



# Progress report 2019

## of the National Platform Future of Mobility

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\* All terms that are marked in red in the text are explained in the glossary.

# Foreword

## Dear Reader,

The National Platform Future of Mobility (NPM) has been working on the future of mobility for over a year now. The interim assessment presented in this progress report gives us reason to be positive. We know that we are taking on an enormous task. Our job is not only to show how we will get about in future. We also have to look at the overarching developments that are affecting the entire mobility system. A particularly significant factor here is digitalisation, which is impacting every level of our living and working environments and visibly changing our everyday life and habits. Mobility is becoming more and more interconnected and shared. There are technological developments that are affecting drive technology, the energy system and the value chain. Last but not least, the discussions on climate and environmental protection are also shifting society's attitude towards mobility.

We have initiated a great deal of momentum thanks to the approximately 240 members of the NPM, who take part in discussions that extend across a wide range of interests and work to develop a common understanding of the future of mobility in six working groups. Our members have the necessary expertise and a huge network in every area of the range of topics relating to mobility. Now it is important to keep this momentum going and ideally accelerate it. Because transforming mobility requires 'momentum and dynamism' in many respects - courage, creative drive, a desire for debate, a willingness to empathise and, last but not least, a great deal of patience.

When we look back to 2019, the NPM's work has already become visible at various overarching points based on the eleven interim reports that have been prepared. The first NPM report 'Wege zur Erreichung der Klimaziele 2030 im Verkehrssektor' (Ways to achieve the climate targets for 2030 in the transport sector), which was published in March 2019 by **WG 1 Transport and climate**

**change** and its recommendations for action, such as CO<sub>2</sub> pricing, have been picked up by the German government's climate cabinet. Together with other recommendations of the NPM team, they were incorporated into the Climate Action Programme 2030 at the end of September and are thus already part of the recently adopted Federal Climate Protection Act.

In November 2019 we participated with NPM representatives in the second auto summit at the Federal Chancellor's office (Concerted Action on Mobility), where various NPM work packages were discussed in detail. Among other things, the master plan for charging infrastructure was determined at this meeting. The Federal Government intends to increase the current 21,299 public charging points (as of November 2019) to 50,000 by the end of 2021 and then to one million by 2030. There are plans to extend and increase the purchase premium for electric vehicles introduced in 2016. The National Platform for Electromobility (NPE, 2010-2018) has undoubtedly carried out crucial preparatory work in this area. **WG 5 Connecting mobility and energy networks, sector integration** will continue to deal with the charging and refuelling infrastructure for the drive systems of the future within the NPM. Many questions regarding implementation and scaling have yet to be answered, not only with regard to the supply and provision of alternative fuels such as CNG, LNG, hydrogen, biogenic and electricity-based fuels.

The Federal Government is assigning hydrogen technology an important role in the future of mobility and with respect to implementing the energy transition. Work is currently being carried out under the joint leadership of the Federal Ministries of Transport and Digital Infrastructure (BMVI) and Economic Affairs and Energy (BMWi) on Germany's hydrogen strategy, which will certainly be incorporated into the NPM's ongoing work, in particular in **WG 2 Alternative drive technologies and fuels for sustainable mobility** and WG 5.

The government hopes that Germany will become a pioneer, especially in automated and networked driving. To achieve this, we need an innovation-friendly legal framework and a mobility data network that is open to all. We already addressed this issue in the report published by **WG 3 Digitalisation for the mobility sector** in June 2019 and put it forward as a recommendation. **WG 6 Standardisation, norms, certification and type approval** is also involved, because the general technical conditions have to be completely redefined at this point. Due to the international scope of many mobility issues, WG 6 also ensures that they can be incorporated into national, European and international standardisation processes.

We must use a forward-looking and controlled restructuring process to meet the challenges that are the result of the structural change the transition is causing in the German automotive and supplier industry. **WG 4 Securing Germany as a place for mobility, production, battery cell production, primary materials and recycling, training and qualification** addresses the topic in its two focus groups Value Creation and Personnel Planning and will make further recommendations in this regard.

Conclusion: This document is the **NPM's Progress report** for the year 2019. As you read it, you will note that we are not administrating the future of mobility in our role of National Platform. Rather, our aim is to actively shape it together with representatives from politics, business, science and civil society. We can now build on the important work of the past months, address the topics in a deeper and more far-reaching way, and work step-by-step to develop a comprehensive picture of the future of mobility. I would like to thank everyone involved for the work they have done so far and look forward to the tasks ahead of us, which we will tackle as partners at NPM thanks to a dialogue-driven approach.

Prof. Dr. Henning Kagermann  
Chairman of the NPM Steering Committee



# The NPM's first year – insights and propositions

# 1 | The NPM'S first year – insights and propositions

The present progress report was compiled to give the public and all stakeholders a comprehensive overview of the **National Platform Future of Mobility (NPM)**, which began its work at the end of September 2018. This report is based on the eleven interim reports of the NPM's six working groups, which were prepared in the course of 2019.

Modern living and working environments are inconceivable without mobility. Various developments are currently changing the way people travel and goods are transported. The existing mobility system is undergoing a fundamental transformation process. Despite the sometimes conflicting ideas held by individual political, economic, scientific and civil society stakeholders, **the future of mobility can only be successfully shaped in close cooperation.**

Commissioned by the Federal Government, the NPM takes a holistic view of the future of mobility and makes recommendations for action. The approximately **240 high-ranking representatives** from politics, business, science, associations and civil society involved in the NPM combine their expert knowledge to outline

a future-oriented, innovative mobility system that is viable, affordable, demand-oriented, climate-friendly and sustainable.

The **ten core propositions** preceding the report address and illustrate the key issues identified by the NPM with regard to the future of mobility up to this point. These are being updated as the work progresses.

The executive summary outlines the results to date in a clear and concise manner. The chapters focusing on the six working groups, which present their main topics and explain them in detail, demonstrate how the future of mobility is being approached in a holistic way. The recommendations for action at the end of the progress report supplement the ten core propositions and express them in concrete terms.

## Ten core propositions for the future of mobility

### 1. Technological and social developments are changing mobility.

The transformation of the mobility system is influenced by technological and societal factors that take place independently of each other but must be integrated into an overall mobility system. Automated and networked driving, alternative vehicle drives and fuels, green hydrogen and electricity as well as renewable energies come up against environmental and climate awareness, social networks, the sharing economy and diverse concepts of life.

### 2. Innovation and speed make the mobility system adaptable.

Openness to new technologies enables innovations that are essential for the development of a future-oriented and sustainable mobility system. **Rapidly translating** these innovations into products and business models is **crucial to success**. In terms of patent applications, Germany remains one of the world's leaders in mechanical and electrical engineering. However, there is still a great deal of catching up to do in terms of implementation in the field of electric mobility, for example.

### 3. The transport sector is subject to binding climate protection targets.

The Paris Agreement, the European Climate Protection Ordinance and the Climate Action Plan 2050 form the basis for the Federal Climate Protection Act. By 2030 Germany must reduce its greenhouse gas emissions by 55 per cent compared to 1990. In the transport sector, the **emissions target for 2030 is 42 per cent lower than levels in 1990**. This corresponds to 95 million tonnes of CO<sub>2</sub> equivalents, starting from around 163 million tonnes in 1990/2017. Reducing emissions in road traffic as well is an essential prerequisite for achieving the overall climate goals.

### 4. Mobility is becoming part of an integrated mobility and energy system.

Germany's **energy transition** advances and supports the **mobility transition** and vice versa. Energy and transport must be considered collectively. Renewable electricity is the key to **sector integration**. Future vehicle drives (battery and fuel cell) and fuels (hydrogen and electricity-based fuels) will be based on the use of renewable electricity. The energy sector will be able to use hydrogen produced by electrolysis and electric vehicles connected to the grid as flexible energy storage systems in the future.

## 5. The future of mobility links road, rail, sea and air transport.

In the **mobility system of the future** most means of transport – whether by road, rail, water or air – will be integrated and networked. In particular, pedestrian, bicycle and micro-mobility transport (e-scooters and electric mopeds), motorised individual transport and local public transport must be interlinked in a **demand-oriented** and **user-friendly** manner. Shifting freight transport to rail and water relieves road traffic.

## 7. Standards and norms promote the marketability of the future mobility system.

A future-oriented, integrated mobility system leads to the development of new products, applications and business models and offers **growth opportunities**. If these are to be successfully offered on the market, certain requirements regarding quality, safety and usability must be met. This requires a common understanding of the technical framework and standards and norms in order to create a level playing field for all market participants.

## 6. Future worlds of mobility must be tested in advance with those involved.

The interplay between future technologies, climate protection requirements and human behaviour can only be modelled theoretically to a limited extent. The various factors that can influence each other are too complex. Spatially concentrated and unobstructed **practical tests in real-world laboratories provide support**. Accompanying information and dialogue processes create understanding. The new worlds of mobility work when they inspire and get people involved.

## 8. The effectiveness of guidelines and funding programmes must be continuously reviewed.

**Policymakers are shaping the framework conditions** for the future of mobility, which must be economically, ecologically and socially sustainable. **Monitoring** must be used to regularly check and evaluate whether the implemented measures are effective. If the desired effects are not achieved, it must be possible to adjust and correct them.

## 9. Germany is aiming to become the leading market and leading provider for the future of mobility.

For Germany, the **mobility sector** – and above all the automotive and supply industry with its diverse interrelationships with other industrial and service sectors – is of **great significance for the economy as a whole**. The country is aiming to retain its leading position as an internationally recognised place for mobility, which it has developed and maintained over the course of decades. A strong domestic market with, for example, **seven to 10 million electric vehicles** and an efficient infrastructure by 2030 will create the conditions for international success.

## 10. The future of mobility must keep employees in mind.

The economic performance of the mobility industry and jobs will be preserved if **key technologies** of a future mobility system can be developed, industrialised and competitively manufactured in Germany and Europe. The incipient **structural change** caused by electromobility with up to ten million vehicles in 2030 must be designed and managed with foresight. Those affected must be involved in the change processes.



The NPM has set out to identify the **action required to ensure that the mobility system is fit for the future**. All participants are aware that the developments behind the ten core propositions will change the mobility system. Some of the questions that have yet to be answered are uncomfortable and have the potential to spark conflict. Possible answers are complex and encounter resistance at different points and junctures. However, the interim assessment after one year shows that expertise and potential solutions are available to successfully manage the transition.

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# Executive summary

## 2 | Executive summary

### Transformation of the mobility system

Mobility is changing: At present, the mobility system is affected by a multitude of factors, which are accompanied by far-reaching structural changes and challenges. Social developments, such as changing mobility needs, the increasing networking of all areas of life and the need for more climate protection in the transport sector play an important role in this. In addition, there are technological innovations and developments in the field of **alternative drive technologies and fuels** as well as in the area of digitalisation and **automation**. These affect the mobility system as a whole. All these factors result in a transformation process that must be shaped by society as a whole. It is clear that mobility is an indispensable part of social life and must continue to be accessible to all people, regardless of their social status. There is an opportunity to create a future-oriented mobility system that is ecologically, economically and socially balanced. Success will largely depend on the extent to which new forms of mobility and mobility solutions are accepted and are appropriate for the realities of people's lives and their current and future needs.

The Federal Government has responded to these factors by launching the National Platform Future of Mobility in September 2018. The NPM aims to develop forward-looking concepts and recommendations for action so competitive companies and jobs remain in Germany in future as well. At the same time, the NPM is to ensure that mobility is viable, affordable, demand-oriented, climate-friendly and sustainable. Experts and stakeholders from politics, business, science and civil society work together across disciplines in the platform. By working on this broad-based structure, balanced and concrete recommendations for action that span the various interests can be formulated and a common understanding of the future of mobility developed.

## WG 1 Transport and climate change

The manner in which climate protection is dealt with is a question of responsibility towards present and future generations. Germany acknowledges this responsibility and has entered into binding international commitments: The country's total **greenhouse gas emissions** are to be reduced by 55 per cent by 2030 compared to 1990 levels. There is a particular need for action in the transport sector. It has not been possible to reduce CO<sub>2</sub> emissions in this sector despite considerable technical progress in recent years, in part due to the massive increase in mobility and transport volumes.

Working Group 1 has identified six fields of action via which the climate target for 2030 in the transport sector – a 42 per cent reduction in greenhouse gas emissions compared with 1990 levels – can be achieved in principle. Changing the drive systems of cars and lorries offers great potential in particular. The aim is to have seven to 10.5<sup>a</sup> million electric vehicles on Germany's roads by 2030. Improving the efficiency of cars and lorries and making increased use of alternative fuels are further options. Strengthening rail transport and

promoting local public transport in conjunction with the expansion of bus, bicycle and foot traffic are important building blocks without which the climate protection goals cannot be achieved. Digitisation can help to increase the efficiency of the transport system without restricting mobility.

The measures proposed in the fields of action must be addressed as simultaneously as possible and require ambitious and consistent action by all those involved in politics, business and society. Ongoing monitoring must be used to verify whether the measures are having the desired effects so countermeasures can be taken and activities can be more clearly defined if necessary.

The results of the activities of Working Group 1 have established a solid foundation for the discussion on climate protection in transport and provided far-reaching impetus in politics and public discourse. In particular, the recommendation of applying **CO<sub>2</sub> pricing** across all non-ETS sectors is worth a mention here.

## WG 2 Alternative drive technologies and fuels for sustainable mobility

The transformation of drive and fuel technologies is a central challenge when it comes to designing a sustainable mobility system. Working Group 2 has looked at the current status and expected future developments for technological electromobility concepts, hydrogen and fuel cells as well as alternative fuels for combustion engines based on an approach that is open to all technologies and **transport modes**. Motorised road transport has a special role to play due to the high potential for saving CO<sub>2</sub> emissions. In addition to the climate policy objectives in the transport sector, technical and economic criteria for establishing new drive and fuel technologies are being examined.

With regard to technological electromobility concepts, Working Group 2 assumes that there will be seven to 10 million **battery electric and hybrid vehicles** on Germany's roads in 2030. They will achieve ranges of between 300 km for small cars and 500 km in the luxury class segment. The range will be up to 250 km for light and medium-sized commercial vehicles. In the area of long-distance road freight transport, the first test routes for overhead line lorries are currently being built. Initial battery-powered prototypes have been developed for shipping (inland ferries), hybrid-electric aircraft and rail transport (multiple-unit trains and diesel-hybrid shunting locomotives).

<sup>a</sup> The recommendation of WG 1 has been incorporated into the key issues paper for the Climate Action Programme 2030. The Federal Government has specified a corridor of seven to 10 million electric vehicles in this context.

**Fuel cell vehicles** have similar ranges to vehicles powered by internal combustion engines. However, the current state of development varies greatly and ranges from initial test vehicles to series production vehicles in the medium and upper-class segment. In local rail passenger transport, non-electrified lines can be served by fuel cell electric local trains running on hydrogen. In the field of aviation, fuel cells are used primarily for small aircraft and auxiliary systems. Initial development projects in the shipping industry are using fuel cells for the on-board power supply on inland vessels and ferries.

Biomass and electricity are resulting in new types of alternative fuels. Second-generation **biofuels**, and especially **electricity-based fuels**, are currently only

available in small quantities. Large-scale fuel production plants in particular must be further developed for large-scale use. Alternative fuels are compatible with the existing refuelling infrastructure and are particularly useful for shipping, aviation and heavy commercial vehicles. In the case of conventional passenger cars, they offer a suitable solution for reducing emissions together with higher vehicle efficiency and hybridisation.

WG 2 has developed a technology-oriented factual basis for alternative drives and fuels. A mix of different measures and technological solutions for reducing CO<sub>2</sub> emissions is required in order to meet the varying requirements and needs.

## WG 3 Digitalisation for the mobility sector

Digitalisation offers Germany the opportunity to make mobility more environmentally and climate-friendly, more efficient, more convenient and more affordable in future. Working Group 3's activities are geared towards a **multi- and intermodal** mobility system. Means of transport that are available at different times or are combined within a route make the available transport options more diverse, improve service and thus provide the decisive incentive to make the switch to environmentally and climate-friendly alternatives more frequently. Autonomous mobility is an important component of this multimodal system. Driverless shuttles, which are part of an intermodal transport system, are used to a higher capacity, connect public transport and rail transport more effectively and consume less public space. The indispensable technological prerequisites for implementing autonomous mobility include an ecosystem of mobility data that enables various options and more efficient traffic and route planning, as well as expanding the mobile phone network and ensuring **cybersecurity**.

WG 3 recommends that intermodal mobility undergoes practical testing in combination with **autonomous driving** in a real-world laboratory. The aim of this testing is to identify essential needs for the introduction of intermodal and autonomous mobility. The focus is to achieve a measurable ecological and economic effect, which is also reflected in changed user habits and behaviour. The associated transformation of mobility must be accompanied by a broad social dialogue that involves citizens on the ground. A corresponding dialogue strategy is to be tested in a real-world laboratory.

## WG 4 Securing Germany as a place for mobility, production, battery cell production, primary materials and recycling, training and qualification

Together with the increasing digitalisation and automation of vehicles and production, the shift from internal combustion engine drives to electric mobility requires a restructuring of (auto)mobile value creation and employment. The first and most urgent task for WG 4 is to analyse this structural change and point out what needs to be done to maintain Germany's competitiveness and keep jobs in the country.

The track record and economic performance of the automotive industry depend heavily on whether modules and components for the new drive concepts can be competitively manufactured on a large industrial scale in Europe in future. First of all, a battery cell production facility must be set up by German or European companies in Europe. This facility has to be capable of covering the needs of the automotive industry even as demand increases and must reduce dependence on imported cells. In the field of power electronics, software skills and cross-system knowledge relating to integrated system technology and solutions need to be expanded in order to make up for deficits and win back market shares. Research and development are also needed in both areas so production can be scaled up to large industrial levels and **disruptive technologies** can be established. This will enable German industry to distinguish itself from international competitors in future. Given that a significant proportion of drive systems will continue to involve internal combustion engines for the foreseeable future, the skills and supply chains for the production of internal combustion engines must be maintained despite declining order volumes. Planning security must be established for companies and consumers in all three areas based on clear and transparent strategies and regulations. This applies, for example, to securing raw materials, expanding renewable energies and promoting electric vehicles.

The electrification of mobility will take place faster than assumed in previous studies as a result of national and European climate protection measures. Within the framework of WG 4, the existing studies ELAB 2.0 and IAB Research Report 2018 were supplemented by two scenarios for the year 2030. These scenarios calculate the effects that the accelerated transition in drive systems will have on employment structures. The new calculations show that significant effects on employment structures are to be expected. Companies must acquire the capability to recognise such changes at an early stage and implement tailored measures. To this end, WG 4 proposes in its second interim report, which is to be published at the beginning of 2020, that a **toolbox** to assist with strategic personnel planning be developed for companies. Successful measures for training personnel are to be made available and scaled across companies within the framework of regional **competence hubs**. In addition, regional **transformation agencies** can be founded which work closely with the hubs or integrate them as building blocks. In order to promote training more effectively, the Skills Development Opportunities Act (**Qualifizierungschancengesetz**) and the regulations on **short-term allowance** are to be adapted to provide labour market policy support, and prospective qualifications are to be facilitated.

## WG 5 Connecting mobility and energy networks, sector integration

**Sector integration** is a key element of technological developments in the field of transport. The provision of energy in the form of electricity, gaseous and electricity-based fuels is increasingly becoming the focus of the debate on the use of alternative drives. New charging and refuelling infrastructure for passenger and freight transport must be created and the transport and energy sectors must be more closely interlinked.

Working Group 5 addresses the development of a demand-oriented charging infrastructure for electric mobility and various aspects along the energy industry value chain, developing the market for **liquefied natural gas** (LNG) and **compressed natural gas** (CNG) as well as the possibilities offered by **power-to-X** technologies.

The growth of electromobility in Germany does not initially pose a major challenge for the energy supply and the energy network infrastructure. At present, the expansion of the charging infrastructure is outpacing the growth in the number of electric vehicles. However, measures must be taken to accelerate expansion in order to ensure that demand-oriented infrastructure is available as new registrations of electric vehicles increase as well. Greater consideration must be given to economic factors in the medium term in order to continue developing a comprehensive nationwide, demand-oriented

network of charging points. Regulatory hurdles must be dismantled and funding opportunities created in connection with private charging infrastructure.

The supply of **natural gas** (and an optional admixture of biomethane) as a fuel is already guaranteed on a comprehensive basis, although the question of whether new filling stations can be profitably operated depends largely on how vehicle numbers develop. Due to the addition of **biomethane** and **bio-LNG**, gas mobility also has a certain potential for reducing greenhouse gas emissions in the transport sector.

Green hydrogen (H<sub>2</sub>) and electricity-based heating fuels, motor fuels and raw materials are set to play a key role in the energy and mobility system in the future. However, their production via **electrolysis** and power-to-X processes using renewable energies requires that suitable competitive conditions be established.

## WG 6 Standardisation, norms, certification and type approval

The transformation of the mobility sector can only proceed in a successful and marketable manner if it is based on internationally agreed standards, norms, certification and type approval. To this end, Working Group 6 works to identify where action is needed in close coordination with all NPM working groups.

In a first step, six topic areas were identified which represent cross-sectoral standardisation needs for the future of mobility: trends in mobility, drive energy, the grid, networking, data and life cycle.

The topic areas describe how existing and new mobility concepts as well as automated and networked driving can be combined into a holistic system. A demand-oriented supply infrastructure for the drive energies of the future must be ensured and is being considered along with the integration of electric mobility into the future grid and the necessary interfaces for intermodal and networked mobility. The collection, use, processing and protection of mobility data and the assessment of the sustainability of mobility solutions over the entire life cycle are also being analysed. WG 6 identifies the necessary standardisation needs relating to these topics.

WG 6 synchronises closely with the DKE and DIN standards organisations and the responsible federal ministries when formulating the recommendations for action. This allows national requirements to be successively incorporated into European and international standardisation processes via the standards organisations. Cooperation projects are currently set up with the US, China, Japan and South Korea.

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# The trans- formation of the mobility system

# 3 | The transformation of the mobility system

## Mobility: a key element of individual freedom and social prosperity

Mobility and transport are part of everyday life: They are an aspect of individual freedom as well as the basis for social prosperity, and they facilitate employment, education, health and culture. Access to mobility and transport services is one of the basic prerequisites of our coexistence in society and must therefore be available to all people – regardless of their social and societal status.

Transport infrastructure, mobility services and transport options make a decisive contribution to prosperity and quality of life in our economy and are a basic prerequisite for entrepreneurial activities and trade. With some 3.8 to 6.1 million employees,<sup>b, 1, 2</sup> the mobility sector is one of the sectors with the greatest impact on employment in Germany.

However, more mobility has thus far often led to more traffic due to the lack of intelligent, forward-looking planning and development. The negative consequences of this development include land consumption, congestion, noise, global warming caused by greenhouse gases, harmful nitrogen oxides and accidents, which are placing an increasing burden on the national economy.

A future-proof and sustainable system is needed that facilitates more mobility with less traffic, takes the burden off the environment and climate, is oriented towards people's needs and thus makes a decisive contribution to quality of life and competitiveness.

### The entire mobility system is undergoing a transition

At present, the mobility system is affected by a multitude of factors, which are accompanied by far-reaching structural changes and challenges. Social developments, such as changing mobility needs, the increasingly networked nature of all areas of life and the need for more climate protection in the transport sector, play an important role in this context. In addition, technological innovations and developments are needed in the field of **alternative drive technologies** and **fuels** as well as in the area of digitalisation and **automation** in order to create new, innovative and viable mobility solutions.

<sup>b</sup> The number of people working in mobility-related occupations varies according to the structure of the analysis. According to M-Five, 3.8 to 4.4 million people were 'directly employed in transport-related economic sectors' in 2014. Analyses conducted by the Federal Institute for Vocational Education and Training (bibb) show some 6.1 million 'persons working in mobility-related areas' in 2015.

## Mobility needs change and must be accounted for

People's expectations relating to mobility are changing, as are their habits. While mobility can increasingly be accessed as a service in metropolitan areas, private cars are mainly used in rural areas. At the same time, people are showing increasing willingness to switch to means of transport such as a bicycle or local public transport. In this way, traffic can be avoided, reduced or relocated. Growing prosperity, the international division of labour and global production facilities are simultaneously causing increasing commuter flows and more frequent business and holiday trips. Changing consumer behaviour such as online shopping and growing online trade is increasing the transport of goods and leading to more traffic based on a steadily growing number of goods and parcel deliveries. For example, the volume of passenger and freight traffic is continuing to rise at present.

A survey conducted by the Allensbach Institute for Public Opinion Research (IfD) and published in May 2019 reveals what citizens in Germany consider to be the greatest mobility problems: congestion and heavy traffic in city centres, air, climate and noise pollution and scarcity of resources with regard to fossil fuels. In addition, there is the impression that motor vehicles make excessive use of public space and that the supply of public transport and rail passenger transport is insufficient. A clear shift of freight traffic to rail is required in this context, and the safety of pedestrians and cyclists in city centre traffic is also considered to be in need of improvement.<sup>3</sup>

In addition, developments such as urbanisation and demographic change have a significant impact on climate protection, the design of living space and the quality of life in both urban and rural areas. Urbanisation is increasingly leading to congestion on transport routes in metropolitan areas. At the same time, population density is declining in many rural regions, which makes it difficult, for example, to operate public transport economically and to ensure comprehensive access to it. The mobility system of the future should therefore en-

sure affordable, safe and flexible mobility in both urban and rural areas, putting the most resource-efficient and environmentally friendly solution first.

Innovative mobility options and new business models such as **ride** and **car sharing, ride hailing and automated valet parking** must take into account people's changing mobility needs and demographic change. At the same time, they should also increase the efficiency potential in the transport system and complement public transport in such a way that people can travel smoothly from A to B. This includes, for example, expanding managed facilities for park and ride and bike and ride services at public transport stops.

The transformation of the mobility system should be understood as a comprehensive process that not only affects economic aspects of the mobility sector such as jobs and value chains, but also has a direct impact on society. The success of the new forms of mobility and solutions depends to a large degree on the extent to which they meet with social acceptance and correspond to the realities of people's lives and their needs. For this reason, society must be involved in the transformation. A broad-based dialogue with all stakeholders is necessary to ensure that people's mobility needs are properly addressed.

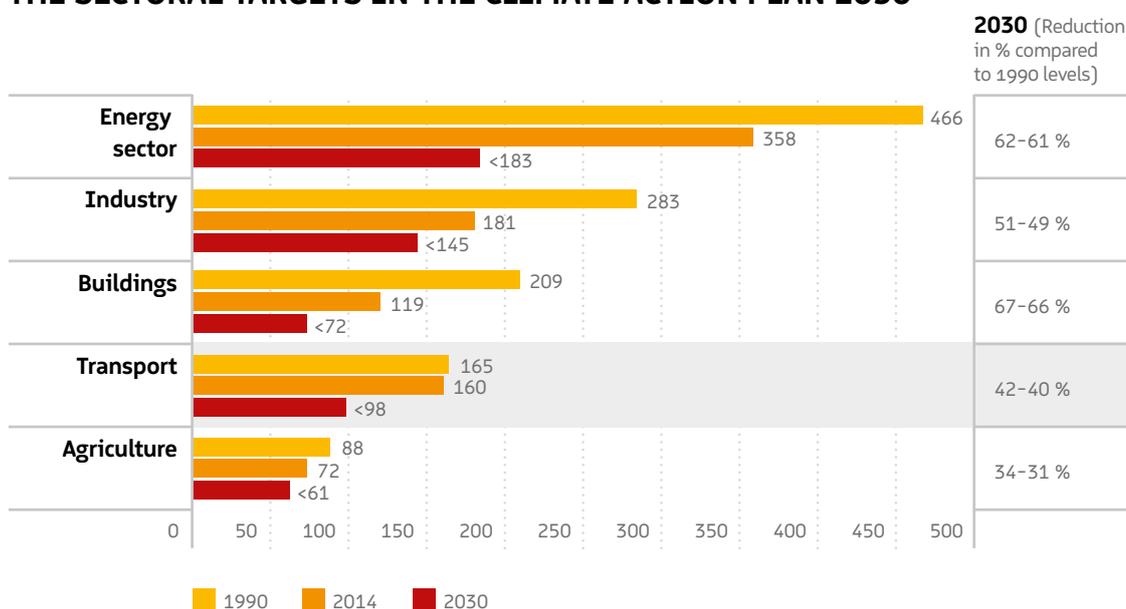
## Climate action encourages the transformation of the mobility system

The change in the mobility system cannot be considered independently of the increased urgency of climate and environmental protection issues. Achieving the climate protection goals that have been set plays a decisive role for the design and success of the future mobility system.

Germany has entered into binding European and international commitments on climate protection. The European Union (EU) has set itself the objective of reducing **greenhouse gas** (GHG) emissions across Europe by at least 40 per cent by 2030 and by 80 to 95 per cent by 2050 compared to 1990 levels<sup>4</sup>. An **emissions trading system** has been in place at the European level for the energy and industry sectors since 2005. In the case of sectors outside the emissions trading system – including transport – the efforts to reduce emissions are shared among the Member States (Effort Sharing Regulation). Under the **EU’s Effort Sharing Decision** (valid until 2020) and the **EU Climate Action Regulation** (valid from 2020), the Federal Government is legally obliged to reduce Germany’s GHG emissions in sectors not covered by the EU Emissions Trading Scheme by 14 per cent by 2020 and by 38 per cent by 2030 (compared to 2005 levels).

In addition, the Federal Government has committed to do its part to limit global warming to well below two degrees Celsius by signing the Paris Agreement. Against this background, the Federal Government has adopted the **Climate Action Plan 2050**, which lays the groundwork for implementing the commitments. The Climate Action Plan provides content-related orientation for all identified fields of action and indicates different greenhouse gas reduction targets for the individual sectors. In terms of the transport sector, this means reducing CO<sub>2</sub> emissions by 42 per cent compared to 1990 levels (see Figure 1 below). The transport sector is the third largest emitter of greenhouse gases, after the energy industry. Despite considerable technical progress, it has not yet been possible to achieve a reduction in absolute CO<sub>2</sub> emissions due to the sharp rise in traffic volumes in the transport sector.

### THE SECTORAL TARGETS IN THE CLIMATE ACTION PLAN 2050



The graph shows the sectoral targets for 2030 based on the Climate Action Plan 2050 (in million tonnes CO<sub>2</sub> equivalents). Source: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (2017). Klimaschutz in Zahlen (Climate protection figures), 2017

**Figure 1:** The sectoral targets in the Climate Action Plan 2050 (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU: Klimaschutz in Zahlen (Climate protection figures), 2017)

## Innovations and technological progress are essential for the transformation of the mobility system

The transformation of the mobility system requires innovations and technological developments. In addition to electrification and the use of renewable instead of fossil fuels, digitalisation plays a decisive role for the mobility system of the twenty-first century. It is key that the technologies of the future see real uptake on the market and are applied on a large scale. This will require cooperation from both the political and industrial sides. Government incentive and support programmes can help to boost the market launch, while companies need to push ahead with development on an industrial scale.

### Automation and networking are part of digitalisation

Automation refers to autonomous driving in particular. Today, automation is already being implemented in assisted and semi-automated driving. These include, for example, steering and track guidance systems as well as automatic parking systems. The primary aim of automation is to make driving safer. At the same time, automated transport can help to reduce emissions and save fuel. In addition to the technical and regulatory challenges, it is necessary first and foremost to make society more aware of the benefits of automated mobility and thereby establish social acceptance.

Automation goes hand in hand with increasing networking between different modes of transport (especially road and rail), means of transport (vehicles) and infrastructure (traffic lights, traffic signs, car parks etc.). New digital services and intermodal platforms enable the use of different means of transport when travelling. Individual mobility needs can thus be met easily, quickly and affordably, while an ecologically sustainable effect is achieved by incorporating environmentally friendly modes of transport (public transport) in a better way. The resulting new and innovative business models and options for mobility services are already being used or are in the process of being developed.

The flow of traffic data in real time also enables intelligent traffic control via sensors and processors. Traffic flows can thus be holistically analysed and optimised. As a result, linking the mobility system together offers the opportunity to make the transport system more efficient and more convenient across all modes of transport, for example, when it comes to optimising routes and making traffic more fluid by increasing the capacity utilisation of passenger and freight transport. Automation and networking can also make a major contribution to the development of an environmentally and user-friendly mobility system.

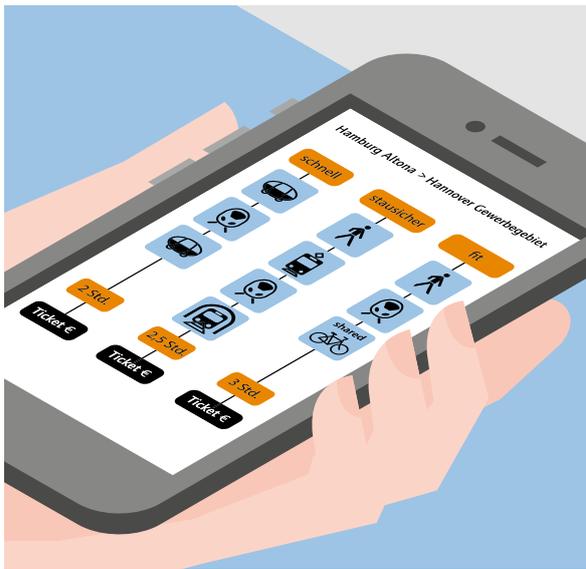


Figure 2: Intermodal mobility from a single source  
(Source: acatech)



Figure 3: Flexible on-demand shuttles stop at virtual stops  
(Source: acatech)<sup>5</sup>

## Alternative drives and fuels

In addition to automation and networking, innovations in the field of alternative drives and fuels also offer great potential for making mobility more climate-friendly, more efficient, more resource-saving and thus more sustainable. In addition to reducing noise and GHG emissions, this also includes reducing **nitrogen oxides** and **particulate matter**, which leads to a significant improvement in air quality in cities.

The switch to electrically powered vehicles in road traffic is already underway. Electric vehicles already have advantages in the overall emissions balance today, with vehicle size and weight, usage scenario and service life representing particular influencing factors. The climate benefit of the electric car will continue to increase as renewable energies and the availability of renewable electricity expand, given that the drive energy is the most important factor influencing the climate balance.<sup>6</sup>

Battery electric technologies are not only available for passenger cars, but also offer initial prototype solutions for heavy commercial vehicles. In addition, the first test tracks for overhead line lorries are currently being built. In the case of ships, there are plans to use shore-side electricity in ports, and the first ferries have already gone

electric. Further prototypes exist for trains and aircraft, which means the entire stock of vehicles of all modes of transport can be at least partially electrified in the future.

In addition to battery electric solutions, there is a wide range of fuel cell applications. The state of development in the passenger car sector ranges from initial trials to series production vehicles. In future, **fuel cell vehicles (FCEVs)** could achieve ranges that are comparable to those of combustion engine technologies. Similar to battery electric vehicles, drives with a fuel cell do not cause local emissions when refuelled with hydrogen. Hydrogen is ideally produced by means of renewable energy via **electrolysis**, and this fuel is also being used in the first regional trains today. This provides the first potential intermodal solutions for the transformation on the part of drive technologies and fuels.

The third component in transforming mobility as regards drives and fuels is alternative CO<sub>2</sub>-neutral fuels for transport. These fuels, which are based on **biomass** or **electricity**, convert energy into liquid or gaseous (**synthetic**) **fuels** by means of chemical processes. They have the same properties as conventional fossil fuels and are

compatible with the existing infrastructure system. They are particularly suitable for means of transport that need to travel long distances, such as aircraft, ships, heavy commercial vehicles or vehicles already on the roads.

The new propulsion and fuel options are feasible in principle, but there are differences in terms of their technological maturity, market readiness and the applications where their potential to reduce emissions can be particularly effective.

## ENERGY EFFICIENCY – COMPARING DRIVES

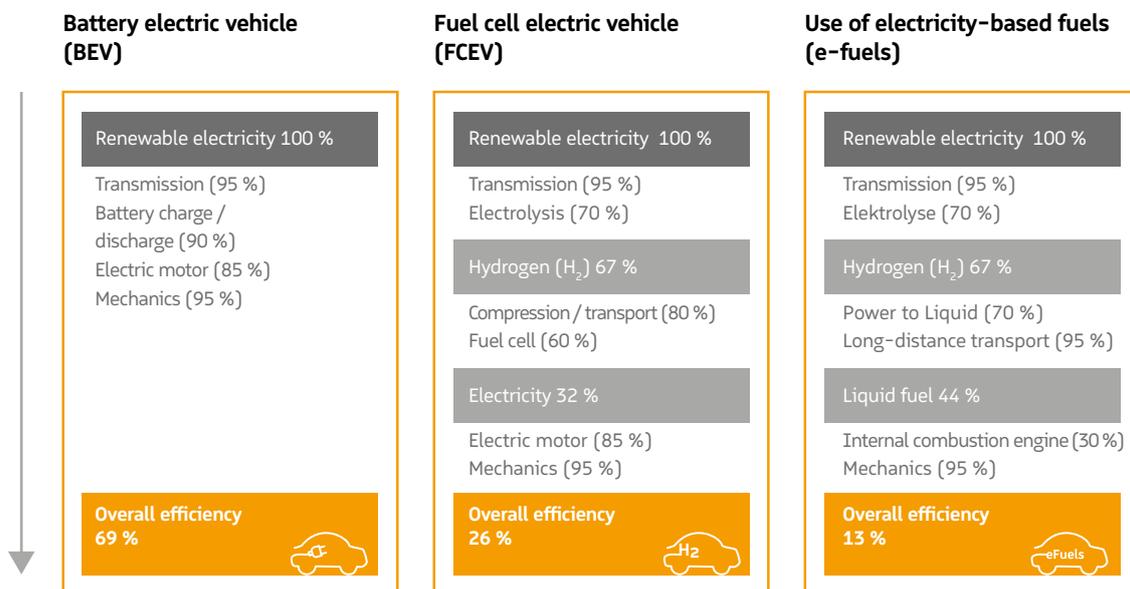


Figure 4: Energy efficiency – a comparison of drives (own diagram)<sup>2c</sup>

## Sector integration

The intelligent coupling of the energy and transport sectors (**sector integration**) allows peak loads caused by the volatile production of renewable electricity to be balanced and transport to move away from fossil fuels towards renewable energies – either by making direct use of renewable electricity in battery electric vehicles or indirectly via hydrogen and synthetic fuels produced from renewable electricity and used in fuel cell

and conventional vehicles. In addition, battery storage systems in electric vehicles can be used in the future as short-term, system-supporting power storage devices and can either draw electricity from the grid or feed it back into the grid by means of **bidirectional energy flow**.

<sup>c</sup> Individual efficiencies are shown in brackets. Multiplying the individual efficiencies results in the cumulative overall efficiencies in the boxes. Based on visual representation: Agora Verkehrswende, Agora Energiewende and Frontier Economics (2018): The future costs of electricity-based synthetic fuels, Berlin, p. 12.

## Regulatory framework

The further development of the transport system is not only to be understood as technical progress, but also as a policy task. A political framework that favours the desired changes is needed so that the new services do not lead to more traffic (**rebound effect**). A possible rebound effect could occur, for example, if existing public transport users access car sharing services and thus create more rather than less private transport. Questions relating to the security and vulnerability of a digitalised transport system must also be clarified and openly discussed. Particularly in the area of **cybersecurity**, the legal and technical framework conditions must be established in such a way that a networked, data-driven mobility system is safeguarded across all modes of transport and security in the overall transport system is guaranteed at all times. Data protection must also be taken into account.

## Setting the strategic course for ecologically, economically and socially sustainable mobility solutions of the future

The future of mobility offers the chance for sustainable prosperity. Technology-neutral developments offer scope for innovations that can be used to tap into future markets. This strengthens Germany's standing as a place for business: Jobs can be secured, new ones created and the country's international competitiveness strengthened. Over the decades, competitive value chains and structures have developed in the mobility sector in Germany and have made a significant contribution to the success of the German economy thus far. Due to the far-reaching changes affecting it, this system is coming under pressure and is facing a profound transformation. Existing process chains must be questioned and restructured. Solving this issue calls for new approaches and concepts that require efforts at the political, economic and social levels.

The transformation of the mobility system poses major challenges not only for the automotive industry, but also for the energy sector and many other branches of industry. We must seize the opportunity to shape this transformation now. Doing so will lay the foundation for new, sustainable value chains and safeguard jobs. Germany has the opportunity to shape the change in a socially acceptable way based on targeted political support.

The transformation process is a task for society as a whole. It assumes that all those involved are ready and willing to structure the mobility system in a forward-looking way. Framework conditions must be set and managed in such a way that investments can be made in research and development and in new markets. Changes in mobility behaviour can be supported by financial incentives and the provision of information. The Federal Government has taken on this task. In the field of climate protection, it has laid important groundwork for the implementation of the Climate Action Plan 2050 with its Climate Protection Act passed at the beginning of October. The NPM's work and the recommendations for action made in previous reports have been incorporated into the political decision-making process. The introduction of a cross-sectoral **CO<sub>2</sub> pricing** system, which Germany will introduce in 2021, was addressed to the Federal Government by the NPM at an early stage as a recommendation for action that was to be examined.

The strategic course is also being set in other areas. The Federal Government has launched 'Concerted action for mobility', a strategy dialogue which can be used to tackle the far-reaching challenges facing the automotive industry.<sup>8</sup> Measures that have already been adopted include a master plan with an incentive programme to promote electromobility, which contains an increased purchase premium for e-vehicles (environmental bonus) and accelerated expansion of the charging station infrastructure. According to the Federal Government, 50,000 publicly accessible charging points are to be built over the next two years.

In addition, the legal and technical framework for autonomous driving is to be established by March 2020. Furthermore, private and public mobility providers want to jointly create a comprehensive mobility data network by the end of 2021 so networking can be used to best possible effect for the mobility transition. In the area of qualification and further training of employees and SMEs, the Federal Government is examining whether the instruments of the **Skills Development Opportunities Act** and the **short-time allowance** need to be subsequently fine-tuned or adapted. In this way, employees who are affected by structural change and digitalisation can receive targeted support. The Federal Government is preparing a comprehensive hydrogen strategy in the field of alternative drive technologies.

The NPM's results so far have been incorporated into the preparation of this strategic dialogue. Representatives of the platform also participated in the preparation of the measures. The NPM will continue to play an active role in the process of redesigning the mobility system and support policymakers.

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# Structure and working methods of the NPM

# 4 | Structure and working methods of the NPM

## Development of the NPM

The National Platform Future of Mobility is based on the coalition agreement of the CDU, CSU and SPD for the nineteenth legislative period. On 19 September 2018, the Federal Government passed a cabinet resolution to establish the platform. The NPM officially commenced its work with the inaugural meeting of the Steering Committee on 26 September 2018.

The NPM builds on the preliminary work of the **National Platform for Electric Mobility** (NPE), which has pooled

the government's activities on electric mobility since 2010. The shift towards new forms of drive technology remains a central topic in the transformation of the mobility sector. The topics of the NPE have been transferred to the structures of the NPM and will be continued there on an integrated basis and across all modes of transport. The range of topics has a significantly broader scope and includes all aspects of a future mobility system.

## Goals and mission of the NPM

The NPM aims to develop – with the involvement of politics, business and civil society – forward-looking concepts and recommendations for action to ensure Germany will have competitive companies and jobs as well as affordable, sustainable and climate-friendly mobility in future. The NPM is an advisory body and formulates its recommendations on the basis of cross-interest discussions and mutual agreement. The decision to implement the recommended measures lies with the political players.

In order to achieve this goal, the platform performs a wide range of tasks. This includes monitoring and analysing current and future trends in mobility and comparing them with existing concepts. Disputed issues are clarified by examining the facts and circumstances. The key focus of the NPM's work is to develop a systemic approach to the future of mobility that integrates

the ecological, economic and social aspects. Due to the wide spectrum of reciprocal effects and complex inter-relationships in the mobility sector, a common understanding of the future of mobility is vital.

Relevant stakeholders and players from politics, business, science and civil society work together in the platform and can discuss and network on future issues. The thematic focal points resulting from this dialogue are thus designed as a broad discussion process and make it possible to formulate recommendations for action to politics, business and society in a balanced manner.

## THREE OVERARCHING OBJECTIVES PROVIDE THE NPM WITH GUIDANCE IN FULFILLING THESE TASKS:

- | Develop intermodal and interlinking solutions for a largely greenhouse gas neutral and environmentally friendly transport system
- | Ensure a competitive automotive industry and promote Germany's standing as a place to work
- | Enable efficient, high-quality, flexible, safe and affordable mobility

These objectives relate to both passenger and freight transport. The NPM pursues the established goals, continuously monitors the implementation of concrete measures and reports on the progress it has achieved in a neutral and independent manner.

## Structure of the NPM

The broad-based nature of the NPM is reflected in the structure of the platform, which is divided into the Steering Committee, working groups and Advisory Commission.

### Steering Committee

The Steering Committee is the highest decision-making body of the NPM and makes recommendations for action to politics, business and society. Along with the working groups, it provides technical and content-related momentum for the platform, identifies new topics to be addressed in the platform and makes suggestions for their implementation. The Steering Committee also manages the content-related work in the working groups, monitors their implementation and provides advice on the results. The Steering Committee is chaired by Prof. Dr. Henning Kagermann.

### Six working groups

The content-related work on the specific topics is carried out in six working groups. Experts from a wide range

of disciplines deal with the central developments in the transport sector here. These include the requirements for achieving the Federal Government's energy and climate policy goals, potentials and challenges in the field of alternative drives and fuels, the digitalisation of the mobility sector, securing Germany's position as a place for mobility and production, linking the transport sector with the energy system, and the standardisation of technological components in the transport sector.

### Advisory Commission

The Advisory Commission, whose members include representatives of the Federal Government and the heads of the working groups as well as representatives of the Bundestag, serves as the NPM's interface to Parliament. It provides the Bundestag with information on the results of the Platform and receives instructions from Parliament. The Advisory Commission forwards its assessments to the Steering Committee.

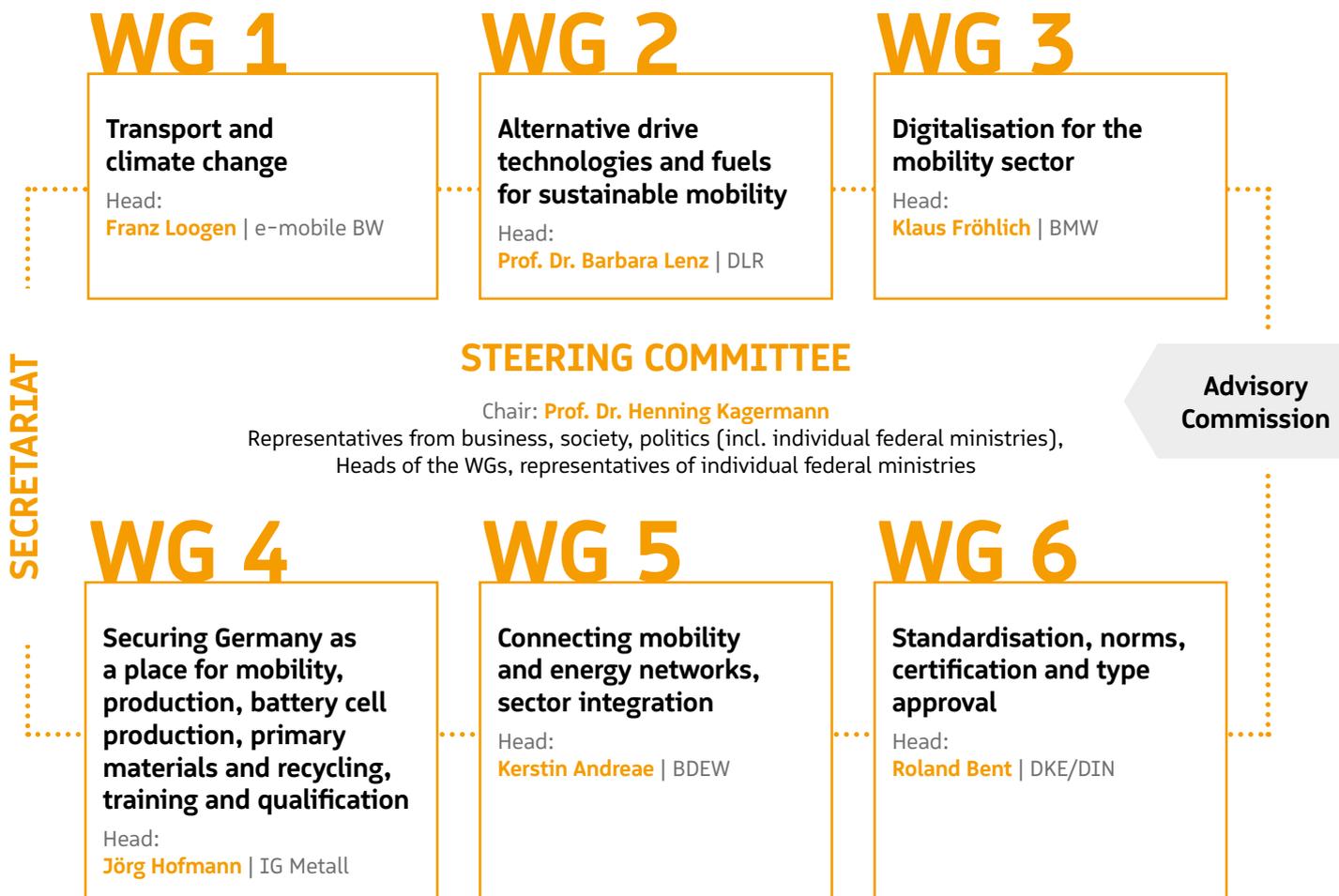


Figure 5: Structure of the National Platform Future of Mobility (NPM) (own diagram)

## Working methods of the NPM

The Platform's work is based on a broad understanding of sustainability. Economic, ecological and social aspects are included in the experts' observations and analyses to an equal extent. A holistic, systemic perspective forms the basis of the working groups' activities.

The work of the NPM pursues an iterative approach. Measures and instruments for designing a sustainable mobility system require constant monitoring of their

effectiveness and impact. Relevant influences include, for example, technical progress, changing social requirements as well as general political conditions and new scientific findings. It is important to keep an eye on these factors in order to allow for any necessary adjustments.

## ITERATIVE APPROACH

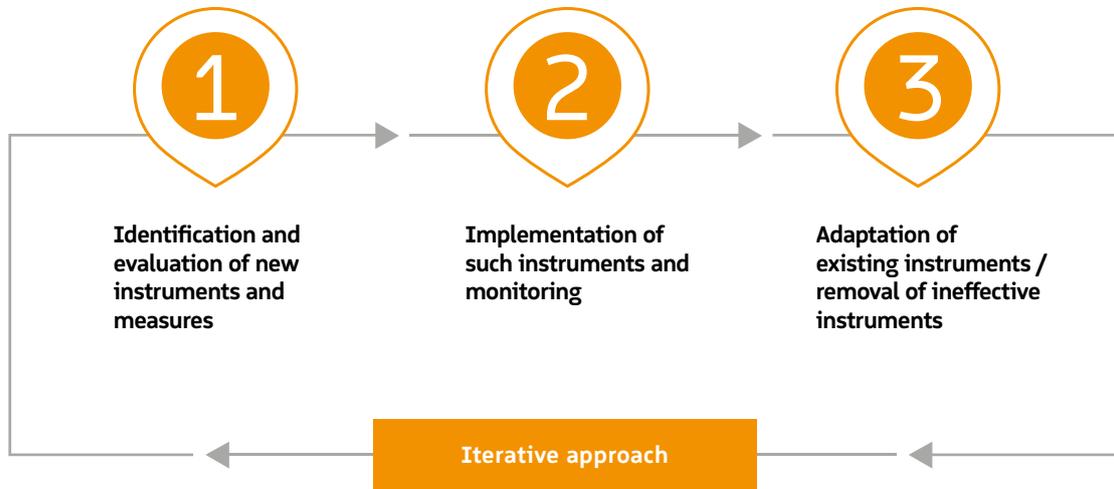


Figure 6: Iterative approach (own diagram)

Model calculations and scenarios are also used for the work of the NPM. They provide a good basis for improving evaluations of instruments and measures. Despite all the precision of these model calculations and scenarios, however, they are only a simplified representation of reality. Developments, such as those concerning the overall economic situation and the sale of specific drives, can only be assumed. Parallel to the model calculations, the NPM is therefore also pursuing an application and testing approach. The recommendations for action are tested in concrete use cases and pilot projects. The insights gained from this will help to further elucidate the proposed measures and instruments and make them more concrete in terms of achieving the objectives. The recommendations are not only directed at politics, but also at business and civil society.

The Platform's content-related work is carried out in six working groups. The heads in charge of the working groups were appointed by the Federal Government. Care was taken when selecting the members to ensure a balanced relationship between business, science and society. The results of the working groups are continu-

ously presented to the Steering Committee by the heads of the working groups and discussed there together with the members of the Steering Committee. This allows interfaces and aspects requiring coordination between the working groups to be identified and addressed at an early stage. A shared picture of the future of mobility can thus be developed over time based on ongoing cooperation across topics in the NPM. A consensus is to be reached in the content-related work in principle. However, there is also the possibility of presenting opposition in the WG reports if no thematic consensus can be reached on individual aspects.

The NPM is financed by the Federal Government. The representatives involved in the platform work independently and on a voluntary basis. They provide momentum and guarantee a broad spectrum of expertise. The platform ensures compliance with antitrust law in its work. Platform management and moderation are independent, non-partisan and neutral. The term of the NPM is initially fixed until the end of 2021.

## Focal points of the working groups

The NPM is divided into six working groups that address specific topics. These have been classified by the Federal Government as key to designing a sustainable mobility system. The working groups develop concepts and recommendations for political action on the specific topics.

### WG 1: Transport and climate change

Working Group 1 has been tasked by the Federal Government with recommending suitable fields of action and instruments for achieving the climate protection target for 2030, a greenhouse gas reduction in the transport sector of 40 to 42 per cent. The guiding principle for the discussions of the working group was to ensure sustainable and climate-friendly mobility that will remain affordable in the future. The proposed instruments or measures are intended to demonstrate ways in which the climate policy goals can be achieved, but also have a positive effect on economic development and social cohesion.

### WG 2: Alternative drive technologies and fuels for sustainable mobility

Based on a technology-neutral approach, Working Group 2 looks at **alternative drives** and **fuels** for all modes of transport with regard to their contribution to sustainable mobility and thus to achieving the Federal Government's climate and energy policy goals for 2030 and 2050. In addition to technical and economic criteria, the evaluation also takes into account the social requirements for the acceptance and use of alternative drives and fuels by households and companies.

### WG 3: Digitalisation for the mobility sector

Digitalisation presents an enormous challenge for Germany. The envisaged potential can only be realised if politics, industry and civil society invest jointly in this challenge for the future. To this end, WG 3 pursues clear, overarching objectives. The central objective of a multi- and intermodal mobility system is defined by focus group A. Autonomous mobility is an important component of a **multimodal** system (focus group B). The diverse technological requirements that are necessary for this will be developed in focus group C. This includes the topics of data, connectivity and security. They enable functioning, user-friendly multimodal mobility in the first place. Mobility cannot be successfully transformed without the involvement of society. For this reason, focus group D is working on implementing a broad social dialogue that includes the participation of local citizens and takes into account the diversity of the population.

### WG 4: Securing Germany as a place for mobility, production, battery cell production, primary materials and recycling, training and qualification

The mobility sector is one of the economic sectors that has the greatest impact on employment in Germany. Digitalisation and the electrification of mobility are leading to a profound structural change in the sector: Transport modes such as road, rail, water and air are affected, as are the production industry and mobility services. Working Group 4 therefore focuses on securing Germany as a place for mobility and production in the long term. The WG is organised as a social partnership and focuses on the effects and requirements of the structural change for existing and future central **value-added networks** and employment in Germany.

## WG 5: Connecting mobility and energy networks, sector integration

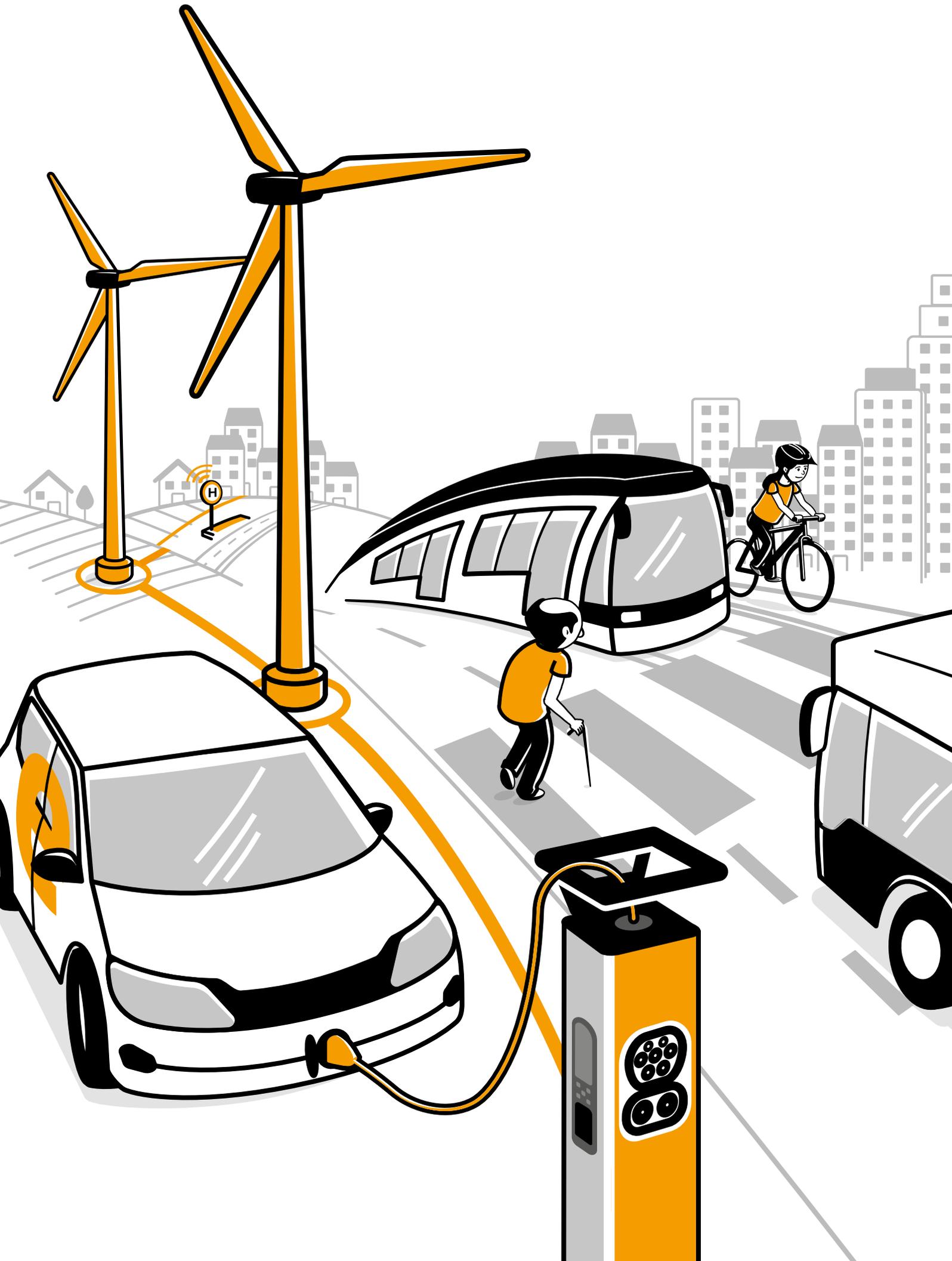
Working Group 5 investigates the infrastructure that is needed for alternative propulsion systems in order to achieve the climate goals in the transport sector in 2030 and what measures should be taken to further expand it. Topics include the charging and refuelling infrastructure for electric mobility, **power-to-X** (hydrogen and e-fuels) as well as **CNG** and **LNG** for passenger cars and commercial vehicles. Furthermore, the prerequisites and data requirements for intelligent **grid integration** of electric mobility as well as aspects of sector coupling are to be discussed.

## WG 6: Standardisation, norms, certification and type approval

Working Group 6 is a body that extends across interest groups and focuses on the initiation, coordination and orchestration of standardisation, norms, certification and type approval requirements for the future of mobility on the basis of a consensus. It defines the strategic position of the platform on this topic and develops recommendations to industry and politics in the form of standardisation roadmaps. These recommendations constitute Germany's standardisation strategy for the future of mobility. WG 6 is closely synchronised with the standards organisations to ensure that national requirements are incorporated into European and international standardisation processes. Coordinating and providing strategic support for these international consensus processes and integrating political support are further focal points of the WG.

5

# Results of the working groups



# 5 | Results of the working groups

## 5.1 | Transport and climate change

### Pathways to a sustainable and innovative mobility system

Climate protection is one of the most important objectives of our time. Germany has acknowledged this responsibility and has entered into international commitments to reduce CO<sub>2</sub> emissions. Despite considerable technical progress, it has not yet been possible to achieve a reduction in CO<sub>2</sub> emissions in the transport sector. This is due to the strong increase in traffic volume in part.

Emissions in 2017 amounted to around 168 million tonnes (t) of **CO<sub>2</sub> equivalents** (CO<sub>2</sub>eq.) compared with 163 million t of CO<sub>2</sub>eq. in 1990. However, the national climate targets set for 2030 include a **greenhouse gas** reduction target of 98 t CO<sub>2</sub>eq. This corresponds to a 42 per cent reduction in emissions compared to 1990 levels. The transport sector therefore faces a special challenge, and there is substantial pressure to act. In order to achieve the climate targets in the transport sector, a turnaround is needed. Society, the economy and politics are faced with major challenges in this regard, which require joint efforts at all levels. Appropriate framework conditions must now be established and instruments selected in view of the entire transport system and taking the economy and society into account.

At the same time, climate protection in the transport sector offers great opportunities to improve individual mobility via new concepts. Investments in climate-friendly and resource-saving products and services are also investments in future markets and offer growth opportunities. Climate protection measures also make a central contribution to preserving and creating jobs in Germany and increase international competitiveness.

Working Group 1 Transport and climate change advanced the discussion on climate protection in transport and provided in-depth momentum in politics and the public sphere based on its interim report 03/2019. In particular, WG 1's recommendation to consider CO<sub>2</sub> pricing across all **non-ETS sectors**<sup>9</sup> has advanced the wide-ranging debate on this issue within society. The recommendations for action of WG 1 were incorporated into the work of the Climate Cabinet and served as the basis for the preparation of a suitable package of measures.

## WG 1 Interim report 03/2019

### Ways to achieve the 2030 climate targets in the transport sector

In this [report](#), WG 1 identifies possible ways to achieve greenhouse gas reductions in the transport sector.



## Fields of action for a climate-friendly and innovative transport and mobility system

Six fields of action have been identified that need to be addressed with concrete measures and instruments for reducing CO<sub>2</sub> emissions in the transport sector:

- **Drive transition for cars and lorries**
- **Increasing efficiency in cars and lorries**
- **Renewable fuels**
- **Boosting rail passenger transport, bus, bicycle and pedestrian traffic**
- **Increasing rail freight transport and inland waterway transport**
- **Digitalisation**

In terms of the implementation and instrumentation of the fields of action, WG 1 has specified the details of important recommendations for the implementation process:

### ■ **A parallel and highly ambitious approach**

Measures in all fields of action must be introduced or stepped up in parallel using a highly ambitious approach. Addressing individual fields of action on their own will not be sufficient.

### ■ **Speed**

Measures, especially those with a high degree of consensus (e.g. charging infrastructure measures) must be taken immediately. A turnaround must be initiated quickly in order to achieve the climate targets.

### ■ **Coordinated package of measures: Push and pull**

The measures in the various fields of action must be considered in combination and coordinated with one another to good effect. This is the only way they can have an optimal effect and the only way to counteract the risk of measures balancing each other out. The measures recommended in the interim report 03/2019, which are mainly aimed at improving infrastructure, direct support and expanding supply (pull instruments), have, according to calculations, been able to close the CO<sub>2</sub> gap to some extent. The options created with appropriate support instruments will only be effective if they are supplemented by robust and sensibly designed push instruments (i.e. primarily price incentives). At this stage, there is no consensus on concepts for push measures. So far, there has been a need for further discussion,

particularly on the concrete design of price signals. There is disagreement, among other things, on the question of introducing quotas for electric vehicles, the bonus-malus system and the development of the **alternative fuels** field of action. The discussion on a balanced mix of push and pull instruments needs to be continued in greater detail.

### **Minimise arising burdens and distribute them in a balanced manner**

Mobility must remain affordable for everyone. The decision in favour of particular instruments and the associated financial responsibility must be based on a necessary consideration of ecological, economic and social factors. The costs incurred by climate protection in transport should be appropriately differentiated into market-based investments and (temporary) burdens on the economy and society.

### **Pursue an iterative approach and adjust**

Measures and instruments should be introduced in different time stages, because rapid action is necessary even though it is not yet possible to fully and transparently assess all effects and developments today. An iterative approach of this type makes it possible to react to uncertainties from the underlying assumptions and models as well as to dissent in society (e.g. in the handling of biomass), and measures can be adapted. This includes subjecting instruments that have now been adopted to a permanent monitoring process and examining their effectiveness at defined points in time (2021, 2023, 2026 and 2029).

For all six fields of action, WG 1 provided an overview of the current situation, identified starting points for next steps and formulated assessments of target corridors of key indicators that are necessary to achieve the climate target. It is essential that the NPM working groups address the identified fields of action in depth in order to quickly close any knowledge gaps regarding technologies and suitable framework conditions and to rapidly advance the implementation of concrete measures and instruments. The other sections of this progress report already contain initial concrete recommendations on the fields of action addressed by WG 1.



## Field of action 1: Drive transition for cars and lorries

A number of alternative drive technologies are available to reduce CO<sub>2</sub> emissions so that petrol and diesel-powered combustion engines can be replaced. The advantages of the various technology options depend on the respective application and **mode of transport**. Due to its high efficiency, the electric motor offers great reduction potential for cars, lorries and buses. In the case of passenger cars, electric motors can be used in pure battery electric vehicles (**BEV**), **plug-in hybrid vehicles** (PHEV) and **fuel cell vehicles** (FCEV). Several technologies are also available for lorries and buses, such as overhead line, battery or hydrogen-powered, or – for a transitional period – gas-powered vehicles<sup>d</sup>. The use of alternative fuels is discussed in field of action 3.

According to the Federal Motor Transport Authority (KBA), only 83,175 electric cars (BEV), 66,997 plug-in hybrid cars (PHEV), 395,592 liquefied petroleum gas (LPG) cars and 80,776 **natural gas** (CNG) cars have been registered in Germany (as of 1 January 2019)<sup>e</sup>. The situation is similar for light commercial vehicles and lorries, with 14,994 registrations for liquefied petroleum gas (LPG) and 13,783 registrations for natural gas (CNG). There are 17,598 vehicles<sup>f,10</sup> in the area of electric lorries with a maximum payload of 11,999 kg.

### Starting points for next steps

The working group assumes that these figures will have to be increased significantly to achieve the climate protection targets.<sup>g</sup> In order to achieve the climate targets for 2030, WG 1 estimates that a share of seven to 10.5<sup>h,11</sup> million electric cars is necessary. Efforts must also be made to promote electrification in the commercial vehicle sector. Massive electrification of smaller lorries and buses is needed along with a switch to other types of drives in all vehicle segments – such as gas and hydrogen.

In order to advance a change in drive technologies and successively electrify the country's vehicles, an expansion of the range of low or zero greenhouse gas drives and a degression of the costs of the applied technologies are required. This is because the costs of electromobility are still relatively high, which represents an obstacle to getting the market up and running despite the environmental bonus. A key factor in stimulating market demand is improving the framework conditions. This includes expanding the refuelling and charging infrastructure as a matter of urgency to make these vehicles attractive to various user groups (see section 5.2).

<sup>d</sup> There are different views on this within the WG. (See NPM 2019 Interim report WG 1, p. 20, footnote 17 in detail).

<sup>e</sup> A differentiation of the different drive trains will only be made once a year by the KBA (cut-off date: 1 January 2019). The figures used here therefore reflect the situation as of January 2019. The most recent figures from October 2019 are only presented in aggregated form (see also Section 3.5, endnote 43): 212,574 BEV and PHEV cars in total; 51,789 gas-powered commercial vehicles in total (quarterly inventory as of October 2019). The commercial vehicles in the KBA's compilation consist of buses, lorries and semi-trailer tractor units. [https://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Vierteljahrlicher\\_Bestand/vierteljahrlicher\\_bestand\\_node.html](https://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Vierteljahrlicher_Bestand/vierteljahrlicher_bestand_node.html).

<sup>f</sup> The figures are based on the KBA's calculation. Please note: the KBA only lists the payload. The tare weight of the commercial vehicle is not taken into account. Reporting date of the survey: 1 January 2019 (taking into account reports received by 13 January 2019).

<sup>g</sup> More precise target corridors can be found in the NPM Interim report 05/2019 published by WG 1.

<sup>h</sup> The recommendation of WG 1 has been incorporated into the Climate Action Programme 2030, based on which the Federal Government has derived a corridor of seven to 10 million electric vehicles (see Climate Action Programme 2030, p. 76).



## Field of action 2: Increasing efficiency in cars and lorries

In addition to increasing the efficiency of the drive system, it is also necessary to take a look at the entire vehicle architecture and to increase the efficiency potential by making its operation more economical and optimising traffic conditions. WG 1 estimates that there is a potential of up to 30 per cent in this field of action compared to 2015<sup>12</sup>. The increase in both **vehicle efficiency** and **system efficiency** promises significant reductions in CO<sub>2</sub> emissions. Increasing system efficiency plays a particularly important role, as these measures can also be used to address the vehicle inventory.

### Starting points for next steps

A reduction in CO<sub>2</sub> emissions per kilometre driven – i.e. an increase in vehicle efficiency – can be achieved, for example, by implementing technical measures on new vehicles (such as improving aerodynamics) or during the service life by using low-resistance tyres and oils. However, energy consumption and thus CO<sub>2</sub> emissions can also be reduced by using foresight when driving. Avoiding braking and accelerating offers high potential for reducing CO<sub>2</sub> emissions. The question of whether introducing general speed limits on motorways and country roads will also increase efficiency and traffic safety is hotly debated.

In order to realise potentials in the area of system efficiency, various IT-supported infrastructure conditions are seen as one important lever for making better use of the existing road infrastructure. Related measures could be, for example, intelligent traffic control and connectivity, dynamic roadworks management, increasing the flow of traffic through intelligent speed management, **platooning**, **car-to-everything (C2X) communications**, promoting the development of a comprehensive and powerful mobile communications infrastructure (LTE, 5G) and the establishment of data platforms.

System efficiency can be increased via measures to promote higher capacity utilisation: In freight transport, for example, freight exchanges can increase loads and avoid empty runs. The efficiency of the system could also be further improved by measures to improve transport efficiency, such as the application-oriented expansion of potential uses for EuroCombi lorries. Occupancy rates in car traffic are currently around 1.5 persons per car. App-based information and booking tools, opportunities for **ride-pooling**, measures by employers or separate lanes for carpools offer starting points and require an in-depth analysis so their potential and operationalisation can be more precisely assessed (see also action field 6).



### Field of action 3: Alternative fuels

Alternative fuels from renewable production are divided into **biofuels** and **electricity-based fuels**. Biofuels are liquid and gaseous energy sources that are produced from biomass. Electricity-based, gaseous and liquid energy sources offer the possibility of making electricity in the form of hydrogen and hydrocarbons (petrol, diesel, kerosene, gas) usable for the transport sector via various conversion steps. The advantage of alternative fuels is that there is no need to change drive systems or set up new refuelling infrastructure and that the entire stock of internal combustion engine vehicles could be addressed. This allows even transport methods that cannot be electrified to be made more climate-friendly.

One disadvantage is the comparatively low level of efficiency. The conversion processes employed to produce the alternative fuel are associated with efficiency losses, which means that significantly more energy must be used compared to electric vehicles, which use electricity directly. Important points such as indirect land-use changes (food or fuel debate) and the industrial scaling of production plants must be taken into account when expanding the demand for alternative fuels. In the case of electricity-based energy sources, some argue that they would have to be produced abroad rather than in Germany if they are to be available in sufficient quantities.<sup>i</sup> The reasons for this are that the potential areas of land available for the production of renewable electricity and the acceptance of the plants in Germany are limited and the production of electricity-based materials is significantly cheaper in certain regions of the world than in Germany thanks to better renewable energy (RE) production conditions (higher solar radiation, higher wind supply).

### Starting points for next steps

Alternative fuels can help to achieve the GHG reductions required in the transport sector by 2030. However, there are varying assessments of the quantities of renewable fuels that can or should be made available in 2030. For example, some stakeholders recommend capping the use of biofuels and focusing on other options, while others call for a high level of expansion and corresponding subsidies. The recommendations are similar for electricity-based fuels – from minimal use only in non-electrified transport to broad use throughout all passenger cars. The recommendations for further research into and promotion of the market ramp-up also differ widely in line with the assessment of the potential of alternative fuels<sup>j</sup> (see Section 5.2).

Clear, predefined sustainability criteria for all types of alternative fuels, as well as their control and compliance, are a prerequisite for a real impact on the climate and for acceptance by the general public. These must ensure, at both the national and global levels, that no negative ecological or social consequences are caused during production.<sup>15</sup> In the long term, liquid and gaseous renewable energy sources will be used in modes of transport that cannot be electrified. These include air and sea transport and heavy-duty transport in particular. There could be further potential in the field of car transport, although this is viewed controversially from the perspective of sustainability criteria.

<sup>i</sup> See, for example, Prognos/UMSICHT/DBFZ 2018 and dena 2018.

<sup>j</sup> For a detailed discussion, see NPM 2019 Interim report of WG 1, p. 30ff.



## Field of action 4: Strengthening rail passenger transport, bus, bicycle and pedestrian traffic

Public passenger transport, both by rail and on the road, can carry many people while producing low emissions per passenger kilometre. Rail-based public transport is already largely electrified and can even be operated emission-free using renewable electricity. Bus transport, if powered by fossil fuels, causes less CO<sub>2</sub> per passenger kilometre than travelling in a private car. In addition, a change in drive systems is underway in the field of bus traffic (see action field 1). Pedestrian and bicycle traffic produce no emissions at all. In addition to reducing emissions, the mentioned means of transport also have a significantly lower land consumption rate than private cars. In urban areas, but also in urban-regional connections, bicycle and foot traffic in particular are a space-efficient element for enabling mobility while reducing emissions at the same time.

The mentioned forms of mobility need to be reinforced in order to reduce CO<sub>2</sub> emissions from transport and facilitate space-efficient mobility options in growing cities. The combination of rail passenger transport by rail, public road passenger transport with buses, underground, tram and light rail as well as cycling and walking<sup>k</sup> must be made more attractive if they are to replace journeys by car.

### Starting points for next steps

Available capacities must be expanded in order to increase rail traffic at peak times. WG 1 considers the upper target corridor for this field of action to be a share of 12 per cent rail, 8 per cent bus, underground and tram as well as 9 per cent cycling and walking of the passenger transport volume – this corresponds to an increase in the passenger transport volume of 53 per cent for rail passenger transport, 17 per cent for bus, underground and tram and 45 per cent for cycling and walking compared to 2015.<sup>14</sup>

In order to take an ambitious approach to climate protection, investment efforts must go well beyond the Federal Transport Infrastructure Plan (BVWP) and be acceler-

ated. Infrastructural expansion and new construction measures, as well as the implementation of the German timetable (“Deutschland-Takt”) and technical upgrades to the **European Train Control System** (ETCS), must be implemented quickly. It is also necessary to speed up planning and approval procedures. In order to make rail travel more attractive, cost reductions for rail transport are just as necessary as improved product quality, which can be achieved in part on this basis, such as the provision of Wi-Fi. The option of planning intermodal routes using digital devices and buying tickets online must also be expanded. In addition, more services must be created in areas with weak demand and during off-peak times. Real-time connectivity with customers also enhances reliability and provides a more attractive profile.

Cycling and walking also require developed infrastructure, and the emphasis must be on both traffic safety and the attractiveness of the routes. City centres must be modified so they are pleasant places to be, which will encourage people to walk. Cycle traffic requires parking facilities, cycle path networks of sufficient scope and safety, and signage. The expansion of sharing opportunities and the creation of intermodal stations should also be promoted. Similarly, legal adjustments are needed to the Road Traffic Act, the Road Traffic Regulations (StVO) and building regulations.

Overall, zero-emission modes of transport must be given greater consideration in the allocation of transport areas. This not only creates low-emission cities, but also cities worth living in. Orienting urban and regional planning towards cycling and walking plays a further role in terms of shortening daily journeys, achieving a mix of uses and providing attractive alternatives to private cars.

The capacities created and attractive opportunities from public transport, cycling and walking will be fully utilised if they are supported by price incentives. Parking space management and city-centre **urban toll systems**, for example, can also contribute to this.

<sup>k</sup> For further decarbonisation effects and positive accompanying effects in public transport, see NPM 2019, p. 36ff.



## Field of action 5: Strengthening rail freight transport and inland waterway transport

Road freight transport accounts for a large proportion of transport-related emissions. Rail and waterway modes of transport can transport goods with lower emissions per tonne-kilometre than road transport. A modal shift of freight transport can thus contribute directly to reducing emissions. In the case of rail freight transport, which is largely electrically operated, this is supplemented by an already high use of renewable energy sources. However, rail and waterways cannot currently be reached from everywhere, access is not guaranteed and their use is therefore restricted. Access, capacity and attractiveness need to be addressed in order to enhance the modal shift to rail freight transport as well as to inland waterway transport.<sup>1</sup>

### Starting points for next steps

Infrastructure, vehicle and personnel capacities need to be expanded in rail freight transport, similar to those of rail passenger transport (see action field 4). According to WG 1, the potential for reducing GHG in the area of rail freight transport is estimated at up to 25 per cent and that of inland waterway transport at up to 9.5 per cent of the transport volume in freight transport. This corresponds to an increase in freight transport volume of 70 per cent for rail and 50 per cent for inland waterway transport compared to 2015.<sup>15</sup>

Concrete instruments were comprehensively developed at the Rail Freight Roundtable and are currently being supplemented and promoted in the Future Alliance Rail. Measures to increase capacity include remedying bottlenecks, expanding important hubs, creating dual-track systems, expanding the network for longer trains as well as optimised operating concepts to enhance the utilisation of the rail network. To this end, the ramp-up of investments in rail infrastructure must be put in motion

based on consistent implementation of the Federal Transport Plan, the completion of ongoing infrastructure measures and additional measures for the German timetable. In order to realise the potential for growth, there needs to be greater fiscal policy commitment to investment in rail infrastructure.

Due to the lead times for planning, legal proceedings, developing building capacities and implementation, the increase must be firmly established in the short term.

Access to the railway system must also be improved, for example by boosting the area covered by single wagon-load traffic, new sidings, multimodal transshipment facilities and the rollout of ETCS. Furthermore, new combined transport services need to be created, which can be increased through new access points and transport concepts. Greater integration into intermodal transport chains is also necessary by ensuring cranes can be used for semi-trailers and by providing incentives for CT-compatible trailers. In addition to continuing support for route pricing, rail freight transport could become more competitive, for example, by promoting CT and area services and reducing the tax and duty burden on traction current.

Strengthening inland waterway transport requires a suitable federal funding framework and the rapid completion of the Inland Waterway Transport Master Plan with precisely formulated recommendations for action as well as rapid implementation of the defined measures. Investments are also needed to ensure the efficiency of the waterway system in keeping with ecological restrictions and a significantly expanded support framework for modernising and reducing emissions in the fleet. The availability of shore-side power plants in ports and at berths must be ensured in line with demand.

<sup>1</sup> For the area of urban logistics and urban freight transport, see NPM 2019, p. 41ff.

## Field of action 6: Digitalisation

Digitalisation in transport offers the opportunity to make the transport system more efficient and more convenient for all modes of transport (see also Section 5.3). However, digitalisation is not only to be understood as technical progress, but also as a policy task, as it can be associated with secondary effects that lead to more traffic if unfavourable framework conditions are put in place.

Digitalisation can have a positive effect on the efficiency of the entire transport system. **Automation** and the connectivity of vehicles can lead to more efficient driving in road traffic. Route optimisation minimises traffic volumes related to searching for parking spaces, and digital traffic control reduces braking and starting. In rail transport, the capacity of the infrastructure can be increased and the utilisation of vehicles and vessels improved. A more efficient driving style can also be achieved here.

In addition to increasing system efficiency, digitalisation can also contribute to preventing traffic, if managed in an optimal manner. This can be achieved, for example, through new mobility services and seamless travel chains. Digital services such as online consultations with specialists also play a role.

A number of test fields and pilot projects are already in operation today, but digital mobility services are not yet available on a comprehensive basis. Uncertain legal and regulatory conditions and a lack of business models, especially in rural areas, are further factors. For these reasons, it is not possible to draw on empirical data to estimate the maximum potential of digital mobility concepts, and there are uncertainties regarding the actual effect of emissions.

### Starting points for next steps

Expanding the digital infrastructure is an overarching prerequisite for digitalising the transport system. The roll-out of the 5G network in key areas such as railway lines, stations and industrial estates is an important aspect. Vehicles and infrastructure in the area of rail transport need to be equipped with the technical requirements for ETCS. In this way, the capacity of the network can be increased, and travel can be made energy-efficient. Investments should also be made in digital signalling systems on the railways.

In the case of mobility services and new mobility concepts in road transport, suitable political conditions are needed to integrate these services into climate-friendly, multimodal transport chains.

In the area of road transport, a comprehensive solution for smart parking using sensors in/at the car park as well as apps for customers and municipal public order offices can help reduce the number of people searching for a parking space. Intelligent traffic management can control both the flow of traffic and access to city centres, thus preventing congestion. This requires a framework and investments, but also an exchange of best practices.

Appropriate framework conditions are also needed for innovative digital applications that help to prevent traffic without restricting mobility. These include home office, **smart health** and the digitalisation of public services. Using these approaches, journeys can be avoided.

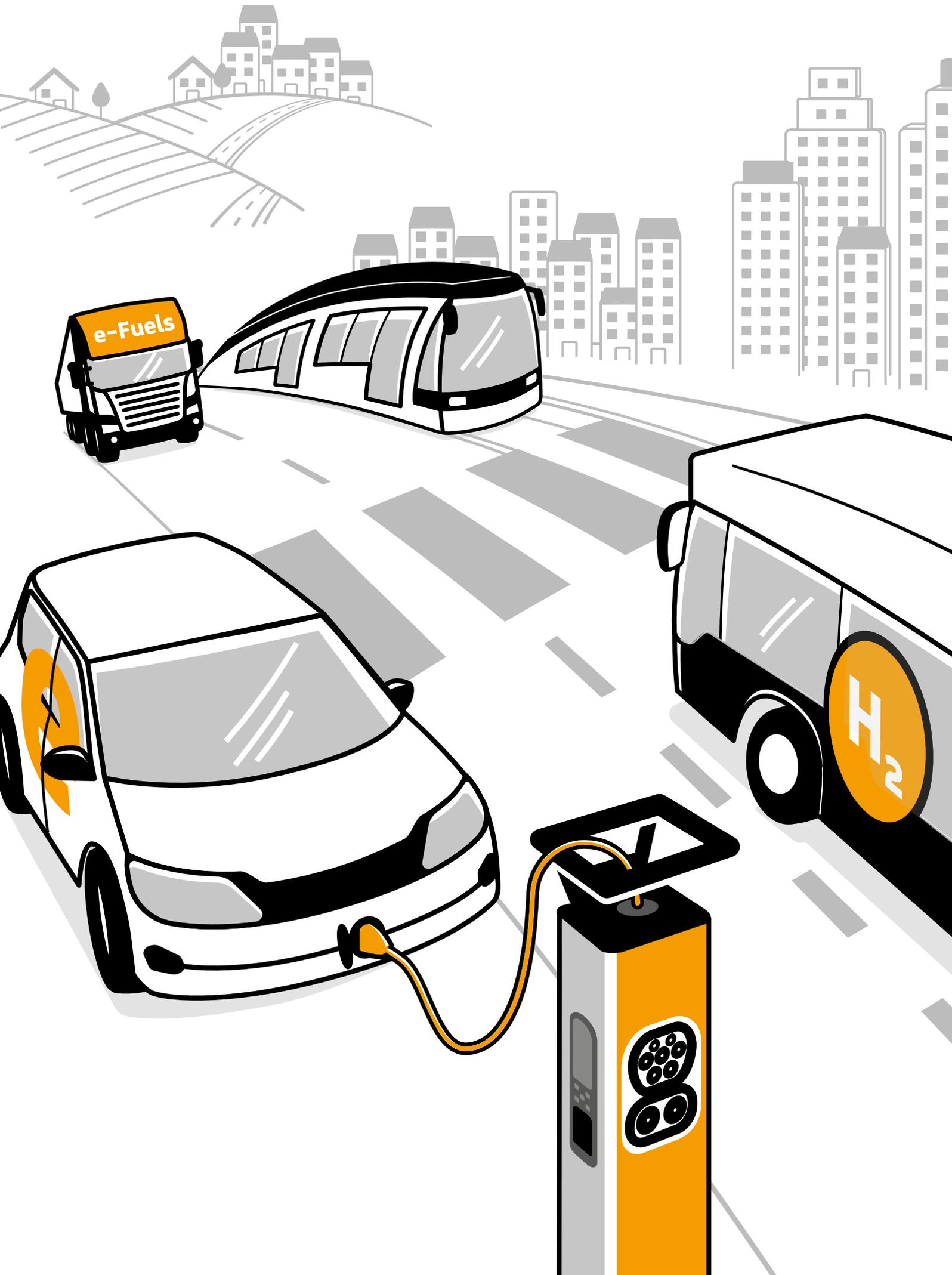
## Conclusion and outlook

The work carried out by WG 1 has made it clear that the climate objectives in transport can be achieved in principle, and the WG has shown how this path can be pursued through its recommendations to policymakers. The status of discussions presented in the interim report 03/2019 has already identified many relevant aspects and has shown the wide range of approaches and the variety of perspectives that need to be considered.

The climate goal for transport can only be achieved with a balanced overall concept, as the interactions between the various instruments are complex. We must act quickly and be ambitious. Mobility must remain affordable for everyone. The decision to use particular instruments and the associated responsibility for costs must be based on an indispensable consideration of ecological, economic and social factors. A wide range of measures have already been initiated by the Federal Government this year.

During the process of identifying necessary instruments, WG 1 has highlighted important areas where discussion and research are necessary. These areas are to be addressed in coordination with the other NPM working groups. After taking stock and identifying areas and needs for action, the NPM, which is based on several phases, is now ready to make concrete recommendations on the operational implementation and ramp-up of the required technologies, infrastructure and inter-modal solutions. The obstacles and risks for the technological paths must also be examined. This is due to uncertainties regarding technological developments as well as varying expectations, especially with regard to changes in behaviour in the area of mobility. There are numerous areas that need to be considered in greater detail. In the coming year, WG 1 will seek to dovetail with the other WGs and work on a joint roadmap on an intensified basis.





## 5.2 | Alternative drives and fuels for sustainable mobility

### Alternative drive and fuel technologies form the basis for mobility with lower levels of CO<sub>2</sub>

WG 2 considers alternative drives and fuels in terms of their contribution to sustainable mobility based on an intermodal and technology-neutral approach. Its focus is on technological electromobility concepts, hydrogen and fuel cells as well as alternative fuels for combustion engines. These new drive technologies and fuels play a key role in achieving the Federal Government's climate targets.

The various drive and fuel options that are available are at different stages of development. However, they differ not only in terms of their technological and market maturity, but also with respect to the concrete application possibilities. A technology-neutral combination of technological electromobility concepts, hydrogen and fuel cells and **alternative fuels** for combustion engines ultimately provides the potential for reducing emissions in the mobility sector in an effective manner.

Before new drives and fuels can be used, the facts need to be clarified. For this purpose, WG 2 considers all **modes of transport** (i.e. road, rail, shipping and aviation) using a technology-neutral approach. Motorised road traffic plays a decisive role in the analysis due to the high share of CO<sub>2</sub> emissions it causes. However, the other modes of transport are also taken into consideration.

The intermodal perspective is not the only viewpoint that is decisive for the development of long-term solutions. There is also a need to define balanced categories so the described technology options can be compared. Possible

categories include ranges, application and recycling potentials as well as various effects of the technologies, also called externalities. In this way, the possible savings become measurable, and recommendations for the use of the technologies can be derived.

WG 2 analyses alternative drives and fuels from various perspectives. The question therefore arises as to which types of drive technologies and fuels can be used effectively in which transport sector to reduce CO<sub>2</sub>. An important aspect here is whether the technology is sufficiently available in the first place and whether users accept the technologies.

WG 2 is thus confronted with a challenging starting position. On the one hand, the transport sector is facing serious climate challenges that can be solved by transforming drive technologies and fuels. On the other hand, the changeover to electromobility, hydrogen and fuel cells as well as electricity and biomass-based alternative fuels is changing everyday usage habits.

WG 2 is tackling this initial situation based on a threefold aim. First of all, a short report systematically presents all the facts relating to the existing technologies and their potential. These are then evaluated based on the corresponding framework conditions. Finally, the effects on the environment, society and economy are presented. Based on this, recommendations are then made on the use of electromobility, fuel cells and alternative fuels. The focus is on which technology has the best chance of balancing climate protection with securing mobility and Germany's role as a place for technology.

## WG 2 Short report 11/2019

### Electric mobility. Fuel cells. Alternative fuels – potential applications from a technological viewpoint

In its Short report, WG 2 identifies technological options with regard to the current development status and that which is to be expected in future under optimal conditions.



## Presentation of the preliminary results

The WG has drawn up a comprehensive basis of facts on drive and fuel technologies and their general conditions along the three central technology options:

- **Option 1: Technological electromobility concepts**
- **Option 2: Hydrogen and fuel cells**
- **Option 3: Alternative fuels for the combustion engine**

The options are initially considered separately so the optimal technological feasibility can be determined. In addition to this, the options are also considered in relation to each other in order to evaluate framework conditions and interactions and then derive technology recommendations.

## Technological electromobility concepts

WG 2 assumes that in 2030 there will be about seven to 10 million **battery electric (BEV)** and **hybrid electric vehicles (PHEV)** in Germany. Ranges differ according to the vehicle segment: In the case of passenger cars, there is a spectrum of up to 300 km in the small car segment and over 500 km in the luxury car segment. There are currently about 60 models on the market. Based on announcements by automobile manufacturers regarding numerous newly developed models, we can expect a significant increase in this number, which leads to the assumption that there will be more than 300 battery electric and hybrid models by 2025.<sup>m</sup> A vehicle with a (partially) electric drive will therefore be available to consumers on the road for almost every application.<sup>16</sup>

Light and medium commercial vehicles can achieve a range of between 100 and 250 km. The first prototypes for battery-electric heavy commercial vehicles are achieving comparatively short ranges. However, the electrification of local public transport and supply chains with light commercial vehicles is being steadily expanded at present.<sup>17, 18</sup> The first test tracks for overhead line lorries are being built in the area of long-distance road freight transport. These are fitted with an additional battery and can cover connecting routes between the motorway and a depot, for example. In addition, there are also prototypes for heavy commercial vehicles weighing up to 40 tonnes in the form of **hybrid** or fully electric vehicles with a fixed route plan.<sup>19</sup>

However, a larger traction battery does not necessarily mean a longer range. Vehicle-specific energy consumption is influenced by vehicle weight, air and rolling resistance and the efficiency of the drive system. This applies to all drive types.

With regard to the charging infrastructure, WG 2 worked closely with WG 5 to describe the charging times shown in Figure 7 depending on the **charging capacity**.

| Charging capacity<br>(50-kWh battery) | Average charging time    |
|---------------------------------------|--------------------------|
| AC / 3.7 kW                           | 14 to 15 hours           |
| AC / DC 11 to 22 kW                   | 2.5 to 5 hours           |
| DC 50 kW                              | approx. 1.5 hours        |
| DC 150 kW                             | approx. 30 minutes       |
| DC 350 kW                             | approx. 10 to 20 minutes |

**Figure 7:** Charging times from 10 to 90 per cent of the capacity depending on the charging capacity (own diagram)

In addition to charging capacity and duration, a dense network of public and non-public charging infrastructure is also required.

Currently, about 1.1 non-public **AC charging points** are being set up per electric vehicle. This is due to the fact that some companies and employers with battery electric service vehicles are setting up their own charging points on their factory premises. In addition, there is the possibility of charging at home. This will mean that the ratio will move in the direction of 1:1 in future given that, among other things, the number of registered electric vehicles will increase. The development of a public charging infrastructure will continue to receive state support in order to rapidly expand the current level of 21,299 charging points (status: November 2019). So far, only 12 per cent of the existing charging points are **DC fast chargers**. The aim is to increase this number, particularly on major routes and in metropolitan areas.<sup>20</sup>

<sup>m</sup> The listed ranges are to be understood as maximum ranges and may be reduced due to the increased use of the heating system in winter where applicable, etc.

In addition to the charging infrastructure, the battery in particular is an important component in the field of electromobility. The handling of batteries in turn has a major influence on the overall sustainability assessment of electric vehicles. For example, ageing vehicle batteries are no longer adequately efficient from a **state-of-health (SOH)** of 70 per cent and can be recycled in **second-use applications**. If these batteries cannot be reused, 70 to 80 per cent of the reusable materials can potentially be recycled. It is expected that this rate can be increased to 90 per cent over the long term, which would mean that components of the battery can be returned to the circular economy, thereby further improving the overall emissions balance of electric mobility.<sup>21</sup>

In the shipping industry, there are plans to use shore-side electricity in ports; electrified prototypes have been developed for (inland) ferries<sup>22</sup>. The first hybrid-electric models are also available for aircraft and are being tested in demo projects. It is expected that ranges of up to 1,000 km can be achieved for small aircraft in future based on a coupling of batteries with gas turbines or fuel cells. There are prototypes for battery-powered multiple units and diesel-hybrid shunting locomotives in the rail transport sector. However, 60 per cent of the rail network is already electrified in this sector.<sup>23, 24, 25</sup>

## Hydrogen and fuel cells

Hydrogen has various applications and can either be used directly in the fuel cell or serve as the basis for **synthetic fuels**. The current development status of the individual fuel cell vehicles varies greatly and ranges from initial trials to vehicles in series production. Currently, series applications are mainly found in passenger cars in the

medium and upper-class segments. **Fuel cell vehicles (FCEV)** have a similar range to petrol or diesel vehicles. The refuelling process also requires a similar amount of time. Figure 8 summarises the segment-specific ranges and average energy consumption.

|   | Car segments<br>Commercial vehicle classes   | Potential range   | Energy consumption  |
|---|--|---|---|
| <b>Car</b>  | Small car  | 500 km  | H <sub>2</sub> consumption of about 0.75–1 kg H <sub>2</sub> /100 km corresponds to an energy consumption of 25–33 kWh. |
|   | Compact class  | 500 km  |   |
|   | Mid-size (incl. family vans)   | 700 km  |   |
|   | Luxury class (incl. SUV and sports cars)   | 600 km (2020)<br>1,000 km (2030)                                |   |
| <b>N1 AND N2</b>                                  | 'Sprinter' scenario up to 3.5 t GVW (up to 16,000 km/a or up to 120 km/d)                      | about 500 km (2019)<br>approx. 1,000 km (2030)                  | 1.4–1.5 kg H <sub>2</sub> /100 km   |
|   | Scenario 7.5 t GVW (up to 25,000 km/a or up to 250 km/d)                                       | In future 1,000 km  | approx. 2–3 kg H <sub>2</sub> /100 km   |
| <b>N3</b>   | Annual/daily mileage of heavy commercial vehicles (approx. 100,000 km/a or approx. 750 km/d)   | 1,000 km  | approx. 8 kg H <sub>2</sub> /100 km   |
| <b>M3</b>   | Annual/daily mileage of local public transport buses (approx. 90,000 km/a or approx. 280 km/d) | 450–500 km (2019)<br>up to about 1,000 km (2030)                | approx. 8–12 kg H <sub>2</sub> /100 km (depending on bus configuration and route)                                       |
|   | Annual/daily mileage of long-distance buses (approx. 180,000 km/a or approx. 1,200 km/d)       | 450–500 km (2019)<br>up to about 1,000 km (2030)                | approx. 8 kg H <sub>2</sub> /100 km   |
| <b>Key:</b>                                       |  |   |   |
| <b>N1:</b> up to 3.5 t gross vehicle weight (GVW) |  | <b>N3:</b> over 12 t GVW (long-distance lorries)                |   |
| <b>N2:</b> 3.5–12 t GVW (distribution lorries)    |  | <b>M3:</b> Local public transport buses and long-distance buses |   |

**Figure 8:** Overview of application fields of fuel cells (FC) in passenger cars with higher annual mileage and commercial vehicles (own diagram)

Non-electrified lines can be served by fuel cell electric local trains running on hydrogen in local rail passenger transport. In pre-series tests, these have achieved a range of 1,000 km at a consumption of approx. 18–28 kg hydrogen/100 km.<sup>26, 27</sup>

In aviation, fuel cells can primarily be used for electric drives in small aircraft and for auxiliary units.<sup>28</sup> Initial development projects in shipping are equipping inland waterway and ferry vessels with fuel cells and using the fuel cell for the on-board power supply.<sup>29</sup>

Hydrogen for transport applications has so far been obtained mainly from **natural gas** or chemical processes. In future, the production of green hydrogen by means of **electrolysis** from renewable energies and biomass will be the main focus.

In terms of reusing the materials in a fuel cell, 98 per cent can already be recycled today. The use of platinum in fuel cells can be critical, but this will only be at a share of 0.125 g/kW from 2020 onwards.<sup>30</sup>

Currently, there are about 77 hydrogen filling stations, with another 26 under construction (as of November

2019).<sup>31</sup> In the case of centralised production, hydrogen can be transported either in liquid or gaseous form (in pressure tanks) in lorries or in pipelines.

## Alternative fuels for the combustion engine

The term “alternative fuels” refers to fuels that are not produced on the basis of crude oil. **Compressed natural gas (CNG), liquefied natural gas (LNG)** and conventional industrial hydrogen from natural gas or chemical processes are therefore considered alternative fuels. Technology options of novel alternative fuels can be identified parallel to biomass-based and **electricity-based fuels**.

When added up, the feasible quantity of alternative fuels in Germany could – if optimistic assumptions are applied to the growth in biomass- and electricity-based fuels and imports are included – amount to 21 per cent of fuel requirements in 2030.

The **Renewable Energy Directive II** of 2018 (RED II) sets the target and regulatory framework for **biomass-based fuels** and distinguishes between first-generation biofuels from cultivated biomass and advanced second-generation fuels from different raw materials such as waste and residual materials. Biomass-based fuels of the first generation are already available on the market in relevant quantities.<sup>32</sup> Biofuels of the second generation are not in competition with feed and food; they are, however, only available in pilot and demonstration plants at present.<sup>33</sup>

Electricity-based fuels (**PtX: power-to-X**) use chemical processes to convert electrical energy into liquid or gaseous fuels. There are two main production methods available for this option. On the one hand, liquid synthetic fuels such as petrol, diesel and kerosene can be produced using the **Fischer-Tropsch process**. However, these fuels are currently only available in small quantities, which means technologies for use in large-scale plants must be further developed in order to distribute them. Secondly, methanol can be used as an intermediate product for liquid or gaseous fuels via the **methanol route**.<sup>34</sup>

Alternative fuels are compatible with the existing refuelling infrastructure and are indispensable over the long term for shipping and aviation in particular. However, they also enable suitable solutions for reducing emissions in the transport sector for conventional passenger cars with an internal combustion engine together with increased **vehicle efficiency** and hybridisation of the country's vehicles.

## Outlook and conclusions

The technological feasibility and realistic assessments of the technical potential and framework conditions of electromobility, hydrogen and fuel cells and alternative fuels for the combustion engine have been presented.

In addition, it has been demonstrated that mobility in Germany is a complex system with varying requirements and needs. The transition will not take a linear path towards one technology but will provide a mix of different measures and technological solutions to reduce CO<sub>2</sub> emissions and ensure mobility. Different fuel and drive options are required for different applications. These depend on the intensity of use and the range requirements of possible updates to the vehicle fleet as well as the period under consideration. However, not all modes of transport can be electrified on the drive side; this applies in particular to inland waterway and ocean-going vessels, aircraft and to some extent heavy road freight. Fuel cell technology and alternative fuels offer suitable options for solutions here.

The development of alternative drives and fuels is accompanied by a potential to increase the efficiency of vehicle drive trains.

In this way, all sub-aspects of the mobility system, from producing vehicles and preserving jobs (see Section 5.4) to sector coupling, especially energy (see Section 5.5), can be integrated sustainably and in a manner that supports a socially and ecologically meaningful transformation.

These technology-oriented potentials and general conditions will now be examined in the further process with regard to their effects on the environment, society and the economy. Based on this, WG 2 can meet its original objective of conducting a comprehensive technology review and analysis of the effects of drive and fuel transformation.

The WG will subsequently focus on a technology roadmap, which will provide targeted, application-specific technology recommendations.



## 5.3 | Digitalisation for the mobility sector

### Exploiting the potential of digitalisation for improved mobility

The digitalisation of mobility is a key topic for Germany's future. WG 3 Digitalisation for the mobility sector of the National Platform Future of Mobility looks at the areas in which digitalisation represents the prerequisite for making the future of mobility more environmentally and climate-friendly, more efficient, more convenient, healthier and more affordable. All modes and forms of transport for passenger and freight traffic are considered and evaluated on the basis of urban and rural requirements and demographic aspects.

#### THE OBJECTIVES OF WG 3

- Increasing the ecological sustainability by reducing emissions and immissions
- Meeting individual mobility needs by creating simple, fast and affordable mobility concepts
- Requirements from urban and rural areas are taken into account as well as demographic aspects.
- Increasing efficiency via seamless, comfortable and comprehensive traffic flows
- Increasing road safety
- Developing the necessary technological prerequisites in the areas of infrastructure, connectivity and enabling **modes of transport**

Based on the analyses and projections of four focus groups, WG 3 formulates concrete recommendations for action to promote the most effective measures for achieving the WG's objectives. It has already presented two interim reports on the topics 'Digitalisation for the mobility sector' and 'Recommendations for action on autonomous driving'.<sup>35</sup>

The members of the four focus groups (FG) work on the following topics:

- | **Multimodal mobility (FG A)**
- | **Autonomous mobility (FG B)**
- | **Enablers for digitalisation (data/software/artificial intelligence, connectivity and security) (FG C)**
- | **Social dialogue (FG D)**



## WG 3 Interim report 06/2019

### Digitalisation for the mobility sector

In its first interim report, WG 3 describes its objectives and the priorities of its work as well as measures that need to be taken for the successful digitalisation of mobility in Germany.

On the other hand, a real-world laboratory is being planned in Hamburg at the initiative of WG 3 in order to test various components and pilot applications of a digital mobility system. The real-world laboratory is a concrete field test for innovation and regulation. The aim is to identify essential needs and prerequisites for the introduction of **intermodal** and autonomous mobility. Based on the measures implemented within this context, it aims to achieve a measurable ecological and economic effect in 2025 and 2030.

## Important topics for the digitalisation of mobility

The objectives of WG 3 can be achieved primarily through attractive multi- and intermodal mobility offers that integrate environmentally and climate-friendly means of transport in a user-friendly way. The digital mobility system of the future will be supplemented by **autonomous driving**. Digitalisation and connectivity, especially of mobile communications and the transport infrastructure, are an indispensable prerequisite for this. They can also have positive effects on vehicle utilisation and more intelligent traffic control. In cities with high traffic volumes, multimodal and autonomous mobility options can help to interlink the transport modes more effectively and create incentives to use eco-friendly alternatives. In rural areas, however, mobility options are often available on a very limited basis. The demand-oriented use of connected and, where applicable, autonomous mobility can boost the availability of mobility.

An important prerequisite for multimodal and autonomous mobility options is a non-discriminatory exchange of data between mobility providers as well as comprehensive connectivity. In addition, the exchange of data, connectivity and mobility products must meet high security requirements with regard to **cybersecurity** as well as high demands on traffic and operational safety in order to be accepted by users in the long term.

The digitalisation of mobility entails a profound transformation process that has a direct impact on people's everyday lives. For this reason, citizens should be involved in shaping the digital future of mobility from the outset. This process of change must be accompanied by a broad social dialogue so users' needs are met during its implementation.

## Diagram of results to date: Shaping the mobility of tomorrow today

The focus groups of WG 3 identify the necessary measures to promote digitalisation for the mobility sector and to achieve the goals for digital, intermodal mobility outlined above. Based on the results and the topics of the focus groups, WG 3 formulates concrete recommendations for action. Responsibilities are clearly addressed, and prompt implementation is recommended.

### Simplifying multi- and intermodal mobility

In its thematic focus on multimodal mobility, WG 3 (FG A) is working on a target vision for a multi- and intermodal mobility system of the future. It allows users to use different modes of transport and, above all, to switch easily between different modes of transport and combine them. Connecting the various means of transport is the central aspect. This gives users the opportunity to include environmentally and climate-friendly means of transport in their route more often.

This goal can only be achieved if users are given transparency with respect to mobility options. WG 3 therefore recommends that mandatory standards for the exchange of data be promoted nationally and in standards organisations such as DIN/ISO in order to ensure the connectivity of mobility services and non-discriminatory data access.

Furthermore, an integrative view of passenger and freight transport is recommended, as well as the optimal use of previously unused resources, such as solutions for the 'last mile', the use of underground railways for freight transport and enabling the rededication of land.

### WG 3 Interim report 12/2019

### Recommendations for action on autonomous driving

In its second [interim report](#), WG 3 elucidates the essential requirements and needs for the introduction of autonomous mobility.



### Promoting autonomous mobility

Autonomous mobility, and above all automated, connected driving in road traffic, is an essential component of a multi- and intermodal mobility system of the future, because it will eliminate networking deficits between the modes of transport and means of transport and can provide better coverage of mobility services for low-demand areas. The stated aim in all modes of transport is to promote autonomous mobility. With regard to road traffic, the introduction of automated connected vehicles in the series production process can only take place within a regulatory framework that has been established by policymakers. The regulations relate to placing the vehicles on the market as well as their operation. Clear rules are needed both for placing the vehicles on the market (type approval) and for operation (compliance with traffic rules).

## Type approval

Before being placed on the market, the vehicles must be type-approved, including the functions for driverless driving. This type-approval of vehicles is based on EU law, which in turn is based on the approval regulations of the United Nations Economic Commission for Europe (UNECE). There are currently no valid regulations with regard to the **automation functions of levels 3, 4 or 5**. At UN level, the rules for level 2 are at an advanced stage, and those for levels 3 and 4 are undergoing preparation. There are plans to adopt a draft regulation for stage 3 in 2020.

The European legal framework also provides for the possibility of regulating innovations via an exemption process. In order to maintain Germany's competitiveness, however, this process must be accelerated.

There is currently no defined safeguarding procedure within the exception process. Until a uniform approval process has been implemented and tested in practice in the EU, national regulations for the granting of a special type of operating licence must be developed and issued. These are to be designed as independently as possible of the European exemption. The granting of national exemptions or national authorisations can only represent an initial intermediate step. The aim must be to create internationally harmonised framework requirements at the UNECE level (so-called horizontal regulations). The fact that Germany holds the chair of the ACSF Group of the UNECE should be used as an opportunity to provide significant impetus for global harmonisation.

In addition, it is necessary to expand the functions of vehicles that already have the appropriate technology by means of software updates during their life cycle. To this end, the appropriate regulations must be created so that vehicles in the field do not lose their approval despite adaptation and improvement of the functions that are relevant to type approval. This will allow for the rapid introduction of safer automated driving functions and their gradual expansion along with correspondingly rapid distribution.

## Operating autonomous vehicles

In addition, the implementation of vehicles with L4 and L5 functionality – irrespective of the existence of (European/international) technical specifications for type approval and periodic technical vehicle inspection – requires further testing and regulation in national road traffic law (for example, regulatory law, approval and registration process, liability law). This is necessary because the driving strategy and the behaviour in traffic are determined by the algorithms of a technical system rather than the driver. The Road Traffic Act (StVG), along with its amendment in 2017, provides the legal framework for the use of automated driving functions in public road traffic. Only autonomous driving is not covered by the StVG (§1a). The use of autonomous, driverless vehicles – in accordance with the planned scenarios – is therefore not permitted in public road traffic. This does not affect the operation of vehicles based on exemption certificates. In accordance with the mandate from the coalition agreement, the BMVI is currently working on legal regulations for the use of autonomous vehicles in suitable applications.

## Enabling autonomous fleets: Reforming the Passenger Transportation Act

With regard to providing the population with public mobility options (public services), it is naturally difficult to ensure sufficient public transport options across the country in terms of organisation, planning and financing. In many cases, demand can only be pooled into scheduled services on certain main routes. **Flexible forms of transport** are increasingly serving the 'axis gaps' and organising feeder traffic to the interfaces of regular services.

Autonomous mobility is therefore associated with high expectations of ensuring good mobility services, especially for areas outside cities and rural areas, but also for suburban areas. In particular, flexible forms of transport, such as autonomous call and collect taxis or shuttles in public transport and private providers, offer new solutions here. Autonomous vehicles can be used to provide round-the-clock mobility even beyond the main axes and at off-peak times.

According to the coalition agreement, the Passenger Transport Act is to be updated during this legislative period. Passenger transport legislation is to be updated where necessary to take account of technological developments in the field of digitalisation and automation. Digitalisation makes it possible to orient mobility services to the actual demand in real time. **Pooling** several passengers in one form of transport can contribute to reducing the volume of traffic. Connected automated systems are particularly suitable for such applications. The step-by-step development of the legal framework and regulations for driverless passenger transport and the digital handling of services is necessary in order to make this possible – while strictly observing the basic requirements of social and employment policy. Individualised, demand-oriented mobility is an important component of current and future mobility as a supplement to traditional line-based mobility services.

## Developing enablers for digitalisation

Introducing new mobility concepts and coordinating them with one another in an optimal manner depends largely on the data, the associated software and the use of artificial intelligence. Data form the basis for various services to meet the mobility needs of citizens in the best possible way. Currently, mobility providers often implement proprietary standards and interfaces for the exchange of data, which inhibits scaling possibilities. Existing mobility concepts and the mobility system as a whole can only become more efficient and, for example, utilise the capacity of means of transport more effectively or provide certain regions with better mobility services if the various mobility providers and traffic control centres exchange and synchronise the relevant user and real-time traffic data. By networking and exchanging relevant data across all modes of transport and means of transport, users are provided with seamless and convenient transfer options.

The early deployment of automated vehicles requires that data be provided in high, reliable quality. The data is to be made accessible on central open data portals such as the BMVI's mCLOUD and the 'Mobility Data Marketplace' (MDM). The portals are to be designed in such

a way that they not only collect data, but that the data is also made available in a uniformly standardised, usable form in future. This will facilitate the consolidation and development of services based on the data. The corresponding data infrastructure requires continuous management. Infrastructure operators must be enabled to systematically collect, process and provide access to mobility-related data using digital methods. This requires increased efforts on the part of infrastructure operators. As part of a voluntary commitment, the automotive industry will also contribute to the establishment of a mobility data ecosystem via an exchange of data by providing the road safety data of the vehicles to which it has access.

The necessary data exchange can only take place if there is a sufficiently good connectivity between the mobility providers and the users. Connectivity thus not only contributes to increasing efficiency in the transport sector in line with the objective of Focus Group A 'Multimodal mobility', but also plays a significant role in improving road safety via the exchange of data relevant to road safety. Advancements must therefore be made in **short-range communications technology** and mobile communications technology (LTE, 5G). Both are relevant for increasing road safety. Information that does not have to be provided as quickly as possible, such as severe weather warnings or potholes, can be immediately transmitted in an efficient and effective manner via mobile networks for many road users. The use of short-range communications technology is recommended for warnings regarding emergency braking or intersection cross traffic or the unexpected occurrence of **vulnerable road users**. The EU Commission's proposal to use only the Wi-Fi standard has been stopped. The majority of vehicle manufacturers and telecommunications companies rely on the **cellular standard**. Both technologies must be given equal opportunities on the market, and the EU Commission should revise the delegated act to make it technology neutral and relaunch it for this reason.

A framework for vehicle and road safety is needed. The goal is to connect the data-driven mobility systems with each other in such a way that they are always safe in traffic and thus increase safety in the overall traffic system. Manufacturers of the means of transport are responsible for product safety and must develop them

according to security-by-design approaches. They have an obligation to monitor the market and provide security updates when necessary. They are also responsible for providing a secure communication interface with the vehicle. This is the only way they will be able to meet their responsibility with respect to product liability, the legal warranty and the guarantee.

Developing a framework for handling security updates is one of the steps that is necessary to guarantee an adequate level of protection. International standardisation and regulation activities that have already been initiated in the area of cybersecurity in the automotive sector must be continued on a consistent basis (see ISO/SAE 21434 and UN-TF CS/OTA). In addition, secure data access and the secure connectivity of vehicles must be ensured in line with the relevant responsibilities. However, vehicle safety and data protection must always come before economic interests.

## Organising social dialogue

Digitalising mobility entails a profound transformation process that not only changes the value-added chain, jobs and vehicles, but all of mobility as it currently exists. In particular, encounters between people and the automated machines of the future in the context of road traffic as well as cooperative interactions between them will result in significant social change.

Given that this process of change has such a direct impact on people's living conditions, citizens should be informed and involved from the outset. Opportunities and risks must be explained and discussed in a transparent manner. A space for discourse is needed for social and individual concerns as well as ethical questions. To successfully implement the transformation of mobility, this space needs to be accompanied by broad social dialogue that involves local citizens and takes into account the diversity of the population. The Ethics Committee's guidelines for automated and networked driving provide a basis for this discussion.

## Pilot testing of the recommended actions in a real-world laboratory

Citizens already travel on a multimodal basis today; that is, they use different means of transport to make different journeys. They also travel on an intermodal basis in metropolitan areas in particular, which means they use different means of transport within a single journey. However, many questions remain unanswered with regard to comprehensive connectivity, increasing vehicle automation and more environmentally and climate-friendly mobility behaviour. The aim is to identify answers to these questions in a real-world laboratory in which the concepts and recommendations developed in WG 3 will be tested, for example relating to multi- and intermodal mobility. The real-world laboratory is being set up in Hamburg. The results will be presented at the ITS World Congress to be held there in 2021. The pilot project is thus intended to provide a blueprint for the digital future of mobility.

The real-world laboratory focuses on users and aligns the mobility system of the future with the objectives

of WG 3. Further necessary measures are to be identified and developed using this approach. The aim is to connect the means of transport of an urban region in such a way that citizens' individual mobility needs can be fulfilled on an intermodal, fast, simple, affordable and ecological basis. The accompanying research in the real-world laboratory is used to determine the changes in users' mobility behaviour. Furthermore, the mobility transition and the digital transformation of the mobility industry in the real-world laboratory will be accompanied by a citizen-oriented dialogue initiative.

The real-world laboratory is creating an integrated application environment for the future of mobility that other communities and regions can use as a blueprint for implementing their own sustainable mobility systems – according to their local and regional needs and conditions. This allows us to contribute to climate protection and takes the burden off municipalities and their citizens over the long term.

## Outlook

The implementation of the recommendations for action listed here will make a significant contribution to Germany's digital future as a place for mobility. Particular importance is attached to networking the various modes of transport. Even though there is often a multitude of mobility services available, citizens are not sufficiently aware of the alternatives in many cases or lack the incentive to integrate more climate-friendly means of transport into their travel, i.e. to change their own mobility behaviour.

The importance of a digital data platform that provides mobility data for all providers and users and creates a data ecosystem for all participants should not be underestimated. Completely new solutions for the future of mobility can also be created on this basis. This could be an app, for example, which allows all mobility options to be planned, booked and paid for in one place. This is not so much a technical challenge as a strategic one involving cooperation between stakeholders who have not worked

together previously. A solution for this challenge is also being tested locally in the real-world laboratory. This is extremely worthwhile because connecting mobility services and comparing them with mobility requirements in real time creates greater transparency for users and can play a significant role in adapting existing habits step by step. This is especially true when new sharing concepts and autonomous mobility are introduced.

Practical testing in a real-world laboratory also highlights unforeseeable challenges. WG 3 will identify these challenges and needs for action within the framework of the National Platform Future of Mobility, both in the working group and in the practical pilot testing in the real-world laboratory and will develop proposals for solutions.



## 5.4 | Securing Germany as a place for mobility, production, battery cell production, primary materials and recycling, training and qualification

### New technologies and increasing automation: Germany's structural change as a place for mobility and production

The mobility sector has some 3.8 to 6.1 million employees, <sup>n, 36, 37</sup> making it one of the sectors with the greatest impact on employment in Germany. Due to its size and strong links with many other industries, the automotive industry in particular is of considerable importance for Germany's overall economic development and value creation. The switch to **alternative drives and fuels** and increasingly digitalised, connected mobility is therefore not only changing the way we are mobile, but also the vehicles and mobility services that are offered by German companies and the areas in which we will be working in future.

In addition to the changes in mobility technology, the advancing automation of workflows plays an important role. The use of technologies such as robotics, artificial intelligence and learning systems can bring about

major gains in productivity and cost reductions. All this is leading to a profound structural change that affects all **modes of transport**, the associated mobility services and production – and thus Germany's workforce.

<sup>n</sup> The number of people working in mobility-related occupations, differentiated according to the segment of the analysis. According to M-Five, 3.8 to 4.4 million people were 'directly employed in transport-related economic sectors' in 2014. Analyses conducted by the Federal Institute for Vocational Education and Training (bibb) show some 6.1 million 'persons working in mobility-related areas' in 2015.

See also Wagner U. et al: Current state of value creation and employment in mobility. Working paper commissioned by the Hans Böckler Foundation, Karlsruhe 2018, p. 32f. and Mergener, A. et al: 'Move on'. Qualification structure and employment in spatial mobility occupations. Bonn 2018, p. 63f.

## Challenges presented by technological and structural change for value creation and employment

Previous technologies, such as the combustion engine, will be less in demand in future as mobility is transformed, while demand for electric vehicles and digital applications for vehicles will increase. Whereas previously the focus was primarily on car manufacturers and their suppliers, the mobility sector is now being expanded: Value creation is shifting towards new technologies and new market participants, such as suppliers of software and battery cells. At the same time,

there is a need to invest in research and development for new technologies. Firstly, this increases competitive pressure, and secondly, a shift in employment is taking place: Jobs in production and segments of development are being cut, while new qualifications and job profiles for innovative and digital technologies are gaining in importance. Today's workers need to be educated or receive further training in these new skills.

## Goals and working methods of WG 4

The transformation of the mobility sector must be ecologically, economically and socially sustainable in equal measure. Competitive companies and jobs form the basis for a restructuring of mobility in Germany that will be sustainable over the long term. Working Group 4 (WG 4) Securing Germany as a place for mobility, production, battery cell production, primary materials and recycling, training and qualification systematically analyses the effects that the transformation of mobility is having on **value creation networks** and employment structures in the mobility sector in its two focus groups (FG) Value creation and Strategic personnel planning and development.

The basis for Germany's competitiveness as a production location and thus also for employment is to maintain or establish the most important value creation networks for the mobility technologies of the future in Germany and its European environment to the most complete extent possible. The Value creation FG of WG 4 highlights potentials and risks that the transformation of mobility presents for existing as well as newly emerging value creation networks.

The capabilities currently available in Germany and Europe are compared with international competitors for strategically important, selected technologies. Which skills will be in demand and where will deficits become apparent? The aim of the FG's work is to communicate areas in which there is a need for action to business and politics at an early stage and to point out possible solutions in the areas of industrial policy, investment, research and development, education and training policy.

In conjunction with this, the Strategic personnel planning and development FG analyses which quantitative and qualitative changes are to be expected for employment structures in the mobility sector in the near future. It then develops concepts as to how policymakers and companies can pick up on this change in employment at an early stage and actively shape it together with their employees.

## Presentation of the preliminary results

The change in value creation and employment in the mobility sector is already being seen today. This change is set to intensify as a result of the ongoing market penetration of electromobility and digitalisation in the transport sector. The track record and economic performance of the automotive industry – which is an important element of the mobility sector – will depend heavily on whether the modules and components for new drive concepts can be competitively manufactured on a large industrial scale in Europe in future.

Based on the recommendations of WG 1 (see Section 5.1), the Federal Government has described in its **Climate Action Programme for 2030** that the number of electric vehicles in Germany is to rise to seven to 10 million by 2030. The Federal Government and companies are supporting this goal with subsidy programmes for vehicles and charging infrastructure as well as tax breaks. In order to comply with the **CO<sub>2</sub> fleet limits at EU level**, the European automotive industry must also

significantly increase the proportion of electric vehicles in its fleet and production mix. The emission values of internal combustion engine vehicles must also be further reduced. Based on these national and European climate protection measures, forecasts anticipate that the market shares of conventional drives will shift towards hybrid and electric drive trains more quickly than assumed in previous studies.

In its first working phase, WG 4 therefore addressed the following questions:

How will value creation and employment develop as a result of accelerated electrification of mobility? Which value creation networks must German industry master in order to remain internationally competitive? In which areas does expertise in development, application and production need to be built up? How can employees be trained for the various new technologies associated with electric vehicles?

## Value creation: Focusing on the production of battery cells, power electronics for vehicles and internal combustion engine drive trains

The drive train of battery electric vehicles is less complex than that of combustion engines and requires different key components. As a result, a shift is occurring in value creation in the area of vehicle production and related industries. Battery electric vehicles use a purely electric drive system consisting of an electric motor, power electronics and battery system. **Hybrid vehicles** with and without external charging have an internal combustion engine drive and an electric drive, which serves to support the internal combustion engine or allows purely electric driving on a temporary basis.

Figure 9 illustrates which components are required for the different types of vehicles and which are omitted in electrified vehicles:

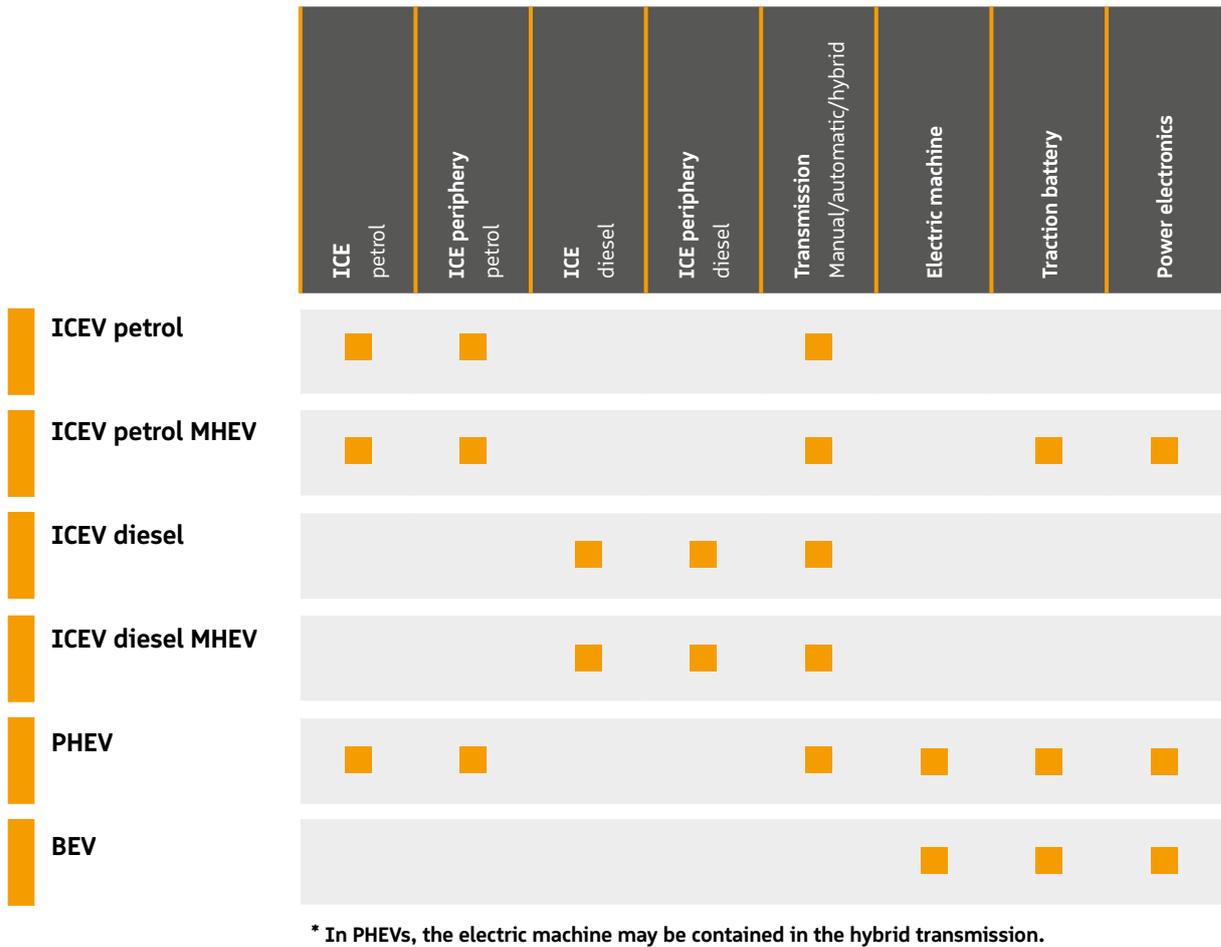


Figure 9: Overview of components for various drive concepts (own diagram based on ELAB 2.0)

Battery cells and power electronics in particular are already set to be decisive components in a vehicle's value in the near future, which means they will also be crucial for the competitiveness of the German automotive industry.

The battery is the heart of every battery electric vehicle. It determines the costs, driving characteristics and range of **BEVs** and **PHEVs** and thus the attractiveness and competitiveness of these vehicles compared to

diesel and petrol vehicles. The demand for battery cells is growing as the market share of electric vehicles increases. However, these are not yet produced on a large industrial scale by German or European companies but are mainly imported from Asia. The German automotive industry needs a sufficient supply of battery cells in order to produce electric vehicles and remain competitive at the international level. German or European companies therefore need to establish a battery cell production facility in Europe to meet demand.

Along with the battery and the electric motor, the power electronics are a central component of every electric drive train in hybrid and electric vehicles. They are also increasingly being used in conventional vehicles – for example in electric machines that increase **system efficiency** and reduce fuel consumption in petrol and diesel engines. Connectivity and automation also open up further areas of application. As a result, the market for power electronics in the automotive industry is growing and becoming more important for Germany as a production location.

In the near future, battery electric vehicles will mainly be used in the form of passenger cars and light commercial vehicles. However, internal combustion engines will continue to be used for the foreseeable future, particularly in freight transport and long-haul transport. As a result, it is still necessary to produce a substantial proportion of conventionally powered vehicles.

The establishment of a battery cell production facility by European companies to meet demand and the expanded industrial production of new components in the field of power electronics are therefore a crucial first step in terms of ensuring the international competitiveness of Germany and Europe as a production location. At the same time, existing competencies for producing internal combustion engine drives must be maintained for the foreseeable future.

## WG 4 Interim report 10/2019

### Value creation in the mobility sector

The [report](#) analyses the competitiveness of German and European industry in the three main value-added networks for lithium-ion battery cells, power electronics and internal combustion engine drives and identifies key areas where action is needed.



The Value creation FG came to this conclusion based on a detailed analysis of the real net output ratio as well as the value-added content for the three technologies under consideration. The analysis of the **real net output ratio** extended from the raw materials to the end product. The examination of the value-added content ranged from the scientific basis and expertise relating to development and production, the available personnel basis, the existing investment basis and location concepts, the investment basis to be established for new technologies, sustainability and environmental compatibility, to the willingness to invest in new technologies and the associated business models.

## ANALYSIS OF THE VALUE CREATION NETWORKS

- | Battery cell
- | Power electronics
- | Internal combustion engine drives

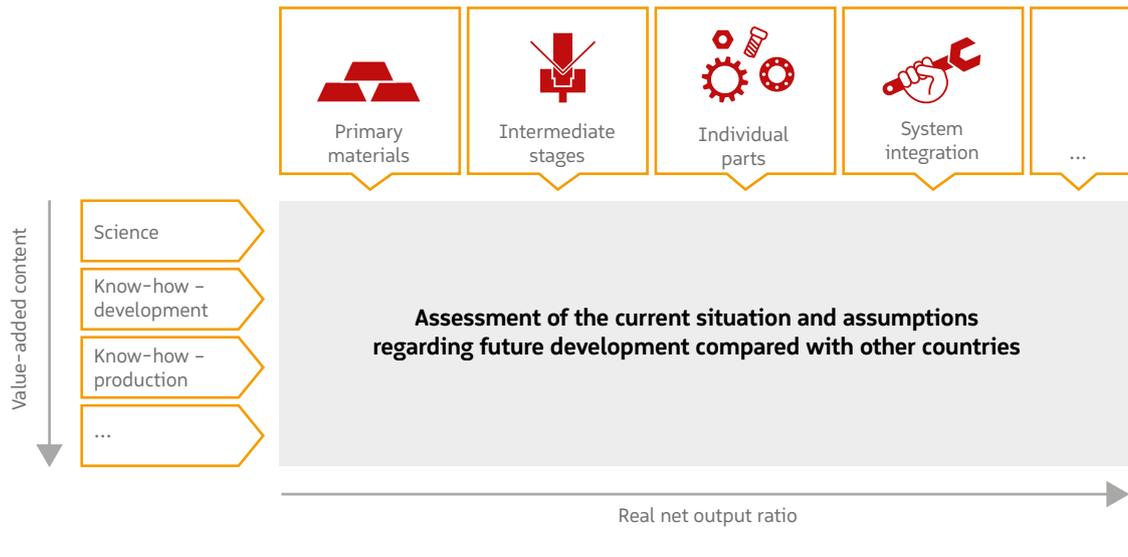


Figure 10: Analysis of the value creation networks (own diagram)

## Lithium-ion battery cell: Securing the supply of raw materials, establishing large-scale production, researching new generations of battery cells, using recycling systems for batteries and raw materials

Battery modules and systems for vehicles are already successfully developed and manufactured in Germany and Europe. Skills are available for many value creation processes, from battery chemistry and the battery cell to the complete battery system. Nevertheless, German and European manufacturers are currently heavily dependent on battery cell imports, as battery cells are not produced on a large industrial scale by German or European com-

panies in Europe as of yet. A significant proportion of battery materials, cells and modules will have to be produced by European companies in Europe in future in order to be able to secure the supply of battery cells to European car manufacturers and thus their competitiveness in the production of electric vehicles even if demand increases or trade restrictions are imposed.

## VALUE CREATION IN THE VEHICLE BATTERY SECTOR

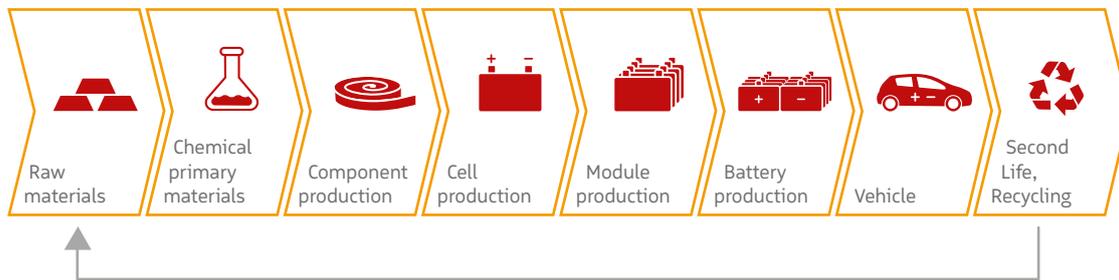


Figure 11: Value creation in the vehicle battery sector (own diagram based on NPE: Progress report 2018)

Material costs account for the greatest share of the total cost of a battery cell. Secure access to raw and primary materials is therefore a basic prerequisite for establishing battery cell production in Europe. Research into alternatives to scarce raw materials should be pursued in the development of new generations of batteries, as should the development of potential sources of European **primary raw materials**.

In addition to the material costs, there are the production costs. At present, Asian manufacturers have an advantage over German and European companies due to their extensive experience, especially in the production of battery cells and cell materials. Government research funding should therefore provide initial support for **R&D** to scale up production: Europe needs basic skills in the area of large-scale industrial production in order to catch up with the market leaders or even gain an advantage. In addition, the existing battery cell technology must be further developed so Europe can set itself apart from the competition and take a leading position in future **disruptive technologies**. To this end, existing research projects must be enhanced and supplemented, and individual projects funded by the BMBF and BMWi as well as national and European projects must be coordinated even more closely. Germany needs an overarching strategy that is pursued in the European environment. The existing activities of the BMBF and BMWi within the framework of the umbrella concept of the Battery Research Factory, the seventh Energy Research Programme and the Important Projects of Common European Interest (IPCEI) must be continued. In order for companies to invest in battery cell production, they need

longer-term supply contracts and planning and investment security to accompany these contracts. Political support is just as desirable in this context as binding funding provisions and a clear and transparent strategy for Germany and Europe.

Electric vehicles can already be more climate-friendly over their entire service life than comparable conventional vehicles even with Germany's current electricity mix. However, a major expansion of the grids and renewable energies is required in order to fully exploit the climate protection potential that both battery cell production and vehicle operation hold. This expansion must therefore be consistently pursued so that renewable energies are available in sufficient quantities and at competitive prices for production and operation in Germany and Europe. If a battery's use ends in an electric vehicle, it can either be reused in other applications (**second life**), for example as a stationary power storage unit, or recycled. Over the medium and long term, recovered materials from spent batteries can serve as an important source of raw materials for cell production in Europe. Innovative business models for recycling batteries efficiently and European strategies for handling **secondary raw materials** must therefore be developed and introduced.

## Power electronics: Expanding cross-system knowledge, developing software expertise, exploring disruptive technologies

As in the value creation network for lithium-ion cells, German industry also possesses expertise in many value creation processes in power electronics. However, it currently occupies leading positions in only a few areas. In some of them, it falls significantly short of the international benchmark – for example in software and production technology. As with battery cell production, Germany and Europe are in competition with Asian regions in particular in these areas. The electrification of drive trains started earlier there, and Asian manufacturers have a closer proximity to consumer electronics than European ones. Japan in particular has highly complex value creation chains with specialised participants that cover all relevant competencies for the production of power electronics and, based on decades of experience, set a benchmark that serves as the standard for Europe and Germany. High levels of expertise are available in the US as well to a certain extent.

Strong R&D programmes for power electronics are necessary to maintain the value creation that has existed in Germany to date, catch up with Asian technology leaders and win back market shares. Expanding cross-system knowledge with regard to device integration and the interaction of components and systems is just as important as successfully applying this knowledge. Integrative, holistic and cross-system research projects should continue to be used in order to develop new skills and close skills gaps. Software competence also needs to be built up across all areas of power electronics. R&D on active components of the next generations is necessary to maintain competitiveness in future and disruptive technologies as well.

There is also strong potential for value creation beyond vehicle production in and of itself, for example in the charging infrastructure. The interface between battery electric vehicles and charging infrastructure is central. When German manufacturers develop intelligent charging systems that make the charging process more customer friendly or energy efficient, this makes an equally positive contribution to international competitiveness as it does to the carbon footprint.

## Internal combustion engine drive train: Maintaining the competence base, securing supply chains, retraining employees

The German automotive industry occupies a leading international position in the field of internal combustion engine drive trains today. The existing value creation networks range from vehicle manufacturers to global system manufacturers and small and medium-sized enterprises. While a shift is occurring from development and personnel resources towards electric mobility in these networks, internal combustion engine drives will continue to be used for the foreseeable future, albeit in smaller numbers and primarily in long-distance freight transport. This presents a twofold challenge, as investment in research and development for internal combustion engine drives is still necessary as well. If fewer combustion engines are produced and sold, the returns in this area will decrease. In particular, suppliers

specialising in components for the combustion engine may no longer have the financial resources to adapt to the changes in technological requirements. This could endanger supply chains for individual technologies. To prevent this, some management of this conversion may be necessary, with measures ranging up to the consolidation of companies and site closures.

Demographic developments, such as the retirement of baby boomers and the shift in resources towards electromobility, also threaten to result in a loss of competent personnel. To counteract this, it is vital to safeguard and communicate the attractiveness of training and studies in the field of combustion engines.

## Overarching recommendations for action

Companies and consumers need planning security in all three value creation networks. Transparent strategies and regulations are necessary, which, for example, secure the supply of raw materials for battery cell production and enable continuous research for future generations of battery cells as well as disruptive technologies in power electronics. Similarly, there is a need for binding guidelines on which subsidies and tax breaks, for example, will help consumers make the switch to electromobility.

In addition, qualified personnel are required for all the technologies under consideration. The attractiveness of training and careers, especially in the fields of electrical engineering, information technology, electrochemistry and the circular economy, as well as internal combustion engine drive trains, should be more strongly communicated and strengthened by means of lifelong learning opportunities. In addition, engineers, IT specialists and

scientists from other disciplines must have the opportunity to gain further qualifications in these areas. However, jobs will be cut in the internal combustion engine drive train segment in future, particularly in the production area. The impact on the existing workforce must be addressed by means of re-qualification and adaptation programmes.

## Demonstrating the effects of electrification and automation on employment structures: a centralised vocational training concept is needed for the mobility sector

The shift in value creation towards new technologies means major changes in employment structures. By updating two existing studies, the working group is also investigating aspects of these changes in quantitative terms. This includes the effects of the drive transition on the more than 850,000 employees in the automotive industry<sup>38</sup> and related industries in particular.

New calculations supplement the existing studies **ELAB2.0** and **IAB Research Report 2018** to include scenarios for accelerated electrification until 2030. Based on the Climate Action Programme, the **IAB Research Report 2018** will be supplemented to include a scenario in which there will be a stock of 10 million electric vehicles in Germany in 2030. The ELAB2.0 study is supplemented by a scenario in which car manufacturers produce a higher proportion of electric vehicles in order to comply with the EU fleet limits. It then examines how the various groups of workers and occupational levels are affected by the impacts of technological change. The results exceed the previous forecasts from **ELAB2.0** and the **IAB Research Report 2018**. They will be included in the first Interim report of WG 4 on personnel planning and training in the mobility sector, which will be published in spring 2020. A considerable reduction in personnel requirements is to be expected due to the combination of the effects of electrification and increased productivity, particularly in the vehicle construction sector. The group of employees directly involved in powertrain production will be affected to a greater extent than indirect employees who are not involved in production or assembly. Other sectors beyond vehicle manufacturing are also affected by a decline in personnel requirements due to their links to the automotive industry. Overall, this reduction is distributed relatively evenly across all levels of activity, from assistant to expert, in terms of the required levels.

In principle, however, it will be significantly more difficult to train the group of unskilled and semi-skilled workers for new job profiles in the future mobility system. It is therefore crucial for all employees to obtain an initial vocational qualification at an early stage. They can then start further training for new technologies and professions on this basis.

On the whole, the results of the calculations underline the urgent need to provide companies and their employees with tools they can use to successfully navigate the impending change. A central concept for further vocational training in the mobility sector is necessary in order to identify requirements for training and (re) training skilled workers in Germany and to make successful strategies and measures available across companies. Companies should pool their capacities for training campaigns in future-relevant areas such as automotive software. To this end, WG 4 proposes that regional **competence hubs** be established based on three pillars: the creation of a central framework by all players, implementation of further training and qualification measures in regional networks, and unbureaucratic, low-threshold and efficient promotion of the measures. Companies can contribute topics and competence profiles in this context and work towards a common labour market in the sector. They can share successful training concepts with other companies and even offer training courses at the hub as training providers. This approach facilitates joint training campaigns. In addition, regional **transformation agencies** that cooperate with competence hubs of this type can be founded. In order to promote training more effectively, the **Skills Development Opportunities Act** and the regulations on **short-time allowance** should be adapted, and prospective qualifications are to be facilitated.

The concept for regional competence hubs, the selection of successful personnel planning and development measures from various companies, as well as the calculations on the employment effects of the accelerated electrification of mobility will be presented in detail in the interim report to be published at the beginning of 2020 and backed up with recommendations for action.

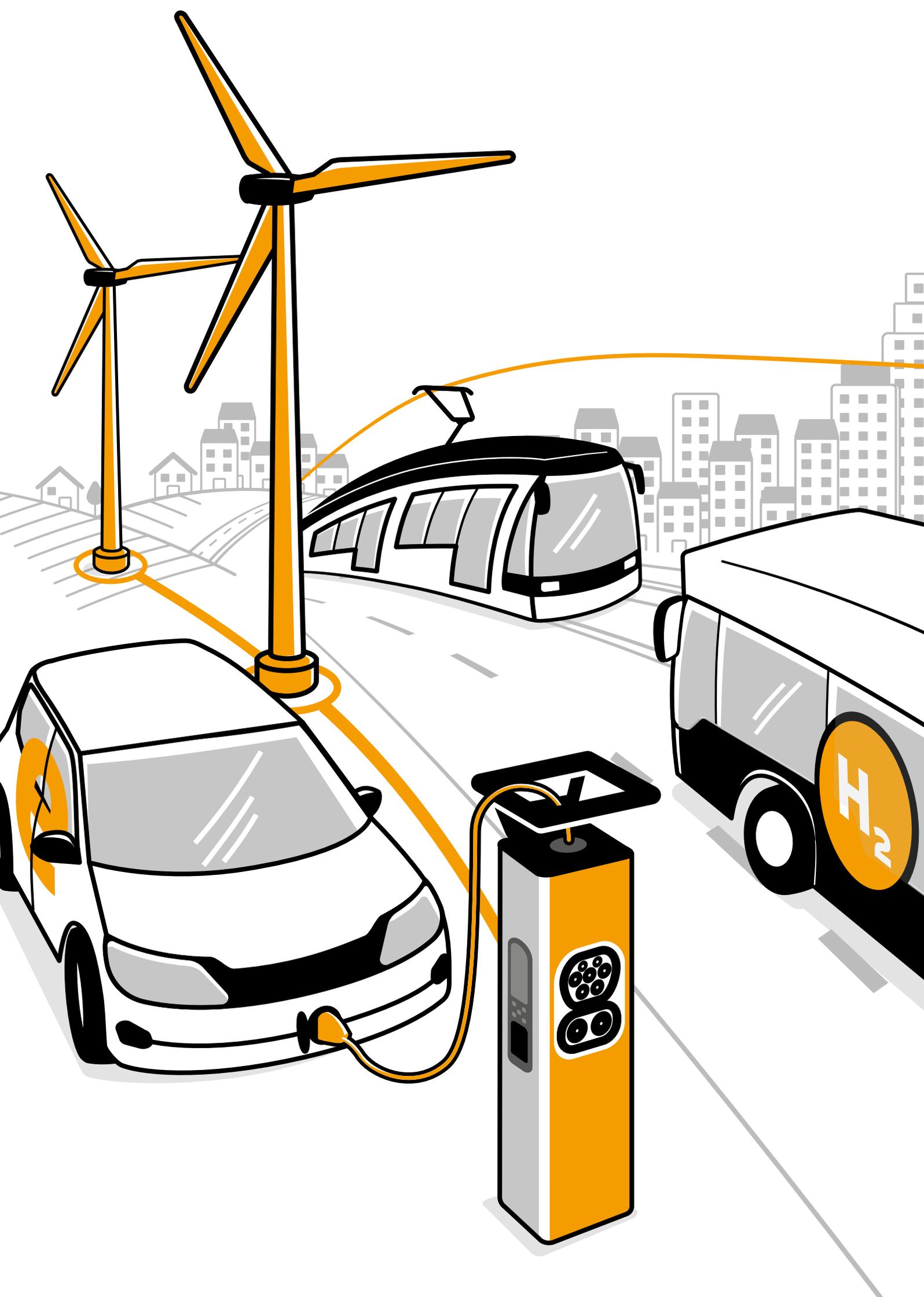
## Outlook and conclusions

The challenges posed by the shift in value creation and the change in employment must continue to be analysed in future and jointly addressed by business, politics and society in the form of active, forward-looking measures. Within the scope of its work to date, WG 4 has already carried out an analysis of the existing conditions in Germany for value creation in the areas of lithium-ion battery cells, power electronics and internal combustion engine drives, with a focus on the drive transition to electromobility. This will be followed up next year by a quantification of the development of value creation in these three areas, which is intended, for example, to reveal investment needs. In addition, the WG will present an updated forecast of the employment effects of accelerated electrification in its forthcoming interim report on personnel planning and development. Following on from this analysis, a **toolbox** for companies is to be compiled in the future. This will enable them to recognise upcoming changes that will affect their specific company and their employees at an early stage and to

derive suitable personnel strategies and training measures. In addition to employment forecasts, this toolbox is to include a guideline for the introduction of strategic personnel planning and a checklist for interpreting the results and developing suitable measures.

During the next work phases, WG 4 would like to focus on further mobility technologies that have potential for value creation and employment in Germany. These include fuel cells, electric motors and the recycling of batteries.

In addition, it would like to continue offering ideas regarding which instruments policymakers can use to accompany structural change and what a structural policy for regions particularly affected by change might look like.



## 5.5 | Connecting mobility and energy networks, sector integration

### Infrastructures form the basis for the mobility system

New infrastructure and close links with the energy sector are fundamental prerequisites for the transformation of the mobility system. In addition to establishing a demand-oriented and comprehensive charging infrastructure for electric vehicles, expanding refuelling facilities for the increased use of **alternative fuels** is also necessary. New drive technologies and fuels can only be successful on the market if appropriate infrastructure is available that is user friendly, safe, affordable and can be operated economically.

Technology neutrality and innovative strength will determine the drive and fuel mix of the future (see Section 5.2). Policy instruments should therefore always be used according to the principle of technology neutrality. However, potential applications in which electricity can be used directly should play a special role for reasons of energy efficiency. The more often energy is converted, the lower the **overall efficiency** and thus the performance. This is particularly relevant in the current situation, where renewable energies account for around 43 per cent (quarters 1–3 of 2019)<sup>39</sup> of Germany's **gross electricity consumption**.

With regard to the transport sector, an intelligent coupling of the energy and transport sectors (**sector coupling / sector integration**) makes it possible to reduce the import of fossil fuels in favour of the use of renewable energy sources. New business areas can also be developed for companies in the transport sector (for example, the provision of balancing energy). With regard to the energy sector, it is necessary to clarify how the

volatile generation of renewable electricity can be more effectively integrated via sector coupling – be it through the direct use of renewable electricity in battery electric vehicles or indirectly via hydrogen and synthetic fuels produced from renewable electricity that can be used in fuel cell and conventional vehicles. In addition, battery storage systems in electric vehicles can be used as short-term power storage devices by end customers or for system-related purposes in future and can either draw or feed electricity back into the system by means of a **bidirectional energy flow**.

The security of supply in Germany must continue to be guaranteed at all times as the electrification of the transport sector and the required energy increase, including for conversion into electricity-based heating fuels, motor fuels and raw materials. This requires an increased expansion of renewable energies and the use of smart grids and storage technologies as a matter of priority.

## Charging infrastructure

Electric mobility is one of the cornerstones of developing sustainable transport in Germany. Electric motors are already more climate-friendly than conventional combustion engines due to their higher energy efficiency. In addition, electric mobility is becoming increasingly

sustainable based on an increase in renewable energies in the electricity mix. The enhanced use of electric vehicles is also helping to significantly reduce emissions of **carbon dioxide**, **nitrogen oxides** and **particulate matter**.

Based on this, the Federal Government has set itself the task of further promoting electric mobility in Germany. In 2030, seven to 10 million electric cars are expected to be on German roads, and a total of one million publicly accessible charging points are to be available<sup>40</sup> (see Section 5.1). In its master plan titled 'Charging infrastructure'<sup>41</sup>, the Federal Government has worked together with NPM stakeholders to present detailed measures to further support the infrastructure and also incorporated concrete proposals from the reports of WG 5. In October 2019, 212,574 **battery electric vehicles (BEV)** and **plug-in hybrid electric vehicles (PHEV)**<sup>42</sup> were registered in Germany. For these vehicles, 21,299 public charging points<sup>43</sup> were available (as of November 2019). This means the expansion of the charging infrastructure is outpacing the increase in the stock of electric vehicles<sup>44, 0</sup>.

In March 2019, the experts in WG 5 analysed the areas of energy generation, grid load and charging infrastructure with regard to the supply of electric vehicles in a 'Red flag report'<sup>45</sup>. Within this framework, concrete areas requiring action were identified in the form of measures that could be quickly implemented. These measures simplify and accelerate the expansion of private and public charging infrastructure. They were summarised in the 'Emergency package of charging infrastructure measures 2019'<sup>46</sup> and addressed to politicians.

### WG 5 Report 03/2019

#### Red flag report: electric vehicles to make up 10 per cent of new registrations

In order to identify the areas requiring action, the report assumed electric vehicles would make up a 10 per cent share of new registrations in the coming years and considered the effects along the energy industry value chain on this basis.



### WG 5 Report 03/2019

#### Emergency package of charging infrastructure measures 2019

The report describes so-called no-regret measures, which can be used to accelerate the expansion of the public and private charging infrastructure in a timely manner.



<sup>0</sup> Note: The European Alternative Fuels Infrastructure Directive (AFID) specifies a ratio of 1:10 (one charging point supplies 10 electric vehicles). In its 2018 progress report (p. 53), the NPE defined a demand-oriented expansion in a ratio of 1:14 for the area of normal public charging and 1:140 for the area of fast public charging for the years up to 2020. A further development of this ratio is currently being discussed within WG 5.

Supplying electric vehicles with power is not a major challenge yet in terms of energy generation and distribution, given that they make up just 2 per cent of new passenger car registrations. If the share of BEVs and PHEVs were to rise to 10 per cent, this would correspond to an increase of 350,000 new vehicles and an increase in electricity consumption of around 0.9 TWh. Considered in terms of electricity consumption in 2018, this would correspond to 0.1 per cent of gross production, 0.4 per cent of renewable energy production or 1.8 per cent of net exports. Consequently, an increase in new registrations of electric vehicles to 10 per cent would have only a marginal effect on energy production and consumption.

Various studies have shown that a share of 30 per cent BEV and PHEV in the country's fleet (approx. 13 million vehicles) could already be mapped with the current network infrastructure. There is the potential that local bottlenecks could arise in the event of concentrated growth in metropolitan areas only. In order to address this aspect and to be able to integrate new charging infrastructure into the grid in a timely manner, an intelligent **load management** system that supports the grid will play a key role, as will efforts to make charging processes more flexible.

In the area of charging infrastructure, emphasis must also be placed on private charging infrastructure, as it is a key lever for accelerating the ramp-up of electric mobility on the market. Around 85 per cent of all charging processes take place at home or at work. However, there are still legal obstacles which make it difficult to charge in a private setting. In order to facilitate the installation of a private charging point, there is an urgent need to adapt laws on tenancy and home ownership. In addition, a subsidy for the installation and hardware of private charging points could be a potential instrument to support electric mobility in Germany. Partially public charging points that are not available around the clock should also be considered in the relevant funding guide-

lines. These recommendations were addressed in the 'Emergency package of charging infrastructure measures 2019' report from WG 5 and have now also been included in the Federal Government's **Climate Action Programme 2030** and the 'Charging infrastructure' master plan. The availability of suitable sites is a key prerequisite for further growth in the area of public charging infrastructure. However, the acceleration and standardisation of municipal approval procedures are also effective instruments for establishing public charging points in line with demand.

WG 5 will discuss further essential factors for increasing the attractiveness of electric mobility in the 'Customer-friendly charging' work package. Charging processes represent a new experience for the consumer and cannot be compared with conventional refuelling. To this end, the WG 5 work package develops criteria for customer-friendly charging and has identified the following aspects in an initial step: simple, always and everywhere, transparent and safe. The 'convenience' factor also plays an important role. Based on these characteristics, the members of the working group are developing recommendations for action in the form of a position paper for market participants. The position paper will be published in 2020.

The operation of charging points must be economically viable in the medium term in order to expand and maintain a network of charging points in Germany in line with demand over the long term. The analysis and evaluation of charging infrastructure needs must be made dynamic in order to adapt to the development of electric vehicles (number and performance) in keeping with demand. Essential criteria relating to **capacity utilisation** and **economic viability** have not been sufficiently taken into account in determining requirements so far.

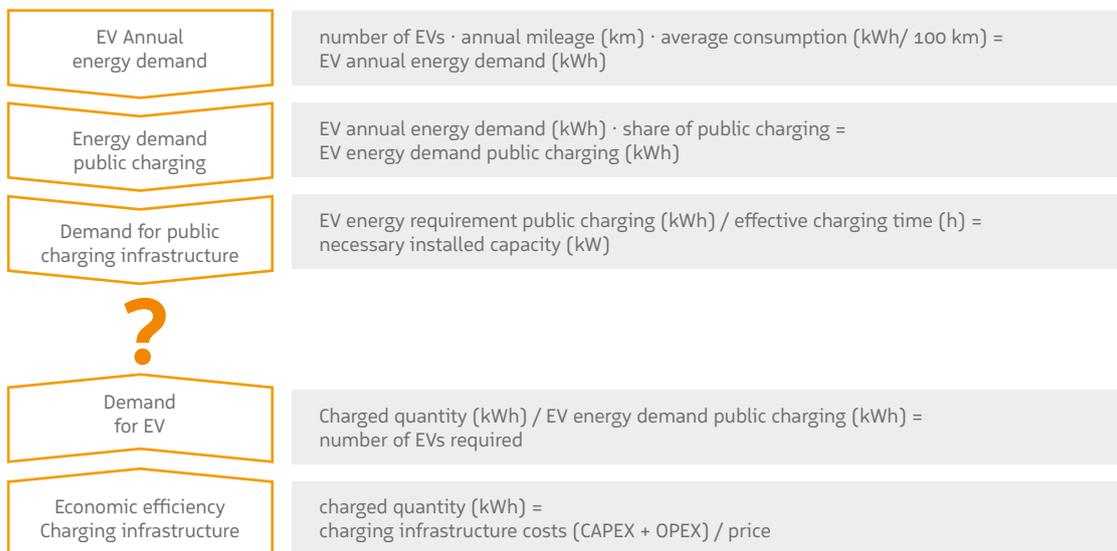
## FACTORS INFLUENCING THE NEED FOR CHARGING POINTS

- The different charging options (e.g. public/private charging or **charging capacity**) act like 'communicating vessels' – if the proportion of one charging option increases, that of the others decreases.
- The area that needs to be covered changes depending on the EV and charging infrastructure charging capacity and the range of the vehicles.
- The need for charging infrastructure is reduced by utilising the charging infrastructure more effectively, which is enhanced by intelligent usage functions and control, among other things.

WG 5 will analyse various scenarios in its **work package called 'demand-oriented and economic charging infrastructure'** by linking an examination of the energy and charging infrastructure requirements of the vehicles together with an economic feasibility study. A report on this will be published in 2020.

The two linked calculation paths can be represented in simplified form as follows:

## DETERMINING THE NEED FOR PUBLIC CHARGING POINTS AND ECONOMIC VIABILITY



**Figure 12:** Determining the need for public charging points and economic viability (own diagram)

A major obstacle to the economic viability of loading points is the costs involved in retrofitting them. The aim is to avoid these costs in future thanks to foresighted, reliable planning. Until the beginning of 2019, the development of conformity-assessed charging stations with **measuring instruments that conform to measuring and calibration regulations** in order to ensure consumer protection was associated with a great deal of regulatory uncertainty for charging station operators due to the lack

of equipment. On the initiative of WG 5, clearer information on the procedure for retrofitting the existing charging infrastructure was successfully developed together with the responsible ministerial and official bodies in order to support further expansion. Nevertheless, there are still no DC meters or DC measuring systems for fast charging infrastructure available on the market that comply with measuring and calibration regulations.<sup>48</sup>

## Liquefied and compressed natural gas (LNG/CNG)<sup>49</sup>

**Natural gas** in the form of **LNG** and **CNG** is a readily available and competitive alternative to diesel in heavy-duty transport. The energy density, which is an important criterion with regard to range, is a decisive factor in its use. LNG has a higher energy density and can be used, for example, for shipping and transit freight transport. CNG has a lower energy density and is therefore particularly suitable for use at lower mileages. Fossil LNG and CNG alone can save around 20 per cent CO<sub>2</sub> compared to the petroleum products most commonly used today. In addition, the emission of **sulphur oxides (SO<sub>x</sub>)** and nitrogen oxides (NO<sub>x</sub>) can be almost completely avoided and fine dust and noise emissions can be significantly reduced. The use of **biomethane** and **bio-LNG** can also offer sustainable and non-fossil development for LNG and CNG. Looking to the future, the use of **synthetic natural gas (SNG)** is also a climate-friendly option. In the field of biomethane, combinations with fossil methane are already possible today without quantity restrictions. At present, about 10 TWh of biomethane is processed in about 200 plants and fed into the gas grid. In principle, a potential of 118 TWh would be conceivable by 2030, which would be enough to power around 12 million cars or 185,000 lorries.

At the beginning of 2019, 117 gas-powered lorries (out of a total of 222,104 lorries) with a total mass of more than 12 t were registered in Germany<sup>50</sup>. The interim report of the NPM's WG 1 sets 70,000 to 130,000 gas lorries (< 20 t) and 12,000 to 125,000 gas lorries (> 20 t) as the target corridor for 2030<sup>51</sup>. The first series models are already on the market in the LNG lorry segment. Similarly, inland waterway and ferry vessels as well as the first cruise ships are already operating with LNG today. On the infrastructure side, Germany has a network of refuelling stations for CNG with around 850 stations. In the LNG sector, there are currently six publicly accessible and permanently installed filling stations. A nationwide supply of LNG and CNG can be guaranteed in Germany via the existing and planned infrastructure up to the filling station. Germany has a well-developed gas grid and can also draw on the European LNG infrastructure. In addition, potential LNG terminals on German coasts offer the opportunity to reduce transport distances and to further decrease transport costs.

### WG 5 Report 10/2019

#### LNG and CNG strategy in heavy-duty transport

The report addresses the question of how the refuelling infrastructure for gas as an alternative fuel in heavy-duty transport can be further developed.



Important policy measures have already been taken to promote the use of LNG and CNG. The task now is to ensure the market is ramped up beyond 2020. The toll exemption that has been in place thus far is a key factor in ensuring stable demand for heavy commercial vehicles with gas-based drives. However, the future design of tolls should in principle have a stronger GHG component in order to promote vehicle technology with lower emissions. Another important factor in the decision to purchase a vehicle is an extension of the purchase subsidy, which compensates for higher purchase costs compared to lorries with conventional drive systems. In the area of tax incentives for fuels, an extension of the energy tax reduction beyond 2026 is recommended so that future investments in gas-powered lorries are not already prevented today. Furthermore, approval procedures for infrastructure should be harmonised and simplified in order to ensure planning security.

The consistent implementation of **RED II** and extending the reference circle to inland navigation within its context is beneficial in terms of increasing the use of biomethane and bio-LNG. Counting biofuels towards fleet limits can also be useful for the further use of **biofuels**. Another measure is equal tax treatment for Bio-LNG and fossil LNG. Since Bio-LNG is treated like liquid gas and not like natural gas in the Energy Tax Act, a higher energy tax rate applies, and rebates on it also diminish at an earlier point.

In summary, the provision and expansion of gas infrastructure for the use of CNG and LNG can be covered in principle. However, the refuelling infrastructure can only be operated in a cost-effective manner if there is sufficient demand for appropriate vehicles. Public transport buses, for example, could offer great potential for demand for gas as a fuel.

## Power-to-X<sup>52</sup>

The term **power-to-X (PtX)** describes a series of processes that convert electrical energy into other heating fuels, motor fuels and raw materials. Potential areas of application for electricity-based fuels include, for example, the transport, heating and industrial sectors. Power-to-X technology thus makes an important

contribution to sector coupling and can also generate medium and long-term capacities for systemic and grid-based electricity storage.

### APPLICATION AREAS AND CONVERSION PROCESSES OF PTX TECHNOLOGIES

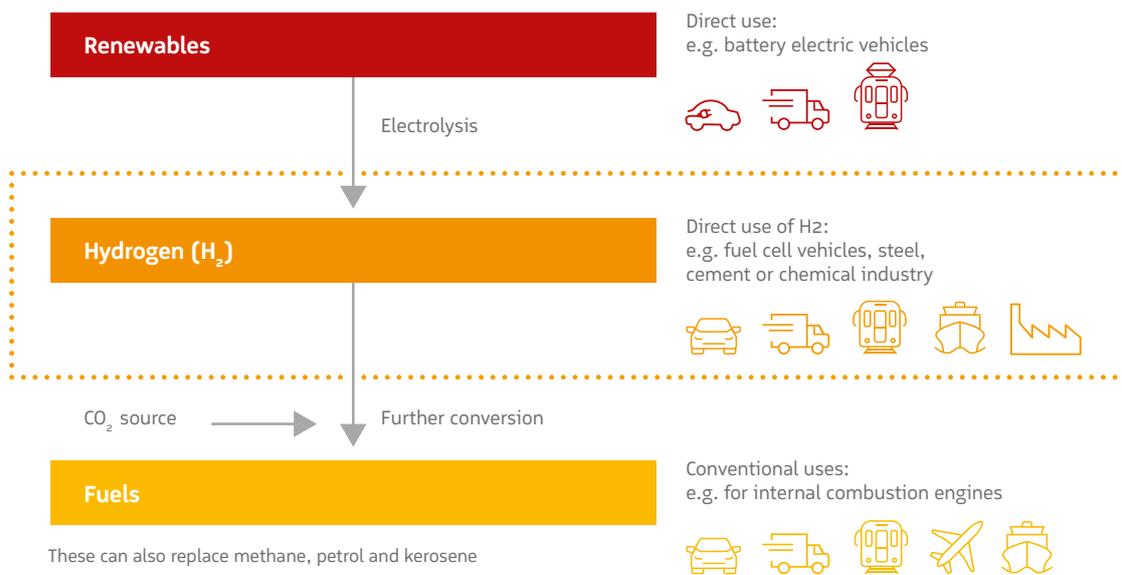


Figure 13: Diagram of the application areas and conversion processes of PtX technologies (own diagram) <sup>53</sup>

In **electrolysis**, water is broken down into hydrogen and oxygen using electrical energy. The hydrogen obtained in this manner can be used directly or stored. Using a carbon source and additional electricity, hydrogen can also be processed into synthetic energy carriers. Hydrogen is the basic material for further conversion processes in

all fields of application for the transport sector currently under discussion. Today's hydrogen production is largely based on fossil energy sources. In future, emission-free green hydrogen can be produced by means of electrolysis from electricity produced from renewable sources.

Electrolysers are still manufactured almost entirely in factories thus far. Corresponding demand for green hydrogen could significantly reduce the specific investment costs for plants through economies of scale. High electricity and ancillary electricity costs in Germany and complex approval procedures for electrolysers are other key aspects that have kept green hydrogen from being competitive thus far. In order to promote market development, electricity levies should be reduced and the exemption from grid charges should be maintained for the operation of facilities that serve to support the system as a whole.

But the size and the operating hours of the electrolyser are also decisive factors for cost-effective operation. The use of '**surplus electricity**' during times of peak production of renewable electricity on its own does not result in a cost-effective option for electrolysers.

## WG 5 Report 10/2019

### PtX roadmap

The report identifies key influencing factors and describes concrete recommendations for action to make green hydrogen competitive.



## PRODUCTION COSTS OF GREEN H<sub>2</sub>

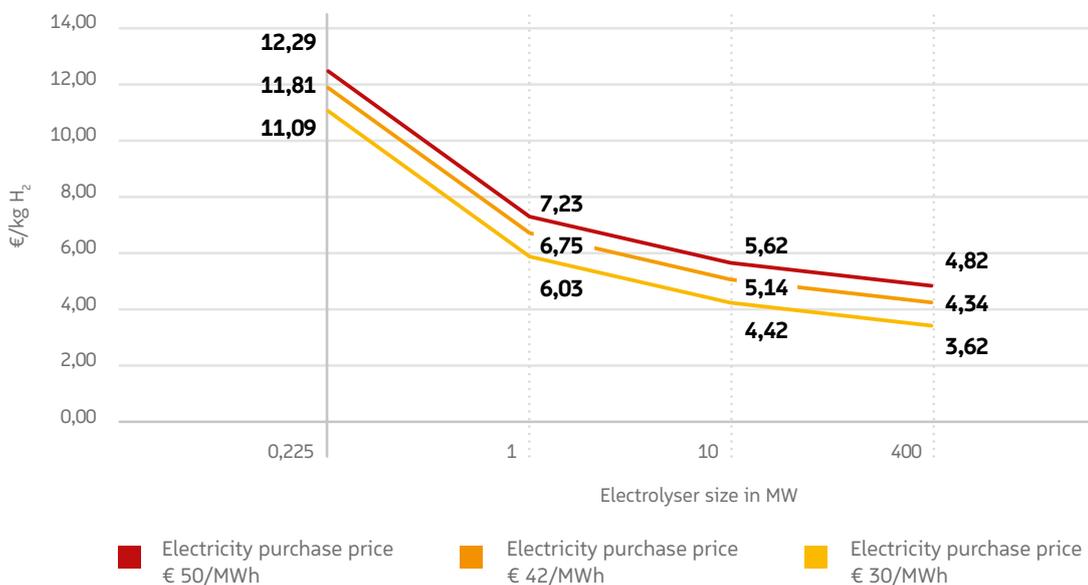


Figure 14: Production costs of green H<sub>2</sub> depending on plant size and electricity price incl. taxes and levies (own diagram)<sup>54</sup>

Current markets in which H<sub>2</sub> is required for industrial processes include applications in refineries, the chemical industry and the glass and steel industry. The current potential to cover the H<sub>2</sub> demand in Germany amounts to about 23.6 GW electrolysis capacity. Until now, this demand has been met almost exclusively by

**steam reforming** using natural gas. The current market potential first needs to be developed to make it possible to serve potential future areas of application, such as heating and transport, with green hydrogen.

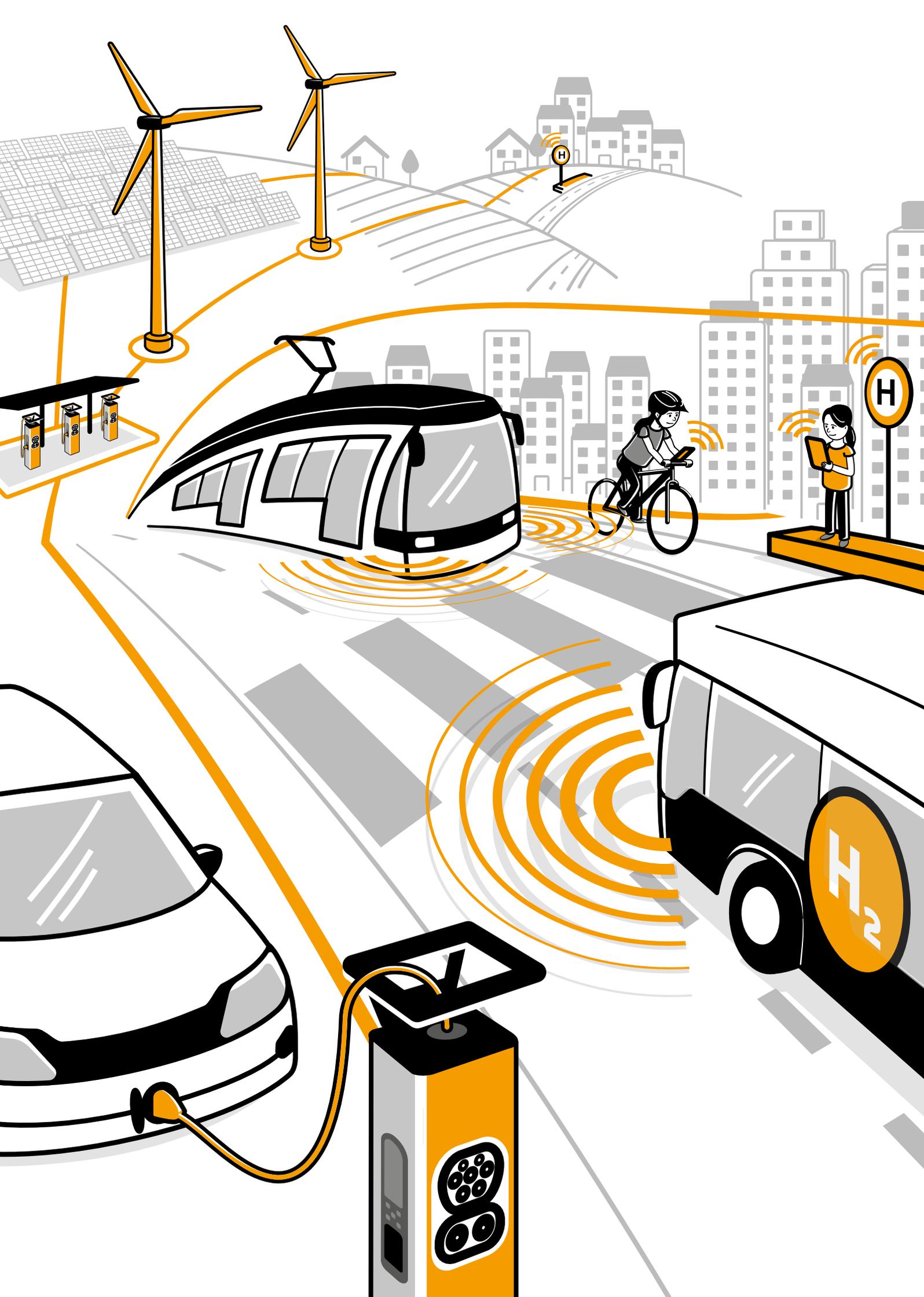
## Outlook

Interlinking transport and energy networks is a necessary component for the success of the transformation in the transport sector. This requires a reliable regulatory framework, fair competitive conditions for **alternative fuels** and drive systems, and active political will to shape the future.

The initial groundwork has already been set for a future mobility system in the form of the Federal Government's Climate Action Programme 2030 and the Climate Protection Act. Individual measures can be evaluated step by step for their impact and, if necessary, readjusted on the basis of an iterative approach. In this

context, the various mechanisms and instruments in the field of energy and transport must be continuously examined and optimised with respect to their compatibility, particularly in the area of sector coupling.

The next WG 5 project comprises the temporal modelling of a preliminary, comprehensive ramp-up of the public charging infrastructure. Furthermore, the experts in the WG will address the requirements of **grid integration** and the energy management effects of sector coupling. A close exchange and joint work packages with other WGs are also planned.



## 5.6 | Standardisation, norms, certification and type approval

### Internationally coordinated norms and standards promote sustainable and affordable mobility in future

The transformation of the mobility sector can only be successful and marketable if it is based on internationally agreed standards, norms, certification and type approval. This enables society, business and politics to jointly formulate technical recommendations and framework conditions. Quality, safety and usability are ensured while safeguarding investments.

Norms and standards support innovation in an increasingly complex and networked world so that the vision of the 'future of mobility' can become reality. Standards are essential for the transformation of the mobility system. They increase social acceptance and confidence in new technologies. The requirements for products and services are defined in a transparent process. This process is based on the principle that standardisation projects are developed by consensus with the participation of all interested parties for the benefit of the general public.<sup>55</sup> Standards are also regularly reviewed by experts and adapted to the latest developments.

Our mobility system already covers a wide range of industries and technologies, such as automotive engineering, electrical engineering and energy technology, as well as information and communication technology. This cross-sectoral interdependence will become even more pronounced in future. Norms and standards ensure the necessary compatibility, **interoperability**, international usability and, above all, the safety of the various mobility systems.

## Goals and working methods of WG 6

WG 6 develops the need for action in the field of standardisation, norms, certification and type approval in close coordination with all NPM working groups. The working group develops recommendations to industry and politics on this basis which are published in the form of standardisation roadmaps on the future of mobility.

WG 6 works closely with the responsible committees of the standards organisations German Institute for Standardization (DIN) and the German Commission for Elec-

trical, Electronic & Information Technologies (DKE) as well as the responsible federal ministries to develop the recommendations for action. The standards organisations ensure that national requirements are incorporated into European and international standardisation work. For this reason, the working group has also set itself the important priority of supporting the necessary international consensus processes and overseeing them from a strategic perspective.

### OVERVIEW OF STANDARDS ORGANISATIONS

|                     | General   | Electrical engineering   | Tele-communications   |
|---------------------|---|--|---|
| International       |  |  |  |
| European (regional) |  |  |  |
| German (national)   |  |  |  |

Figure 15: Overview of national and international standards organisations (own diagram)

## Enhancing the results of the National Platform for Electric Mobility

In the field of electromobility, extensive preparatory work has already been carried out in the **National Platform for Electromobility** (NPE). All basic requirements for the operation and charging of electric vehicles that are directed at standardisation were addressed in the 'German Standardisation Roadmap Electromobility 2020' published in 2017. Thanks to the international standards established as a result, standardised plugs with the corresponding communication standards for interoperable charging have gained acceptance in Europe, the US, Korea and other countries. WG 6 builds on the results of the NPE and continues to implement them in the NPM's electromobility topic area.

The standards in the field of electromobility must be continuously adapted to technological developments. This concerns topics such as increasing **charging power**, **grid integration**, **bidirectional energy flow** and automated billing. One example of the continuation of the subject area is the initiation of DIN SPEC 91412 'Electric Mobility – Terminology and graphical symbols', which is intended to support the uniform use of terms and graphical symbols for the public and professional communication of electromobility.

## White paper: ‘Current developments and challenges for the future of mobility’

In its white paper titled ‘Current developments and challenges for the future of mobility’, WG 6 takes up central challenges from all the NPM working groups. Based on this, the necessary standardisation needs which must be addressed in the near future are identified. Needs relating to the adaptation of certification and type-approval processes are also described. The white paper summarises the findings as the current state of work and serves as a first step and basis for the focus roadmaps that are to be subsequently developed.

A total of six topics were identified in cooperation with the other NPM working groups: trends in mobility, drive energy, the grid, networking, data and life cycle.

**WG 6 White paper 11/2019**

**Current developments and challenges for the future of mobility**

The [white paper](#) presents the cross-industry standardisation needs for the future of mobility.



### TOPICS OF WG 6

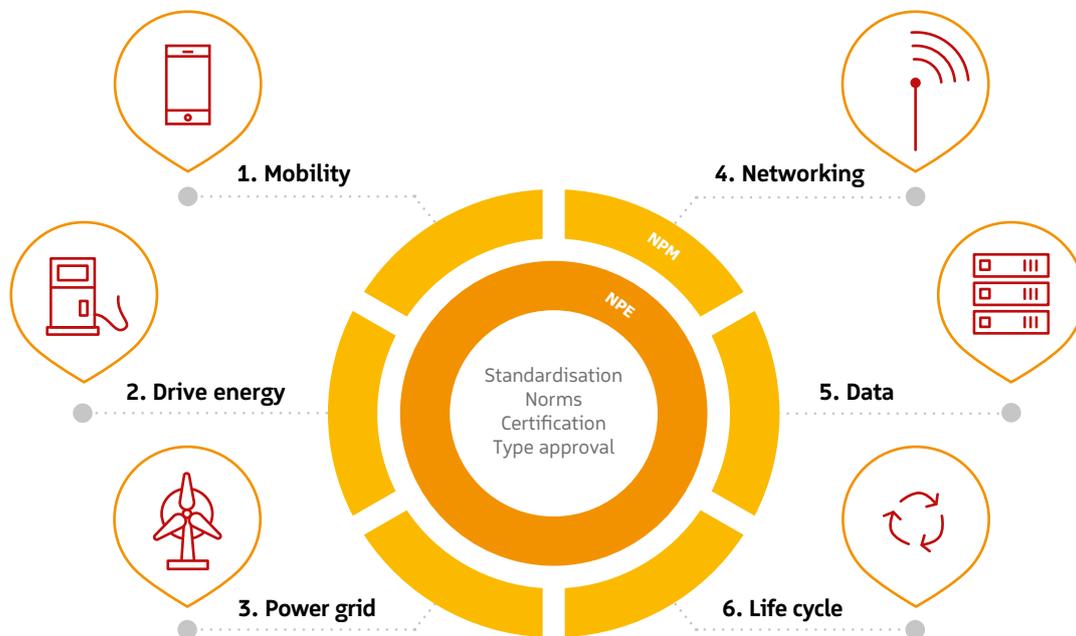


Figure 16: Overview of the topics of WG 6 (own diagram)

## Trends in mobility

Existing and new mobility concepts as well as connected and automated driving are to form a holistic system. This mobility system will be able to deliver the greatest added value if it builds on standardised components and interfaces. The number of accidents can be reduced, and environmental pollution and economic costs can be cut on this basis.

Electrification and increasingly automated and connected driving are expected to bring about massive potential for change in the coming years. This affects both privately and publicly operated road vehicles. To this end, the following main technical challenges have to be overcome: Firstly, harmonised communication systems must be provided and traffic data exchanged via appropriate interfaces without regional or national variation. Secondly, data security must be ensured for all systems in and around the vehicles.

Further challenges include specifying type approval criteria and test scenarios that are tailored to the respective level of automation, regulations for mixed operation and defining user interfaces and the interaction between the driver and vehicle.

In order to exploit the full potential of the new mobility solutions, the design phase must always consider how they can be meaningfully connected to other systems such as public transport, rail, inland waterways and even aviation. The focus should be on the needs of customers and users: The interfaces and transitions for changing modes of transport must be optimally designed to achieve a high level of acceptance for intermodal transport.

### STANDARDISATION NEEDS FOR AUTOMATED AND CONNECTED DRIVING

Uniform and internationally coordinated communication systems for traffic data must be developed in order to keep pace with current trends in a timely manner. These form the basis for the communication between the vehicles themselves and with the infrastructure. The interfaces between vehicle and user must also be precisely defined. Standards are also needed to ensure the data security of the systems in and around the vehicles. This includes interference resistance, data protection and data sovereignty. Type-approval criteria and test scenarios must also be developed. These must be adapted to the respective level of automation. In addition, clear regulations for mixed operation are needed. Last but not least, regulations on the 'electronic tow bar' (**platooning**) are also necessary. This is particularly necessary for freight transport.

## Drive energy

Utilising any kind of drive energy requires a comprehensive infrastructure, both for passenger as well as freight transport (see Section 5.5). One thing is clear: In the passenger car sector, **battery electric** and **plug-in hybrid vehicles** will play a key role in the coming decade.

In addition to traditional filling station solutions, a large number of new charging options are emerging in the field of electromobility in private households, blocks of flats, companies, customer car parks and public places. A sufficient infrastructure can only be created through a combination of these diverse solutions. However, it is

important in this context that the individual charging points are as compatible and future-proof as possible in order to avoid later upgrades and additional investments.

Among other things, different **performance parameters** for **AC** and **DC charging** as well as, looking to the future, solutions from the research and development area for wireless charging and charging while driving have to be taken into account when building the infrastructure. Automated wired charging, user identification, billing

systems, connection to **smart meter gateways** and bi-directional energy flow are also relevant aspects for the drive energy sector.

In the field of hydrogen technology, the availability of drive energy can be provided by refuelling infrastructure comparable to today's filling stations for petrol and diesel fuel. In this context, however, the approval procedures must be further specified and standardised, questions relating to calibration law must be clarified and the design of fuel dispensers for **transport modes** must be ensured.

## STANDARDISATION ACTIVITIES IN THE FIELD OF DRIVE ENERGY

The standardisation of technology for the production, processing and use of hydrogen in both liquid and gaseous form and of **synthetic fuels** must be further developed. The battery cell formats for the traction battery need to be further defined for the area of vehicle component standardisation. The performance parameters for AC/DC charging must also be defined and compatibility and sustainability must be ensured. In the area of charging, the standards on wireless charging, charging while driving (e.g. inductive or on overhead lines) and (automated) wired charging must be further developed.

The compatibility of vehicles and the infrastructure (e.g. via communication protocols) must also be ensured and the classification of different systems in the private, commercial and public sectors must be clarified. In addition, the 2030 guidelines for hydrogen must be set. This includes the approval, compatibility, calibration and classification of hydrogen as a source of energy. Norms and standards must also be developed for the subsequent use of the natural gas infrastructure.

## Grid

The market ramp-up of electric mobility must be successfully integrated into the grid of the future. The strong growth of electromobility in both passenger and freight transport is creating new challenges for our grid. These primarily relate to the provision of sufficient grid capacities in line with demand and the associated establishment of corresponding supply points. The intelligent **load management** that is required must take into account, among other things, the potential that the batteries installed in electrified vehicles may be used as decentralised energy storage devices (see Section 5.3).

Only in this way will it be possible to make a significant contribution to a sustainable, future-proof and economical power supply. Looking to the future, the bi-directional flow of energy, which must be clearly regulated in both technical and legal terms, will play a key role.

A further key success factor in intelligent load management is that customers, individual and large-scale consumers can actively contribute to a stable and secure supply of electricity for all via coordinated usage behaviour. To this end, the required data must be identified and standards for a uniform exchange of data, such as via smart meter gateway, must be defined – taking into account the aspects of data protection and IT security.

## STANDARDISATION ACTIVITIES FOR INTELLIGENT LOAD MANAGEMENT

The data required for intelligent load management – and particularly for a bidirectional energy flow – must be defined. Data exchange protocols between the grid, charging infrastructure and consumers must also be standardised. The minimum requirements are to be specified for smart meter gateway products. The design of load profiles for the development of electricity demand, which are known as load forecasts, are another criterion for intelligent load management.

## Networking

The future of mobility is networked. Public and private means of transport will be intelligently combined to create new demand-oriented and efficient mobility solutions (see Section 5.3). Transport networking involves electronic communication between road users in various forms: from vehicles to other vehicles, to the road, to networks, to people – this is summarised in the term **vehicle-to-everything (V2X)** and from another perspective **infrastructure-to-everything (I2X)**.

From the point of view of norms and standardisation, this requires first and foremost the creation of secure interfaces and open platforms for intermodal, automated and networked mobility. In addition to creating the technical aspects of interfaces, establishing cross-organisational cooperation along the value chains is of particular importance. In order to make the vision of networked mobility a reality, providers must cooperate extensively, for example to create comprehensive IT security solutions.

The flow of traffic in continually growing cities can only be improved in a decisive way via intelligently networked solutions, preferably with a high degree of automation. At the same time, intelligent mobility concepts can ensure comfortable connections and participation even in rural regions. The increasing transport volume can also be handled in freight transport by means of intermodally networked logistics concepts from different providers and the combination of air, rail and water transport with expressways and concepts for the 'last mile' in city centres.

The prerequisites for successful networking are, on the one hand, clearly defined interfaces that support the safe flow of traffic, enable the development of new business models and platforms for intermodal mobility services and take into account the legitimate interests of users and operators. On the other hand, a high level of information security must be ensured in addition to functional security.

## STANDARDISATION ACTIVITIES IN THE FIELD OF NETWORKING

In order to further promote transport networking, the exchange of data and data interfaces must be defined in the V2X and V2I areas. In the area of intermodal transport, the necessary uniform interfaces must be defined or optimised, taking into account the needs of necessary stakeholders. The requirements for open and independent platforms for exchanging data must be clarified as well. The provision of information on intermodal mobility options can also be improved by means of standards. Ensuring information security is an important aspect in this context. It is vital to make sure that data and critical infrastructures are protected against human and technical errors as well as attacks and misuse.

## Data

Data is the basis for new traffic concepts and mobility services. In terms of the future of mobility, it is therefore necessary that the collection, use, processing and protection of mobility data are defined and brought in line with data protection law. Clarifying the rights of use and ownership of the data, data security and the associated obligations are the basis for users' trust and acceptance.

Enormous quantities of data are already generated in motor vehicles and infrastructure facilities today. The amount of data increases rapidly at higher levels of automation. Safe (partially) autonomous operation is made possible in the first place by a variety of data-generating devices such as cameras, radar, lidar and ultrasonic sen-

sors. But which of this data can be used beyond driving in and of itself, for example to train self-learning systems for automated driving or to clarify issues relating to traffic and insurance law in the event of an accident?

Of course, these questions not only relate to road traffic, but also to all other modes and means of transport – from rental scooters to public transport and pedestrians, which are digitally recorded by other road users. As a result, there is a need for overarching rules on how to handle this data.

### STANDARDISATION ACTIVITIES IN THE FIELD OF DATA

The standardised use of mobility data is essential for the future of mobility. This is particularly necessary for creating test scenarios, intelligent load management and teaching and training artificial intelligence. The vehicle and environmental data to be generated and collected must be defined in the area of data collection and intended application. Consideration must also be given to the type of data clustering and storage and to ensuring that the collected data is standardised. Mandatory standards for non-discriminatory data access in networked mobility services are necessary from the perspective of data ownership and usage rights. The requirements for information security, data models and data economy must be defined on the whole.

## Life cycle

The ecological footprint that is left behind for every kilometre travelled is comprised of many different factors: There are the emissions directly at the vehicle – which include pollutants and noise in addition to **greenhouse gases** – as well as the environmental impact generated by the manufacture of the vehicle and the provision of the required form of energy for the drive. Recycling the means of transport at the end of its life cycle must also be considered. In addition, social and ethical aspects also play a role in a relevant sustainability assessment.

The first step when assessing the sustainability of vehicles with different drive energies is to create a common understanding of the various relevant evaluation criteria and influencing factors. Expected future developments, such as the potential to boost efficiency or fuels produced from renewable sources, must also be considered in this context.

The entire life cycle must be considered when assessing the sustainability of a battery. In terms of the circular economy, recycling or a possible secondary use (see Section 5.4) must also be taken into account in this context. The discussion on the extent to which battery cells or modules can be standardised and what sustainability benefits can be expected from this also needs to be specified in further detail.

An efficient circular economy can only be implemented by using digital technologies. These include, above all, the possibilities of documenting individual ingredients from extraction to processing and recycling. A dedicated **block chain**, for example, could be used to securely share such data with all participants, and the information would be available in real time. This would enable a trustworthy and transparent supply chain that is geared towards resource efficiency.

## STANDARDISATION ACTIVITIES IN THE FIELD OF SUSTAINABILITY

A sustainability comparison is necessary for vehicles and drive energies over the entire life cycle, including future development potential, for example in a circular economy. Existing sustainability assessment schemes or standards must be reviewed and further developed to this end. The development of a label for sustainability should also be examined. In the case of intermodal transport, the assessment of sustainability potentials must take into account the potential offered by digitalisation in the mobility sector. Cycling and pedestrian traffic must also be included as factors.

## International cooperation

International standards serve as a common technical language between trading partners and promote global trade. WG 6 is therefore actively working to expand international cooperation in this area. Standards coordinated at the national or European levels are to be observed worldwide.

In the US, an agreement between the International Organization for Standardization (ISO) and the Society of Automotive Engineers (SAE) has governed the cooperation between the two organisations since 2016. It enables the creation of common standards in the automotive sector and improves the acceptance and application of international standards from the ISO and the International Electrotechnical Commission (IEC) in the US. The extension of the agreement, which was initially temporary, is currently being negotiated.

The German and Chinese governments also agreed to collaborate closely on electromobility starting in 2011. The Electromobility Subgroup was founded in this con-

text under the German-Chinese Commission for Collaboration on Standardisation (DCKN). The technical dialogue deals with the topics of charging with higher charging capacities, wireless charging and traction batteries. The DCKN is also currently examining the form and topics in which cooperation is possible on standardisation issues in automated networked driving.

In addition, WG 6 discussed and redefined the strategic cooperation with the Japanese Ministry of Economy, Trade and Industry (METI) in coordination with the Federal Ministry for Economic Affairs and Energy (BMWi). The content of an updated work programme is currently being agreed within the framework of a joint strategic group, which is made up of the WG 6 Steering Committee and other representatives of the BMWi on the German side. In addition, WG 6 and the Korean Autonomous Vehicle Standardization Forum (KAVSF) aim to establish a cooperation on standardising the future of mobility. The concrete form and structure of such a cooperation are currently being discussed.

The GRVA working group was set up in 2018 at the level of the United Nations Economic Commission for Europe (UNECE). This working group focuses on functional requirements, test requirements, new assessment methods as well as **cybersecurity**, software updates and data storage for automated driving functions and vehicles. The work at UNECE level is essential to define a common understanding relating to a uniform approval framework for vehicle technology and its use between

the signatory states of the UNECE. WG 6 is keeping a close eye on developments at UNECE level in this regard.

The same applies to the platform for cooperative, networked and automated mobility, CCAM, launched by the European Commission. The aim of the group is to develop principles for European regulation in the areas of access to and the exchange of data, road transport infrastructure, digital infrastructure, communication technology, cybersecurity and road safety.

## Conclusions and outlook

The goal of WG 6 is to develop important recommendations for action from the subject areas described in the White Paper by 2021 by means of focus roadmaps that are coordinated across all affected sectors. These recommendations constitute Germany's standardisation strategy for the future of mobility.

A sub-working group of WG 6 is currently dealing with issues related to certification and type approval. A paradigm shift is occurring in the field of vehicle development away from the approval of individual vehicle types. In the digital age, the approval of automated driving functions should also be combined with simulations and monitoring in the field. Internationally harmonised test specifications for use in the type-approval procedure are needed for vehicle systems with higher levels of automation in the near future. These are to include the verifiability of the vehicles in the operational phase. The sub-working group is preparing a separate white paper on this subject, which is to be published in 2020.

In addition, focus roadmaps on the standardisation requirements for the subject areas of 'Intelligent load management', 'Automated and networked driving' and 'Sustainable mobility' are already in progress.

Norms and standardisation are core elements for the development of future transport systems. They must be addressed and implemented early on to ensure that the systems are ready for the market and that their positive effects are felt on a large scale. Standards provide companies with guidance and assistance in implementing new technologies. Producers and users can rely on functioning and manufacturer-independent interfaces thanks to standardisation and norms. This creates the requisite trust and social acceptance for new technologies that are necessary for the transformation of the mobility system to succeed.

6

# Recommendations for action

# 6 | Recommendations for action

The recommendations for action from the six working groups are summarised in the following. More detailed information can be found in the respective WG chapters and in the interim reports already published by the NPM. Some of the detailed recommendations for action contained in the interim reports have already been taken up by the Federal Government and are currently being implemented. One example is the recommendation of WG 1 to examine CO<sub>2</sub> pricing across all non-ETS sectors. Furthermore, the recommendation of WG 3 to establish a real-world laboratory is already being examined, and measures from WG 5 have already been incorporated into the master plan charging infrastructure.

## WG 1 – Promoting climate protection in transport

Greenhouse gas emissions from the transport sector must be reduced to 95 million tonnes by 2030, a 42 per cent reduction compared to levels in 1990. In the first report of the NPM, WG 1 developed a system of objectives with key indicators for the transport sector covering six fields of action. The target corridors developed in the fields of action show which changes must be achieved in order to meet the climate targets in the transport sector. It is indispensable that the target fig-

ures presented in the fields of action are backed up with appropriate instruments and framework conditions and that incentives are provided. It is important for measures and instruments from various fields of action to be considered in combination and coordinated with each other. The measures and instruments required for this purpose have been and are being further developed and specified by Working Groups 2 to 6 of the NPM (see recommendations for action by the working groups).

## THE NPM RECOMMENDS:

- In order to increase the potential to reduce CO<sub>2</sub> emissions, extensive and highly ambitious measures must be taken simultaneously in all six fields of action and implemented rapidly. All modes of transport and technologies are needed.
- Promoting electromobility via incentive programmes to start with: Increasing the number of electric cars to between seven and 10.5 million by 2030.
- Exploiting the efficiency potential of internal combustion engine vehicles.
- Increasing the share of alternative and synthetic fuels, taking into account sustainability standards.
- Increasing the share in passenger transport volume of rail transport and cycling and walking.
- Enhancing the share of rail and inland waterways in freight transport volume.
- Leveraging the potential of digitalisation to make transport systems more efficient and low-emission mobility more convenient across modes of transport.
- Climate protection must be designed as a dynamic process. There is a need for regular monitoring and continuous follow-ups on instruments and measures.

## WG 2 – Promoting alternative drives and fuels based on a technology-neutral approach

Alternative drives and fuels each have specific fields of application in transport in which they contribute to sustainably reducing CO<sub>2</sub> emissions in particular. WG 2 advocates a technology-neutral approach in order to make efficient and effective use of the full range of these possibilities.

### THE NPM RECOMMENDS:

- Expanding research and innovation funding along all drive systems and all types of energy sources and fuels. This involves both technological research as well as studies relating to implementation and the market.
- In order to achieve a targeted and sustainable overall reduction in CO<sub>2</sub> emissions, the transport system must not be separated from the energy sector and must be considered from the perspective of its interplay with the industrial and heating sectors. The availability of 'green' energy sources must be expanded.
- Political support is needed for the market ramp-up of battery and vehicle production and for the establishment of the necessary infrastructure.
- Appropriate framework conditions – such as technology-specific use quotas or tax incentives – must be created to enable the market launch and market ramp-up of electricity-based fuels.
- Due to the energy density of hydrogen, the use of fuel cells is already a viable option today, especially for vehicles with high mileages. CO<sub>2</sub>-free hydrogen production and infrastructure development should be promoted. The world-leading fields of competence that Germany possesses in research and industry should be used to this end.
- Alternative fuels are indispensable, particularly in shipping and aviation. In addition, electricity-based and, in the short term, biomass-based fuels should be used in a reasonable manner in road transport. Efficiency potentials of the combustion engine and hybrid drives should be further promoted.

## WG 3 – Using the potential of digitalisation for the transport sector

Digitalisation can make the future of mobility more environmentally and climate-friendly, more efficient, more convenient, healthier and more affordable. In order to make the potential of digitalisation available to the transport sector,

### THE NPM RECOMMENDS:

- Practical testing of intermodal mobility in combination with autonomous driving in a real-world laboratory to investigate effective incentives to change mobility behaviour.
- Promoting autonomous mobility by accelerating the type-approval process for vehicles with automated driving functions as well as by creating the conditions to enable functions requiring type approval to be activated via software updates.
- Laying the groundwork for a mobility data ecosystem, primarily via uniform specifications and standards for exchanging infrastructure, vehicle and dynamic mobility data. A common implementation roadmap is to be defined.
- Creating an appropriate legal framework for passenger transport without drivers based on automation levels 4 and 5.
- Guaranteeing cybersecurity, for example by transmitting data from the means of transport to third parties only via a backend that is implemented and certified by the transport manufacturer.
- Establishing and supporting a 'Dialogue initiative for digital mobility', which includes the participation of local citizens, and testing of a dialogue strategy in the real-world laboratory.

## WG 4 – Securing Germany as place for mobility and production

Together with the increasing digitalisation and automation of vehicles and production, the transition from internal combustion engine drives to electric mobility requires a realignment of (auto)mobile value creation and employment. The NPM offers the following recommendations for action

### TO MANAGE THIS STRUCTURAL CHANGE:

- Setting up a battery cell production facility by German or European companies in Europe, which can ensure the needs of the automotive industry are met even as demand increases and will reduce dependence on cell imports.
- Expanding software expertise and cross-system knowledge for integrated system technology and solutions in the field of power electronics.
- Maintaining competencies in the field of combustion engines via training and degree programmes in order to keep value chains intact here for the foreseeable future as well.
- Establishing regional competence hubs and testing regional transformation agencies in order to promote successful cross-company training for personnel in the course of structural change.
- Supporting companies with analysis and forecasting tools for the purpose of strategic personnel planning in order to cope with structural change.
- Developing the Skills Development Opportunities Act and regulations on short-time allowance to support training more effectively.

## WG 5 – Enhancing links between transport and energy networks

Sector integration is a key element of technological developments in the transport sector. The provision of energy in the form of electricity, gaseous and electricity-based fuels requires new charging and refuelling infrastructure.

### **TO SUPPORT THE DEVELOPMENT OF NEW INFRASTRUCTURES, THE NPM RECOMMENDS:**

- Accelerating legal adjustments to facilitate the installation of private charging infrastructure.
- Considering economic factors in determining demand for public charging infrastructure.
- Accelerating and harmonising approval procedures in the field of charging infrastructure.
- Creating available central areas for public charging infrastructure, especially in urban areas.
- Giving greater consideration to the GHG component in the lorry toll and extending the purchase subsidy for LNG and CNG vehicles.
- Reducing investment, electricity and ancillary costs and creating a level playing field for the conversion of electricity from renewable energies into hydrogen and electricity-based fuels.

## WG 6 – Continuing the development of standards and norms

The transformation of the mobility system requires technical framework conditions such as standardisation and norms so that technological developments can be translated into marketable products and services.

### THE NPM RECOMMENDS:

- Standards and norms that are defined across sectors and internationally agreed are needed as well as recognised processes for certification and type approval.
- Actively shaping and advancing international cooperation in the field of norms and standards.
- Defining and describing secure interfaces and open cooperation platforms for intermodal, automated and connected mobility across all modes of transport.
- Defining and organising the collection, use, processing and protection of mobility data and synchronising it with data protection law.
- Evaluating and considering the sustainability of future mobility solutions over the entire life cycle.



# Glossary \*

All terms that are marked in red in the text are explained here.

## AC charging

Charging with alternating current (AC).

## Alternative drive technologies

Alternatives to conventional drives with a combustion engine (petrol and diesel engines), such as battery electric, hybrid, natural gas or liquid gas-powered drive technologies.

## Alternative fuels

Alternatives to petrol and diesel, such as electricity, hydrogen, biodiesel, bioethanol, plant-based oils, natural gas and LPG.

## (Automated) valet parking

Driverless system for parking garages which guides the vehicle through an intelligent parking garage infrastructure to the vacant parking space and parks the vehicle itself.

## Automatically Commanded Steering Function (ACSF) Group

Informal working group of the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) of the United Nations Economic Commission for Europe (UNECE). It develops technical requirements for automated vehicles.

## Automation (of vehicles) / autonomous driving

Automated driving functions take over driver tasks at various levels of automation – from a driver assistance system to completely taking over the driver's task.

See also 'Levels of automation'.

## Axis distances

Spaces between major public transport axes. These spaces may not be sufficiently supplied with mobility services. Autonomous vehicles could fill these supply gaps.

## Backend

A server and background system on which data is stored and processed.

## Battery electric vehicle (BEV)

A purely electric vehicle, which is equipped exclusively with an electric motor and receives its energy from a battery in the vehicle.

## Bidirectional energy flow

Energy flow in which current can flow both from the grid into the vehicle and from the vehicle into the grid, making a charge flow possible in both directions; also called vehicle-to-grid technology (V2G technology).

## Biofuels

Fuels produced from biomass. Examples are bioethanol, biogas and biodiesel.

## Biomethane, bio-LNG

Biomethane, also known as bio natural gas, is upgraded biogas which, after treatment (drying, CO<sub>2</sub> capture and desulphurisation), has the same chemical and combustion properties as natural gas in the public gas network and can therefore be fed into that network as a substitute for natural gas.

Bio-liquid natural gas. Liquefied biomethane.

## Blockchain

Chained sequence of data blocks that is continually updated over time. A blockchain is not stored centrally; rather, it is managed as a distributed register. All participants save their own copy and update it. It is vital to ensure that an identical chain is created for all participants. Cryptographic procedures are used to ensure that the blockchain cannot be subsequently changed. The chain of blocks is therefore unchangeable and cannot be falsified or manipulated.

## Car sharing

Customers of a car sharing provider can rent a car on a flexible basis.

## Car-to-everything (C2X)

Car-to-everything communication refers to the exchange of information and data between motor vehicles and the transport infrastructure.

**Carbon dioxide (CO<sub>2</sub>)**

Colourless and odourless gas that is a natural component of the atmosphere. Carbon dioxide is mainly produced during the combustion of carbon-containing fuels.

**Charging capacity**

Capacity required to charge electrically powered vehicles.

**City toll systems**

Regulation of entrance/access to the city. Due to the increasing negative consequences of growing traffic flows (such as air and noise pollution), especially in metropolitan areas, cities and municipalities can regulate the access of vehicles. For example, vehicles with high CO<sub>2</sub> emissions may only drive in certain zones.

**Climate Action Plan 2050**

The Climate Action Plan summarises the climate protection policy principles and objectives of the German Federal Government and sets out the process via which Germany can become largely greenhouse gas neutral by 2050. It specifies Germany's existing climate protection target for 2050 and the agreed interim targets in concrete terms and describes measures to implement the Paris Climate Protection Agreement.

**Climate Action Programme 2030**

Programme for implementing the Federal Climate Protection Act, adopted in autumn 2019. By introducing the Climate Action Programme 2030, the Federal Government is pursuing an approach to achieve its specified climate protection goals with a broad package of measures comprising innovations, funding, legal standards and requirements as well as pricing for greenhouse gases.

**Competence hub**

Regional association of companies, political entities, educational institutions and associations.

**Compressed natural gas CNG**

This is a natural gas compressed to approx. 200 to 250 bar. Due to its high energy density and low emission values, it is very well suited for the operation of vehicles that have to be equipped with an appropriate high-pressure tank for this purpose. One advantage of CNG is that it can be processed as a fuel without additives and complicated refining processes.

**CO<sub>2</sub> equivalent**

Unit of measurement for standardising the climate impact of various greenhouse gases. CO<sub>2</sub> equivalents show

which quantity of a gas would have the same greenhouse gas effect as carbon dioxide (CO<sub>2</sub>) over a period of 100 years.

**CO<sub>2</sub> pricing**

A CO<sub>2</sub> price, also called carbon price, is a price that must be paid for emissions of carbon dioxide (CO<sub>2</sub>).

**Cybersecurity**

Protection of computer systems, networks, information, data and protection against digital attacks.

**DC charging**

Charging with direct current (DC). Charging with direct current (DC) is typically used for higher charging capacities.

**Directive (EU) 2018/2001 of the European****Ride hailing**

Principle of riding with a taxi. Ride hailing services use Internet-enabled platforms to connect passengers with local drivers with their private vehicles.

**Disruptive technology**

Disruptive technologies are innovations that interrupt the continued success of existing technologies, processes, products or services and replace them or completely displace them from the market.

**(Electricity) production costs / Levelised cost of electricity generation**

In general, production costs are the costs of producing a good. These include the cost of materials and manufacturing costs. The costs for transport and distribution are not included.

The production costs of electricity are referred to as 'levelised costs of electricity'; these are the costs that have to be incurred to convert a form of energy into electricity. They arise mainly from the cost of materials such as fuel and manufacturing costs, which include, for example, the costs of a power plant and its operation. The costs are usually expressed in euros per megawatt-hour.

**Electricity-based fuels**

Electricity-based, gaseous and liquid energy sources offer the possibility of making electricity in the form of hydrogen and hydrocarbons (petrol, diesel, kerosene, gas) usable for the transport sector via various conversion steps.

**Electrolysis**

Splitting of chemical compounds using electrical energy. An essential distinction is made between three processes (alkaline electrolysis, PEM electrolysis and solid oxide electrolysis).

**EU Effort Sharing Decision and EU Climate Action Regulation**

These are binding European legal acts in which the European targets for 2020 and 2030 in the non-ETS sectors (transport, agriculture and buildings) are legally binding and have been divided between the Member States. By 2020, Germany has committed itself to reducing its non-ETS emissions by 14 per cent compared to the 2005 level as part of the 2009 Effort Sharing Decision. A reduction of 38 per cent by 2030 compared to 2005 levels is set for Germany's non-ETS emissions in the Climate Action Regulation of 2018.

**EU Emission Trading System (EU-ETS)**

This has been a central instrument to limit carbon emissions within the EU on a continuously decreasing trajectory since 2005. It covers emitters from the energy and industry sectors. Certificates are auctioned among emitters, which effectively results in a price per tonne of CO<sub>2</sub> emissions. This is intended to stimulate reductions in emissions. So far, some 11,000 plants in the power generation and some industrial sectors have had to buy certificates for their emissions. The transport sector is not covered by the ETS in the EU, with the exception of international air transport.

**EU fleet limit value**

European regulation to limit CO<sub>2</sub> emissions for passenger cars and light commercial vehicles. The average emissions of a manufacturer's newly registered vehicles may not exceed a legally fixed limit value in grams of CO<sub>2</sub> per kilometre driven. The average emissions of passenger cars must not exceed 95 g/km from 2020 and 147 g/km for light commercial vehicles (vans up to 3.5 t).

**European Train Control System (ETCS)**

The ETCS enables trains to run without main and approach signals, and safety can be increased as a result. This system is similar to an autopilot, which is also used in commercial aviation.

**Fischer-Tropsch process**

The Fischer-Tropsch process can be used to synthetically produce electricity-based liquid fuels such as petrol, diesel and kerosene that are compatible with the existing infrastructure (vehicle drives, filling stations).

**Flexible forms of transport**

Forms of transport that supplement conventional public transport with demand-oriented mobility services.

**Fuel cell electric vehicle (FCEV)**

FCEVs are electric vehicles that obtain their drive energy from the reaction of hydrogen and oxygen in the fuel cell.

**Greenhouse gases (GHG)**

Greenhouse gases are atmospheric trace gases that contribute to the greenhouse effect and can have both a natural and an anthropogenic origin. The main greenhouse gases are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O/laughing gas).

**Grid integration**

Integration of the electricity provided by decentralised/distributed production plants/energy sources into the general grid/distribution grid, which requires active management and direct communication between suppliers and consumers. This is closely related to the market penetration of electric mobility, the increase in grid load and controllability of the charging system. E-vehicles are regarded as controllable loads and mobile storage units.

**Gross electricity consumption**

Gross electricity consumption is the total amount of electricity produced or imported in an economy less the amount of energy exported. All sources of electricity generation are taken into account. Compared to net electricity consumption, this figure also includes the electricity generation plants' own consumption, pumping electricity consumption and power losses.

**Hybrid electric vehicle (HEV) / hybrid vehicle**

A commercial vehicle that combines an electric and conventional drive and energy system. The vehicle is equipped with both a combustion engine and an electric motor.

**Infrastructure-to-everything (I2X)**

Electronic communication between the transport infrastructure and road users.

**Intermodality**

Intermodality describes a transport system that offers users the option of using and switching between different modes of transport.

**Internal combustion engine (ICE)**

An engine that generates motive power by burning fuel inside itself.

**Internal combustion engine vehicle (ICE/ICEV)**

Passenger car, powered by internal combustion engines, potentially with hybridisation as well, but without an external power supply.

**Interoperability**

Ability of different systems, programs and techniques to work together as seamlessly as possible.

**Levels of automation**

Vehicle automation is classified by levels in Europe and the US. It is considered the standard by most experts:

Level 0:

Driver only, no intervening vehicle system active

Level 1:

Assisted, system takes over longitudinal or lateral assistance permanently

Level 2:

Semi-automated, system takes over longitudinal and lateral assistance in a specific application

Level 3:

Highly automated, system takes over longitudinal and lateral assistance in a specific application, and it recognises system limits and asks the driver to take over with sufficient time reserve

Level 4:

Fully automated, system can handle all situations automatically in specific applications

Level 5:

Driverless, system takes over the driver's task completely, this applies to all road types, speed ranges and environmental conditions.

See also 'Automation (of vehicles) / autonomous driving' entry

**Light detection and ranging (lidar)**

Optical method for measuring distance and speed. Lidar systems work in a similar way to radar. Instead of radio waves, however, laser beams are used.

**Liquefied natural gas (LNG)**

Natural gas that is liquefied by cooling it to below 160 °C and is thus highly compressed. Due to its small volume (approx. 1/600th of the gaseous state) it can be transported in special containers, e.g. by ship. LNG can be used in its liquid state or, after regasification, in its gaseous state.

**Load management**

In the current power supply system, the demand for electricity generally determines the operation of power plants. The electricity supply adapts to fluctuations in demand via the operation of the power plants. As the power supply system becomes increasingly geared towards renewable energies, it will be important in future to adapt the load to the supply to a certain extent, i.e. to the availability of wind and solar power first and foremost. This reduces the need for fossil power plants and storage capacities.

**Methanol route**

Methanol can serve as an intermediate product in future fuel logistics chains and can be processed into various fuels.

**Mild hybrid electric vehicle (MHEV)**

In mild hybrid vehicles, the electric drive only has a supporting function. It increases the performance and energy efficiency of the combustion engine.

**Modes of transport**

Modes of transporting passengers, goods and services. Transport modes include land transport (rail, road, inland waterways), maritime and air transport.

**Multimodality**

Multimodality describes a transport system that offers users the option of using different modes of transport.

**National Platform for Electromobility (NPE)**

An advisory body of the German Federal Government founded in 2010 to promote electromobility, which was transferred to the National Platform Future of Mobility (NPM) in 2018.

**Natural gas**

Combustible fossil gas mixture whose main component is methane (CH<sub>4</sub>) and which occurs in underground deposits. It was formed over 500 million years ago in some cases and is naturally colourless, non-toxic and odourless.

**Nitrogen oxides (NOX)**

Nitrogen oxides is a collective term for various gaseous compounds that are made up of the atoms nitrogen (N) and oxygen (O). In simplified terms, only the two most important compounds, nitrogen monoxide (NO) and nitrogen dioxide (NO<sub>2</sub>) are included.

**Non-ETS sectors**

The non-ETS sectors consists of transport, buildings, agriculture and smaller section of energy and industry. The Climate Action Regulation establishes binding national GHG targets in this area.

**Overall efficiency**

Efficiency describes the ratio of energy input to the output obtained (e.g. electricity or heat). The overall efficiency of plants for generating electricity consists of the electrical and thermal efficiency.

**Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (RED II)**

This directive stipulates that at least 32 per cent of energy consumption (electricity, heat and transport) in the EU is to come from renewable sources by 2030. In the heating sector, Member States are to increase the share of renewable energy by at least 1.1 percentage points per year. In the transport sector, the share of renewable energies is to increase to 14 per cent by 2030.

**Particulate matter (PM<sub>x</sub>)**

Particles in the air that do not sink to the ground immediately but remain in the atmosphere for a certain time. Particulate matter can be of natural origin or produced by human activity. In conurbations, road traffic in particular is a significant source of particulate matter, with particulate matter not only being emitted into the air from engines – primarily diesel engines – but also from brake and tyre wear and from dust swirling up on the surface of the road.

**Performance parameter**

Characteristic property of a technical process or installation.

**Platooning**

In platooning (electronic drawbar), several lorries are linked together by electronic means. They are able to communicate with each other in real time. If the vehicles are arranged in a convoy, the lead vehicle can transfer its driving behaviour to the others. This makes it possible to carry out acceleration or braking processes for all vehicles synchronously.

**Plug-in hybrid electric vehicle (PHEV)**

A plug-in hybrid electric vehicle whose battery can be charged both via the internal combustion engine and the grid.

**Power-to-X (PtX)**

In this context, power-to-X stands for fuels that are converted into hydrogen using (renewable) electricity and then further converted synthetically with CO or CO<sub>2</sub> into gaseous (power-to-gas = PtG) and liquid hydrocarbons (power-to-liquid = PtL).

**Primary raw materials, secondary raw materials**

Primary raw materials are natural resources that have not yet been processed apart from being removed from their natural source.

Secondary raw materials do not originate directly from natural sources but are obtained through reprocessing (recycling).

**Real net output ratio**

The real net output ratio describes the share of production that a company contributes itself and the share that is provided externally, i.e., by other companies. Another term is vertical integration.

**Rebound effect**

Refers to the difference in volume between the potential resource savings that result from certain efficiency improvements and the actual savings. The effect thus corresponds to the increased demand for resources induced by increased resource efficiency.

**(Ride) pooling**

A group of passengers with similar destinations is bundled together in a carpool in one vehicle. This can be done more easily and efficiently in a digitalised mobility system by means of an algorithm.

**Ride sharing**

Ride sharing is a permanently organised carpool and can be organised privately or through a provider.

**Second-life/second-use application**

Further use of aged batteries in secondary storage applications, for example in stationary electricity storage systems.

**Sector coupling / sector integration**

Linking of electricity, heat, mobility and industrial processes and their infrastructures with respect to energy technology and energy management. The aim is to decarbonise energy use in industry, households, commerce/trade/services and transport while at the same time making it more flexible, based on the premises of economic efficiency, sustainability and security of supply.

**Short-range communication technology / cellular standard**

Transmission technology for vehicle communication. Driving information is transmitted from vehicle to vehicle over short distances, for example to warn of danger. In contrast, mobile phone technology enables communication over long distances. The different transmission technologies can be used on an alternative, complementary or redundant basis. NPM is committed to technology neutrality in transmission standards.

**Short-time allowance**

If, for certain reasons, the normal working hours are temporarily reduced, the loss of earnings can be partially compensated for by the short-time allowance, which is a benefit from unemployment insurance.

A cellular mobile communications network is based on a large number of base stations. The coverage area is divided into radio cells. The cellular structure allows optimal use of the limited number of available radio channels.

**Skills Development Opportunities Act**

Law to strengthen training opportunities and provide more protection in unemployment insurance, in force since 1 January 2019.

**Smart health**

Smart health stands for the digitalisation of the health-care system and means the use of new technologies for process optimisation and better care in the health-care system. The collective term covers various systems and applications, such as apps that make it possible to monitor human fitness and health, or the possibility of attending virtual consultations with a doctor (e.g. via video chats).

**Smart meter gateways**

Communication unit in an intelligent metering system for receiving and processing metering data.

**State of health (SOH)**

Condition of a battery compared to the ideal conditions. A battery typically has a 100 per cent value at the time of manufacture.

**Steam reforming**

Process for producing hydrogen from carbon-based energy sources (especially natural gas). The energy source reacts with steam at high temperatures to form hydrogen and carbon monoxide.

**Sulphur oxides (SO<sub>x</sub>)**

Sulphur oxides is the collective name for oxides of the chemical element sulphur. In particular, sulphur dioxide (SO<sub>2</sub>), a colourless, pungent smelling, water-soluble gas, affects human health and the environment. Sulphur dioxide is mainly produced during combustion processes of fossil fuels (e.g. coal and oil) due to oxidation of the sulphur contained in the fuel.

**Surplus electricity**

Surplus electricity comes about during periods when production exceeds demand, and even storage or other flexibility options do not allow for a shift in time. A distinction must be made here between periods in which nationwide production from renewable energies exceeds demand (nationwide 'surpluses') and situations in which renewable electricity quantities cannot be integrated into the current energy system due to local grid bottlenecks.

**Synthetic fuels**

Synthetic fuels are certain fuels that differ from conventional fuels due to their more complex production process. Like hydrogen, they belong to the category of so-called electricity-based fuels. Together with biomass-based fuels, they are referred to as alternative fuels.

**Synthetic natural gas (SNG)**

Synthetic gas whose chemical properties are identical to those of natural gas. The starting material is hydrogen, from which methane is produced with the addition of carbon dioxide.

**System efficiency**

System efficiency describes the improvement in vehicle utilisation and optimisation of operation.

**Toolbox**

In this context, toolbox refers to the set of tools for developing strategic personnel planning and training for companies.

**Transformation Society (Transformationsgesellschaft)**

Network for the development of regional transformation plans, with the participation of the Federal Employment Agency, trade unions and employers' associations, state governments and chambers as well as companies with training needs and services.

**Value-added network**

Network of companies for cooperation in the production process.

**Vehicle-to-everything (V2X)**

Describes an intelligent traffic system in which all vehicles and infrastructure systems are digitally linked.

**Vehicle and driver efficiency**

Vehicle and driver efficiency describes the reduction of energy consumption in the vehicle per kilometre driven.

**Vulnerable road users**

Unprotected road users who are at particular risk of being injured or killed in road traffic, for example because they are not surrounded by a driver's cab. Vulnerable road users include pedestrians, cyclists and motorcyclists as well as persons with reduced mobility.

# List of abbreviations

|                         |   |
|-------------------------|---|
| <b>AI</b>               | artificial intelligence   |
| <b>AC</b>               | alternating current   |
| <b>BEV</b>              | battery electric vehicle  |
| <b>BMBF</b>             | Federal Ministry of Education and Research  |
| <b>BMU</b>              | Federal Ministry for the Environment, Nature Conservation and Nuclear Safety  |
| <b>BMVI</b>             | Federal Ministry of Transport and Digital Infrastructure  |
| <b>BMWi</b>             | Federal Ministry for Economic Affairs and Energy  |
| <b>BVWP</b>             | Federal Transport Infrastructure Plan   |
| <b>bn</b>               | billions  |
| <b>CCAM</b>             | Platform of the European Commission for a Cooperative, Connected and Automated Mobility                             |
| <b>CEN</b>              | European Committee for Standardization (French: Comité Européen de Normalisation)                                   |
| <b>CENELEC</b>          | European Committee for Electrotechnical Standardization (French: Comité Européen de Normalisation Électrotechnique) |
| <b>CNG</b>              | compressed natural gas  |
| <b>CO<sub>2</sub></b>   | carbon dioxide  |
| <b>CO<sub>2</sub>eq</b> | carbon dioxide equivalent   |
| <b>CT</b>               | combined transport  |
| <b>DC</b>               | direct current  |
| <b>DCKN</b>             | German-Chinese Commission for Collaboration on Standardisation  |
| <b>DG GROW</b>          | European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs                    |
| <b>DIN</b>              | German Institute for Standardization  |
| <b>DKE</b>              | German Commission for Electrical Engineering, Electronics & Information Technologies of DIN and VDE                 |

|                      |  |
|----------------------|--|
| <b>ELAB 2.0</b>      | 'Electromobility and employment' study of the Fraunhofer Institute for Industrial Engineering IAO, 2018  |
| <b>ETCS</b>          | European Train Control System  |
| <b>ETSI</b>          | European Telecommunications Standards Institute  |
| <b>EU-ETS</b>        | European Emission Trading System   |
| <b>EV</b>            | electric vehicle   |
| <b>FCEV</b>          | fuel cell electric vehicle   |
| <b>FG</b>            | focus group  |
| <b>g</b>             | gram   |
| <b>GHG</b>           | greenhouse gas emissions   |
| <b>GRVA</b>          | UNECE working group on autonomous and networked driving (French: Groupe de Rapporteur des Vehicules Autonomes)   |
| <b>GVW</b>           | gross vehicle weight   |
| <b>H<sub>2</sub></b> | hydrogen   |
| <b>IAB</b>           | Institute for Employment Research, Research Institute of the Federal Employment Agency   |
| <b>ICE/ICEV</b>      | internal combustion engine / internal combustion engine vehicle  |
| <b>IEC</b>           | International Electrotechnical Commission  |
| <b>IPCEI</b>         | European funding initiative for Important Projects of Common European Interest   |
| <b>ISO</b>           | International Organization for Standardization   |
| <b>ISO/SAE 21434</b> | standard on cybersecurity/information security of networked road vehicles, currently under development and due for publication at the end of 2020: ISO/SAE 21434 Road Vehicles – Cybersecurity Engineering |
| <b>ITU</b>           | International Telecommunications Union   |
| <b>KAVSF</b>         | Korean Autonomous Vehicle Standardization Forum  |

|                       |  |
|-----------------------|--|
| <b>KBA</b>            | German Federal Motor Transport Authority   |
| <b>kg</b>             | kilogram   |
| <b>km</b>             | kilometre  |
| <b>km/a</b>           | kilometres per year  |
| <b>km/d</b>           | kilometres per day   |
| <b>kW</b>             | kilowatts  |
| <b>kW/h</b>           | kilowatt-hour  |
| <b>Lidar</b>          | light detection and ranging  |
| <b>LNF</b>            | light commercial vehicles  |
| <b>LNG</b>            | liquefied natural gas  |
| <b>m</b>              | millions   |
| <b>METI</b>           | Japanese Ministry of Economy, Trade and Industry   |
| <b>MHEV</b>           | mild-hybrid electric vehicle   |
| <b>NO<sub>x</sub></b> | nitric oxide   |
| <b>NPM</b>            | National Platform Future of Mobility   |
| <b>OEM</b>            | original equipment manufacturer  |
| <b>PHEV</b>           | plug-in hybrid electric vehicle  |
| <b>PtX</b>            | power-to-X   |
| <b>P2P</b>            | peer-to-peer   |
| <b>RE</b>             | Renewable energies   |
| <b>RED II</b>         | Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (RED II) |
| <b>R&amp;D</b>        | research and development   |
| <b>SAE</b>            | Society of Automotive Engineers  |
| <b>SNG</b>            | synthetic natural gas  |

|              |  |
|--------------|--|
| <b>SoH</b>   | indicator that describes the condition of a battery in relation to its ideal power state (state of health) |
| <b>SOx</b>   | Sulphur oxide  |
| <b>SUV</b>   | sports utility vehicle   |
| <b>t</b>     | tonnes (metric ton)  |
| <b>TCMV</b>  | Technical Committee on Motor Vehicles of the European Commission   |
| <b>TWh</b>   | terawatt-hour  |
| <b>UNECE</b> | United Nations Economic Commission for Europe  |
| <b>VDA</b>   | German Association of the Automotive Industry  |
| <b>WG</b>    | working group  |
| <b>5G</b>    | mobile phone standard of the fifth generation  |

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# List of publications of the NPM

## Working Group 1 – Transport and climate change

- WG 1 Interim report 03/2019 – ‘Wege zur Erreichung der Klimaziele 2030 im Verkehrssektor’ (Ways to achieve the 2030 climate targets in the transport sector).

## Working Group 2 – ‘Alternative Antriebe und Kraftstoffe für nachhaltige Mobilität’ (Alternative drive technologies and fuels for sustainable mobility)

- Short report 11/2019 – ‘Elektromobilität. Fuel cells. Alternative Kraftstoffe – Einsatzmöglichkeiten aus technologischer Sicht’ (Electric mobility. Fuel cells. Alternative fuels – potential applications from a technological viewpoint).

## Working Group 3 – Digitalisation for the mobility sector

- Interim report 03/2019 – ‘Digitalisierung für den Mobilitätssektor’ (Digitalisation for the mobility sector)
- Interim report 12/2019 – ‘Handlungsempfehlungen zum autonomen Fahren’ (Recommendations for action on autonomous driving)

## Working Group 4 – Securing Germany as a place for mobility, production, battery cell production, primary materials and recycling, training and qualification

- Interim report 10/2019 – ‘1. Zwischenbericht zur Wertschöpfung’ (First interim report on value creation)
- Interim report 12/2019 – ‘1. Zwischenbericht zur Strategischen Personalplanung und -entwicklung im Mobilitätssektor’ (First interim report on strategic personnel planning and development in the mobility sector) (to be published at the beginning of 2020)

## WG 5 – Connecting mobility and energy networks, sector integration

- Report 03/2019 – ‘Sofortpaket Ladeinfrastruktur 2019’ (Emergency package of charging infrastructure measures 2019)
- Report 03/2019 – ‘Red-Flag-Bericht 10 % EV-Neuzulassungen’ (Red flag report: electric vehicles to make up 10 per cent of new registrations)
- Report 10/2019 – ‘Roadmap PtX’
- Report 10/2019 – ‘LNG- und CNG-Strategie im Schwerlastverkehr’ (LNG and CNG strategy in heavy-duty transport)

## WG 6 – Standardisation, norms, certification and type approval

- White paper 09/2019 – ‘Aktuelle Entwicklungen und Herausforderungen zur Zukunft der Mobilität’ (Current developments and challenges for the future of mobility)

As of: December 2019

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# Endnotes

- <sup>1</sup> See Wagner et al. 2018, p. 32 f.
- <sup>2</sup> See Mergener et al. 2018, p. 63 f.
- <sup>3</sup> See Allensbach Institute 2019.
- <sup>4</sup> See European Commission 2018.
- <sup>5</sup> See Lemmer 2019.
- <sup>6</sup> See Agora Verkehrswende 2019.
- <sup>7</sup> See Ausfelder et al. 2017, p. 88.
- <sup>8</sup> See Bundesregierung 2019 Mobilität der Zukunft gestalten.
- <sup>9</sup> See NPM 2019 Interim report WG 1, p. 53 f.
- <sup>10</sup> See Kraftfahrt-Bundesamt 2019 Fahrzeugzulassungen, p. 10, p. 30.
- <sup>11</sup> See Bundesregierung 2019 Eckpunkte für das Klimaschutzprogramm 2030, p. 9.
- <sup>12</sup> See NPM 2019 Interim report WG 1, p. 25 ff.
- <sup>13</sup> See NPM 2019 Interim report WG 1, p. 30 ff.
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- <sup>15</sup> See NPM 2019 Interim report WG 1, p. 41 ff.
- <sup>16</sup> See Bannon 2019.
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- <sup>18</sup> See Bauer 2018.
- <sup>19</sup> See Hoffmann 2018.
- <sup>20</sup> See BNetzA 2019 Ladesäulenkarte.
- <sup>21</sup> See Kwade et al. 2016.
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- <sup>33</sup> See Meisel et al. 2019.
- <sup>34</sup> See Günther 2019.
- <sup>35</sup> See NPM 2019 Interim report WG 3.
- <sup>36</sup> See Wagner et al. 2018, p. 32 f.
- <sup>37</sup> See Mergener et al. 2018, p. 63 f.
- <sup>38</sup> See Statistisches Bundesamt 2019.
- <sup>39</sup> See BDEW/ZSW 2019.
- <sup>40</sup> See Bundesregierung 2019 Klimaschutzprogramm 2030, p. 78.
- <sup>41</sup> See Bundesregierung 2019 Masterplan Ladeinfrastruktur.
- <sup>42</sup> See Kraftfahrt-Bundesamt 2019 Vierteljährlicher Bestand (Oktober).
- <sup>43</sup> See BNetzA 2019 Ladesäulenkarte.
- <sup>44</sup> See NPM 2019 Sofortpaket Ladeinfrastruktur, p. 4.
- <sup>45</sup> See NPM 2019 Red-Flag-Bericht.
- <sup>46</sup> See NPM 2019 Sofortpaket Ladeinfrastruktur.
- <sup>47</sup> See Bundesregierung 2019 Klimaschutzprogramm 2030, p. 78 f.
- <sup>48</sup> See BMWi 2019.
- <sup>49</sup> See NPM 2019 LNG- und CNG-Strategie im Schwerlastverkehr.
- <sup>50</sup> See Kraftfahrt-Bundesamt 2019 Fahrzeugbestand.
- <sup>51</sup> See NPM 2019 Interim report WG 1.
- <sup>52</sup> See NPM 2019 Roadmap PtX.
- <sup>53</sup> See NPM 2019 Roadmap PtX.
- <sup>54</sup> See NPM 2019 Roadmap PtX.
- <sup>55</sup> See DIN Deutsches Institut für Normung e. V. 2017, p. 9.

# Legal notice

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# **NPM**

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