight services. Rail transport is already climate-friendly and should be able to fully deploy its potential for contributing to the energy and climate policy objectives. To this end, the MFS is addressing not only the

electrification of further lines but also innovations that can fundamentally enhance the attractiveness of rail transport. These include new technologies for container handling, for simplifying combined transport and for reducing costs through digitalization, for instance for the more reliable operation of less-than-wagonload services. In addition, technological developments in the field of alternative types of drivetrain are being studied and progressed by means of pilot programmes. These include, for instance, the hybridization of diesel traction and the use of battery electric power cars.

A suitable alternative from a present-day perspective is the operation of hydrogen and fuel cell powered trains. If the hydrogen is generated from renewable electricity, no emissions are produced, either at the point of use or in the overall footprint. The development of a hydrogen fuel cell railcar has thus been funded within the scope of the NIP. The first train is due to operate on regular regional services in Lower Saxony as early as 2018. By 2021, a total of 50 vehicles are due to be in operation on passenger services in three further

### The traction current mix as a lever for environmentally friendly rail transport

In percent

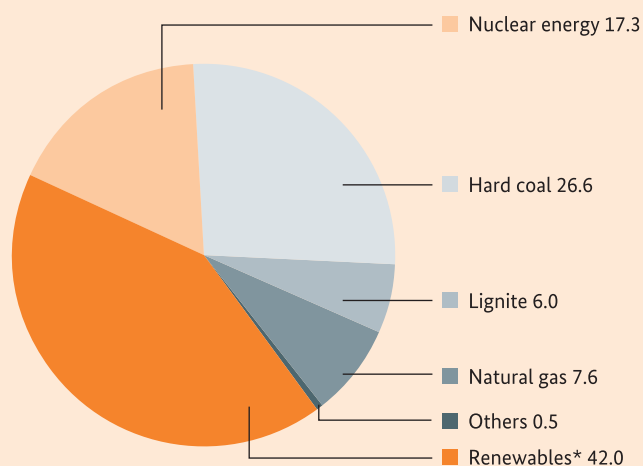


Figure 6: Share of renewables in the traction current mix in 2016.

(Source: Deutsche Bahn "Integrierter Bericht 2016 – Konzernperformance Ökologie." 2017)

\* The traction current mix also includes all additionally procured amounts of electricity for offers with 100 percent green electricity. In the case of railway undertakings that do not order any additional amounts of green electricity, the share of renewables in the traction current mix is 27 percent.

federal states (North Rhine-Westphalia, Baden-Württemberg and Hesse). To complement this, a study was carried out in the NIP to examine and identify technological, legal and economic prerequisites for the operationally sound supply of hydrogen to the non-electrified railway infrastructure in Germany. Because of their higher efficiency and lower maintenance costs, it is assumed that the operation of hydrogen and fuel cell powered trains could make it possible to save up to 25 percent of the costs incurred today for the operation of diesel rolling stock.



#### Alstom's Coradia iLint – fuel cells in rail transport

Alstom has developed the first zero-emission fuel cell powered regional train – the Coradia iLint. Power is provided by a hydrogen fuel cell. It supplies electrical energy by combining hydrogen from the on-board tanks with oxygen from the ambient air to generate electricity. The only thing that is produced is water. Because the electricity is generated without a generator or turbine, the process is rapid and efficient. In addition, the system stores energy in lithium ion batteries if the energy produced is not required at a certain time or kinetic energy is generated during braking. This reduces the consumption of hydrogen. The intelligent energy management system means that the range and power output of the Coradia iLint are similar to those of other regional trains. Another distinctive feature is that the train is very quiet, thereby reducing noise emissions from rail transport.

In addition, the BEMU (“Battery Electric Multiple Unit”) project, which was funded under the “Electric Mobility Funding Guidelines”; involves trialling an electric multiple unit fitted with modern traction batteries on non-electrified or partially electrified lines. The aim of the project is to trial new technological developments in the field of battery powered multiple units and to furnish proof of the technological feasibility of battery electric powered trains, taking environmental aspects into account. It is also to study the overall value for money and, against an operational and financial background, draw a comparison with conventional diesel rolling stock. Practical recommendations for action are to be derived from the findings.

With the help of digitalization and electrification, existing diesel multiple units can also be made more climate friendly and energy efficient. One example of this is the Eco-Train project, which is likewise being funded by the Federal Ministry of Transport and Digital Infrastructure within the scope of the Electric Mobility Pilot Regions. When this train moves off and brakes, surplus energy from the diesel engine is produced and temporarily stored in a large battery. The energy management system, which is interlinked with the driver assistance system and all load components in the vehicle, then proactively decides how the most efficient use can be made of the stored energy. The modular system is initially designed for Class VT 642 DMUs, which operate

mainly on regional services. After approval (scheduled for 2018), it is planned to convert an initial small batch of a further 12 units operating on the Erzgebirgsbahn railway in Saxony by 2021. Subsequently, it will be possible to use similar modular systems on other classes.

There is significant scope for energy savings not only in the drivetrain technologies but also on the existing rolling stock. According to the MFS study entitled “Potential Modal Shift to Rail Freight in Germany” (cf. p. 65), there have been hardly any technological improvements to freight wagons with long service lives in recent decades. The installation of innovative brakes, couplings and the use of regenerative braking could save a lot of energy.

The “Innovative Freight Wagon” research project, for which the Federal Ministry of Transport and Digital Infrastructure is providing funding totalling 17 million euros within the scope of the programme of investments for the future, is studying what such a wagon could look like in the future. This involves DB Cargo AG and VTG AG developing and testing various types of wagon with which noise can be effectively reduced and energy consumption lowered.

## Aviation

Aviation is the transport sector with the highest growth rates in the world. According to the 2030 forecast of transport interconnectivity and the delineation criteria it uses, the number of air passenger kilometres travelled is expected to rise by a total of 65 percent and the number of cargo tonne kilometres flown by 94 percent between 2010 and 2030 in Germany alone. Although today the sector is responsible for only around 10 percent of greenhouse gas emissions from transport, it will play an increasingly important role in achieving the energy and climate policy objectives because of the forecast growth. In this context, it must also be borne in mind that the effects of aviation, because of its emissions at high altitudes, are significantly more relevant in terms of climate change than emissions from surface modes of transport.

Technological improvements to aircraft are ensuring that the specific fuel consumption per seat and kilometre is steadily falling. There is still great potential inherent in the optimization of flight routes and operational procedures and in increasing load factors. However, these efficiency enhancements alone will not offset the growth rates, which is why further measures have to be taken if aviation is to make a significant contribution towards achieving the energy and climate policy objectives.

Since a large proportion of air services are of a cross-border nature, approaches to more sustainable transport are always viewed in an international context. Further challenges are posed by the long development and life cycles of the aircraft, which often cover five decades from the development to the decommissioning of an aircraft generation. Consequently, the introduction of new propulsion technologies in the aviation sector is only possible on a very long-term basis. Higher amounts of energy are required for long-haul flights and greater volumes of passengers and cargo. For this reason, the energy sources must have a high energy density, since larger tanks would additionally increase energy consumption.



#### Hydrogen and fuel cell propulsion in aviation

A new and innovative propulsion technology for aviation that is conceivable in the future has been trialled with the “Antares DLR-H2” research aircraft. The aircraft, which was funded by the NIP, serves as a platform for the application of hydrogen and fuel cell technology. It has shown that the technology lends itself to the on-board power supply of commercial aircraft operating short- and medium-haul flights and for the propulsion of small passenger aircraft.

In addition, the system architecture and components for multi-functional fuel cell systems for the on-board power supply on commercial aircraft have been tested within the scope of the “BRIST” and “BeZel” research projects, which were also funded by the NIP. The aim is to make the components commercially viable for both the on-board power supply and the main propulsion systems (10 to 50-seaters). However, it is unlikely that there will be an initial demonstration on scheduled day-to-day services before 2025.

A suitable measure for making aviation more sustainable today is the use of renewable kerosene from different source/raw materials. Thus, in keeping with the MFS’s recommendation that alternative fuels be tested and evolved within the scope of aeronautical research, a number of stand-alone projects have been conducted or are currently being implemented.

The study entitled “Drop-in Fuels for Aviation” is studying various alternatives to kerosene that can be blended with conventional kerosene in existing fleets in the short to medium term and comparing their requirements in terms of the demand resulting from the growth in the aviation industry with their foreseeable availability. With regard to the technical, economical and ecological characteristics of drop-in kerosenes, it is clear that, despite the fact that renewable kerosene has great potential for reducing greenhouse gases, their production costs will, for the foreseeable future, be significantly higher than those of fossil kerosene. In addition, it must be borne in mind that the climate impact caused by the combustion of kerosene at high altitudes is

[Drop-in Fuels for Aviation](#)  
[\(in German\)](#)



considerably amplified by other emission factors such as water vapour, black carbon, nitrogen oxides and resultant contrails and cirrus clouds. It requires more than just examples of good practice to establish the supply of renewable kerosene to the aviation sector. What is also needed is a permanent strategy for the incorporation of renewable energy sources and the reduction of environmental effects of aviation.

The study entitled “Biokerosene and Renewable Jet Fuel for Future Aviation – From Theory to a Pilot Project” consolidates the findings of previous research, pilot and demonstration projects and identifies what gaps in knowledge and experience still exist, where in Germany specific projects for the use of drop-in kerosene could be most appropriate and how they would have to be fleshed out. Alongside the technical feasibility, it is not only the possibilities for long term cost reduction that are relevant here but also the requirements from a sustainability point of view and the measures necessary for a successful implementation of pilot projects in Germany.

The MFS project entitled “Feasibility Analysis for a PTG HEFA Hybrid Refinery in Germany” studied the feasibility of a hybrid refinery in Germany on the basis of specific plant designs. This refinery combined the production of kerosene using the HEFA (hydrotreated esters and fatty acids) method on the basis of vegetable oils with the production of the required hydrogen via the use of (surplus) electricity from renewable energy sources for water electrolysis (power-to-gas or PTG). This involved studying not only the actual material and energy balances of the designs but also their infrastructure requirements, their costs and value for money and the potential for greenhouse gas reduction inherent in them. To complement a site in Germany, it also addressed selected favourable regions throughout the world in terms of their comparatively more favourable conditions for the provision of renewable electric current for the PTG part.

With the aim of studying and verifying the behaviour of various renewable multi-kerosene blends under realistic conditions in the fuel supply infrastructure of a major airport, the Federal Ministry of Transport and Digital Infrastructure has commissioned, within the scope of the MFS, a comprehensive “Research and Demonstration Project on the Use of Renewable Kerosene at Leipzig/Halle Airport” (DEMO-SPK for short), which is the first project of its kind in the world. In addition to verifying the use of renewable multi-blends at the airport, a number of other issues are being examined. These include, but are not limited to, the impact on air quality at the airport, the development of practicable sustainability documentation and the question of a standardized method of crediting in emissions trading. In this context, the actual life cycle emissions of the renewable kerosene used are to be compared with those of conventional Jet A-1 kerosene. The findings of the project are due to be published in mid-2019.

[Biokerosene and Renewable Jet Fuel for Future Aviation – From Theory to Pilot Projects \(in German\)](#)



[Research and Demonstration Project on Renewable Kerosene \(DEMO-SPK\) \(in German\)](#)



There is also potential for reducing emissions and energy consumption at the airports themselves. More and more airports are converting their vehicles such as buses, pushback tractors and vans to alternative drivetrains. The Federal Ministry of Transport and Digital Infrastructure is supporting this conversion. For instance, within the scope of the Electric Mobility Pilot Regions projects, the “E-PORT AN” project has been funded at Frankfurt Airport and has been used to procure diverse electric ground handling vehicles. In addition, aircraft also require electricity and conditioned air when they are on the ground being prepared for their next flight. For this purpose, the aircraft have auxiliary power units (APUs), which are powered by kerosene and are not very energy efficient. To prevent the pollutant and noise emissions this involves, more and more gate parking spaces at airports have, in recent years, been equipped with ground power supply via the airport’s electricity grid. For parking spaces on aprons and at remote areas, on the other hand, greater use is being made of mobile ground power units (GPUs) which, although more energy efficient than the auxiliary power units on the aircraft, are currently still mostly powered by diesel. In the medium to long term, there is the possibility here of also using alternative fuels (for instance hydrogen) for the mobile supply of ground power, thereby further reducing emissions. The use of alternative drivetrains and generators at airports reduces not only emissions but also local noise exposure.

## Developing a regulatory framework

The airlines that are organized in the International Air Transport Association (IATA) have undertaken to reduce fuel consumption by 1.5 percent a year over the period to 2020 and to achieve carbon-neutral growth as of 2020. By 2050, CO<sub>2</sub> emissions are to be as much as halved compared with 2005. This means that the voluntary commitments by the industry are in keeping with European and international developments.

As early as autumn 2009, the International Civil Aviation Organization (ICAO) decided to develop a CO<sub>2</sub> standard for aircraft, thereby creating incentives to improve fuel efficiency. The limit for an aircraft’s fuel consumption is defined by flight kilometres and cabin size; it is more stringent for large aircraft (> 60 tonnes) than for small aircraft (≤ 60 tonnes). Likewise, the standard for newly certified aircraft is more stringent than for aircraft already in production. The standard for new aircraft types will enter into force in 2020, and the standard for aircraft already in production will enter into force in 2023. By 2028 at the latest, it will no longer be permissible to produce aircraft that do not meet the standard. From the perspective of the Federal Ministry of Transport and Digital Infrastructure, the limits agreed upon will make a good and important contribution to reducing the climate change impact of aviation.

The use of alternative fuels is also supported by an international ICAO resolution. The Federal Ministry of Transport and Digital Infrastructure and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety joined forces to contribute to the development of this resolution. A key tool of this agreement is CORSIA (“Carbon Offsetting and Reduction Scheme for International Aviation”). With this instrument, greenhouse gas emissions from aviation are to be kept at the 2020 level, thereby decoupling growth in the sector from its CO<sub>2</sub> emissions. Participation in CORSIA will be voluntary as of 2021 and mandatory as of 2027. CORSIA will stimulate the global demand for alternative kerosene.

In February 2017, the European Commission presented a proposal for a regulation amending the EU Emissions Trading System (ETS) in the aviation sector. This includes, but is not limited to, continuing the ETS for flights within the European Economic Area (flights to and from third countries and to and from outermost regions are to be excluded) and reducing the number of allowances by 2.2 percent a year as of 2021. Another MFS study is currently systematizing approaches and forecasts presented in this context and studying how IATA's international climate change and energy targets can be met in Germany and Europe.

## Shipping

With the onward march of globalization, there has been a huge increase in the amount of **freight moved by sea** in the past few decades, despite the intervening economic crisis. In 2016, the volume of freight traffic in the maritime transport sector in Germany was 296.5 million tonnes. And maritime traffic is likely to continue growing in the future. The maritime traffic forecast for 2030 assumes that there will be annual growth in the volume of cargo handled of 2.25 to 2.64 percent. Accordingly, the volume of cargo relevant to Germany handled by the 36 European seaports considered in the forecast is to rise by a total of 65 percent between 2010 and 2030.

Growth of this nature cannot currently be observed in the **inland waterway transport** sector. In 2016, inland waterway transport's share of the freight moved in Germany was eight percent. Its share of air pollutant emissions from transport is less than 3 percent. In 2016, a total of 221.3 million tonnes of goods were moved in the inland waterway transport sector, which was almost as many as in 2015.

To prevent emissions from shipping, various directives and limits apply at national and international level. In **maritime shipping**, the International Maritime Organization (IMO) champions the establishment of limits and their evolution. In 2008, within the context of a revision of the International Convention for the Prevention of Pollution from Ships (MARPOL Convention), stringent limits with regard to the sulphur content of marine fuels and nitrogen emissions from ships were established. These apply in the Emission Control Areas (ECAs) established by IMO. The North Sea and Baltic Sea already belong to the Sulphur ECAs, and they will belong to the Nitrogen Oxide ECAs as of 2021. This is designed, in particular, to counter ocean acidification and reduce pollutant emissions at the point of use. At the same time, it progresses the introduction and retrofitting of new propulsion systems which, as a rule, also produce fewer climate change emissions. In addition, at the end of October 2016, IMO decided to reduce the global limit for the sulphur content of fuel oil used on board ships from 3.5 to 0.5 percent as of 2020.

IMO also decided to introduce the "Energy Efficiency Design Index" (EEDI), which makes it possible to calculate and compare the efficiency of new-builds per tonne kilometre. With the introduction of a data gathering system, IMO is also making it mandatory for ships to collect and store data relating to their fuel consumption and, as of 2019, provide these data to their flag states in the form of collected anonymized datasets. This is part of a comprehensive strategy to reduce CO<sub>2</sub> emissions in international maritime shipping that IMO is due to have completed by 2023. The EU has developed a similar system – MRV (Monitoring, Reporting, Verification). As a first step, EU Directive 2015/757 is designed to produce an overview of emissions from shipping.

As of 2018, all shipowners will have to record and report the annual CO<sub>2</sub> emissions from ships of over 5,000 gross tonnage if they call at EU ports. Voluntary initiatives by stakeholders also play a major role in limiting emissions. Thus, for instance, the World Ports Climate Initiative (WPCI) has developed an instrument for identifying environmentally friendly ships – the Environmental Ship Index (ESI) – which makes it possible to grant these ships special conditions in ports if they comply with the required standards.

In the **inland waterway transport** sector, it is not only the reduction of CO<sub>2</sub> but also the reduction of emissions of particulate matter, nitrogen oxides and sulphur oxides that play a major role. At European level, new ships and replacement engines have to comply with the requirements set out in European Regulation (EU) 2016/1628 (non-road mobile machinery emissions). Since 2010, EU Directive 2005/33/EC has mandated the use of low-sulphur marine diesel oil.

The Central Commission for Navigation on the Rhine (CCNR) plays a major role in reducing emissions from vessels navigating on the Rhine. It has adopted a strategy for reducing the fuel consumption and GHG emissions from vessels navigating on the Rhine, which describes ways of reducing fuel consumption and CO<sub>2</sub> emissions.

## Alternative methods of ship propulsion

Because of the long design life of ships, especially in inland waterway transport, shipping faces the challenge of long cycles of technological innovation. In addition, their high energy needs hamper the use of alternative methods of propulsion and fuels. For this reason, the internal combustion engine using liquid fuels continues to be the dominant method of propulsion. In the maritime shipping sector, heavy fuel oil with high GHG and pollutant emissions continues to be used as a fuel on a large scale. In coastal areas, such as the European Sulphur ECAs, marine diesel oil, which emits fewer GHGs and pollutants, is frequently used. The fuel most used in the inland waterway transport sector is light fuel oil, which is comparable to diesel in terms of its properties such as the share of sulphur and the resultant emissions.

One of the most promising options for reducing emissions is the use of liquefied natural gas (LNG). Because it can be used in both maritime shipping and inland waterway transport, both sectors are addressed and studied together in the MFS. The specific requirements of the two sectors to be met by alternative fuels are included in the considerations.

[LNG as an Alternative Fuel for the Operation of Ships and Heavy-Duty Vehicles](#)



The technology for the use of LNG for both maritime shipping and inland waterway transport is already available today. Following a recommendation for action made by the MFS, an MFS study is analysing the potential inherent in “LNG as an Alternative Fuel for the Propulsion of Ships and Heavy Goods Vehicles”. According to this study, the maritime shipping sector could, if there is an appropriate regulatory framework, develop into the largest LNG consumer as early as 2030.

The key obstacle in the way of greater market penetration of LNG propulsion systems is the high level of initial investment required in a shipping industry dominated by short term planning. In the inland waterway transport sector, the costs of an LNG propulsion system are several times higher than those of present-day diesel propulsion machinery and constitute an investment barrier that is too high, especially for small and medium-sized shipping companies. This is compounded by the fact that, given the current state of play, LNG propulsion in inland waterway transport is economically viable only if mileage is sufficiently high and on major waterways. In the maritime shipping sector, the technology could be used on many ships. What is problematical, however, is the fact that there is not yet sufficient infrastructure in place for bunkering ships with LNG.

To provide assistance in the necessary approval procedures for the installation of LNG supply infrastructure, the Federal Ministry of Transport and Digital Infrastructure has launched an exchange of ideas and experience with the coastal states and North Rhine-Westphalia. The aim is to arrive at uniform application of the law at German ports.

The ongoing MFS study entitled “Commercial Maturity of Natural Gas Fuelled Engines in the Inland Waterway Transport and Maritime Shipping Sectors”, which involves intense consultation with the key professional stakeholders, is addressing the specific economic and operational reasons for the currently still very low market penetration of natural gas fuelled engines and investigating ways of remedying this. The analysis is focusing on, among other things, considerations of the investment and operating costs compared with other methods of propulsion and the scope for savings inherent in the use of this technology in terms of energy consumption and greenhouse gas emissions compared with marine diesel oil and heavy fuel oil. This is designed to identify suitable ways of establishing LNG as a fuel in shipping.

To demonstrate the suitability of LNG-fuelled ships for use in everyday applications, the Federal Ministry of Transport and Digital Infrastructure is launching pilot projects in the maritime and short sea shipping sectors and in the inland waterway transport sector. Thus, for instance, the Federal Ministry of Transport and Digital Infrastructure is currently funding the conversion of a container feeder ship to LNG, which will in the future operate

on the North Sea and the Baltic Sea. In addition, the Ministry has commissioned the construction of a new research vessel for the Federal Maritime and Hydrographic Agency, the “Atair”, which is to operate in areas with stringent environmental constraints. At 74 metres, it will be the largest ship in the Agency’s fleet and the first LNG-fuelled sea-going government vessel. In the field of inland waterway vessels, a further financial assistance project is addressing the development of an LNG propulsion system for a ferry on Lake Constance, which is to be operated by the Municipal Utilities of the City of Konstanz. This project, too, is the first of its kind in the world.

Based on all the lessons learned, the Federal Ministry of Transport and Digital Infrastructure is providing financial assistance within the scope of the MFS over the period to 2020 in the form of funding guidelines for equipping and converting sea-going ships to use LNG. Both private sector companies and public corporations and institutions are eligible to apply. This is designed to expedite the introduction of LNG as a fuel in the German shipping sector.

There is also potential inherent in hydrogen and fuel cell technology for reducing emissions from shipping. Its use can help in particular to improve the quality of the air in ports, urban shipping centres and near-coastal sea areas. To expedite the development of fuel cell systems as propulsion systems and for the on-board power supply of ships operating in both the maritime shipping and inland waterway transport sectors, the lighthouse project entitled “e4ships” is being funded within the scope of the NIP. This project involves funding not only continuous research and development but also extensive demonstration projects. For instance, the research project entitled “RiverCell – ELEKTRA” is studying the development of an energy-efficient hybrid-powered inland cargo vessel. In the inland waterway transport sector, it has also been announced that two fuel cell powered excursion ships are to be placed in service. It is also believed that, in the medium term, there is potential for the use of hydrogen and fuel cell technology as the main propulsion system on sea-going ships. Today, the generation of on-board power by means of fuel cells on sea-going ships can already help to reduce emissions. Within the scope of various NIP projects, studies are being conducted into the possibility of meeting the energy requirements of cruise ships docked in port by means of fuel cells installed on board.

The trialling of fuel cell systems on board sea-going ships also raises questions regarding economic viability and the development of international safety standards and regulations. On the basis of the “e4ships” project, the Federal Government has lobbied the International Maritime Organization to enshrine appropriate standards. In the inland waterway transport sector, there is a comparable development at the Central Commission for Navigation on the Rhine and in the European Union.

[Guidelines on the Provision of Grants for Equipping and Converting Sea-Going Ships to Use LNG as a Marine Fuel \(in German\)](#)



To promote low-emission inland waterway transport, the Federal Ministry of Transport and Digital Infrastructure has launched the “Financial Assistance Programme for the Sustainable Modernization of Inland Waterway Vessels”, which supports the conversion to low-emission propulsion systems. Funding is provided to modern diesel and gas engines, which produce fewer emissions than conventional diesel engines. In addition, when gas engines are installed, the associated gas storage and supply system is also eligible for funding. Further eligible measures for reducing pollutants are: technologies and systems for exhaust after treatment, such as catalytic converters, particulate traps or combined exhaust reduction systems. The use of hydrogen-water emulsions as a fuel can also make a significant contribution towards reducing pollutant emissions. In addition, financial assistance is provided to measures to improve energy efficiency, especially to reduce fuel consumption and thus CO<sub>2</sub> emissions, and to reduce noise emissions. The replacement of engines and the funding of exhaust gas cleaning systems constitutes implementation of specific recommendations for action from the MFS.

There have so far been very few zero-emission (at the point of use) ships, for instance with battery electric propulsion systems. They can represent an option if – for instance in the case of ferries or passenger ships – they cover relatively short distances and can recharge their batteries when docked. Initial successful projects have already been implemented. A further possibility for (partial) electrification is auxiliary electric motors, which support the conventional engines if there are additional requirements, plus gas- or diesel-electric propulsion systems. Thus, for instance, in waters with high velocity, high power outputs are required, whereas the relevant requirements on canals or canalized bodies of water are significantly lower. With the aforementioned methods of propulsion, both requirements can be better met in terms of environmental protection and climate change mitigation than with just an internal combustion engine, which would have to produce the maximum required power in order to be able to navigate the ship in all the aforementioned areas of application. As the trend towards higher-power electric motors is already apparent, it can be assumed that, at least in the case of ships with multi-engine systems, electric motors powered only by a battery could be a climate-friendly alternative, provided that appropriate charging infrastructure is available.

## Alternative fuels infrastructure in shipping

Alternative energy supply options have to be found both for the propulsion of ships and for their on-board power supply – at sea and in port. At ports, in particular, it is essential that pollutant emissions be avoided at the point of use.

During layovers in port, shore-side electricity supply is a suitable option for ensuring the supply of energy to ships with reduced emissions at point of use. For the deployment of the infrastructure, the AFID calls for the installation of shore-side electricity supply at seaports and inland ports by 31 December 2025 if demand exists, the cost-benefit ratio is positive and there is an environmental benefit. To this end, the Federal Government is funding a project at the Port of Hamburg, which provides a shore-side electricity connection for arriving cruise ships that has been in operation since 2016. In Lübeck, a shore-side connection for merchant shipping has been in place since as early as 2008. In the inland waterway transport sector, too, some berths have already been equipped with shore-side connections. The problem so far has been that shore-side electricity is more expensive than electricity generated by a ship's on-board machines. In the maritime shipping sector, in particular, installation entails high investment costs on the port and ship sides. In addition, the power grid has to be appropriately upgraded to be able to provide the necessary charging power. The Federal Government is discussing further options for supporting shore-side electricity supply, for instance by exempting the generation of shore-side electricity from the renewable energy and CHP surcharges.

For the uninterruptible power supply to container ships docked in port, the Federal Ministry of Transport and Digital Infrastructure is also funding the application of LNG generators in standard containers ("PowerPacs"). While ships are in port, the PowerPacs are lifted on board and replace the ship's own engines during layovers. This makes it possible to greatly reduce pollutant emissions. A similar approach is pursued by the LNG Barge. This vessel moors alongside the ship to be supplied in the water, produces the necessary electricity with the help of LNG and transmits it by cable. In addition, the Federal Ministry of Transport and Digital Infrastructure is endeavouring to expedite, within the CCNR, the use of shore-side electricity for inland waterway transport.

Because LNG represents a relevant fuel option for shipping, the provision of equipment at major ports for the supply of shipping traffic must also be considered in the deployment of LNG infrastructure. Here, the Federal Ministry of Transport and Digital Infrastructure is cooperating with the **Maritime LNG Platform**, an amalgamation of representatives from companies, associations and ports who discuss the introduction of LNG as a marine fuel and thus, in particular, the requirements to be met by an appropriate infrastructure. Today, ships are already being refuelled with LNG by trucks at the ports of Mannheim, Brunsbüttel, Bremerhaven, Hamburg and Rostock. This "truck-to-ship bunkering" represents an initial solution that does not require any costly infrastructure investment. The targeted upgrading of the infrastructure is also described and progressed by the "2015 National Ports Strategy". This contains specific requirements for

environmental protection and climate change mitigation in ports and the deployment of alternative fuels infrastructure. In particular, the Strategy describes measures for the deployment of infrastructure for the bunkering of LNG-fuelled ships, thereby helping shipping to meet the demands placed on it in the MFS.

Cost-benefit analyses have come to the conclusion that ship-to-ship bunkering currently does not yet represent value for money in Germany. Shore-to-ship bunkering facilities for ferries and cruise ships could be funded in the long run to kick-start the market ramp-up of LNG. Here, too, the Federal Government's long-term objective is to increase demand in order to make upgrading the infrastructure (bunkering terminals, bunkering vessels, distribution stations, etc.) commercially attractive, thereby ensuring nationwide LNG supply. To this end, the Federal Ministry of Transport and Digital Infrastructure is providing financial assistance, within the scope of the MFS, for the conversion of ships to LNG, thereby ensuring demand at ports. As part of a broad-based dialogue, the Federal Ministry of Transport and Digital Infrastructure also supports uniform application of the law in approval procedures for LNG at German ports.



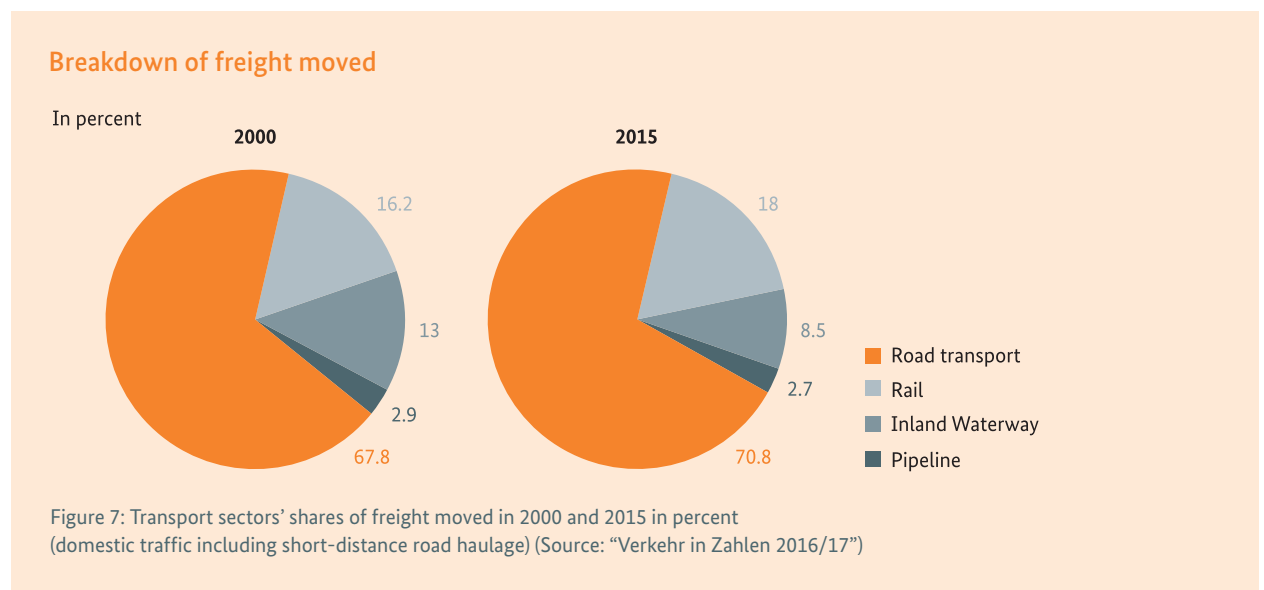


# Modal shift, mobility and logistics strategies

Shifting traffic to climate-friendly modes of transport is one of the key building blocks for achieving the Federal Government's energy and climate policy objectives. Within the scope of the 2050 Climate Action Plan, the Federal Government has set itself the objective of increasing the share of public transport, rail freight and inland waterway transport even further compared with the Federal Transport Infrastructure Plan's traffic forecast for 2030. To this end, an appropriate strategy is being developed on the basis of the findings of the MFS.

In actual fact, traffic in terms of passenger and tonne kilometres in the rail and waterways modes has risen in recent years. However, because of the overall increase in the size of traffic flows, their share of total traffic in terms of passenger and tonne kilometres is stagnating, and is even declining slightly in the freight transport sector.

The distribution of traffic flows to the individual modes of transport is illustrated by the modal split. Accordingly, the roads account for the bulk of passenger and freight kilometres in both the passenger and freight transport sectors (80 and 70 percent respectively). In the passenger transport sector, it is apparent that there was a slight increase in public transport between 2000 and 2015. However, one of the reasons for this is the increasing volume of air travel. In the freight transport sector, there has been a slight increase in the share of rail freight in recent years. On the other hand, inland waterway transport has lost shares of the modal split and the share of road haulage has grown.



## Breakdown of passenger kilometres travelled

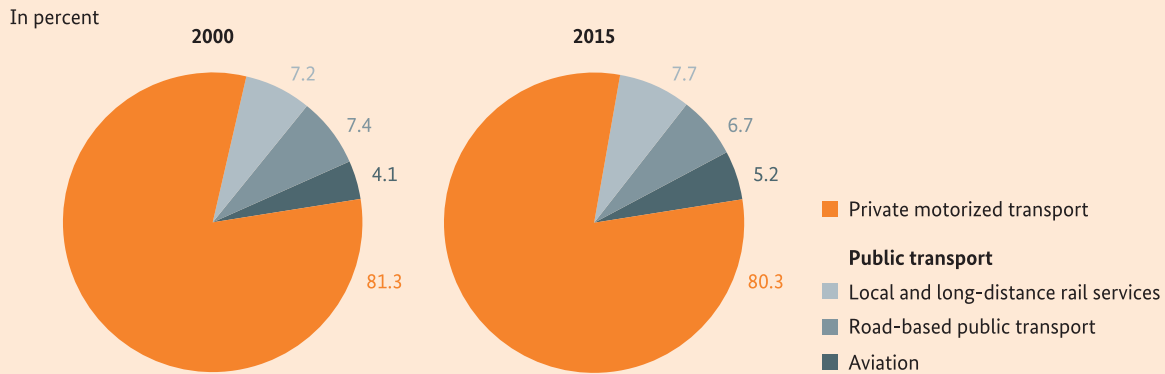


Figure 8: Transport sectors' shares of passenger kilometres travelled in 2000 and 2015 in percent. (Source: "Verkehr in Zahlen 2016/17")

## Greenhouse gas emissions from means of transport in 2015

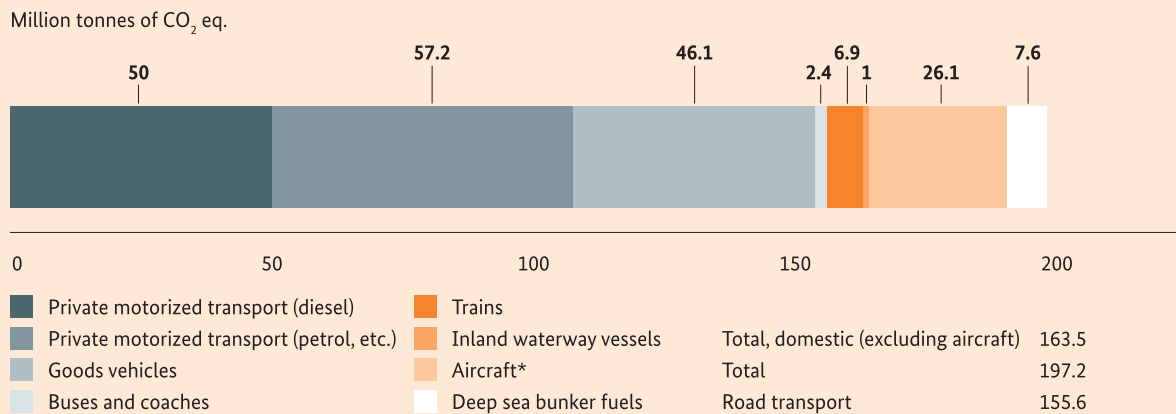


Figure 9: Greenhouse gas emissions from means of transport in 2015. (Sources: Energy Balance Working Group 2015 (AGEB), German Institute for Economic Research "Verkehr in Zahlen 2016/17", DIN EN 16258, M-Five in-house calculations) \*Figures for aircraft calculated from fuel refuelled in Germany according to AGEB 2015

\* TREMOD stands for Transport Emission Model and is a computing tool for determining the energy consumption of and emissions from motorized transport in Germany that was developed by the Heidelberg Institute for Energy and Environmental Research on behalf of the Federal Environment Agency.

The benefits of modal shift become especially clear if the emissions from the individual modes of transport are considered. Around 75 percent of the emissions from the total transport sector come from road transport. On the other hand, the railways emit just under 3 percent of the greenhouse gas emissions, although their share of the modal split is significantly higher. The graph shows the GHG emissions from the individual means of transport in 2015. Unlike the presentation of the transformation pathways in the interview with the members of the academic consortium earlier in this brochure, the demarcation here is based on Tremod\*.

In the freight transport sector, a shift of traffic from the roads to the more climate-friendly rail and waterway modes, in particular, is to be expedited. However, there is also additional potential inherent in making collections and

deliveries (especially in conurbations) more efficient by means of consolidation, thereby reducing the number of trips required.

The use of cargo cycles on “last mile” transport operations opens up new perspectives. Studies have shown that these cycles (in some cases equipped with electric motors) can take over part of city-centre supply and service operations that have hitherto been performed by internal combustion engine vehicles.

In the passenger transport sector, the greatest potential is inherent in shifting passenger flows from private motorized transport to local and long-distance public transport. Here, too, the consolidation of traffic flows plays an important part in enabling load factors that are as high as possible. Given the rising levels of air travel, it is becoming increasingly important that passenger traffic be shifted from short-haul domestic and European flights to the railways.

To identify the potential for a shift to more environmentally friendly modes of transport, several studies have already been conducted within the scope of the MFS. To be able to unlock this potential in practical applications, further studies are analysing innovative approaches with which the attractiveness of the railways can be enhanced and journey and freight transport wishes can be better organized. The studies are centred on the question as to how people’s mobility needs can be met in a way that produces as few emissions as possible and how the movement of goods can be made as environmentally friendly as possible.

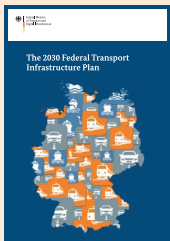
If the amount of freight moved by rail and the number of rail passenger kilometres travelled are to be significantly increased, better capacity utilization of the existing infrastructure and its targeted upgrading are essential. To analyse the key bottlenecks on the railway infrastructure, identify suitable measures for removing them and estimate the level of investment that will be required, the MFS study entitled “Potential for Modal Shift to the Railways in Germany Taking Infrastructure Restrictions into Account” was conducted. This study reveals that, if a modal shift to the railways is to be achieved, it will be necessary in particular to optimize the capacity of the main lines and junctions.

The 2030 Federal Transport Infrastructure Plan (FTIP) makes a significant contribution to this. It underscores the Federal Government’s objective to use the investment in transport infrastructure to lay the foundations for an environmentally sustainable transport system. A contribution to this is made not only by the distribution of the funds to the modes of transport, as set out in the FTIP, but also by strengthening the principle of “giving structural maintenance precedence over upgrading and new construction”. Thus, capital maintenance investment and investment in replacement infrastructure account for

[Potential for Modal Shift to the Railways in Germany Taking Infrastructure Restrictions into Account \(in German\)](#)



## 2030 Federal Transport Infrastructure Plan



around 69 percent of the total level of funding over the period from 2016 to 2030. In the upgrading and new construction projects, the principal focus is on unblocking congested corridors and junctions, thereby optimizing the flow of traffic on the overall network.

Of the total level of funding of the FTIP 2030 of 269.6 billion euros, the more environmentally friendly rail mode accounts for 112.3 billion euros or 41.6 percent of the funds and the more environmentally friendly waterway mode accounts for 24.5 billion euros or 9.1 percent of the funds. Thus, the distribution of the intended investment of the FTIP 2030 marked a significant shift in favour of the more environmentally friendly modes of transport, measured against the traffic in terms of passenger and tonne kilometres of the road, rail and inland waterway modes. The upgrading and new construction projects contained in the FTIP 2030 on the rail and waterway networks may result in a shift in flows of traffic, which would mean a reduction in total energy input and thus also GHG emissions from transport.

## Freight transport and logistics

Per tonne kilometre, freight trains produce only approximately one quarter of the climate change emissions of an HGV. For the same volume and distance, inland waterway vessels emit around 40 percent of the emissions produced by road haulage using almost exclusively diesel engines. This comparison illustrates why these modes of transport are to be especially promoted.

### GHG emissions from freight transport per tonne kilometre

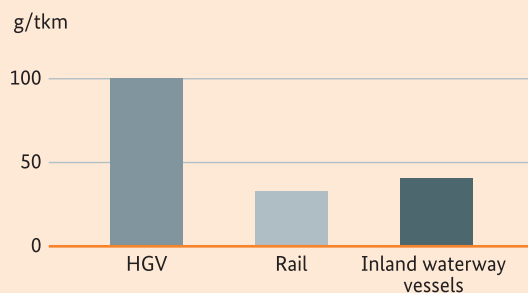


Figure 10: GHG emissions from freight transport in 2014  
The figures include emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O in CO<sub>2</sub> equivalents. (Source: TREMOD 5.62)

The MFS study entitled “Potential Modal Shift to Rail Freight in Germany” analysed the measures that can be taken to **shift freight traffic to the railways**. It revealed that infrastructure projects alone can achieve comparably little shift. The study thus also addressed possible effects of government funding. Among other things, it examined the extent to which cargo handling can be optimized by deploying information and communications technologies and by evolving handling facilities.

On the basis of these findings, a further MFS study is currently developing “Integrated Measures for Shifting Road Freight to Combined and Conventional Rail Freight”. The aim is to develop specific recommendations for action with which the rail freight sector can be equipped to tackle the **logistical challenges**. The starting point is the requirements of shippers and logistics service providers with regard to rail-based logistics systems. Thus, for instance, it is to address access points to rail freight (handling facilities, private sidings, rail freight terminals) and their design (technologies, range of services). It is also studying how rail freight can be technologically evolved.

The bulk of cross-border freight transport has so far also been by road. Better exploitation of the scope for modal shift is partly prevented by technological and organizational obstacles. Thus, for instance, it is apparent that, despite the strong process of commercial exchange between Germany and France, the share of rail freight is especially low compared with other origin-destination pairs. The causes of this, and possible measures to increase the railways’ share, are being consolidated in the ongoing MFS study entitled “Measures to Increase the Modal Share of Cross-Border Freight Transport”.

The **promotion of combined transport (CT)** is essential for enhancing the attractiveness of rail transport. The Federal Government has adopted guidelines to support the construction and upgrading of terminals operated by private undertakings for rail-to-road transshipment and waterway-to-road transshipment. In the current financial year, 92.7 million euros is available for providing financial assistance to CT terminals. This is designed to bring about a further modal shift from the roads to the railways and waterways.

The construction of new and upgrading or existing CT terminals operated by DB Netz AG is funded in accordance with the provisions of the Federal Railway Infrastructure Upgrading Act. The aim is to satisfy the rising requirements of the market with regard to the quality and capacity of CT terminals. Around 177.0 million euros has been earmarked for the further upgrading of the CT terminals at three further locations. Of this sum, almost 102.0 million euros is for the construction of the “Lehrte Megahub” and around 46 million euros for the Rhine-Ruhr CT Hub in the docks at Duisburg-Ruhrort.

[Potential Modal Shift to Rail Freight in Germany \(in German\)](#)



In addition, the modal shift to rail is supported via the Federal Government's Guidelines on Funding for the Construction, Upgrading and Reactivation of Private Sidings. This makes it possible to provide financial assistance to private sector companies for the construction of new, the upgrading of existing and the reactivation of disused private sidings. In the recast guidelines, funding can now be provided for "light goods". This is designed to unlock new modal shift potential for the railways in the future. For 2017, 14 million euros is available for funding private sidings.

In addition to the railways, a **modal shift to the inland waterways** can also help to reduce emissions from freight transport. Inland waterways and the shipping lanes running parallel to the coast enable efficient, reliable, low-cost and environmentally sound freight transport. Many European industrial regions are located in the vicinity of a coast or on waterways and also enjoy optimum connections to the rail network.

A large number of goods, for instance bulk cargoes such as ores, coal, salt, gravel or grain, lend themselves to movement by waterway, as do heavy loads such as machines or wind turbines. If such goods are moved by waterway, the pressure on the roads is eased and the risk of congestion and accidents can be reduced. Even in the transport of industrial and consumer goods, there is a wide range of options for using and/or combining alternative modes of transport. This is especially true of shipments that can be consolidated, which can be moved by container.

In Germany, the topic of "modal shift to the waterways" is addressed by the "Short Sea Shipping Inland Waterway Promotion Center", a public-private partnership project. The project to promote short sea shipping and inland waterway transport, especially within the framework of intra-European multimodal freight transport chains, involves the Federal Government, the federal states plus the maritime industry and trade associations. The focus of the SPC's activities is the provision of information and the conduct of publicity campaigns to dismantle obstacles to modal shift and to create more transparency in the logistical handling of intermodal freight movements. In addition, the Federal Ministry of Transport and Digital Infrastructure has commissioned a study to identify the scope for modal shift to inland waterways on the Rhine Corridor.

In addition to a shift to less polluting modes of transport, it is essential that logistics operations and strategies be addressed if emissions from freight transport are to be reduced. An important building block for reducing GHG emissions from freight transport could therefore be an **improvement in load factors**. To be able to quantify possible effects (especially over the period to 2030), an ongoing MFS study is examining what potential still exists here, for instance by further reducing empty running.

## Passenger transport and mobility strategies

Because many journeys in the passenger transport sector continue to be made by car, significant potential for reducing GHG emissions is inherent in shifting traffic to ecomobility. Because of the collectivization of transport processes, public transport exhibits lower specific emissions than passenger cars.

Moreover, electrically powered vehicles account for around 60 percent of all passenger kilometres travelled on public transport in Germany (especially in the rail sector), which is why a high public transport share of the modal split also makes a major contribution towards reducing pollutant emissions at the point of use.

The availability of bicycles with electric motor assistance (pedelecs) increases the potential inherent in cycling for replacing passenger cars over longer distances as well.

In the future, the MFS will focus more attention on changes in mobility patterns. In particular, it will examine what potential can be created by new mobility strategies such as car sharing and ride sharing, and what impact automated and connected driving will have on mobility patterns. This will involve studying both urban and rural areas and the specific mobility patterns in each case.

## Local transport and everyday mobility

The MFS study entitled “Everyday Mobility: Scope for a Modal Shift to Non-Motorized and Public Transport in the Passenger Transport Sector” identifies the scope for shifting passenger car traffic to ecomobility for shorter daily journeys. As examples of best practice regarding mobility patterns in this sphere, it cites the Netherlands, which has an especially high share of cycling, and Switzerland, where public transport accounts for an especially high share of all journeys made.

The study comes to the following conclusion. Given the different responsibilities of the Federal Government, federal states and local authorities, the focus for the Federal Government is on creating an overarching regulatory framework and building the necessary cycling infrastructure capacity by means of coordination and (co-)funding. For instance, local authorities could be supported in developing cycling strategies. In the local public transport sphere, the Federal Government could give its approaches and instruments a nationwide focus and make them visible.

[Everyday Mobility: Scope for a Modal Shift to Non-Motorized and Public Transport in the Passenger Transport Sector \(in German\)](#)



Company-based and local authority mobility management schemes also make a major contribution towards shifting passenger traffic flows to ecomobility. Building on the objectives defined in the “2020 Climate Action Programme”, the Federal Ministry of Transport and Digital Infrastructure and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety joined forces to launch the “Mobile Wins” initiative, which provides companies and institutions with initial advice on establishing their in-house mobility management and awards prize money for especially innovative schemes. Building on this, the Federal Ministry of Transport and Digital Infrastructure is currently developing funding guidelines that are designed to provide financial assistance to best practice mobility strategies as of 2018. Thanks to these and other activities, the importance of the issue of mobility management has already grown significantly. Taking the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the Federal Ministry of Transport and Digital Infrastructure as an example, the National Sustainable Development Strategy is currently exploring how a mobility management scheme can be introduced throughout the federal administration.

The sharing of vehicles is increasingly becoming one of the elements in making everyday traffic sustainable, especially in urban areas. The increasing importance of **car sharing** in terms of both transport policy and urban planning is indisputable. This is a service which, in recent years, has developed into a major building block of a range of sustainable mobility services, especially in towns and cities. By adopting the Act Granting Privileges to Car Sharing, the Federal Government is pursuing the objective of promoting car sharing throughout Germany. Implementing a requirement of the Coalition Agreement, the Act creates a sound legal basis for parking spaces to be designated for use by car sharing vehicle. Among other things, the Act defines the concept of privileges for car sharing and makes provision for the marking of car sharing vehicles.

The promotion of car sharing is designed to make a contribution towards:

- the aim of reducing the number of vehicles, especially in towns, cities and conurbations;
- reducing the number of vehicles looking for vacant parking spaces and the pressure on parking space;
- a long term improvement in the residential environment, because better urban design use can be made of the freed-up parking spaces.


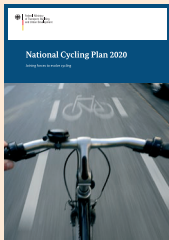
Non-motorized transport is also assuming increasing importance. Walking and cycling are not only environmentally friendly, because they produce zero emissions, but also make an active contribution towards improving the quality of life and reducing the costs of health care. As of 2017, the Federal Ministry of Transport and Digital Infrastructure will provide a record 130

million euros annually to promote cycling. This will make it possible to construct 200 to 300 kilometres of cycle tracks along federal trunk roads each year and to strengthen towpaths along federal waterways for cycling. In addition, this sum also includes financial assistance for cycle superhighways to be constructed by the federal states and local authorities. These premium cycle tracks are designed to enable cycling that is as trouble-free as possible and to encourage commuters to cycle to work, even over longer distances, thereby significantly reducing the volume of private motorized traffic. To implement this measure, the Federal Trunk Roads Act has been amended.

In recent years, the Federal Ministry of Transport and Digital Infrastructure has promoted cycling by making legislative amendments. Among other things, the most recent recast of the German Road Traffic Regulations changed several points in favour of cyclists. The establishment of cycle lanes in built-up areas has also been simplified. Thus, for instance, the federal states may establish cycle lanes without having to first prove that there is a high potential for accidents on the road affected.

The strategic policy document for cycling is the “National Cycling Plan”. It defines the fundamental guiding principles of the promotion of cycling, especially with regard to current challenges. A financial assistance programme with annual funding totalling 3.2 million euros is in place to implement the National Cycling Plan. In particular, this programme provides financial assistance to projects that can also serve as a model for other regions of Germany. In this way, over 180 projects have been supported since 2006.



[National Cycling Plan](#)



## Long-distance transport

Given its comparatively low specific energy consumption, and the resultant low level of GHG emissions per passenger kilometre, the provision of financial assistance to the long-distance rail mode is of great importance. According to the MFS study entitled “Scope for a Modal Shift to Long-Distance Passenger Rail Services in Germany”, the most important levers for enhancing attractiveness are not only train fares but also the entire journey experience, which is defined by the total journey time, the number of changes required and connectivity with local transport services. As far as running speed is concerned, however, it must be borne in mind that faster rail services cause a significant rise in energy consumption. For this reason, the main focus is on enhancing overall service quality and the attractiveness of rail transport.

[Scope for a Modal Shift to Long-Distance Passenger Rail Services in Germany \(in German\)](#)



To increase the share of rail transport even further compared with the Federal Transport Infrastructure Plan’s traffic forecast for 2030, the Federal Ministry of Transport and Digital Infrastructure is exploring the creation of an integrated regular interval timetable for long-distance and regional/local services. To this

end, a model timetable for optimized clock-face timetabling on the entire German rail network is being developed (“Deutschland-Takt”). This can result in more rail services, shorter journey times, more reliable connections and thus an increase in demand. A regular interval timetable can make railway operations more productive and enable better use to be made of the existing infrastructure capacity.

The ongoing MFS study entitled “Measures to Increase the Share of Long-Distance Passenger Rail Services in Rural Areas” is addressing further scope for modal shift away from the railway lines between major cities, which already enjoy a very high level of services. Accordingly, the scope is greatest where new (direct) services are introduced. On the other hand, where the existing service has been improved by reducing the intervals between trains or accelerating them, the modal shift turns out to be lower. However, the possible scope for savings in greenhouse gas emissions through a shift to other services is offset by relatively high investment in infrastructure and operations.

Further MFS studies are currently analysing what GHG and final energy reductions can be achieved by reopening disused railway lines and the associated modal shift impact and what investment and operating costs this would entail. It is also being examined what contribution the provision of better local public transport services to major amenities and recreational facilities – such as large cinemas or out-of-town shopping centres – could make with regard to the greenhouse gas and final energy savings that could be achieved and how this benefit, too, is offset by the investment and operating costs.





# Automated and connected vehicles

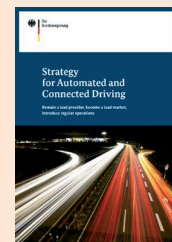
## Automated and connected road vehicles

As the digital transformation progresses, mobility will assume a new dimension. The road transport of the future will be characterized in particular by automation and connectivity. Back in 2013, the Federal Ministry of Transport and Digital Infrastructure thus established a body – the Round Table on Automated Driving – that enables stakeholders from industry, academia, associations and government to engage in a close exchange of ideas and experience on this issue, which will be of great importance in the future. With the “Strategy for Automated and Connected Driving - Remain a lead provider, become a lead market, introduce regular operations”, the Federal Government has adopted guidelines on how to exploit the opportunities for growth and prosperity inherent in the mobility of the future. Germany is to become a leading innovator and lead market for the new technologies. These technologies harbour the potential for increasing road safety and traffic efficiency, reducing emissions from transport and strengthening Germany as a competitive site for economic activity and a more attractive location for innovative businesses. Implementation of the strategy is focusing on the following key thematic areas: infrastructure, legislation, innovation, connectivity, cyber security, data protection and societal dialogue. The Federal Government is including experts from the Round Table on Automotive Driving in the implementation of the strategy.

Research and trialling are major building blocks of the implementation of the Automated and Connected Driving Strategy. Thus, in 2016, the Federal Ministry of Transport and Digital Infrastructure published a research programme on automated and connected road vehicles. This programme is to study transport and social issues. In addition, a “Digital Motorway Test Bed” has been established on the A 9 motorway to give the industry and the research community an opportunity to trial, assess and evolve technologies for automated and connected vehicles and the intelligent road infrastructure in real world driving conditions. To make it possible to trial automated and connected driving functions in more complex traffic environments in urban areas, the Federal Ministry of Transport and Digital Infrastructure is also funding various urban test beds. Lawmakers have created legal certainty for the use of automated and connected vehicles. Thus, the most recent amendment to the Road Traffic Act sets out the rights and obligations of the driver when using conditional (level 3) or highly (level 4) automated driving functions.

Whereas a number of in-depth studies in the fields of efficiency and safety have already been published, very little specific knowledge currently exists on reducing the final energy consumption of and emissions from automated and connected vehicles. The MFS study entitled “Energy and Greenhouse Gas Effects of Autonomous Road Vehicles” thus illustrates how the total costs and the specific components costs of automated and connected driving are

### [Strategy for Automated and Connected Driving](#)



developing and what suitability for mass production can be derived from this. The second step involves addressing the possible impact of the technology on the flow of traffic and examining what behavioural changes and “rebound” effects (for instance a modal shift back to the roads because of the attractiveness of automated driving) this might entail. Finally, this is to be used to estimate what energy and climate policy consequences are associated with the levels of automation.

Because of their high mileage and the demands placed on them in terms of efficiency and road safety, commercial vehicles are important drivers of innovation in the digital transformation of road transport. To continue to be able to meet the challenge posed by rising levels of freight moved on the roads, it is necessary to unlock the potential inherent in intelligent transport technologies and, in particular, automated and connected vehicle systems in the freight transport sector. For instance, studies are being conducted into platooning, where several HGVs are coupled together as a convoy by means of vehicle-to-vehicle communication (Wi-Fi link) and additional sensor technology, thereby enabling them to exploit the slipstream and thus reduce energy consumption.

## The potential inherent in the digital transformation of public transport

As the digital revolution progresses in the mobility sector, it also opens up great opportunities for public transport. New approaches can make the range of public transport services more efficient and attractive. Within the scope of the “Research Programme on Automated and Connected Road Vehicles”, the Federal Ministry of Transport and Digital Infrastructure is also providing financial assistance to measures for implementing the Automated and Connected Driving Strategy in local public transport in urban and rural areas.

The digital transformation offers options to public transport for improving the quality of its services, in particular. New ranges of digital services can improve the connectivity between individual means of transport and the multimodal use of the transport system.

Information and communications technologies are playing an increasingly important role in better interlinking ecomobility services and for the intermodal or multimodal use of the individual means of transport. They make it possible to develop new ranges of mobility services, which can be easily used by means of mobile devices. The Federal Ministry of Transport and Digital Infrastructure is thus funding innovations that are likely to reduce access barriers, thereby enhancing the attractiveness of public transport. A dialogue and stakeholder process on digital connectivity in public transport is designed

to help better interlink the existing systems in both a technical (for instance the connectivity of timetable information and ticketing) and a spatial (for instance across federal state and regional borders) respect, thereby making the intermodal and multimodal combination of different means of transport easier. The first result of this process is the roadmap entitled “Digital Connectivity in Public Transport”.

#### **The “Digital Connectivity in Public Transport Roadmap”**

The “Digital Connectivity in Public Transport Roadmap” outlines the need for action, the necessary steps and the corresponding responsibilities for digitally connected public transport. The document was developed in cooperation with representatives of the federal states, local authorities, transport operators and integrated transport authorities, the industry and consumers’ associations and adopted in June 2016. The Roadmap describes visions and goals in the thematic areas of “passenger and customer information”, “fares and eTicketing” and “multimodality” and comprises a total of 25 individual measures.

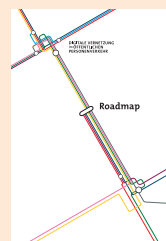
The Federal Ministry of Transport and Digital Infrastructure is involved in the implementation of the Roadmap by providing pro rata funding to research and development projects. Twelve collaborative projects were launched at the beginning of 2017 on the basis of the “eTicketing and Digital Connectivity in Public Transport” funding guidelines. With the financial assistance it has provided so far to a seamless electronic timetable information system (DELFI) and the “(e)Ticket Deutschland”, the Federal Ministry of Transport and Digital Infrastructure has played its part in enabling passengers to obtain better information and reach their destination more easily by public transport.

### **The digital transformation of rail transport**

The digital transformation is assuming increasingly great importance with regard to the competitiveness of rail transport. The railways are a complex system and are in a good position to use technological innovations to become more productive and efficient along the entire value chain. If rail transport is to be an innovative sector, it is crucial that the activities of the Federal Government be dovetailed with those of the industry. For this reason, the Federal Ministry of Transport and Digital Infrastructure, the German Railway Industry Association and Deutsche Bahn AG jointly signed a “Five-Point Strategy for Digital Railways” in June 2016, thereby providing a joint impetus for further digital transformation in local, long-distance and freight transport.

The ongoing MFS study entitled “Contributions to the Digitalization and Automation of Signalling Technology as Part of the Railway Infrastructure” is addressing the impact of the introduction of the “European Train Control

#### *[Digital Connectivity in Public Transport \(in German\)](#)*



#### *[Forum for the Future of Digital Railways – Five-Point Strategy \(in German\)](#)*



System” (ETCS). Train control systems are necessary to ensure safe railway operations with a high density of traffic and at higher speeds. ETCS harmonizes the different national train control systems, creates a single European railway area, simplifies the signalling equipment of the trains on the trans-European networks and lays the foundation for automated train operations. The study addresses the following questions. What is the positive impact of ETCS on timetable stability? What effects do improved operations have on rolling stock savings? To what extent does the prevention of unnecessary stops and braking manoeuvres through predictive train operation make it possible to save energy.

## The digital transformation of shipping and ports

In shipping, too, the digital transformation is making a significant contribution towards enhancing the attractiveness of the mode and to the development of new logistics strategies. The financial assistance programme entitled “Innovative Port Technologies”, which the Federal Ministry of Transport and Digital Infrastructure launched in June 2016, is supporting the digital transformation in the maritime sector. It supports the introduction and spread of new port technologies, promotes the improvement of the digital infrastructure and helps to progress the greater use of IT at ports and in logistics chains. In addition, the financial assistance programme helps to evolve IT systems and cyber security. It will provide up to 64 million euros for this purpose in the years ahead.





# International cooperation for climate-friendly transport

Like Germany, many states are confronted by the challenge of reducing transport-induced emissions despite rising volumes of traffic. The transition towards sustainable mobility is taking place under great competitive pressure, which requires a permanent exchange of ideas and experience on recent developments.

International collaborative schemes are the key to researching new technologies and implementing sustainable mobility and transport strategies. The Federal Ministry of Transport and Digital Infrastructure is thus pursuing the establishment of climate-friendly transport systems at the international level in various collaborative projects. Collaborative ventures with, among others, China, India, Japan, France and Israel are designed to progress innovations and help sustainable mobility to evolve throughout the world.

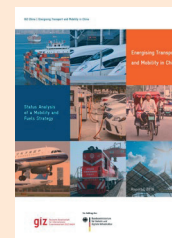
## Sino-German dialogue for the promotion of a mobility and fuels strategy for China

With over 144 million privately owned vehicles, China is already the most important automotive market in the world and has a high growth dynamic. Every day, they are joined by a further 35,000 vehicles. The motorway network has grown to its present-day length of around 120,000 kilometres, and the railway network also has a length of around 120,000 kilometres, with high-speed lines accounting for 19,000 of these. In addition, seven of the largest ports in the world are in China, and air travel is growing at an annual rate of 4.5 percent.

Given this high dynamic, the Federal Ministry of Transport and Digital Infrastructure launched the bilateral project entitled “Sino-German Dialogue on the Promotion of an MFS” for China, which has been implemented in China by the German Agency for International Cooperation (GIZ). The project identified current trends, obstacles and challenges in the Chinese transport sector. Building on this, the “Energising Transport and Mobility in China” policy forum brings together policymakers from Germany and China to develop an MFS for China by 2019 using approaches from Germany. This will involve taking requirements relating to climate change mitigation, energy security and air quality management into account, as well as expectations regarding efficiency, value for money in the transport sector and acceptance of the changes by the users.

In addition, the Federal Ministry of Transport and Digital Infrastructure is cooperating with the Chinese Ministry of Science and Technology (MoST) on the basis of the “Sino-German Strategic Platform for Electric Mobility” and the Memorandum of Understanding on Cooperation in the Field of Electric Mobility, which builds on this platform. The first Sino-German collaborative projects have been implemented and more are to follow.

[Energising Transport and Mobility in China – Status Analysis of a Mobility and Fuels Strategy](#)



## **International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)**

The “International Partnership for Hydrogen and Fuel Cells in the Economy” is an international forum comprising 18 states and the European Commission for an exchange of ideas and experience on and the coordination of recent developments and the associated policies and standards in the field of hydrogen and fuel cell technology. The aim of the forum is to make a contribution to energy security and environmental protection alike by promoting the technology. To this end, the perception of the technology in society is to be enhanced, its acceptance ensured and ultimately its market launch accelerated. Germany is represented in the IPHE by the Federal Ministry of Transport and Digital Infrastructure and the NOW.

## **German-Japanese dialogue on hydrogen and fuel cell technology**

The Japanese Ministry of Economy, Trade and Industry (METI) is providing a total of 222 million euros for 2017 to promote hydrogen and fuel cell technology. In addition, the Japanese Government is providing further funding to support the deployment and expansion of hydrogen infrastructure and the market launch of fuel cell powered vehicles. The METI is also considering power-to-gas technologies and hydrogen-capable turbines.

Because of the great importance enjoyed by hydrogen and fuel cell technology in Japan as well, there is a dialogue – supplementing the cooperation in the IPHE – between the NOW and the Japanese “New Energy and Industrial Technology Development Organization” (NEDO) on the development of the technology and market launch options.

## **German-Israeli dialogue on electric mobility**

Since 2010, there has been close cooperation between the Federal Government and the Israeli Government in the field of innovative drivetrain technologies, especially electric mobility. Within the scope of the “Fuel Choices Initiative”, financial assistance has so far been provided to over 500 innovative projects by start-ups and by 200 research groups in the mobility sector in Israel. Against this background, the Federal Ministry of Transport and Digital Infrastructure is promoting the dialogue and exchange of knowledge between Israeli and German start-ups and, in addition, with already established companies in the sector.

## **Franco-German Initiative on Electric and Digital Mobility**

In September 2016, the “Franco-German Initiative on Electric and Digital Mobility” was launched with the aim of joining forces to progress innovations in the fields of electric mobility and automated driving and to enable people to experience them by means of cross-border projects.

In the field of electric mobility, the exchange of ideas and experience is being intensified by means of financial assistance programmes and cooperation in the harmonization for trans-European electric mobility. This also includes joint activities for a speedy expansion of the charging infrastructure for battery electric and hydrogen powered vehicles.

In the field of automated and connected driving, a cross-border “Franco-German Digital Test Bed” is being established to promote developments and trials in the field of cross-border automated and connected driving on different road categories (motorway, near motorway standard road, federal highways, rural roads and urban roads). The test bed will run from Merzig via Saarlouis and Saarbrücken to Metz. In addition to private motorized transport, ACD applications will also be trialled in the local public transport and freight transport sectors.



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# Glossary of abbreviations

ACD	Automated and Connected Driving
ACD Strategy	Strategy for Automated and Connected Driving
AFID	Alternative Fuels Infrastructure Directive
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BMVI	Federal Ministry of Transport and Digital Infrastructure
BMWi	Federal Ministry for Economic Affairs and Energy
BSH	Federal Maritime and Hydrographic Agency
CCNR	Central Commission for Navigation on the Rhine
CEP	Clean Energy Partnership
CNG	Compressed Natural Gas
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPT Initiative	The European Union's "Clean Power for Transport" initiative (EU strategy for alternative fuels)
CT	Combined transport
DB	Deutsche Bahn AG
ECA	Emission Control Area
ETCS	European Train Control System
ETS	Emissions Trading System
FTIP	Federal Transport Infrastructure Plan
GHG	Greenhouse gas
HGV	Heavy goods vehicle
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
METI	(Japanese) Ministry of Economy, Trade and Industry
MFS	The Federal Government's Mobility and Fuels Strategy
NCP	National Cycling Plan
NEDO	New Energy and Industrial Technology Development Organization (Japan)
NIP	National Programme of Innovation for Hydrogen and Fuel Cell Technology
NOW	National Organization for Hydrogen and Fuel Cell Technology
PHEV	Plug-in hybrid electric vehicle
Pkm	Passenger kilometres
PTG	Power-to-Gas
SPC	Short Sea Shipping Inland Waterway Promotion Center
STS	Smart trolleybus system



# Institutions supporting the MFS



## National Organization for Hydrogen and Fuel Cell Technology (NOW)

As a project management association of the Federal Government, the NOW implements the Federal Ministry of Transport and Digital Infrastructure's financial assistance programmes for hydrogen and fuel cell technology, battery-powered electric mobility and charging infrastructure. Within the scope of the MFS, the NOW supports the Ministry in evolving the strategy and monitors specific funding measures for its implementation.



## The MFS Project Office

The MFS Project Office, managed by IFOK GmbH, coordinates the integration of the key professional stakeholders into the MFS. This ensures that the academic studies and the planning activities for pilot projects and financial assistance programmes are fleshed out by the most recent practical knowledge and their outcomes are compatible with everyday practice. Complementing the expert dialogue, the Project Office also coordinates the communication activities and publicity campaigns relating to the MFS.

The Federal Ministry of Transport and Digital Infrastructure's website provides regular updates on the latest developments in the field of the MFS. The MFS pages can be accessed at [www.mks.dialog.de](http://www.mks.dialog.de). The site also contains abstracts of the completed academic studies with the option of downloading them.





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