acatech HORIZONS
Transforming Mobility

acatech

NATIONAL ACADEMY OF
SCIENCE AND ENGINEERING

The acatech HORIZONS series explores significant fields of technology that are looming large on the horizon, but whose impact remains uncertain. Each issue of HORIZONS is prepared by an independent, interdisciplinary project group with members from academia and business.

acatech HORIZONS strengthen and promote understanding and debate around new technologies. They open up new possibilities for shaping the future of society, define policy themes and so contribute to building a forward-looking consensus on innovation policy.

acatech HORIZONS

Transforming Mobility

Preface

Mobility and human development have always gone hand in hand and continue to do so. In the absence of efficient systems for transporting people and goods, modern industrial societies would be unthinkable. As well as determining the everyday life of our society, mobility enables participation in social life and is fundamental to a high quality of life.

Traffic does, however, have unwanted side effects. Many of today's means of transport cause noise, pollution and traffic accidents, while transport infrastructure often occupies valuable land and breaks up the landscape. And modern transport requires energy, which until now has largely been supplied by fossil-based fuels. As a result, together with housing and industry, the transport sector is a major emitter of climate-damaging greenhouse gases.

There is therefore an urgent need to shift transport and mobility as completely as possible to sustainable energy sources. However, completely new mobility options involving digital solutions are currently emerging.

We are thus going through a fundamental change in our transport systems and our mobility behaviour. Individualised solutions, new technologies, digital transformation, urbanisation and environmental targets will determine the mobility of tomorrow. We are at the dawn of an age of multi-modal "neo-mobility". Simply extrapolating from the past into the future is therefore inadequate. When it comes to evaluating different solutions, any underlying assumptions and conflicts of interest must be set out transparently and subjected to ongoing review.

The aim of this publication is to explain this complex transformation of our mobility system to the public at large and lead them on towards an attractive, liveable future. Ten key messages and four chapters discuss the challenges, potential and possible solutions for an innovative mobility system of the future. The focus is on people, while also taking account of technological, economic, environmental and social aspects.

We hope this issue gives you something to reflect on and wish you happy reading.

Karl-Heinz Streibich
President

Prof. Dr. Jan Wörner
President

Prof. Dr. Thomas Weber
Vice-President

3

Contents

Ten key messages on mobility

1. Mobility is much more than just being able to get around. It helps meet needs such as housing, education, food, work and leisure, and enables interaction with other people. Mobility thus means **participating in life.**

2. Even when we ourselves are not moving about, we generate traffic, for instance by ordering goods online. Globally, ever more **freight and passenger movements** are taking place.

3. Transport is thus (partly) responsible for traffic jams and noise in towns, where more and more people are living worldwide, for polluted air to breathe, more transport infrastructure and less nature and living space – and not least for **climate change.**

4. "Switching off" or restricting transport is not an option, but neither is simply carrying on as before. We need **new mobility concepts**, which make the transport of people and goods more environmentally friendly and are attractive to both urban and rural dwellers. This is because it is especially in the countryside that many people are dependent on cars.

5. Establishing this **balance between environment, transport and mobility** is one of the great challenges of our time. This is because it is **now** that we are **confronted with the big question of how we want to live in the future.**

6. Mobility is how we get around, but it is also how we plan residential areas and towns. If **urban and transport planning** were no longer thought of separately, but **together,** considerable traffic could be saved while simultaneously improving mobility conditions.

7. We are already in the midst of a **massive transformation** of mobility. Key levers for managing this transformation are digitalisation, green energy, and the expansion of rail, local public transport (LPT) and cycle paths, as well as new (drive) technologies and business models. Solutions may involve electromobility (e-mobility), hydrogen technologies, power-to-X (P2X) or sharing platforms. **Innovation** and environmental technologies also have the potential to create new jobs.

8. Particularly for people who have physical limitations on their mobility or who live in remote areas, future technologies, such as autonomous or on-demand systems, open up new **possibilities for mobility that are tailored to their needs.**

9. **Data is the lifeblood.** Businesses, policy makers, authorities, scientists and individuals using mobility data can now rethink data sharing and set the rules of the game for a **shared data space** which enables technology and new business models while at the same time protecting private and sensitive information.

10. **People** are key: only if as many people as possible get on-board with innovation, are **open to change** and use their market power as consumers by behaving sustainably will we be able to make mobility systems fit for the future.

1

What is mobility and why is it important?
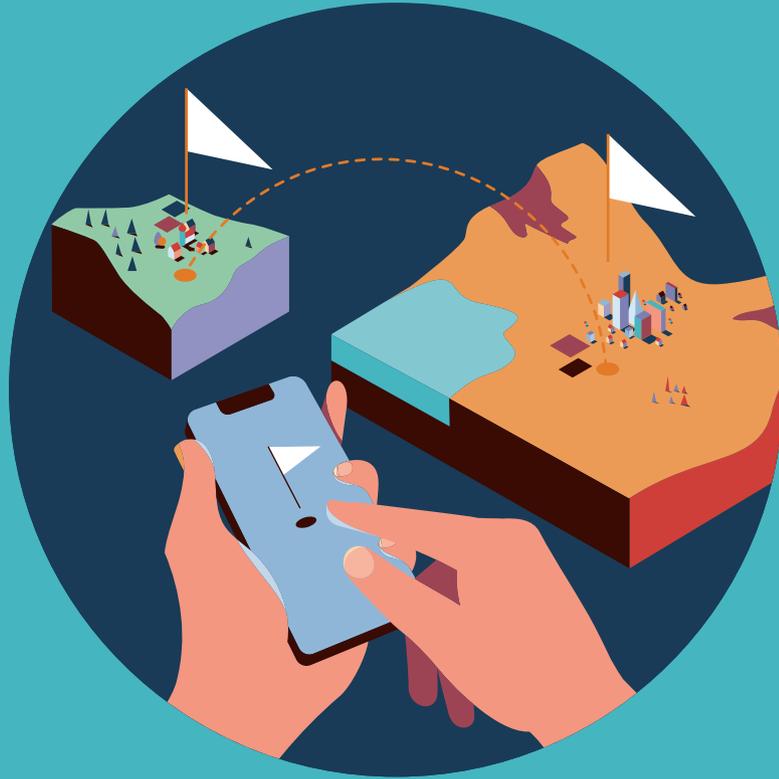
Most people are familiar with the term mobility. The first thing that comes to mind is often the car, train, bicycle or plane, but mobility is much more than that. So what's the hidden part of the iceberg? Who does it affect, and why is it more important today than ever? **Chapter 1** provides an overview.

Derived from the Latin "mobilitas", **mobility** means the ability to move or be moved. However, it is **much more complex and wide-ranging than the ability to move in physical space.** Each and every one of us is mobile on a daily basis to feed ourselves, travel to work, attend medical appointments, educate ourselves or travel. Even when we are not moving, we can still be "mobile", for instance by placing online orders or participating in video calls. Anyone who is mobile is able to meet daily, basic survival needs and interact with other people. Mobility thus concerns us all because it means **participating in life** and society.

> "Mobility is a prerequisite
> for meeting needs such as security,
> housing, food and employment.
> Transport is the physical
> implementation, i.e. moving
> from A to B."*

Throughout history, mobility has always shaped humanity. The first illustration in Chapter 1 provides an overview. It should be noted that mobility does not only enable participation, progress and freedom, if it is restricted it can conversely also lead to social inequality, exclusion and lack of freedom. Moreover, mobility and transport as we use them today have a serious **impact for the climate and the environment** (see Chapter 2.1).

We are therefore now confronted with the big question of how we want to live in future and how we can successfully and fundamentally transform **transport and mobility without disregarding people's mobility needs.** Since mobility is not natural but "made" by humans, redesigning it is our responsibility. The following chapters shed some light on what this might look like in future.

What do we mean by traffic and mobility?

While the phenomena of traffic and mobility have always existed, the current meaning of the words is relatively new. Historically, traffic could be taken to mean the social dealings or communications between people. It is only since the 20th century that we have understood it to mean the **transport of goods and people** and, more recently, expanded the meaning to include the **exchange of information in the form of data.** In German, the cognate term for mobility was coined as recently as the 1970s when it was used to denote intellectual and social mobility. Today it expresses our ability to easily **access the facilities necessary for our daily life.** However, there is still no generally applicable definition in German.[1]

> "Sustainable mobility means ensuring
> as many opportunities and freedoms
> as possible to shape everyday life
> with the least possible traffic volume
> and as little negative impact on the
> environment as possible."

---

*   Some selected key ideas expressed by interviewees are included in the text as anonymised quotes.

Mobility yesterday, today and tomorrow

Throughout history, mobility has always shaped people and their way of life, both spatially, i.e. through the transport of goods and people, and intellectually. This is why today we also associate mobility with the ideal of social participation and social equality.

Mobility
(ideally) is …

… supply of goods and data

Boats transport **people** and **goods** along the rivers of Mesopotamia.
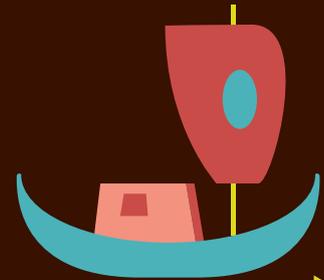
6th millennium BCE

The **railway revolutionises the transport of goods, people** and information; the **bicycle** and car usher in **private transport.** With industrialisation, factories emerge; for the first time, people ensure their day-to-day survival outside their village community: **mobility becomes a necessity of modern social life.**
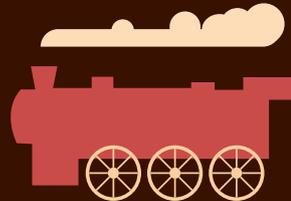
19th century

Cars and **passenger aircraft** become available to the mass market. Transport networks, rules of the road and motorways emerge. Humans no longer travel only out of necessity or for trade, but also for pleasure. **Travel,** previously the preserve of the elite, becomes **available to the masses.**

20th century

The **wheel** and **chariot** spread rapidly from Mesopotamia to all **cultural groups** and regions of the world.
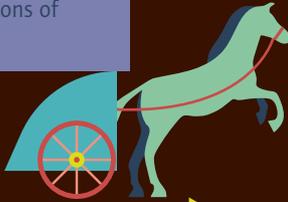
Beginning of the **Silk Road** establishing itself over the following centuries as the **largest trade route** across different cultures.
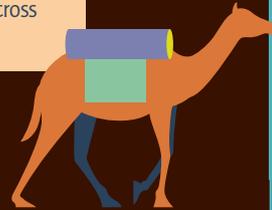
The **Roman Empire's road network** includes features of a **modern transport system.** Centrally planned and maintained from Rome, it extends from Europe through Asia Minor to North Africa.

4th millennium BCE

5th century BCE

2nd century

Steam navigation liberates shipping from wind and rowing, enabling more **precise scheduling and route planning.**
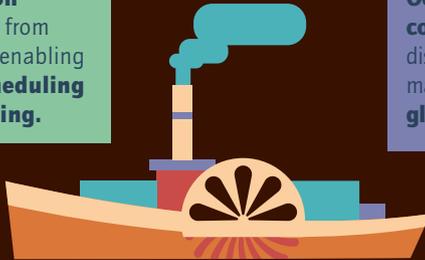
Ocean navigation and the **compass** enable the discovery of America, marking the beginning of a **global trading system.**
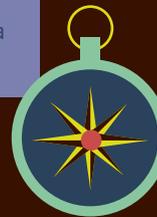
18th century

15th century

Virtual mobility: the internet becomes universally accessible; **data mobility is revolutionised.** Climate change and digital technologies usher in a fundamental transformation of mobility.
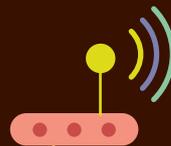
Climate targets achieved. Transport is digital, autonomous and connected. The mix of innovation, drive technologies and mobility solutions makes mobility **more sustainable, more flexible and more inclusive.**

21st century

2050

Source: own presentation

11
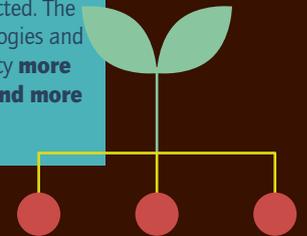
2

How are mobility and transport changing? Where do the challenges and the potential lie?

Climate change, urbanisation and digitalisation are driving the transformation of mobility. They are both a challenge and an opportunity to make a fresh start. **Chapter 2** throws light on future scenarios which are already being trialled and in some cases hotly debated today.

2.1 Climate change: in search of sustainable solutions for the future

> "We need new technologies which enable us to get around in an environmentally friendly way."

In recent years, we have seen **massive growth in traffic: ever more movements of goods and people** are taking place. Also **more and more people are living in cities:** globally, 55 per cent of the world's population already live in cities and by 2050 this proportion is likely to grow to around 70 per cent.[4] In Germany, some 75 per cent of the total population currently live in cities.[2,a] This all has an impact on increasing traffic, noise pollution, the air we breathe, high levels of stress on nature and habitats caused by transport infrastructure, and climate change. Transport is accordingly responsible for a quarter of Europe's greenhouse gas emissions and is a major cause of urban air pollution.[5] At this point, at the latest, it is clear that **environmental harm and climate change** pose enormous challenges to Europe and the world.[6]

> "In Germany, an internal combustion engine car travels on average 15,000 kilometres per year.[7] This corresponds to CO_2 emissions of 3 tonnes per year. By way of comparison, the CO_2 emissions from a long-haul flight between Germany and Australia (15,000 kilometres) amount to just under 3.2 tonnes, albeit per passenger."[8,b]

The European Union and Germany as well have therefore signed up to the **Paris Climate Agreement** and are endeavouring to achieve greenhouse gas neutrality in order to attempt to limit global warming to 1.5 degrees Celsius.[10] However, we will only achieve **overall climate targets if all sectors make their contribution.** This includes the transport sector which, after the energy sector and industry, is the third largest emitter of greenhouse gases.[6] Simply shutting down or turning off this sector is not an option if we want to enable people to continue to be mobile. It's more a matter of reducing traffic levels and making the sector greenhouse gas-neutral with **ever cleaner technologies.**

The second illustration provides an insight into some **possible energy sources and technologies for today and the future.** Experts from all over the world are currently investigating and discussing the potential and challenges posed by these innovations.

European Green Deal: on the way to the first climate-neutral continent?

Have you already heard about the European Green Deal? It's a kind of **roadmap for a sustainable EU economy,** defining a new strategy to help Europe achieve an environmentally friendly, resource-efficient and competitive economic model which is **designed to be fair and inclusive for all.** So quite a tall order! The ambitious goal is to become greenhouse gas neutral and thus the world's first climate-neutral continent by 2050.[9] Germany's Federal government is set to go one step further by amending the Climate Protection Act to bring the target date for achieving greenhouse gas neutrality forward to 2045 (as of May 2021).

---

a   Around 27 per cent of Germans live in medium-sized cities of 20,000 to 100,000 inhabitants and some 31 per cent in large cities of over 100,000.[3]

b   In Germany, the CO_2 emissions for travelling the same distance by train amount to 534 kilograms per passenger.

c   As technology currently stands, producing carbon-neutral hydrogen and in particular carbon-neutral e-fuels requires very high inputs of green electricity.

d   A wide range of models of electric vehicle are already available and they make a significant contribution to reducing transport sector emissions. For existing combustion vehicles, e-fuels are also an option for climate-friendly mobility. E-fuel production involves a chemical process to convert renewable electricity into liquid fuels, but nitrogen oxides continue to be released during combustion. Besides, hydrogen is a solution for the future. The production process for clean hydrogen is still highly complex. Corresponding vehicles which use a fuel cell to convert hydrogen into electricity, which in turn drives an electric motor, are not yet available in sufficient numbers.[12]

"We must not allow technological development to bypass people. Any developments must remain accessible and affordable to all."

A contribution to the environment: joined-up thinking on energy and transport

Environmental problems can only be solved if we bring energy and transport together. Accordingly, **electric power is becoming the most important energy source for the vehicles of the future,** either directly in battery electric drive systems or indirectly via the electrolytic production of synthetic motor fuels or e-fuels, and hydrogen[c] and the use of fuel cells. Such locally emission-free vehicles can, however, only make a **contribution to climate protection** if the **electricity used for transport is renewably generated.** Power generation, which is increasingly based on wind and solar, is, however, weather-dependent and therefore intermittent. This means that generation exceeds demand on some days while on others too little "green electricity" is generated. As the energy transition progresses, there is a need for flexible and smart coordination of electricity supply and demand. Controlled and bidirectional charging of electric vehicles and using hydrogen storage systems can provide precisely such flexibility. The **transport and energy sectors are complementary** in this way and are growing hand in hand thanks to "sector coupling".[11]

"E-mobility and hybrid technology are already a reality and most advanced in light vehicles. In future, hydrogen and e-fuels will be conceivable for aviation, shipping, railways, trucks and possibly cars. A number of technologies will coexist.[d] But technology neutrality will be required."

Rebound effect: when one step forwards means two steps back

Many people are putting their faith in technological innovation to be the cure-all for achieving climate targets. But it often doesn't turn out this way, as the rebound effect shows. For instance, a modern car achieves the same performance as older models while consuming less fuel. However, this can have an impact on driving behaviour. Precisely because fuel consumption is lower, people tend to travel more often by car and drive longer distances. At the same time, heavier and larger vehicles are becoming increasingly popular. The upshot is that **technological efficiency can indirectly result in additional consumption.**[13] Although vehicles have become significantly more efficient, effects like this mean that emissions from the transport sector[e] in Germany are still stuck at 1990 levels.[10] So what's important is **being more aware of consumption** and asking oneself what is really necessary.

## More rail transport? A question for society and Europe

If what we want is to make mobility more environmentally friendly, more freight and passenger traffic should be shifted to rail. This will in turn mean expanding, modernising and digitalising rail transport. This can only work if **all European countries pull together:** it would make little sense to modernise rail transport say in Austria if, for example, the rail networks in Germany or Italy were then no longer compatible.

In addition, there is a **social issue.** Plans to build new railway lines or bring old ones back into service often give rise to citizens' action groups and protests, for instance because of noise pollution.[14] Technically, more options for noise control are available and now is the time to put money into this and to pave new ways forward jointly with citizens. More difficult to resolve, however, is the conflict of interests between expanding rail transport and protecting the local environment.
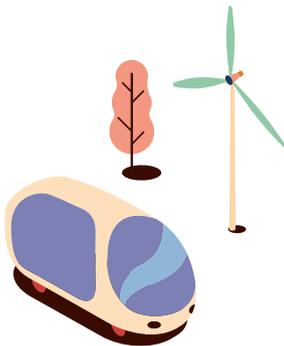
"We need European cooperation: only if everyone joins in can rail modernisation work."

---

e   This is also due to ongoing growth in passenger numbers and freight volumes. Moreover, Germany is a "transit country" with large volumes of transiting passenger and freight traffic. There have also been sharp increases in travel, online shopping and returns of ordered goods. All of this increases traffic volumes and consequently emissions as well. So the overall result goes well beyond a rebound effect.
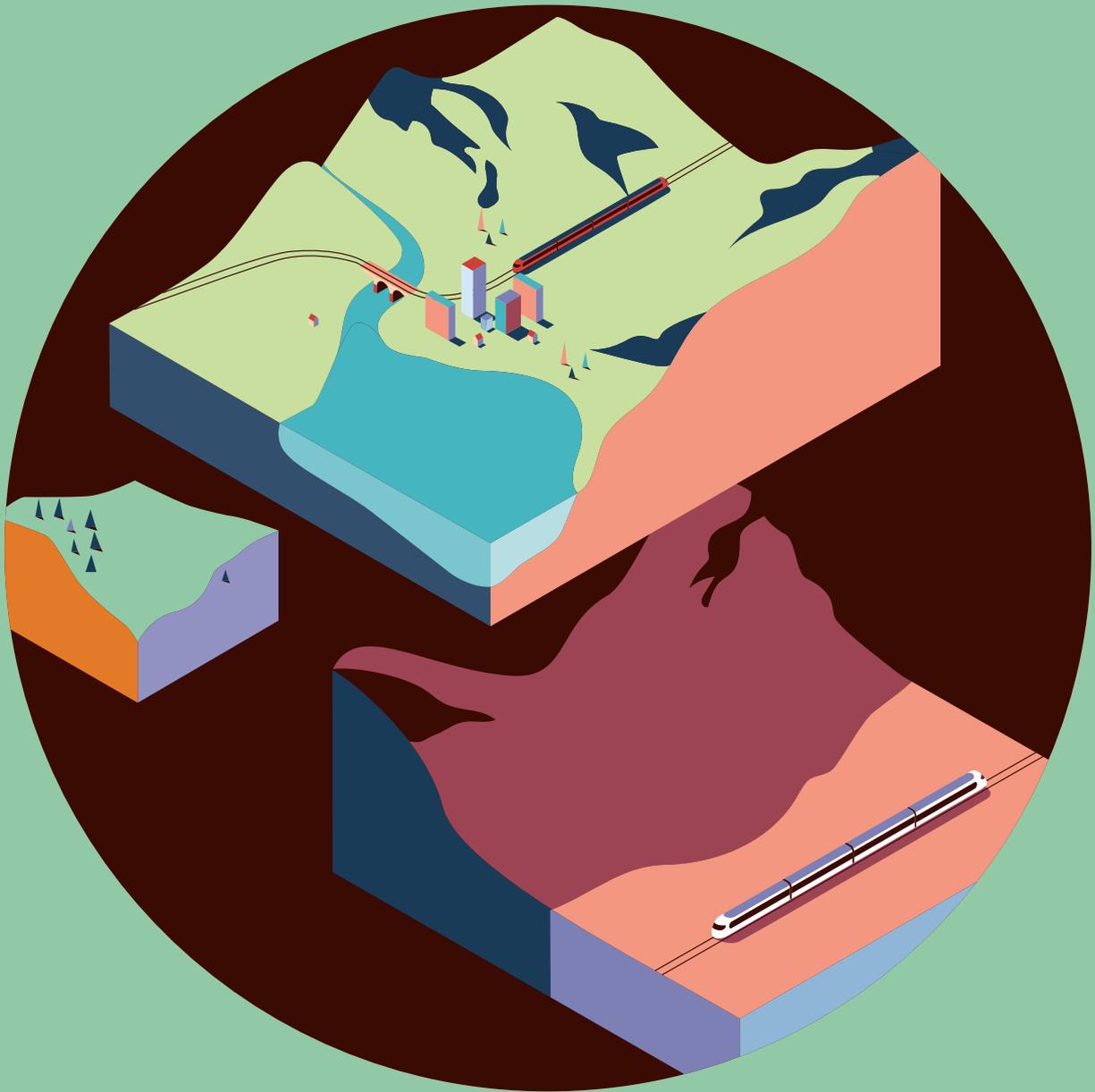
Climate change: in search of sustainable solutions for the future

Freight transport and traffic leave a substantial carbon footprint and so contribute to climate change. But mobility can also be more sustainable. Electricity from renewable energy sources, hydrogen and power-to-X are all **clean energy sources** and are the target of **global research** and investment.

	European Green Deal: Europe wants to be greenhouse gas neutral by 2050.
	Several of the United Nations' Sustainable Development Goals are directly or indirectly associated with the mobility of people and goods.
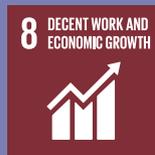
	The German Federal government is set to amend the Climate Protection Act to bring the target date for achieving greenhouse gas neutrality forward to 2045 (as of May 2021).

Electricity from renewable energy sources

We all know about electricity – it's what comes out of the socket. All the same, it's difficult to get a handle on what it actually is. Renewable electricity is a form of energy obtainable from wind, water and sun. It is of particular interest for e-mobility.

Source: own presentation

Hydrogen

Water (H_2O) consists of oxygen (O_2) and hydrogen (H_2). Once separated, the hydrogen can be used as an energy source.

Power-to-X

Using electricity generated from renewable energy sources, hydrogen is combined with CO_2, resulting in climate-neutral e-fuel.

O_2

H_2 $\longrightarrow$

H_2 $\longrightarrow$

H_2 $\longrightarrow$

CO_2

CO_2

H_2

H_2O

Electrolyser

Synthesis reactor
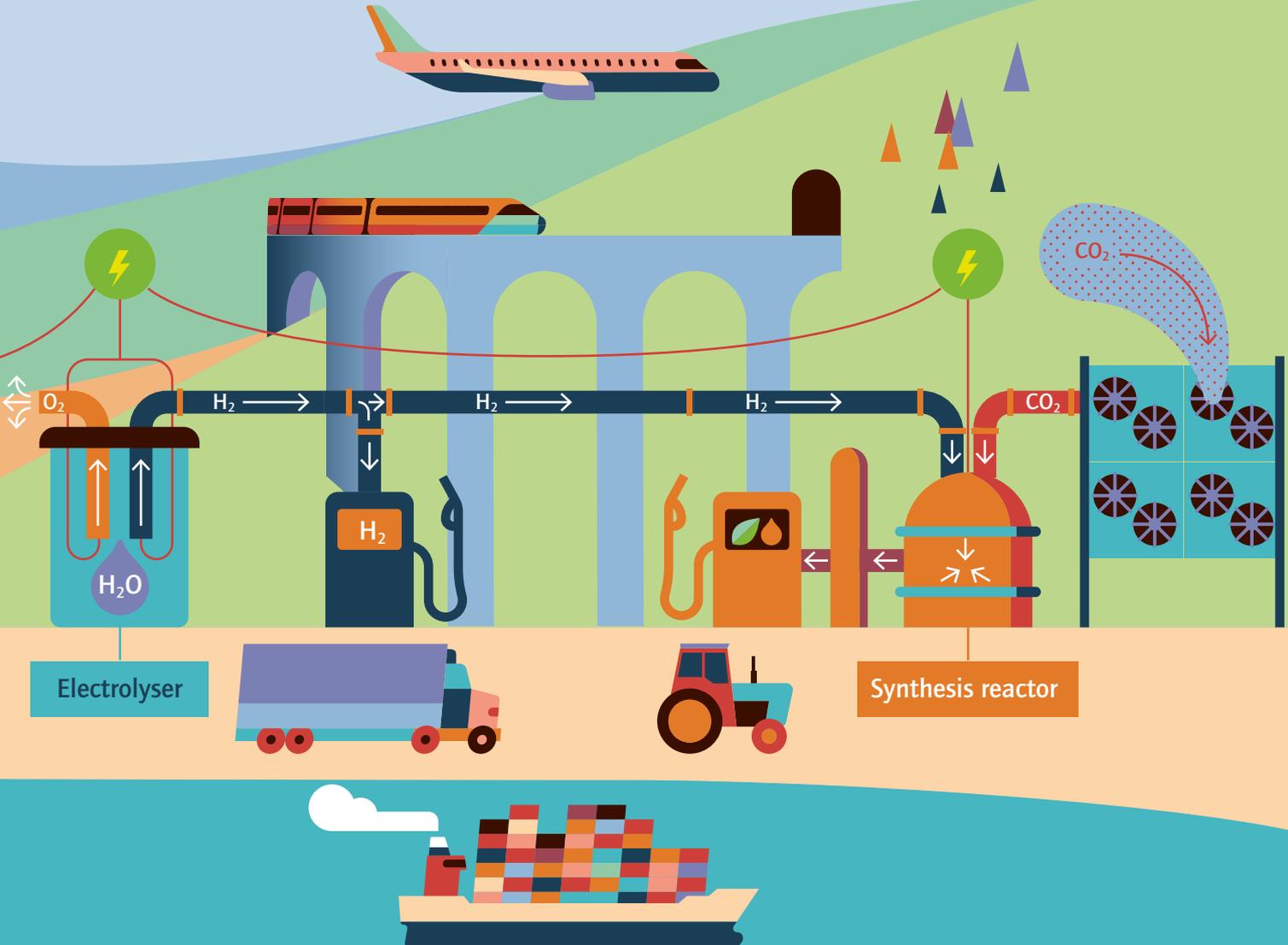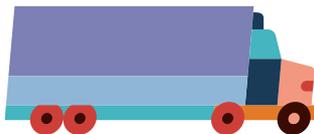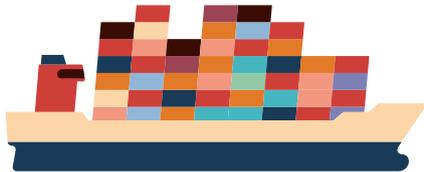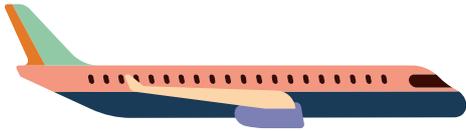
Electricity from renewable energy sources

We all know about electricity – it's what comes out of the socket. All the same, it's difficult to get a handle on what it actually is. Renewable electricity is a form of energy obtainable from wind, water and sun. It is of particular interest for e-mobility.

How does it work?

The principle is simple: wind or flowing water set a turbine in motion and a generator converts the movement into electricity. For solar power, it's even simpler: sunlight hits a solar panel and generates a flow of electrons, i.e. electricity.

What's the potential?

Unlike fossil fuels such as coal, this "clean" electricity gives rise to no CO_2 by combustion. E-mobility, such as electrically powered e-scooters or buses, is only climate-friendly if it's powered by clean electricity.

So how far have we come?

There were hydroelectric power stations as long ago as the 19th century. Since the start of the energy transition, renewable energies have become increasingly significant and in Germany they already account for about half of electricity generation.

What are the snags?

Wind, water and sun are not necessarily available when we would like them to be, so we're dependent on the weather and the season. The problem is that electricity is not so easy to store.

Why not just use batteries?

Only limited amounts of electricity can be temporarily stored in batteries, for instance in the battery of a smartphone. If we wanted to used renewable energy to replace the energy that is available around the clock today by burning fossil fuels or from nuclear power, the number of batteries needed for storage would be unaffordable.

Hydrogen

Water (H_2O) consists of oxygen (O_2) and hydrogen (H_2). Once separated, the hydrogen can be used as an energy source.

How does it work?
By means of an electrolyser, a large-scale plant which splits water into its component parts. This requires electricity, ideally from renewable energy sources. Only then is the result of electrolysis green, climate-friendly hydrogen. This can be transported in gas or in the combined form and subsequently converted back into electricity.

What's the potential?
Hydrogen is one solution for storing and transporting renewable energy. In addition to cars, it is of particular interest for heavy vehicles, trains, ships and aircraft, where batteries come up against their limits because such vehicles require much more energy and consequently much larger, heavier batteries.
In the car, train or aircraft, hydrogen is converted back into water in a fuel cell, so giving rise to energy, i.e. electricity. The advantages are less noise, fewer wear parts and no exhaust fumes.

So how far have we come?
This technology has been around for over thirty years. It is on everyone's lips today as researchers around the world are seeking out clean energy sources. Germany and other countries have even developed their own hydrogen strategies.

What are the snags?
In itself, the technology is simple. As things stand at present, using hydrogen on a large scale across a number of sectors would mean importing large volumes of hydrogen.
Moreover, fuel cells are less energy-efficient than battery electric vehicles.

Power-to-X

Using electricity generated from renewable energy sources, hydrogen is combined with CO_2, resulting in climate-neutral e-fuel.

How does it work?
Using electricity (power) from renewable energy sources, hydrogen is mixed with CO_2 drawn from the atmosphere in synthesis reactors. The result is a liquid (power-to-liquid) or gas (power-to-gas) which refineries can then use to produce climate-neutral e-fuel.

What's the potential?
E-fuel is in particular of interest because it works with conventional diesel and petrol cars and can be supplied via ordinary filling stations. Ideally, this means you don't need a new car to drive climate neutrally.

So how far have we come?
Pretty much at the beginning as energy-efficient processes are not yet available.

What are the snags?
Again, large quantities of renewable energy are required and the repeated energy conversion results in losses. At present, burning e-fuel still produces fine particulates which pollute the air.

2.2 Transforming mobility by digitalisation

"In future, we'll have a mix of private, public and sharing-based mobility solutions."

Digitalisation is transforming mobility and it's already **simplifying people's lives.** For example, car drivers are benefiting from navigation systems, parking aids, voice control, driving assistants or apps for paying parking charges and reserving parking spaces. Public transport passengers can book their journey, receive (online) journey information and pay digitally via the internet or apps. Many new sharing solutions such as car, bike and e-scooter rental systems are only possible thanks to digitalisation.

In the future, **digitalisation will be key** to making **mobility even more flexible, convenient and accessible to all.** This will be helpful for the economy and society in equal measure. For instance, combinable transport systems ranging from e-scooters and (autonomous) on-demand shuttle buses to tram and rail systems which can all be booked and easily paid for in a single app can make an important contribution. As a result, digitalisation can improve individual mobility. However, it also has the potential to make mobility more environmentally friendly and space-saving by **more efficiently bundling transport solutions, avoiding congestion and reducing traffic.**[15] The third illustration provides an overview of what this might look like in the future.

At the same time, digitalisation is not only changing the way we move around, but also our need to do so: home offices, video calls or online courses enable us to be virtually mobile and to communicate with other people without having to move physically. Instead of road traffic, **virtual mobility generates data traffic in data spaces.** The computers and servers required for this purpose in turn consume electricity. Right now there is an **urgent need** to address the **high energy and resource consumption** of digital technologies[f] in order to make digitalisation and mobility truly environmentally friendly. In other words, digitalisation is a significant key to making mobility more sustainable – provided that digitalisation is itself sustainable. This means not simply blindly digitalising but instead planning from the outset how the consequent high power requirements can be met with clean energy.

"Used responsibly, digitalisation can be a positive tool for managing the transformation of mobility. Sustainability by design is the watchword. Leading experts have already taken this on-board in terms of both hardware and software."

What will autonomous connected transport look like from 2030?

acatech's **New autoMobility II STUDY** gives you a picture of what the traffic of the future might look like! Twelve snapshots of the future describe the technological possibilities of smart traffic control and new forms of cooperation between automated and non-automated road users from the standpoint of social participation and ethical issues.[18]

"Traffic could flow much more smoothly with smart traffic light control or smart parking,[g] so considerably cutting down on city centre traffic. In my opinion, we're just at the beginning of what's technically feasible."

Data – the lifeblood of digitalisation

Data privacy and security are highly valued in Germany and Europe. At the same time, data is **key to innovative, digital mobility solutions.** The time is right for society to take a joint look at the rules of the game for a mobility data space which **not only enables innovative mobility services but also protects private and sensitive information.** However, taken alone, the best rules of the game will not achieve much if the potential offered by data and digitalisation to society and industry remains untapped. There is a need for all players here: private and public mobility providers and infrastructure operators across institutions and sectors, from the automotive industry and the IT sector to policy makers and society, must be creative, put innovation into practice, and drive forward new, user-friendly and sustainable mobility solutions. If you would like to find out more, take a look at the **Mobility Data Space,** which is co-sponsored by acatech.[17]

"Over ninety per cent[19] of traffic accidents involve human error. New technologies such as driver assistance systems up to autonomous driving could considerably reduce this number."

---

f   One study estimates that, as digitalisation progresses, the **production and operation of terminals** (such as smartphones or computers) together with the operation of data centres and network infrastructure could cause between **16 and 22 megatonnes of CO_2 emissions annually** across Germany. Estimates do, however, suggest that **digital technologies** also have the **potential to save around five times as much CO_2 as they cause.** It is estimated that, **by 2030,** digitalisation **could save up to 28 megatonnes of CO_2 in the mobility sector,**[16] which is almost as much as a city like Berlin emits in an entire year!

g   There is reason to fear rebound effects here too since improvements in traffic flow make travelling by car more attractive. This results in more cars and any "gain" is lost. The same rebound effect can occur even more acutely with parking: finding parking spaces more easily very quickly increases the number of vehicles which can then only continue to park more easily until the increasing traffic volume makes it more difficult again. New technologies can therefore reduce environmental impact, but only if they are put to sensible and carefully considered use. In this consideration, the disadvantages of increased traffic volume must be balanced against the advantages of better, cleaner and safer traffic.

Transforming mobility by digitalisation

Transport is responsible for a quarter of the EU's entire CO_2 emissions, with road traffic accounting for the majority. Digitalisation and new technologies can help to make transport and mobility more sustainable and more inclusive in the future.

Connected vehicles

Autonomous vehicles communicate in real time with each other and their surroundings. The entire traffic system is intelligently connected: traffic lights and digitalised lane markings control traffic flows in order to avoid congestion.

Mobility-on-demand

New business models emerge which focus more on use than ownership: with car sharing and ride sharing, mobility increasingly becomes a service. Such models also enable people without a car as well as the elderly to drive to the doctor's or supermarket.

Railway stations becoming mobility-hubs

with park and ride parking spaces, service stations for rental e-scooters, rental bicycles, autonomous e-buses and with a direct rail link to the city. All bundled into one app applying to both town and countryside. Mobility is connected, simple and convenient.

Source: own presentation

24
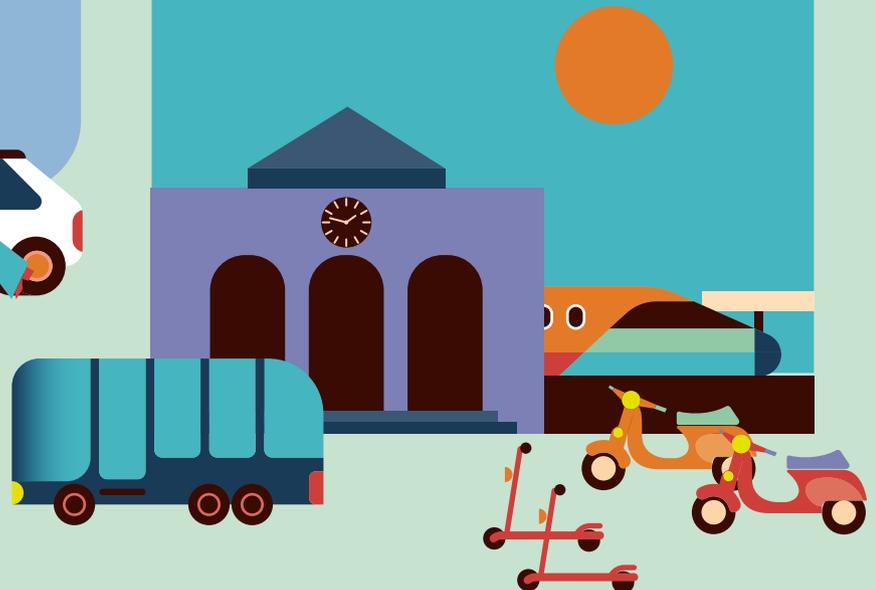
Energy and mobility interlinked

Photovoltaic panels on the roof generate electricity for the e-car. This in turn also acts as a mobile energy storage unit which returns the surplus electricity to the smart home, so saving considerable energy costs and making e-mobility more flexible.

Applied on a large scale, this could be a solution for storing renewable energy.

Safety

Walking sticks and helmets enhanced with sensors transmit a signal when danger occurs, improving safety for children, elderly or disabled. Driving becomes safer thanks to vehicles communicating with each other and scanning their surroundings so they can avoid accidents.

Mobility cloud

This is a prerequisite for digitalisation: businesses, public bodies, cities, local authorities, public transport operators and citizens share and use their data in a secure mobility cloud. Data is anonymised to protect privacy and sensitive company information.

Smart parking

Car drivers receive information about parking availability and price via app and are guided to the ideal parking space, so saving time, avoiding congestion and, above all, CO_2 emissions.

Digital souvereignty

German and European start-ups and businesses can now start working more intensively on establishing environmental and technological standards worldwide which are "Made in Europe". Europe has an opportunity to create its own data spaces and infrastructure and boost its economical and technical independence.
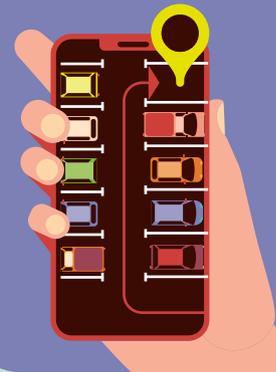
2.3 Town and country: linking two worlds

"Transport planning has always been an engineering matter. We absolutely have to get away from this silo mentality and coordinate transport planning with urban and regional planning."

What made good sense fifty years ago, namely separating the (then noisy) factories from the (then quiet) residential areas, is no longer appropriate today. Despite many people no longer working in factories but instead in offices, many of them still have to travel **long distances** to get to work, to the doctor's or to go shopping, **so causing more and more traffic.** There is **no longer any need for strict segregation between residential and industrial areas,** not least because it has long been possible for modern factories to be quieter, cleaner, smaller and more environmentally friendly. Such new, small-scale and smart factories are already making it possible **to radically rethink our manufacturing infrastructure:** away from manufacture in concentrated industrial areas, towards **decentralised manufacture in mixed-use areas** which combine rural living with jobs in the factories of the future. Structural change of this kind would be a **win-win situation for both town and country.** Cities, which at present often suffer from noise, traffic congestion and air pollution due to outdated urban planning, would be relieved of traffic and could **transform industrial areas** into urgently required **residential areas.** And **rural areas** would become more attractive thanks to new, **well-paid jobs.**

"Nowadays we are travelling increasingly long distances in our daily lives, but that doesn't mean we're getting more out of life."

There is also a lot of potential in railways. If disused railway lines can be brought back into service and local transport expanded in rural areas to connect outlying areas as well, town and country could be better connected, **while traffic could be considerably reduced** in volume and made cleaner. However, at least in the near future, local transport will not reach every small village away from conurbations. Any remaining gaps could in some places be bridged by buses or shared taxis. Indeed, something like this is already available.[20] Every building block counts.

But while more and more people on low incomes around the world live along noisy city streets, in the countryside they are isolated unless they can afford a car because, even in Germany, there is often no alternative to the car outside urban areas. **Distances can therefore lead to social inequality and "mobility poverty".**[21] This is not what liveable mobility should look like; mobility must not be an elite issue.

The fourth illustration shows how this can be counter-acted **by better coordinating urban, regional and transport planning.** The fifth illustration shows why it is important to develop new concepts which are geared towards the **rural environment** and the **needs of the people living there.**

"We must not have an urban outlook on rural areas — concepts are needed there which differ greatly from those in cities and are much better adapted to the needs and environment of the rural population."

Mobility Monitor: keeping a permanent eye on the population's opinions

What impact has the coronavirus crisis had on Germans' mobility behaviour? How well accepted is electromobility among the population? Are climate and environmental protection still important concerns? The **annual Mobility Monitor survey helps** us to keep the **opinions and needs of the population in mind** when designing the mobility system of the future. When it comes to electromobility, there is a yawning gap between reality and citizens' perceptions. We are being called upon to communicate better and more comprehensibly and to involve the public even more in the processes of transforming mobility. The Mobility Monitor survey revealed, for instance, that **59 per cent of the population regard environmental and climate protection to be particularly urgent political concerns,** that 61 per cent want to promote public local transport, but that the majority, at least of car drivers, still consider cars to be indispensable. Nevertheless, about a quarter of respondents want to ride their bikes or walk more often even once the coronavirus restrictions have been lifted. Curious to find out more? Then take a look at the **"Mobility Monitor" survey jointly initiated by acatech.**[22]

> "While we have extremely heavy traffic in cities, twenty kilometres outside there's nothing much going on. In the countryside, people without a car are often left behind and it shouldn't be that way."

Women on the move

Have you ever wondered what **gender has to do with mobility?** In fact, **transport planning** is not gender neutral, but instead **often reflects a male outlook on the world.**[23] Up to now, urban and traffic planners have mainly been men. **As a result,** cities and infrastructure are optimised for cars and **often do not meet women's needs.** While men around the world traditionally drive straight to and from work by car, women are more likely to walk or cycle and use public transport, making a number of shorter journeys throughout the day to combine shopping, childcare and work. Poor bus connections, lack of lifts or cycle paths and the risk of sexual violence in the underground or in dark streets and parks face women all over the world with more than just logistical challenges. Moreover, gearing urban and transport planning better to the needs of women has immediate benefits for other groups such as senior citizens or people with physical disabilities. So it's time to care about **needs and differing mobility behaviour** and take them into consideration as a matter of routine.

Planning town, country and transport together

Inclusive mobility means focusing on the differing needs of women and men from both town and country. Thus, **transport, rural and urban development can be adjusted to fit the needs.**

Openness to new ideas
Cities, and local and regional authorities work hand in hand to plan new residential areas and new mobility concepts. The government also demonstrates its openness to new ideas by updating building legislation.

Greater proximity, shorter distances
Urban and rural areas are designed in an integrated and inclusive manner. Doctors' surgeries, pharmacies, shopping, culture and work are all within walking or cycling distance.

Source: own presentation

Real-world laboratory: citizen participation
As a first step, there are many conversations to be had with women and men from the town and countryside. New mobility concepts that meet their needs are jointly tested.

Town and country as a single (mobility) space
Wherever possible, old railways are brought back into service and public transport systems expanded. Town and country are no longer separate, but instead compatibly linked together. At the weekend, people can drive out into the countryside to relax or take a trip to the city.

Liveable residential areas
Attractive new residential areas are created with more green space, pedestrian zones, cycle paths and parks. People enjoy better rest and relaxation and have an improved quality of life.

New technologies
Digitalisation plays an important role. Private companies, local authorities and cities offer flexible mobility solutions such as sharing or on-demand models which consolidate and reduce traffic. The solutions offered are affordable and convenient, so people like to use them.

29

Off the beaten track? Innovation also works in the countryside!

"Virtual mobility" and home offices make it possible: many people are drawn back to green rural living but soon find themselves rather off the beaten track. For the time being, people therefore continue to rely on their cars but in the long term **there have to be new mobility concepts,** which are **specifically tailored to a rural environment.**

zero emissions
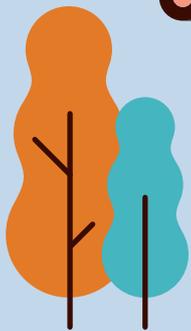
The problem: scarce local transport, ageing societies

Getting about in rural areas is a **challenge** in almost every country in the world, especially without a car.

In addition, we are living longer. In ageing societies such as Japan or Germany, more than a third of the population will be over 65 by 2055. These people often live in the country-side and at some point will no longer be able to drive.

Access to local transport is limited in remote areas. With a bit of luck, the bus runs twice a day, half empty at that.

New, more efficient and more **needs-oriented mobility solutions** are being tested.

Source: own presentation after Bernhart 2018[24]

The solution: mobility-on-demand

Electric shuttles have neither timetable nor fixed destinations. They run "on demand", adapting themselves to passenger requirements. In future, the shuttles will be **autonomous,** an approach which is already being piloted in Japan and Germany.

Shuttles are particularly suitable for short distances: passengers can book them conveniently via app or phone and be driven to the train station, hospital, shopping centre or government office. An **algorithm** calculates the fastest and **most efficient route** in real time.

The **railway is also going digital:** smart vehicles transport **goods and people** on demand, an algorithm calculating, again in real time, the most efficient utilisation of the rail network and constantly readjusting the timetable. As a result, many more trains are able to run at shorter intervals.

On-demand and sharing concepts are important building blocks for tailoring mobility solutions to rural needs. This is called **mobility-as-a-service.**

Everyone's a winner! Mobility becomes more participatory and inclusive

Mobility-on-demand provides increased autonomy to anyone who doesn't drive or is not mobile due to age or physical limitations, enabling them to get out of the house more often, move around more and keep in touch. In a nutshell, it enables greater **participation in society.**

A wider range of mobility solutions has a positive impact on the **health and quality of life** of the population.

2.4 Fresh thinking on goods transport and logistics

Online shopping is simpler and quicker than ever. Recent years have seen massive growth in this area:[h] we can order goods from all over the world which are delivered to our doorstep in no time at all. Shipping and returns are often free of charge for the consumer. However, by moving goods and commodities from all over the world,[i] **we are generating** ever more traffic and thus also **CO_2 emissions, even if we do not ourselves move in the process.**

> ”Online ordering is both a blessing and a curse: ordering one pair of shoes online in three different sizes and sending two of them back has an impact on the environment. Maybe click and collect and more regional trade would be good alternatives?”

Digital innovations can also be helpful here: what are known as geoinformation systems (GIS), a smart, highly connected type of GPS, create a virtual traffic and infrastructure model in real time and so have an overview of the system. Specifically, they are, for instance, capable of assisting electric delivery vehicles and cargo bikes with location-based data in order to optimise routes and loads and so avoid empty trips. They can also help drivers find and reserve free parking spaces in real time.

Various cities are now researching and trialling new, more environmentally friendly concepts to allow deliveries to continue *without* clogging up city centres with delivery trucks. Accordingly, one study[27] suggests that new **delivery procedures** using the **“logistics tram” can save almost sixty per cent of CO_2 emissions in comparison with conventional goods deliveries!** The sixth illustration shows what's involved.

> "Isn't it absurd that we order Italian mineral water in Germany and, when we're on holiday in Italy, there's German sparkling water on the shelves?”

Safe on the road with the blind spot assistant

Trucks and buses turning off at junctions are a daily hazard to pedestrians and cyclists, often causing accidents and sometimes fatalities. This is where the blind spot assistant can help. It has **sensors which respond to optical or acoustic signals** and warn truck, tram or bus drivers in **critical traffic situations** or in future **will even brake automatically,** if, for example, a cyclist is passing by. So the blind spot assistant can be a real lifesaver.[29]

E-mobility by rail

Did you know that **e-mobility is already a day-to-day reality on the railways?** For instance, ninety per cent of suburban and underground trains, long-distance trains and trams already run on electricity. This is only climate-friendly if the electricity is sustainable, i.e. comes from solar, hydro or wind power. This **"green" electricity** currently accounts for **sixty per cent of the electricity used by the railways.**[28] So there is great potential here for achieving climate targets.

---

h   Over the last ten years, online business in Germany has **increased** by almost **370 per cent.**[25] Freight transport volumes are set to grow from 437 billion tonne-kilometres in 2010 to 607 billion tonne-kilometres in 2030, i.e. by 39 per cent.[41]

i   The coronavirus pandemic has demonstrated once again how much Germany's supply of goods and food depends on global supply chains and international trade.[26]

Fresh thinking on logistics

Mobility is more than moving from A to B, it also means bringing everyday goods to us from B to A. So even when we're not moving, we're generating traffic, for instance by placing online orders of all kinds, from clothing to electronics to food. These online transactions have seen constant growth in Germany in recent years, leading to more traffic and noise and poorer air quality.

Germany is experimenting with new ideas for the logistics of the future. It is not yet clear which ideas will catch on nor which are also affordable and efficient.

1. City-Hub for the "last mile": The final leg of a journey to the front door can sometimes demand a lot of effort. In particular for suppliers who can consolidate only a few shipments, the courier sometimes has to drive halfway across a city for a single delivery, which is inefficient and generates traffic. This is where the city-hub comes in, a kind of urban logistics centre which collects and consolidates shipments. Large cities should in future have a number of them.

2. A **logistics tram** collects the goods from the city-hub and takes them along on its regular route, especially at times when there are only few passengers, so relieving the inner cities of delivery traffic during the day. Incidentally, the logistics tram was in existence as long ago as the 1930s!

3. The tram delivers the consignments to the various **stops,** where they are stored in containers until they are collected. This way, people can directly pick up their shipments on their way home. A convenient and practical solution.

Source: own presentation
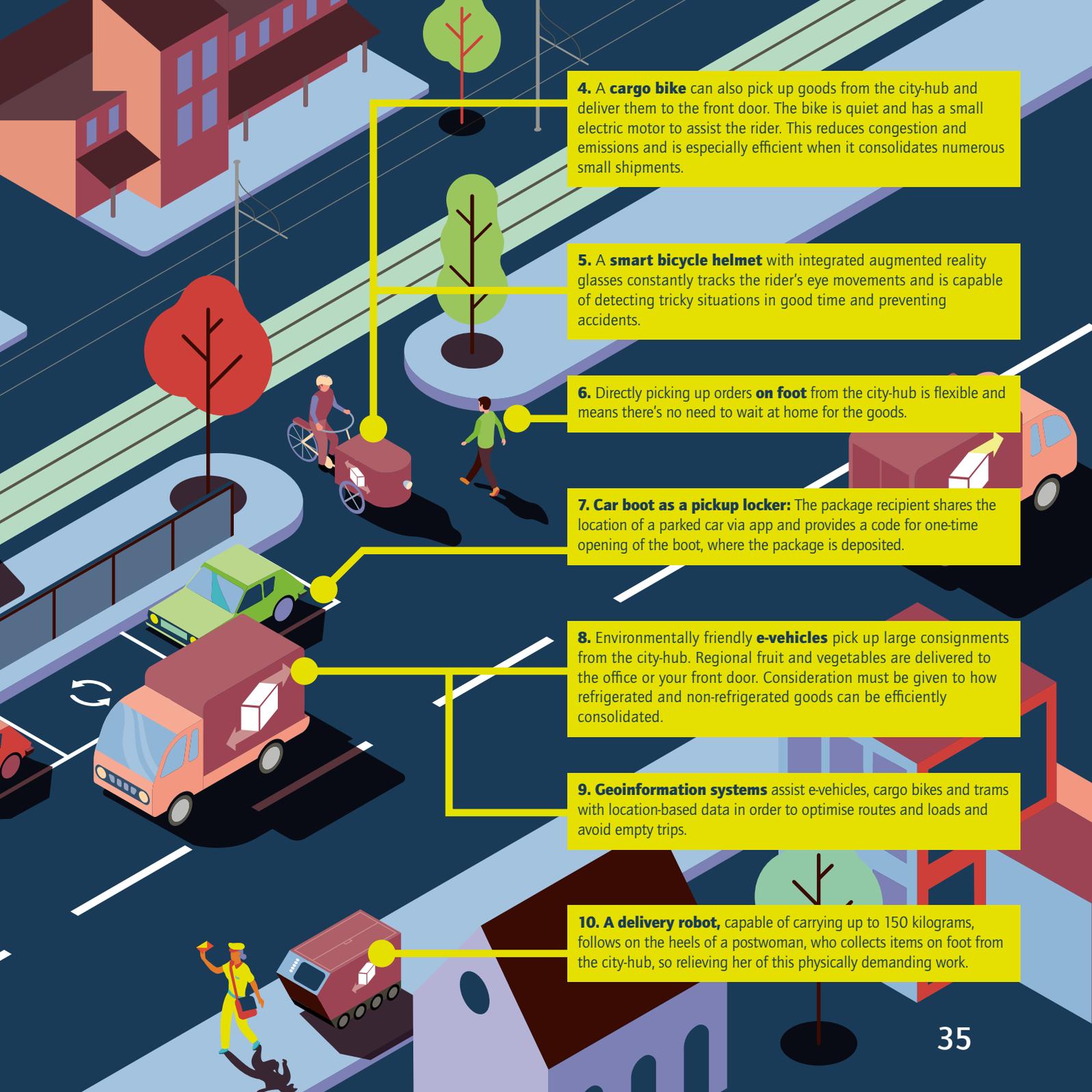
4. A **cargo bike** can also pick up goods from the city-hub and deliver them to the front door. The bike is quiet and has a small electric motor to assist the rider. This reduces congestion and emissions and is especially efficient when it consolidates numerous small shipments.

5. A **smart bicycle helmet** with integrated augmented reality glasses constantly tracks the rider's eye movements and is capable of detecting tricky situations in good time and preventing accidents.

6. Directly picking up orders **on foot** from the city-hub is flexible and means there's no need to wait at home for the goods.

7. Car boot as a pickup locker: The package recipient shares the location of a parked car via app and provides a code for one-time opening of the boot, where the package is deposited.

8. Environmentally friendly **e-vehicles** pick up large consignments from the city-hub. Regional fruit and vegetables are delivered to the office or your front door. Consideration must be given to how refrigerated and non-refrigerated goods can be efficiently consolidated.

9. Geoinformation systems assist e-vehicles, cargo bikes and trams with location-based data in order to optimise routes and loads and avoid empty trips.

10. A delivery robot, capable of carrying up to 150 kilograms, follows on the heels of a postwoman, who collects items on foot from the city-hub, so relieving her of this physically demanding work.

3

From Copenhagen to Singapore: the global view

Climate change concerns us all. Numerous international approaches and pilot projects have shown how mobility can be redesigned. Of course, megacities like Mexico City or Jakarta have entirely different problems to deal with than does a small town in Europe and each country is starting from a very different place. These varying circumstances mean that models cannot simply be copied and pasted. Nevertheless, more and more cities around the world are demonstrating with individual, innovative solutions that, given the right incentives, sustainability is possible and can even improve people's quality of life. The more cities come on-board, the closer we get to reaching our goals.

Copenhagen: Bike Capital

"Working together with its population, Copenhagen has managed to reshape itself while ensuring a large degree of legitimacy, pluralism and participation."

What would it be like if cars were no longer the mode of transport of choice in a city? This is a question the citizens of Copenhagen can answer, living as they do in **Europe's, if not the world's, first true cycling metropolis.** A number of measures are responsible for this: both slow and fast cyclists feel safe on wide, multi-lane cycle paths that are structurally separated from car lanes. Everywhere there are bicycle bridges with beautiful viewpoints, bicycle highways for commuters, service stations with air pumps and water dispensers, dedicated parking garages for bicycles, footrests by traffic lights and rubbish bins, together with phased traffic lights in the city centre. In winter, it is even the cycle paths which are always cleared first - before the car lanes. As a result, travelling by bike is more convenient, healthier, usually faster and costs less. It has worked so well that the verb **"to copenhagenise"** is now a well-known concept in urban planning, meaning **to plan a city around the needs of bicycles.** Fun fact: Denmark has even its own official Cycling Embassy![30]

Singapore: Garden City

Singapore has its **own special recipe for sustainable, efficient transport:** the Southeast Asian city state introduced a cap on vehicle licences back in the 1980s. This limit was reached in 2018 and since then new cars can only be registered if an old one is deregistered. Moreover, in addition, licence holders pay a city toll. Since independence in 1965, this island nation has been struggling with its small land area, a growing population, dense traffic and high levels of environmental pollution. Since the car is the most land-intensive form of transport, the city decided that it would like to use its **land for parks and green residential areas,** some of which are **even being built on decommissioned roads.** Singapore also has one of the best and **most modern public transport systems in the world,** which is part-funded by the city toll. So who needs a car there when the closest metro station is only five minutes away? And who misses busy streets when they can walk through a park with fresh air instead? It is not for nothing that Singapore calls itself a "Garden City" and, in recent years, this has taken it to the **top of the list of the world's "greenest" cities.**[31]

"E-bikes enable a switch to cycling even in hilly cities."

"Cities like Paris or Vienna have shown that we can considerably cut down on motorised traffic volumes in urban areas. This has no negative social consequences, but instead in many respects actually increases the attractiveness of these places."[32,j]

---

j   At present, over 75 per cent of Germany's total population live in cities,[2] around 27 per cent in medium-sized cities of 20,000 to 100,000 inhabitants and some 31 per cent in cities of over 100,000.[3]

Lagos: a life in traffic jams - a glimpse into another reality

Thirty hours per week is how some Europeans see their future working week. People in Lagos associate thirty hours with a sad reality of a completely different kind – it's the time they spend every week **in traffic jams!** That's about ten times as much as in Los Angeles. Nevertheless, more and more people are drawn to Lagos, mostly fleeing poverty, natural disasters, terror and hunger in search of work. This makes the city, which already has twenty-two million inhabitants, the fastest growing metropolis in the world and estimates suggest it will become **the world's biggest city by 2100.**[42] The consequences of rapid growth and rushed expansion include overloaded infrastructure, chaotic traffic, too few and poorly built roads, power cuts and malfunctioning traffic lights. New neighbourhoods are being built haphazardly rather than being planned, streets intended only as side streets suddenly turn into major arteries; **at every level, growth is outpacing controlled development.**

Diseases due to pollution, injuries in traffic accidents and psychological stress are the price that the population has to pay every day. The government recently banned motorcycle taxis and motorised tricycles in an attempt at least to rein in the **alarming number of road deaths.** However, for many people, especially the poor, these vehicles, known locally as okada and keke, were the only way to get to work through the chaos. Hundreds of thousands of commuters have been affected, many have lost their jobs or now have to walk to work,[43] illustrating that, **in the absence of alternatives, bans are pointless.** Meanwhile, people in Lagos can only dream of public transport and cycle paths like those in Singapore and Copenhagen. If you're lucky enough to be able to drive, you'll still be stuck in a traffic jam. Thirty hours per week is sadly the length of time you have to spend in jams in Lagos.

Beijing: from bicycle to car – and back again?

A bicycle has fallen over in Beijing. While this figure of speech is intended to express utter insignificance, traffic in Beijing is an issue to which the **government attaches great importance.** The People's Republic is, after all, the **world's largest greenhouse gas emitter,** ten per cent of which is attributable to the transport sector.[44] Until the late nineties, Beijing was still considered a bicycle metropolis. Now, driven by economic growth and prosperity, a car and home ownership are must-haves on the marriage market, a situation only too apparent from the huge numbers of cars on the road and the length of the traffic jams. When it comes to road works, patience is the order of the day: in 2010, there was a traffic jam lasting ten days on the motorway into Beijing![45]

Congestion, noise and air pollution reduce the quality of life of Beijing's population. Some days, the authorities have to declare a "smog alert" and the whole city, from shops and schools to motorways and even industry, shuts down. The government has long recognised that this is a real threat which affects everyone. In a similar way to the European Green Deal, China is now talking about an **"ecological civilisation"** and is working hard towards this goal. For instance, **Beijing's Metro** is one of the longest in the world, ever more **emission-free vehicles can be found on the streets** and **bike sharing** is booming. In addition, under the motto "mobility-as-a-service", bicycle, car and public transport in Beijing can be combined by an app which is intended to encourage individuals to be as carbon-neutral as possible when they're out and about. If you ride your bike, take the bus or walk, you will be rewarded with coupons, for example for public transport. Beijing is unlikely to become a pure cycling city again, but it is hoping that its **mix of different measures and technologies** will create some light at the end of the (smog-filled) tunnel.

"Only through a bundle of measures with clear, long-term goals and the involvement of the population and all stakeholders will it be possible to shape a liveable 'city of the future'. This is how Beijing has managed to improve air quality significantly in recent years."

39

4

What next?

What next? What active role can individuals, business, academia and policy makers play? One thing is certain, only society as a whole will be able to make a success of transforming mobility. While this process of transformation will indeed involve very extensive, complex steps that can only be hinted at here, the **fourth chapter** and the final illustration offer food for thought and perhaps even some encouragement to take action.

Ideas for the future: a debating space for policy makers, business and civil society

The transformation of industry is already in full swing. Companies worldwide and also in Germany are working flat out to drive forward **new trends in mobility: sustainability, digitalisation and data, e-mobility, connectivity, sharing and autonomous driving.** So while the ultra-modern, clean, quiet and environmentally friendly factories of the future are in some cases already a reality, the mobility of future is still emerging.

But how can the **delicate balance between the environment, economy and social welfare be struck?** The aim is to boost industrial wealth creation in Europe as a centre for innovation in a way which is environmentally sustainable, globally competitive and socially cushioned in order to ensure continued prosperity. In Germany, there is a platform where **experts from civil society, associations, academia, industry and policy makers can meet in a debating space** and, in six working groups, have an integrated discussion about how this aim can be achieved.[k]

Climate protection in the transport sector: How can we maintain mobility without harming the climate? This can only be achieved through a mix of various (largely) greenhouse gas-neutral solutions.

Alternative drive systems and fuels: What role can e-mobility play? Which alternative drive systems, fuels and infrastructure should we focus on? E-mobility has already had a central leverage effect in the mobility transition and will continue to do so in the future. But other highly promising alternative drive systems and fuels can also play an important role.

Digitalisation: What is the potential of data and digitalisation? Digital solutions are already assisting us, for instance in the form of mobility apps or driver assistance systems. In the future, they can help to make the overall movement of people and goods safer, more efficient and more sustainable.

Securing our position as a centre for mobility and manufacturing: How can we secure our position in a globally competitive market? Battery cell manufacture has great potential for ensuring manufacturing sites remain in Europe once the internal combustion engine is history. However, new business models such as battery recycling also hold considerable promise. Vocational training and skills development in the mobility sector must adapt to the challenges of technological change. People need to be taught digital skills today to prepare them for the work of tomorrow.

Sector coupling: Where will we get the clean energy to enable e-mobility and new drive systems and ensure they are climate-neutral? This can only be achieved if we think about transport and energy networks together and link them up.

Standardisation: How can we make the individual components function in an integrated overall system, so that, for example, e-vehicles are compatible with the charging infrastructure? To do this, we need a roadmap for international norms and standards.

If you want to find out more, take a look at National Platform Future of Mobility coordinated by acatech.[33]

"Mobility of the future is more than the car. But at the same time, the car reimagined is integral to shaping the transportation of the future."

4.1 The role of the individual: spectator or player?

"Everyone and anyone is a role model, everyone has their part to play."

So remind me, what's it all about? Mobility. It's everyone's business, ultimately it's about our needs and desires, about how we get around, what kind of cities and neighbourhoods we want to live in. It is therefore obvious that **we as a society can think about and decide upon the future of mobility together.**

What does this mean for me? As a woman or a man, as an older or a younger person, as a rural or urban dweller, I have to make my voice more audible to policy makers and business and act purposefully. **As citizens, we are ourselves asked to play an active part** and to be open to innovation and change. After all, even the best new technologies and solutions won't catch on if they see little use or even meet with rejection.

So how does this work? As consumers, we have market power, otherwise there would probably be no organic supermarkets. It's a matter of supply and demand. **Our demand helps to shape the market:** Do we opt for sustainable products? Do we order online or shop locally? Do we book long-distance or a regional travel? Do we buy a smaller or a larger, an electric or a conventionally powered vehicle? Do we make more use of sharing models as well as cycling and public transport? Do we take part in social media discussions or in participation and dialogue formats? **Every decision is a vote!** Of course, all this only works if there are attractive alternatives on offer and if excitement can be generated about new ideas. And this is where business and politics come into play.

"There are many attractive ways to save CO_2 which improve our everyday lives instead of making them worse."

4.2 The economy: it's the complete package that counts

Climate change: we have our backs to the wall. Man-made climate change is changing pretty much everything (see Chapter 2.1). Jointly rethinking the transport sector and also all other **sectors such as industry or energy is not merely desirable but essential.** Understanding and acknowledging this new reality is a task for everyone and for the entire economy.

Twin challenges from Asia and the USA.[34] German cars and German engineering have long held the lead. The pressure for change has now become enormous: the big money from using data is often made in Silicon Valley, while China manufactures most e-cars. Both areas are crucial for global competitiveness. Ultimately, it's a question of who will be the first to establish international standards, for instance for e-mobility charging infrastructure (and the associated green electricity), in order to serve their domestic market and also other global markets. However, it's also about coveted natural resources such as lithium or cobalt for the development of new battery technologies. Here, too, China is making quick and decisive progress. **The race is still on. The future of the European automotive and transport industries depends heavily on how well digitalisation, connectivity and the development of technology succeed.**

"In the Asian context, data is something you use to increase efficiency and convenience, and is fun and this is of vital significance in automated systems. In the USA, data is something that can be very effectively monetised. In Europe, the first thing that comes to mind when we think of data is data protection."

k The results of the consultations are then submitted to the German Federal Government as policy recommendations.

What will become of the workforce? The transport sector[l] is deeply rooted in the German economy. It is estimated that this sector employs up to 4.4 million[6] people.[m] It is therefore understandable for people to be apprehensive about root-and-branch transformation in the transport sector. There will be change in the way we manufacture and move around and likewise in the job profiles and requirements for millions of workers.[36] **Preparing now for the work of tomorrow,** updating staff skills and building trust is huge task in which companies, works councils and the workforce should act hand in hand.

"German industry and the works councils in the mobility sector are much more open-minded and forward-looking than you'd think; they are even working closely with environmental groups."

The aim is for sustainability to become the "new normal". The stated challenges offer opportunities to make a fresh start. In particular, progress will be sustainable if the environment, economy and social issues are in harmony and if the focus is on human safety and quality of life (see box "European Green Deal", Chapter 2.1). It is precisely with high, **reliable "Made in Europe" quality and environmental standards,** which guarantee the protection of both private and confidential corporate data, that Europe and Germany **can position themselves globally.**

"We will only achieve climate targets if, in addition to new technical solutions, there is also a change in thinking. Making this transformation can be fascinating — offering attractive solutions and incentives is the way to make it work."

It's the complete package that counts. Value is created not only by the stand-alone product, i.e. the car, train or e-bike, but also by the associated services. This means sharing business models or e-battery recycling services can be exciting concepts for the future. The trick is to use **data to create a complete package of product and services, software and hardware:** after all, an individual e-scooter (as a product) would spend most of its time standing unused in the garage. If the same e-scooter is embedded (via software) in a data system, multiple people could conveniently find it and book it via their mobile phone and put it to much more efficient use.

"If I only drive my car one hour a day, it will sit around in the garage for the other 23 hours. It's much more efficient to share, possibly using rental or sharing schemes, or some other new concept which is yet to be devised."

Everyone needs to consider how to put this complete package to best use. This means looking at the bigger picture. If, for example, the strengths of **public and private providers[n] are coordinated to form new "mobility packages",** customers will benefit from **more flexible transport services from a single source.** Such packages will combine train or tram with car sharing and on-demand shuttles from a single company. Achieving an **integrated understanding of mobility as an all-round package** will open up innovative new fields. In the long term, this will create new jobs in environmental and new drive technologies, e-batteries, charging infrastructure,[o] software, data and technology platforms, and mobility services. This overarching task equally affects the established transport industry, public and private mobility providers, cities, local authorities and municipalities, major automotive and rail vehicle manufacturers, supply companies, small and medium-sized enterprises and start-ups: **now is the time to reinvent ourselves!**

"We need to move away from fixating on hardware because the software is also where it's at. This is where we must not give away the potential held by data."

---

[l] This includes vehicle manufacture, trading and maintenance, which account for the lion's share, 57 per cent, of value added in transport-related sectors of the economy. This is followed by transport services (at 40 per cent) and fuel and infrastructure (with 3 to 4 per cent).[6]

4.3 Science and knowledge for all

Where do we stand? German and European **science is excellently positioned and has outstanding international links.** This applies to researchers and experts from the engineering sciences, transport engineering and urban planning.

What are the snags? Until now, **each area has stood on its own:** engine development has traditionally been purely an engineering matter while urban planning has been something for architects and planners. That was previously also the case for academia and business, which have sometimes been two different worlds. Society, too, has not previously been directly involved and has not been able to contribute its wishes and needs at an early stage.

Thinking about mobility in an integrated manner, i.e. **thinking in interdisciplinary terms:** academia and business[p] and expert teams from regional, urban and transport planning should be brought together; there should be greater cross-fertilisation between courses of study in the technical and social sciences.

Knowledge for all. The expertise is available. **However, science must not be an elite subject, nor knowledge a privilege.** Experimental spaces and real-world laboratories (see Chapter 4.4) with citizens and stakeholders from academia, business and policy makers are a good way of communicating this knowledge **in an easily comprehensible way and also putting it (more quickly) into practice.** Otherwise, there is a risk of the public debate becoming less technical and fact-based and more emotionally charged.

---

m The German automotive industry is currently undergoing a long-term process of structural change and transformation that poses major challenges for companies, regions, the workforce and the entire country as a centre for manufacturing.[35]

n This may involve a diverse range of services provided by various companies. The two classic sectors of public and private transport could conceivably in future also be merged to form new "mobility companies" providing all-round mobility services.

o One study suggests that setting up the **charging infrastructure** for charging e-cars **could by itself give rise to a skilled workforce of 255,000 over the next ten years.**[37]

p For instance in the form of joint consultation and stakeholder forums.

"The fundamental question is how we can harmonise the environment and mobility. This is where research can help things go more smoothly."

"Europe is world-beating in analysis and setting goals, but we are at best in the middle of the pack when it comes to implementation."

4.4 The policy – "transformation by design"

Primacy of policy: With a view to growth and prosperity, European and German policy makers have promoted the car and car-centred transport planning for decades. Fundamental rethinking and replanning cannot simply be conjured up overnight. The prerequisite, however, is that policy makers now moderate, (jointly) manage and create an appropriate framework for this transformation "by design"[34]. How?

Climate-damaging behaviour should have a cost. Europe and Germany have already taken action. **The EU emissions trading scheme,**[38] which regulates and limits CO_2 emissions, is accordingly the **cornerstone of European climate protection.** However, the only sectors to have been affected as yet are the energy, energy-intensive industry and (in part) commercial aviation. Since 2021, Germany has even gone one step further and is additionally pricing the transport and heating sectors.[10]

Making innovation attractive: **Policy makers are already promoting a mix of innovations** in the areas of new environmental and drive technologies including not only e-mobility, hydrogen, e-fuels and the associated infrastructure, but also new digital business models.[q] It is important to keep on giving customers and the market **some freedom so technologies can develop freely** and remain competitive.[r] The new data strategy illustrates just how explosive the topic of data is (see Chapter 2.2). This strategy is intended to provide a policy framework and to identify opportunities for how we as a society can best use data.[39]

> *"Policy makers create an innovation-friendly framework without being too specific about individual technologies."*

---

q   See the Federal government's Climate Protection Programme 2030.[10]
r   However, particularly at the outset, it is important to define targeted incentives, for instance by promoting e-vehicles and charging infrastructure.

Openness to new ideas: citizen participation in the real-world laboratory

Did you know that the Hamburg real-world laboratory is an experimental space for innovation in the field of digital mobility? **The intention is for the population itself to decide on the mobility of the future.** In this way, residents can test various technologies and transport services in everyday life and contribute their experience and concerns to a dialogue. At the same time **real-world laboratories help policy makers understand what rules and regulations the digital world of tomorrow will need.** If you want to find out more, visit the National Platform Future of Mobility coordinated by acatech.[40]

From car-focused to human-centred mobility: If transport, urban and spatial planning are to come together, not only will skilled experts have to drive the issue forward with a vision for the future but legislation will also have to enable the process. The ball is therefore also in the policy makers' court to modernise transport planning and building legislation and adapt them to the current needs of town and country, young and old, women and men. Real-world laboratories are already an important step because they test innovation outside existing legislation in order to learn more about the necessary regulations and to involve the population from the outset.

However, it's not only a matter of rules and regulations. For instance, many rural dwellers, who depend on their cars, object to driving or parking prohibitions. **Only by offering attractive alternatives,** which people like to use without being forced to do so, **do new ideas stand a chance:** more bicycle and pedestrian paths, better rail links in rural areas, more environmentally friendly cars, more using instead of owning, convenient, affordable mobility solutions, quieter, family-friendly residential areas with playgrounds, parks and green spaces, shorter distances, less traffic, greater proximity and more air to breathe and finally **more time, a better quality of life, more freedom of movement and more mobility.**

"We have to accept that an economy is only successful if it is sustainable, so we need a healthy mix of regulation and incentives."

"It's not about taking something away from people, it's about giving us all something back."

Transformation to a new mobility: Where do we want to go?

Mobility is participation in life, it concerns each and every one of us. Transforming mobility thus means transforming the whole of society and this requires fundamental rethinking on everyone's part. The direction is clear, the initial course has been set, but there is still a long way to go before we reach our goal.

Openness to innovation & innovation mix: scalable, affordable mobility solutions

Fixation on specific technologies

Climate targets & new purpose: sustainability as the "new normal": environmentally friendly technologies

Climate-damaging behaviour

Digitalisation as a technological driver & secure mobility data space

Digitalisation not all-encompassing, dormant **data troves**

Integrated mobility: experts from engineering, architecture and the social sciences plan living spaces and transport together; expansion of railways

Fragmented mobility: separate transport, urban and spatial planning

Real-world laboratories: academia, business, policy makers and society test innovations together

„Top-down" transformation

Mobility brought together into an **all-round package,** new sharing and on-demand business models

Isolated mobility solution

Mobility for all, social mobility: early inclusion of the needs of women and men, young and old, town and country

Mobility for the few, bypassing the needs of the general public

zero emissions

49

50

Contributors

Bibliography

1   Holzapfel, H. (2020): Urbanismus und Verkehr. Beitrag zu einem Paradigmenwechsel in der Mobilitätsorganisation. 3. Auflage. Springer Fachmedien Wiesbaden GmbH, Wiesbaden.

2   Zukunftsinstitut (2021): Urbanisierung: Die Stadt von morgen. https://www.zukunftsinstitut.de/artikel/urba-nisierung-die-stadt-von-morgen/

3   Bangel, C. (2017): Stadt, Land, Vorurteil. Zeit Online. https://www.zeit.de/feature/deutsche-bevoelkerung-stadt-land-unterschiede-vorurteile

4   United Nations Department of Economic and Social Affairs (2018): 68% of the world population projected to live in urban areas by 2050, says UN. https://www.un.org/develop- ment/desa/en/news/population/2018-revision-of-world-urbanization- prospects.html

5   European Commission: Transport emissions. A European Strategy for low-emission mobility. https://ec.europa.eu/ clima/policies/trans-port_en

6   Nationale Plattform Zukunft der Mobilität, Arbeitsgruppe 1 "Klimaschutz im Verkehr" (2019): WEGE ZUR ERREICHUNG DER KLIMA-ZIELE 2030 IM VERKEHRSSEKTOR. Zwischenbericht 03/2019. Bundesministerium für Verkehr und digitale Infrastruktur. https://www.plattform-zukunft-mobilitaet.de/wp-content/uploads/2020/03/NPM-AG-1-Wege-zur-Erreichung-der-Klimaziele-2030-im-Verkehrssektor.pdf

7   Statista (2021): Fahrleistung der Pkw in Deutschland im Jahr 2019. https://de.statista.com/statistik/daten/studie/246069/umfrage/laufleistung-privater-pkw-in-deutschland/

8   Quarks, Westdeutscher Rundfunk Köln (WDR) (2019): CO_2-Rech-ner für Auto, Flugzeug und Co. Wie viel CO_2 setzt du frei? https://www.quarks.de/umwelt/klimawandel/co2-rechner-fuer-auto-flugzeug-und-co/#rechner12

9   Europäische Kommission: Ein europäischer Grüner Deal. Erster klimaneutraler Kontinent werden. https://ec.eu- ropa.eu/info/strategy/priorities-2019-2024/european-green-deal_de

10   Bundesministerium für Umwelt, Naturschutz und nukleare Sicher-heit (BMU) (2019): Klimaschutzprogramm 2030 der Bundesregierung zur Umsetzung des Klimaschutzplans 2050. Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU). https://www.bundesregierung.de/resource/blob/975226/1679914/ e01d6bd855f09bf05cf7498e06d0a3ff/2019-10-09-klima-massnah- men-data.pdf

11   Göhlich, D., Raab, A. (2021): Mobility2Grid - Sektorenübergrei-fende Energie- und Verkehrswende. Springer Verlag.

12   Nationale Plattform Zukunft der Mobilität, Arbeitsgruppe 2 "Alternative Antriebe und Kraftstoffe für nachhaltige Mobilität" (2019): ELEKTROMOBILITÄT. BRENNSTOFFZELLE. ALTERNATIVE KRAFT-STOFFE – EINSATZMÖGLICHKEITEN AUS TECHNOLOGISCHER SICHT. 1. KURZBERICHT DER AG 2. Bundesministerium für Verkehr und digitale Infrastruktur (BMVI). https://www.plattform- zukunft-mo-bilitaet.de/wp-content/uploads/2019/11/NPM-AG- 2-Elektro-mobilit%C3%A4t-Brennstoffzelle-Alternative-Kraftstoffe-Ein-satz-m%C3%B6glichkeiten-aus-technologischer-Sicht.pdf

13   Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU) (2019): Rebound-Effekte. https://www.umwelt bundesamt.de/themen/abfall-ressourcen/oekonomische-rechtliche-aspekte-der/rebound-effekte

14   Süddeutsche Zeitung (2021): Bahn legt Vorschlag für Trassen-neubau im Inntal vor. https://www.sueddeutsche. de/bayern/bahn-rosenheim-bahn-legt-vorschlag-fuer-trassenneubau-im-inntal-vor-dpa.urn-newsml-dpa-com-20090101-210412-99-176770

15   Nationale Plattform Zukunft der Mobilität, Arbeitsgruppe 3 (2019): Digitalisierung für den Mobilitätssektor. ERSTER ZWISCHEN-BERICHT ARBEITSGRUPPE 3. Bundesministerium für Verkehr und digitale Infrastruktur (BMVI). https://www.plattform-zukunft-mobilitaet.de/wp-content/uploads/2020/03/NPM-AG-3-

Digitalisierung-f%C3%BCr-den-Mobilit%C3%A4tssektor.pdf

16   Bitkom e.V. (2020): Digitalisierung kann fast die Hälfte zu den deutschen Klimazielen beitragen. https://www. bitkom.org/ Presse/Presseinformation/Digitalisierung-kann-fast-die-Haelfte-zu-den-deutschen-Klimazielen-beitragen

17   Deutsche Akademie der Technikwissenschaften (acatech) (2020): Datenraum Mobilität. https://www. acatech.de/projekt/ datenraum-mobilitaet/

18   Lemmer, K. (2019): Neue autoMobilität II. Kooperativer Straßenverkehr und intelligente Verkehrssteuerung für die Mobilität der Zukunft. Deutsche Akademie der Technikwissenschaften (acatech). https://www.acatech.de/publikation/neue- automobilitaet-ii/

19   Runter vom Gas – Eine Verkehrssicherheitskampagne von Bundesministerium für Verkehr und digitale Infrastruktur, Deutscher Verkehrssicherheitsrat e.V. (2020): Die häufigsten Unfallursachen. https://www.runtervomgas.de/ratgeber-und-service/ unfallursachen/ die-haeufigsten-unfallursachen/

20   Löwa, M. (2018): Mobil auf dem Land: Die große ADAC Umfrage. ADAC. https://www.adac.de/verkehr/stand-punkte-studien/mobilitaets-trends/monitor-land/

21   European Platform on Mobility Management (EPOMM) (2019): Was ist Mobilitätsarmut? http://www.epomm. eu/newsletter/v2/ eupdate.php?nl=0419&lan=de

22   Deutsche Akademie der Technikwissenschaften (acatech) (2020): Mobilitätsmonitor 2020. https://www. acatech.de/medien/ mediathek/mobilitaetsmonitor-2020/

23   Bellmann, F., Ypma, L., Polack, D. (2020): Women move differently- what everyone working in mobility should know. World Economic Forum. https://www.weforum.org/agenda/2020/01/mobili-ty-in-2020-a-female-perspective/

24   Bernhart, W. (2018): Autonomous vehicles breathe new life into rural communities. Roland Berger. https://www.rolandberger.com/en/ Insights/Publications/Reconnecting-the-rural- Autonomous-driving. html

25   Poleshova, A. (2020): E-Commerce-Umsatz mit Waren in Deutschland in den Jahren 2000 bis 2019. Statista. https://de.statista .com/statistik/daten/studie/71568/ umfrage/online-umsatz-mit-waren-seit-2000/

26   Deutsche Akademie der Technikwissenschaften (acatech) (2020): Resiliente und nachhaltige Lebensmittelversorgung. Die Corona-Krise und weitere Herausforderungen. https:// www.acatech. de/publikation/resiliente-und-nachhaltige-lebensmittelversorgung/

27   Schocke, K.-O., Schäfer, P., Höhl, S., Gilbert, A. (2020): LastMile Tram. Empirische Forschung zum Einsatz einer Güterstraßenbahn am Beispiel Frankfurt am Main. Frankfurt University of Applied Sciences, Research Labor for Urban Transport (ReLUT). https://www. frankfurt-university.de/fileadmin/standard/Hochschule/ Fachbereich_1/FFin/Neue_Mobilitaet/Veroeffentlichungen/2020/ Abschlussbericht_LastMileTram.pdf

28   Allianz pro Schiene: Elektromobilität: Die Mobilität von morgen schon heute auf der Schiene. https://www. allianz-pro-schiene.de/ themen/umwelt/elektromobilitaet/

29   Bundesministerium für Verkehr und digitale Infrastruktur (BMVI) (2021): Aktion Abbiegeassistent. https://www.bmvi. de/SharedDocs/DE/ Artikel/StV/Abbiegeassistent/aktion-abbiegeassis- tent.html

30   Cycling Embassy of Denmark (2021). http:// www.cycling-embassy.dk/

31   Alonso, T. (2020): Success story: the transformation of Singapore into a sustainable garden city. Tomorrow Mag. https:// www.smartcitylab. com/blog/urban-environment/singapore-transforma- tion-garden-city/

32   Jones, P. (2014): The evolution of urban mobility: The interplay of academic and policy perspectives. IATSS Research, 38(1):7–13.

33   Bundesministerium für Verkehr und digitale Infrastruktur (BMVI) (2021): Nationale Plattform Zukunft der Mobilität. https://www.plattform-zukunft-mobilitaet.de/

34   Bormann, R., Fink, P., Holzapfel, H., Rammler, S., Sauter-Servaes, T., Tiemann, H., Waschke, T., Weirauch, B. (2018): Die Zukunft der deutschen Automobilindustrie. Transformation by Design oder by Disaster? Friedrich-Ebert-Stiftung. http://library.fes.de/pdf-files/ wiso/14086-20180205.pdf

35   Presse- und Informationsamt der Bundesregierung (BPA) (2020): 4. Spitzengespräch der Konzertierten Aktion Mobilität - "Transformation unterstützen, Wertschöpfungsketten stärken". Pressemitteilung 410. https://www.bundesregierung.de/breg-de/aktuelles/4- spitzengespraech-der-konzertierten-aktion-mobilitaet-transformation-unterstuetzen-wertschoepfungsketten-staerken--1815818

36   Nationale Plattform Zukunft der Mobilität Arbeitsgruppe 4 – "Sicherung des Mobilitäts- und Produktionsstandortes, Batteriezellproduktion, Rohstoffe und Recycling, Bildung und Qualifizierung", Fokusgruppe Strategische Personalplanung und -entwicklung (2020): 1. ZWISCHENBERICHT ZUR STRATEGISCHEN PERSONALPLANUNG UND -ENTWICKLUNG IM MOBILITÄTSSEKTOR. Bundesministerium für Verkehr und digitale Infrastruktur. https://www.plattform-zukunft-mobilitaet. de/wp-content/uploads/2020/03/NPM-AG-4-1-Zwischenbericht-zur-stra-tegischen-Personalplanung-und-Entwicklung-im-Mobilit%C3%A4tssektor. pdf

37   Bundesverband eMobilität e.V. (2019): BEM Pressemitteilung: BEM-Prognose Arbeitsmarkt. https://www.bem-ev.de/bem-pressemitteilung-bem-prognose-arbeitsmarkt/

38   European Commission: EU Emissions Trading System (EU ETS). https://ec.europa.eu/clima/policies/ets_en

39   Die Bundesregierung (2021): Deutschland als Vorreiter bei Innovationen. Bundesregierung beschließt Datenstrategie. https://www.bundesregierung.de/breg-de/aktuelles/datenstrategie-be- schlossen-1842786

40   Nationale Plattform Zukunft der Mobilität (2020): Startschuss für RealLabHH: Hamburg erprobt die digitale Mobilität von Morgen im Alltag. https://www.plattform-zukunft-mobilitaet.de/ news/startschuss-fuer-reallabhh-hamburg-erprobt-die-digitale-mobilitaet- von-morgen-im-alltag/

41   Bundesministerium für Verkehr und digitale Infrastruktur (BMVI) (2014): Verkehrsverflechtungsprognose 2030. https://www.bmvi.de/ SharedDocs/DE/Anlage/G/verkehrsverflechtungs-prognose-2030-zusammenfassung-los-3.pdf

42   Akorede, S. (2019): Employees in Lagos are stressed, burned out and exhausted because of 'hellish traffic'. CNN. https://edition.cnn.com/ travel/article/traffic-stress-lagos-nigeria/index.html

43   Dörries, B. (2020): Motor aus. Warum viele Nigerianer neuerdings zur Arbeit laufen müssen. Süddeutsche Zeitung. https://www.sueddeutsche .de/politik/verkehr-motor-aus-1.4819346

44   Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ): Deutsch-chinesische Zusammenarbeit für klimafreundlichen Verkehr. https://www.giz.de/de/weltweit/34150. html

45   BBC (2010): Thousands of vehicles stuck in 120km China traffic jam. https://www.bbc.com/news/world-asia-pacific-11168622

acatech –

National Academy of Science and Engineering

acatech advises policy makers and society, supports consensus building in innovation policy and represents science and engineering internationally. Commissioned by national and federal state authorities, the academy provides independent, science-based advice on a non-profit basis. acatech clarifies the opportunities and threats of technological developments and is committed to transforming ideas into innovation and innovation into prosperity, wellbeing and quality of life. acatech brings academia and business together. The members of the academy are outstanding scientists from engineering and the sciences, medicine and from humanities and social sciences. The senators are prominent figures from technology companies and associations and major scientific organisations. In addition to its head office at the acatech FORUM in Munich, acatech also maintains offices in Berlin and Brussels.

Further information: www.en.acatech.de.

More about acatech HORIZONS Transforming Mobility, including graphics, can be found at:

https://en.acatech.de/project/acatech-horizons-mobility/

When people think about mobility, it is often cars, bikes, buses or trains that first come to mind. But mobility is much more than that: it enables us to get to work, to the shops or to the doctor's, to meet friends and to take our children to school. So it is also participation in life. At the same time, we generate traffic as a result and this has a major impact on the environment. How can we design mobility that meets everyone's needs while simultaneously making a contribution to achieving climate targets? What role can technologies and new mobility models that focus more on use than ownership play in this? What can we learn about modern urban planning from the cycling capital Copenhagen? This issue of HORIZONS focuses on these and other fascinating questions.