MEGATREND STUDY

NORTON ROSE FULBRIGHT × zukunftsInstitut

14 TRENDS for the future of mobility

Outlook, potentials and challenges

- Green Shift
- Regulatory Complexity
- Efficient Logistics
- Sustainable Fuels
- Co-Creation Frameworks
- Electrified Mobility
- Inclusive Mobility
- Electric Aviation
- Intelligent Transportation Systems
- Liveable Cities
- Mobility as a Service
- Aerial Density
- Rail Alignment
- Seamless Mobility

14 TRENDS for the future of mobility

IMPRESSUM

MEGATREND STUDY MOBILITY

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Note on the use of gendered language
We write about people of all genders. For reasons of better readability, the masculine form is used in this study for personal designations and personal nouns. In the interest of equal treatment, corresponding terms shall be deemed to include all genders. The shortened language form is used for editorial reasons only and does not imply any evaluation.

Notes on the use of AI
The images in this study were generated using artificial intelligence and edited manually thereafter.

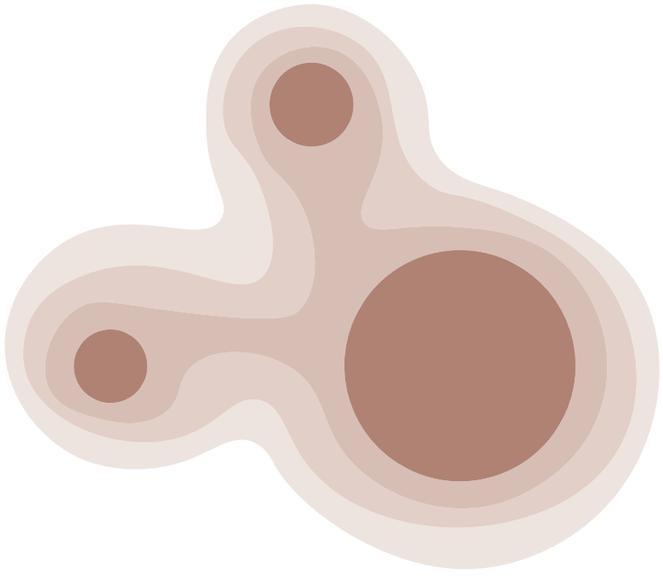
MEGATREND STUDY

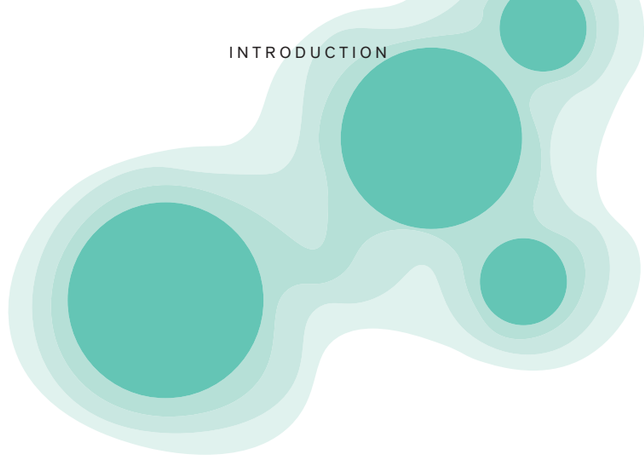
MOBILITY

This Megatrend Study offers strategic orientation for companies, innovators, mobility providers, urban planners, political actors and anyone else who wants to take a comprehensive look at the mobility of the future. It helps to identify opportunities at an early stage and serves as a basis for individual reflection on significant changes.

INTRO

Those who understand mobility exclusively as traffic or mere movement of people and goods underestimate the dimensions of this Megatrend and its far-reaching consequences. Mobility is more than just movement – it is technological innovation, economic transformation and social change. It is a question of political decisions, individual behaviour and economic investment. Mobility influences how we live, work and do business. It defines spaces on land, on water and in the air and determines infrastructure, social participation and access to resources. The Megatrend of Mobility interacts with other key developments such as eco-intelligence, security, connectivity and urbanisation. At the same time, numerous stakeholders – from users to producers to political decision-makers – are actively involved in shaping it. Their decisions will have a significant impact on the future of mobility.





TEAMING UP ON THE WAY TO THE FUTURE OF MOBILITY

In view of this complexity, Norton Rose Fulbright and the Zukunftsinstitut have joined forces to analyse and specifically support key developments in mobility. In a strategic partnership, we combine research expertise, systemic analysis skills and in-depth industry knowledge. We identify formative trends, derive relevant fields of action and show organisations how they can optimally use their potential.

The Trend Radar and the Megatrend Study on Mobility provide the first substantiated future insights. They serve as an orientation for decision-makers in mobility industries and beyond. Overall, this work lays a solid foundation for the future design of mobility. The next step is to derive specific scenarios and generate insights that are relevant for action – step by step towards a sustainable future of mobility.

MOBILITY TRANSITION: FULL SPEED WITHOUT CLEAR DIRECTION

A glance at the Trend Radar shows: The Green Shift will be the key driver in the years to come. Materially influenced by a change in social awareness, technological progress and regulatory intervention, mobility is becoming more sustainable. But despite this momentum, the direction of the mobility transition remains unclear. Different drive systems, investment strategies and geopolitical developments raise questions. Political zigzags increase uncertainty amongst investors, producers and mobility providers alike.

»It's a mess«, is how mobility expert Prof. Dr. Massimo Moraglio from the Technical University of Berlin sums up the current situation. But there is also enormous potential in this uncertainty: The mobility transition offers far-reaching opportunities for innovation, economic development and an increase in quality of life. Technological and political breakthroughs and clear strategic guidelines will be essential to realise this potential. Currently, however, there still is a lack of orientation points in the long term for rethinking mobility as a user-centred, networked service offering.

AN INVITATION TO SHAPE THE FUTURE

With this Megatrend Study, we offer you a sound basis for reflection and strategic planning. We are already working on the next publication, which, on the basis of scenarios, future narratives and visionary approaches, will identify specific options for action for the mobility of tomorrow.

Let's shape the future of mobility together. This first step has been taken – now it's time to set the right course.

We are on the move!

Harry Gatterer & Karsten Kühnle

CONTENTS

QUESTIONS AND IMPULSES

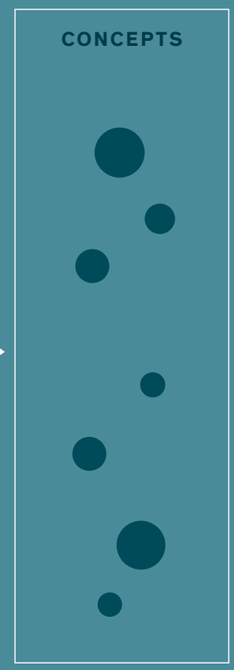
WHAT DOES THIS TREND MEAN FOR OUR ORGANISATION?

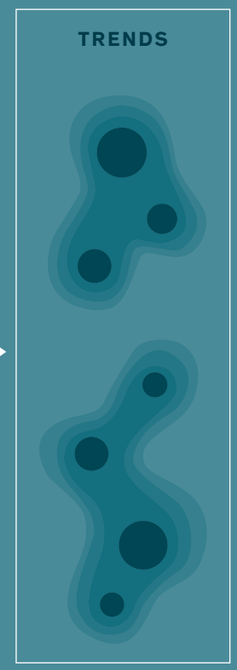
The trends presented herein raise questions about the day-to-day running of an organisation. They can only be addressed in a very generalised way in this study and serve as an initial impetus to engage with the trends. Please do not hesitate to contact us if you require any further information or support!

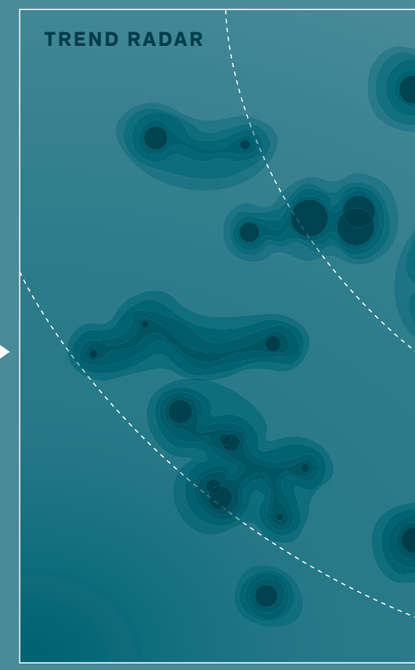
TRENDS

PORTFOLIO

MEGATREND RESEARCH







01
SAMPLING 4X4 MATRIX

The Megatrend Research process starts with the first collection of data. The aim is to obtain the data base for the PELC network analysis.

02
PELC NETWORK ANALYSIS

The network analysis is conducted to analyse the fields of action. A field of action is a condensed bundle of movements of change which – in contrast to an individual consideration of trends – has a holistic effect.

03
SAMPLING EXPERT INTERVIEWS

The purpose of the expert interviews is to gain in-depth knowledge from experts. An expert is someone who takes responsibility for solving problems or has exclusive access to information and, based on comprehensive knowledge, skills and experience in his field, makes well-founded decisions, solves problems and is regarded as an authority, offering guidance and orientation to others.

04
SYSTEMIC CODING

The systemic coding aims at identifying sub-trends of the respective analysed Megatrend. For this purpose, a three-stage procedure is carried out:

01
Code identification: Designations or short phrases that represent a specific topic, a relevant aspect or an emotion.

02
Determination of concepts: They represent related phenomena, ideas and elements.

03
Designation of trends (trend narration): Trends are observable general development tendencies.

ASSESSMENT OF QUALITY CRITERIA

The quality assessment serves to ensure the quality of the information obtained and comprises scientific as well as economic and systemic criteria.

MOBILITY

DATA BASE

The PELC network analysis is a process specifically developed for and used in the context of the Megatrend Research by the Zukunftsinstitut. Its structured approach provides the basis for identifying trends in a comprehensive way, taking into account the complex interrelationships that exist between them. At first, significant amounts of data are collected along the grid of the 4×4 data matrix (01). For the Megatrend of Mobility, more than 150 documents were collected, the contents of which provide various perspectives on mobility. Based on the ubiquitous (i.e. affecting all areas of society) and global idea of Megatrends and on the diversity of sources, three levels are taken into account:

SUBSYSTEMS OF SOCIETY

The topics that are relevant in connection with Megatrends are …

- Politics: legislative, executive, judiciary, bureaucracy
- Economy: production, services, technology, information, finance
- Legitimation: science, religion, fundamental rights, basic assumptions
- Community: arts, education, general public, NGOs

TYPES OF MEDIA

Which topics are discussed in the media of …

- Empiricism and theory: scientific journals and research institutes
- Positioning: think tanks and networks
- Application: consultancies and specialised media
- Coverage: daily media and other journalism formats

CONTINENTAL TRENDS

In terms of their basic characteristics, Megatrends are global phenomena that can be found on all (inhabited) continents, which is why this geographical framework is also applied for source research. Continental perspectives beyond Europe are necessary to account for the criterion of globality.

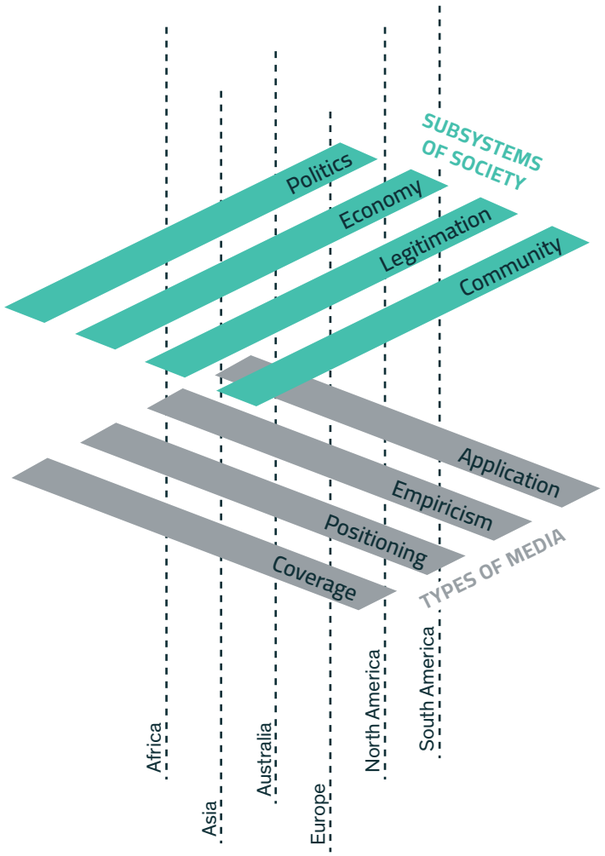
In terms of their basic characteristics, Megatrends are global phenomena that can be found on all (inhabited) continents, which is why this geographical framework is also applied for source research. Continental perspectives beyond Europe are necessary to account for the criterion of globality. The PELC network analysis (02) is based on this collection of data and used to identify the key Megatrend Areas for organisations. The sources of the information collected are analysed as to their semantic proximity using AI and converted into a network.

For the assessment of future prospects, the conduct of a holistic analysis of all four sub-systems of society is interesting. This is the next stage, in which the cross-system Megatrend Areas arise. The more connections a code has and the more central it is in the network, the more relevant it is for the respective Megatrend analysed. By use of artificial intelligence, clusters are formed from similar codes related to each other. Such condensed "bundles" of movements of change are the Megatrend Areas – i.e. the particular fields of action a Megatrend comprises in which companies can take action to exploit a Megatrend for their own benefit.

The advantage of Megatrend Areas lies in their temporal stability due to which they can serve as orientation for the future work of organisations. For the clients of the Zukunftsinstitut, they often are the key fields of action that are relevant for about a decade. These Megatrend Areas were used as a basis for the subsequent expert interviews (03) by the Zukunftsinstitut.

As regards Mobility, six Megatrend Areas that will be relevant for the next decade have been identified after an iterative process:

- Urban Mobility
- Sustainable Mobility
- Transport Technologies
- Traffic Safety
- Transport Policy
- Mobility Management



CONTINENTAL TENDENCIES

On the basis of the identified Megatrend Areas, experts were selected to conduct interviews to identify trends. At this point, the time horizon should be mentioned again: Megatrend Areas reflect change movements of a decade; trends, on the other hand, cover a shorter period of approximately three years. Megatrend Areas are starting points for companies to engage more intensively with Megatrends at the strategic or visionary level. Trend monitoring, however, offers access to innovation and current opportunities (for example, as regards communication or marketing). The PELC network analysis has the great advantage that it can clearly differentiate between short-lived trends and Megatrend Areas that are relevant in the longer term. Which area of knowledge is relevant in each case depends on the specific questions of the respective company.

TREND RADAR

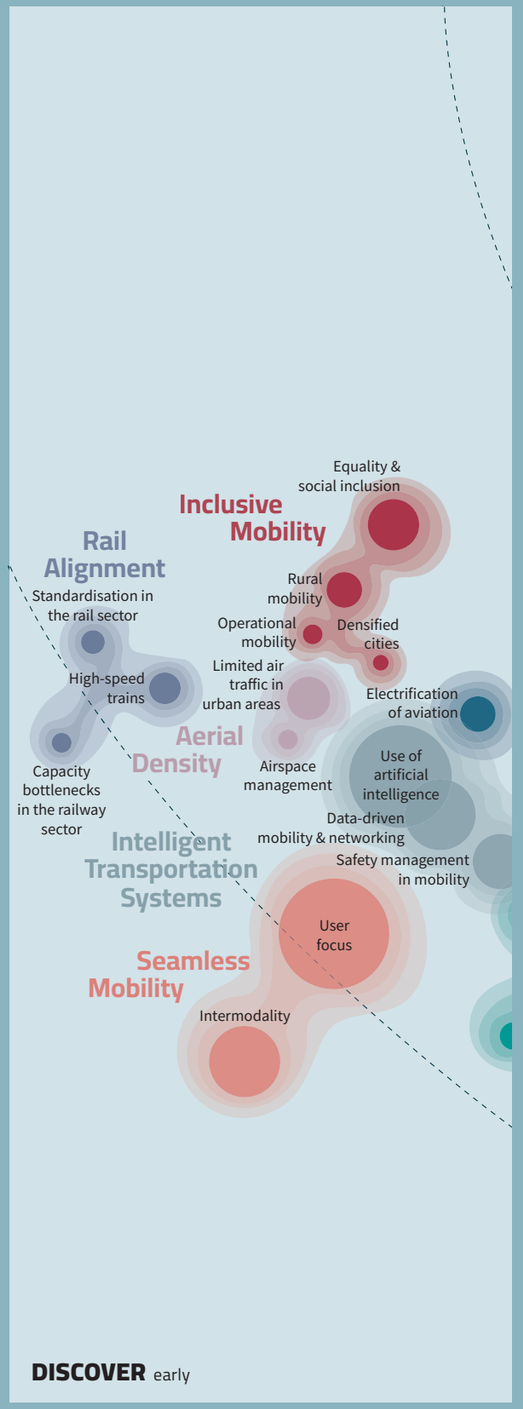
MEGATREND »MOBILITY«

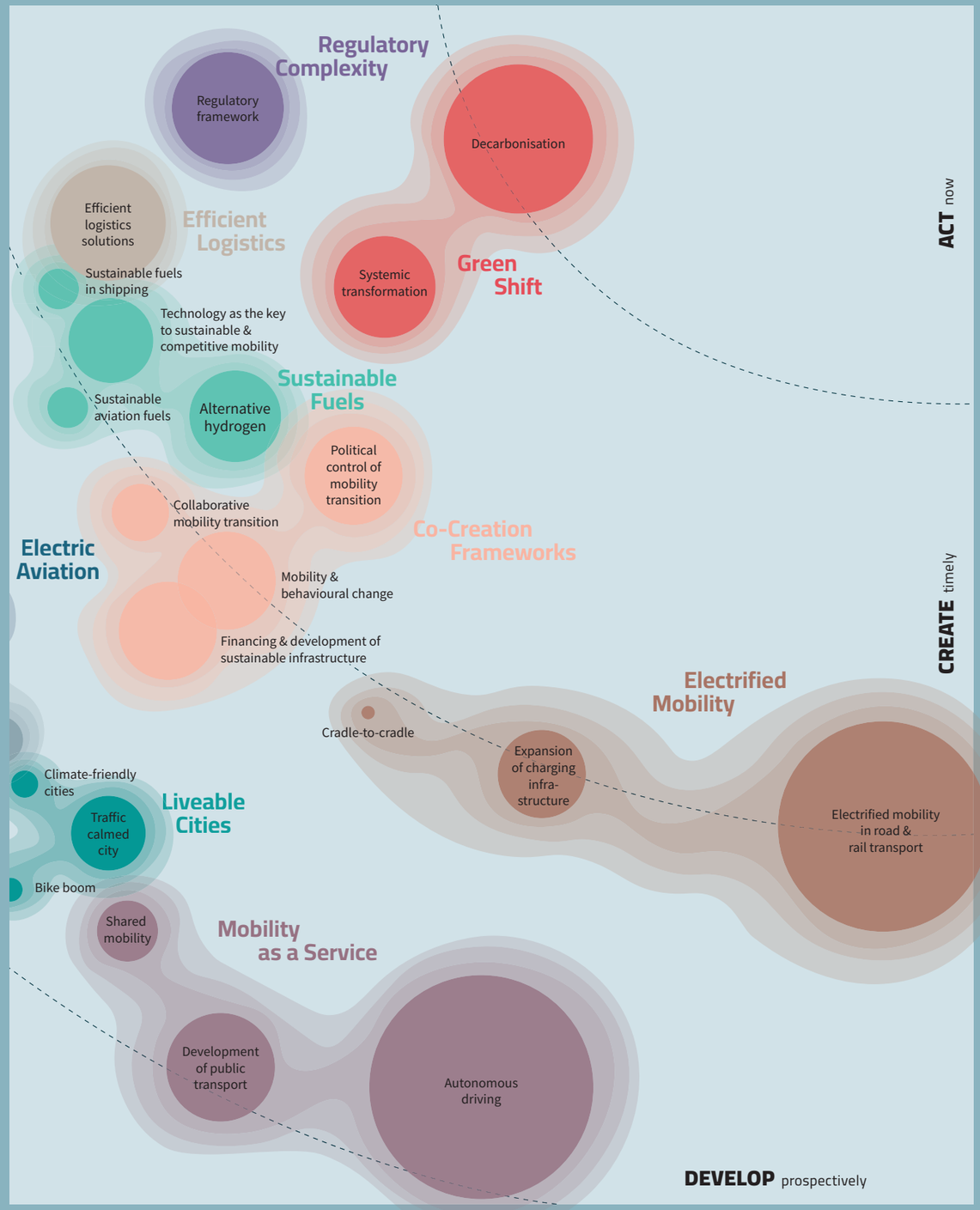
The Trend Radar to the present Study "14 Trends for the Future of Mobility" is the result of the data-based Megatrend research of the Zukunftsinstitut. The concepts and trends it reveals are based on a comprehensive research design, as described in "Megatrend Research" by H. Gatterer and S. Tewes (Murmann Publishers, 2023). The Trend Radar shows the trends that will have the greatest influence on the Megatrend of Mobility in the years to come. The arrangement of the trends in the radar reflects both the signal strength of the individual concepts and the intensity of their interconnectedness.

Download the trend radar as a poster

KEY

- Trend concepts
- Trends
- Signal strength
- Proximity in the segment
- Cross-linking intensity
- Act / Create / Develop / Discover





GREEN SHIFT

The Green Shift trend stands for the fundamental transformation of mobility towards climate-neutral and eco-intelligent transport solutions, driven by decarbonisation, technological innovation and regulatory frameworks.

GREEN

TREND

Green Shift is the key mobility trend for the years ahead. It marks the systemic shift towards eco-intelligent, low-emission and resource-efficient mobility, driven by a combination of the intensified effects of climate change, growing environmental awareness, regulatory intervention and technological innovation.

Climate change is no longer an abstract threat, but has become a tangible reality for an increasing number of people, one that also directly impacts mobility and transport systems. Air pollution, rising temperatures and sea levels, as well as extreme weather events such as droughts, heavy rainfall and flooding are forcing a rethink. At the same time, social awareness of environmentally friendly solutions is growing – consumers, companies and political players are increasingly recognising the urgency of a mobility transition. Products, marketing, campaigns and projects are going green. The Green Shift dynamic is driving profound changes in regulation, market requirements and investment flows. Governments are setting ambitious climate targets, with carbon reductions being legislated and sustainability standards tightened. Investors are focusing on ESG criteria, with sustainable investments combining the traditional criteria of profitability, liquidity and security with environmental, social and ethical considerations. Companies are developing eco-propositions as low-emission operations are no longer just a competitive edge, but an economic imperative.

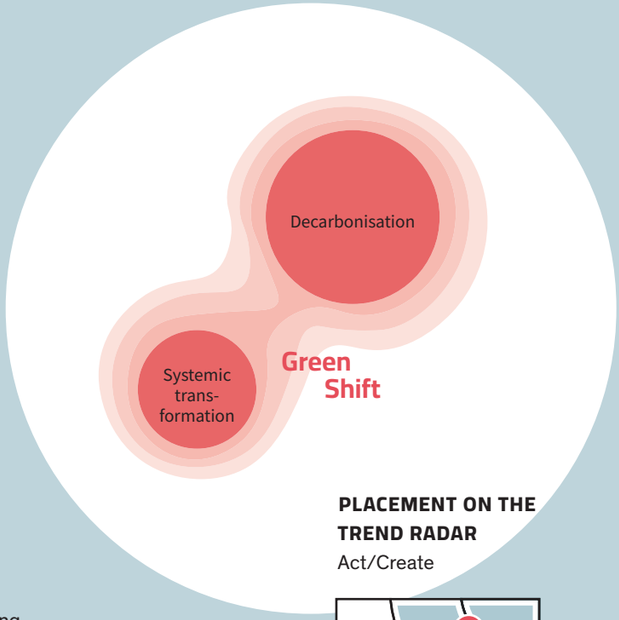
Aside from regulatory pressure, technological innovations enabling more efficient mobility services are a major Green Shift driver. Many companies and start-ups are working ambitiously to improve battery technology, both in terms of range and charging time. Solid-state batteries such as aluminium-ion batteries or lithium-ceramic batteries are to become more compact, powerful and safer alternatives to lithium-ion batteries in the next few years. New generations of fuel cell technologies also promise lower consumption and higher performance for hydrogen-powered mobility. Research into synthetic fuels such as e-fuels is being pursued intensively in order to make millions of existing vehicles with diesel and petrol engines more climate-friendly, with AI significantly expanding the possibilities of digital control systems for improved traffic flow. These innovations not only drive decarbonisation, but also increase the efficiency and adaptability of mobility systems.

But transformation also holds its challenges. The shift away from fossil fuels and traditional mobility structures is not only a technical, but also a social and economic task. Social justice, economic stability and the resilience of mobility systems are crucial aspects here. An unbalanced mobility transition – for example, due to excessive costs for individual groups or one-sided funding models – will trigger social resistance. The success of the Green Shift is therefore closely tied to its acceptance and active participation by politics, businesses and the civil society. Isolated initiatives will not suffice. The Green Shift requires action across systems – from urban infrastructure to global supply chains and personal mobility. Without holistic planning, participative implementation and systemically interacting measures, there is a risk of side effects such as new social inequalities or rebound effects. The challenge for the coming years will be to realise a fully sustainable mobility transition that is not only ecologically better but also economically viable and socially just.

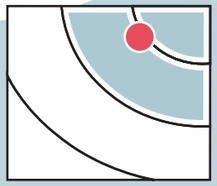
SHIFT

The Green Shift focuses on the following identified trend concepts:

- ➔ Decarbonisation
- ➔ Systemic transformation



PLACEMENT ON THE TREND RADAR
Act/Create



WHAT'S BEHIND THE TREND?
Decarbonisation is the process of reducing or eliminating carbon emissions – and this shift away from fossil fuels and the transition to zero-emission or climate-neutral technologies is already underway. One of the goals of decarbonisation is to transform the entire mobility sector such that carbon emissions are minimised or at least fully compensated. Besides drive technologies such as e-mobility, hydrogen and other sustainable fuels, modal shifts to mobility forms such as rail or shared mobility also foster decarbonisation. Systemic transformation describes the need to consider the mobility transition holistically, across systems, in terms of its interactions and dependencies. The aim is to go beyond isolated solutions and shape change in such a way that it has interacting effects. Several factors play a role here, including economic compatibility, political framework conditions and social acceptance. The Green Shift cannot be achieved by legislative measures alone; it also requires a structural adaptation in industries, new business models and supportive investments.

Decarbonisation is the technological component of the Green Shift trend. But only when combined with a systemic transformation is this change economically, socially and politically viable. Without systemic changes, a decarbonised mobility can cause new issues, such as social inequalities or a shift of emissions to other sectors. The mobility transition can only be successful with the close networking between different players and industries, as well as largely harmonised political framework conditions.

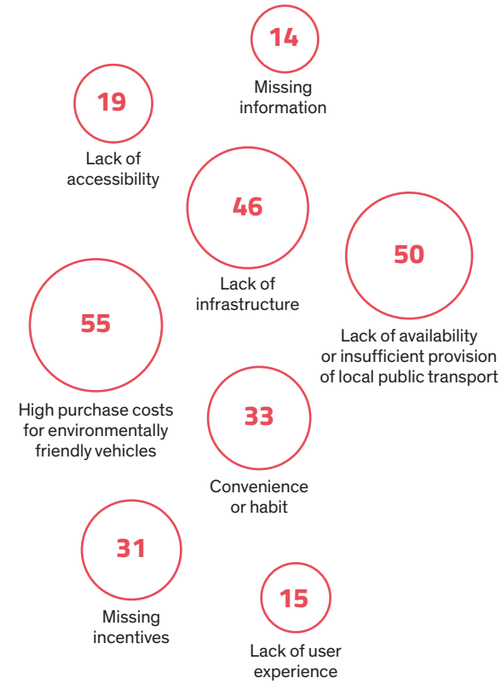
ZOOM-IN

CONTEXT

HOW IS THIS TREND MANIFESTED?
The Green Shift is not a futuristic vision, but a dynamic process that is already transforming mobility systems. Politics, industry and society are increasingly taking measures to drive the decarbonisation of mobility. Particularly in the areas of infrastructure, regulation, technology and business models, major developments are visible showing that the shift towards eco-intelligent mobility is in full swing.

Political action to implement the Green Shift particularly includes ambitious climate targets and regulatory measures. With its "Fit for 55" package, for example, the European Union is aiming to reduce carbon emissions by at least 55 percent by 2030. The intended shift away from the combustion engine in Europe as from 2035, for example, is putting the automotive industry under tremendous innovation pressure. At the same time, cities and regions are increasingly focussing on political strategies that specifically promote eco-friendly mobility concepts – for example, by investing in the expansion of public transport, promoting bicycle infrastructure, car-free zones, cycle paths and parks. Singapore, for example, has been consistently investing in its public transport system since 2017 and plans to have invested a further 40 billion euros in network expansion by 2031, in order to offer 80 percent of Singaporeans a metro station within a ten-minute walk. Paris has turned streets into pedestrianised zones and has doubled its cycle paths to over 1,000 kilometres at a cost of 150 million euros. A further 250 million euros are to be invested in the French capital's cycling policy over the next few years. The removal of urban motorways and heavily used roads has also been put on the agenda in many places, even in the US, where the Federal Highway Federation supports the implementation of highway removal and road diet projects.

What obstacles do you currently see to using sustainable means of transport?
In per cent



Source: Statista, 2024

Note: Germany; 2,500 survey participants; 16 years and older

Globally, electric vehicles are not a niche product in the automotive industry, but established market players. Over 41 million electric cars were sold worldwide in 2023 - an increase of over 14 million vehicles compared to the previous year. Frontrunners such as Norway demonstrate that a widespread electrification of transport is possible. In 2024, the share of electric vehicles in newly registered vehicles was almost 90 percent. At the same time, leading automotive companies such as Volkswagen, Toyota and BYD are investing billions in the development of new battery technologies and the expansion of the charging infrastructure.

Top 3 leading green tech sectors

Based on patent numbers

01 **Efficient production**
more than 40,000 world-class patents

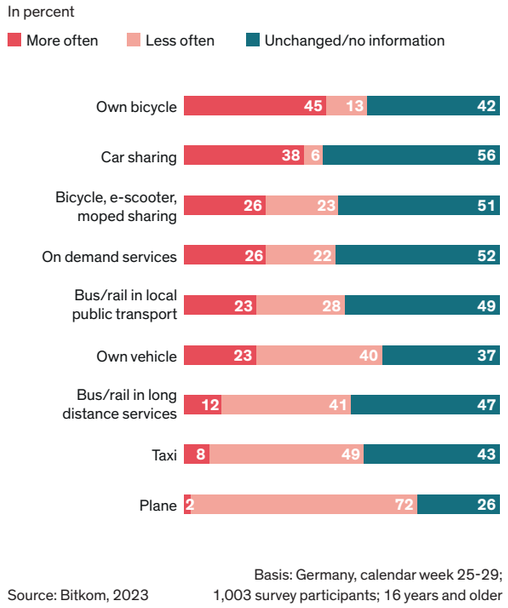
New mobility 02
around 36,000 world-class patents

New energy 03
around 20,000 world-class patents

Source: EconSight, 2023

In what way has your mobility behaviour changed fundamentally in recent years?

In percent



Source: Bitkom, 2023

Basis: Germany, calendar week 25-29; 1,003 survey participants; 16 years and older

Aviation and shipping transport is also transforming. While Sustainable Aviation Fuels (SAF) are being tested as alternative fuels for the aviation sector, the shipping industry is increasingly turning to hydrogen and methanol as lower-emission alternatives to heavy fuel oil. However, scaling up these technologies remains a challenge – experts have expressed concerns about whether the targeted quotas for SAF can actually be achieved.

Beside these regulatory and infrastructure changes, the Green Shift is also reflected in changing consumption and mobility patterns. People are increasingly choosing not to have their own car and are instead making greater use of intermodal mobility solutions that combine different modes of transport. Sharing concepts, mobility-as-a-service (MaaS) and digital mobility platforms are becoming more important. At the same time, cities, regions and states are testing new incentive models to make sustainable mobility more attractive. For example, the Australian state of Queensland trialled a 50 cent ticket for public transport to encourage people to switch to more climate-friendly means of transport. All these developments show that the Green Shift is not just a technological transformation, but entails a far-reaching social and economic transformation. The coming years will show how successfully the measures are working and to what extent the shift towards zero-emission mobility can be anchored in the long term. However, it is clear that the mobility sector is moving towards a more climate-friendly future.

OUTLOOK

The course has been set, but implementing the transition to sustainable mobility remains a complex task and depends on many factors. While initial regulatory measures and technological innovations are already signalling clear progress, economic, infrastructural and social conditions must be further adapted to enable a large-scale mobility decarbonisation.

Technological progress will be a key driver for further development. Improvements in battery technology, a more efficient charging infrastructure and successes in alternative drive systems such as hydrogen and synthetic fuels will have a significant impact on how quickly zero-emission mobility becomes the new standard. While the electrification of road transport is rapidly advancing, air and sea transport remain major challenges. Scaling sustainable aviation fuels (SAF) and hydrogen propulsion systems is essential, but there are still major barriers in production, costs and infrastructure to overcome.

Also, the mobility industry‹s market and business models will continue to change. Automotive manufacturers are facing a paradigm shift. Instead of just selling vehicles, they are increasingly focusing on mobility services, sharing models and intermodal platforms. Companies adapting to these changes at an early stage will benefit from competitive edges, while traditional business models will come under pressure.

Social acceptance of a sustainable mobility will be key to determining if the Green Shift will be successful. The change requires not only a technological, but also a cultural transformation. Governments and mobility providers face the common challenge of making eco-intelligent mobility options so attractive that they are embraced by broad population groups. Financial incentives, an improved public transport infrastructure and sharing models will play a key role here. The expansion of a zero-emission infrastructure, the regulatory framework for new technologies and the creation of economic incentives to encourage the transition to sustainable mobility systems are essential to achieving the climate targets set.

The Green Shift is transforming the mobility sector and will also have a profound impact on economy, society and politics. The coming years will be driven by efforts to establish a form of mobility that is ecologically sound, economically viable and socially acceptable. The Green Shift is not an option. It is the major driver for the mobility's future in the years to come.

TREND REGULATORY COMPLEXITY

REGULA-TORY COMPLEXITY

Increasing regulatory complexity is associated with major challenges for mobility operators. Stricter environmental, safety and market regulations, as well as geopolitical influences and national funding strategies, create new competitive conditions – and sometimes also uncertainty.

TREND REGULATORY COMPLEXITY

REGULATORY

TREND

Regulation is among the most powerful levers for change in the mobility sector – it can drive innovation, but it can also jeopardise entire business models. Over the last years, the regulatory and funding landscape has become increasingly complex: National governments and supranational institutions such as the EU are increasingly relying on regulation to achieve their climate targets, increase security, enforce standards or protect their internal markets. At the same time, possible twists in the regulatory landscape are hard to predict in many countries due to the prevailing political dynamics.

One example of a landmark regulation is the ban on combustion engines in the EU from 2035, which will force traditional automotive manufacturers to radically change their production lines while suppliers will have to adapt or completely reinvent their business models. At the same time, however, there is no global consensus: While Europe is preparing to phase out the combustion engine, China is pursuing a mixed strategy of electric mobility, hybrid technologies and synthetic fuels. In the United States, the Inflation Reduction Act has, among other things, massively boosted the production of electric vehicles and batteries – a trend that cannot be completely reversed even by a change of course under Donald Trump since the corresponding funds have already been invested in projects such as lithium mining in California, solar cell factories in Texas and factories for the production of batteries and electric cars in Georgia. Meanwhile, Europe is responding to Trump's return to fossil fuels by preparing a decarbonisation agenda. The Clean Industrial Deal prioritises clean products from the EU and provides 100 billion euros for this purpose.

While the EU and some US states are introducing strict CO2 regulations, other markets continue to rely on fossil fuels or subsidise high-emission technologies. This is causing global companies to develop different product and business strategies in parallel in order to meet the requirements of their respective markets. Automotive manufacturers like Toyota argue, for example, that there are many reasons not to entirely rely on pure e-mobility just yet, because relevant infrastructure, variable price ranges and a reasonable selection of vehicles for the different parts of the world are still lacking. At BMW, there is concern that Europe's automotive industry may be susceptible to blackmail if it focuses exclusively on battery electric propulsion. The regulation of autonomous vehicles also shows quite different patterns worldwide: In China, driverless taxis are being tested on a large scale, while the EU is still working on comprehensive safety standards, and the US has regulations that vary from state to state.

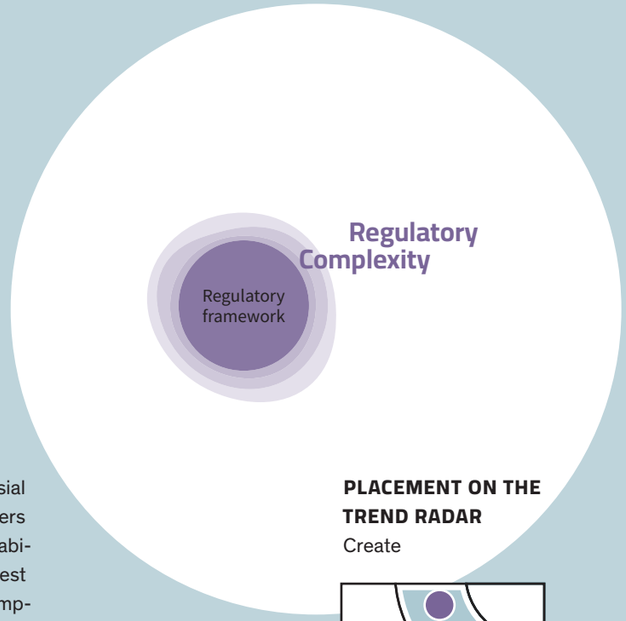
This divergence of regulatory frameworks in different markets means that companies can no longer develop their business strategies based on technical or economic considerations only but need to conduct an in-depth analysis of the current regulatory landscape also taking into account future scenarios. The development of new vehicles, mobility services or infrastructure projects is hardly sustainable today without knowledge of applicable laws, planned regulatory initiatives and potential political changes. It is essential to analyse funding landscapes and tax incentives as these have significant influence on which technologies have economic potential. With the EU taxonomy, for example, the EU has introduced a classification that defines which investments are considered environmentally sustainable – a decision that directly influences which mobility solutions are eligible for funding. To remain competitive in such an environment, it is not enough to simply comply with the current regulations, but companies also have to anticipate how the legal framework will develop – an aspect that increasingly makes market success dependent on a companies' regulatory agility.

On top of all this, there is increasing political unpredictability. In Europe, the days when catch-all parties were constantly in power and guaranteed a certain degree of stability are increasingly a thing of the past. New parties with more radical regulatory approaches – in one direction or another – are gaining influence. Even economic big players like the US are questioning established practices, agreements and regulations. Due to the fragmented and volatile political landscape, also mobility providers must expect to be confronted with policy changes and completely new regulations at short notice – for example, in form of stricter climate requirements or cancelled subsidies and new restrictions on certain forms of mobility. Geopolitical uncertainties in form of ongoing wars such as in Ukraine or the Middle East, rebel attacks such as in the Red Sea, smouldering conflicts such as that between China and Taiwan, or bold claims to important infrastructure such as those of the USA regarding the Panama Canal are causing movement in the mobility markets. Sanctions, tariffs, geographical or technological trade barriers can impede access to important raw materials, production capacities, transport routes or sales markets.

COMPLEXITY

The Regulatory Complexity trend focusses on the following identified trend concept:

➔ Regulatory framework



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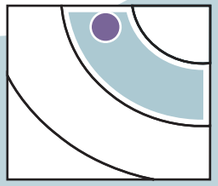


WHAT'S BEHIND THE TREND?
The regulatory framework is one of the most controversial fields in the mobility debate. While some industry players see it as an indispensable instrument for safety, sustainability and fair competition, others see it as one of the biggest hurdles to innovation – especially in Europe. Critics complain that the multitude of laws, regulations and bureaucratic requirements delays technological progress, slows down start-ups and puts European companies at a disadvantage in international competition. Particularly in comparison to dynamic markets such as the US, India or China, where innovations can be implemented and scaled under less, or more flexible, regulatory conditions, the European economy is seen as lagging behind due to excessive regulation. This view is supported by the sluggish introduction of new mobility technologies such as autonomous driving or alternative drive systems, which are only making slow progress in Europe due to lengthy approval processes or inconsistent funding.

Still, there are also supporters of strict regulation. In particular, in sensitive areas such as data processing, traffic safety and consumer protection, clear legal requirements are seen as a potentially important competitive advantage. With initiatives such as the General Data Protection Regulation (GDPR) or the AI Regulation, Europe is regarded, depending on one's point of view, either somewhat disparagingly as the 'world champion of regulation' or as a pioneer of trustworthy and transparent technology standards. In the field of mobility, well thought out regulation can help European companies to develop secure, inclusive, fair and environmentally friendly solutions that are in demand internationally.

ZOOM-IN

The real problem lies not so much in the existence of regulation, but in its structure, speed and adaptability. A regulatory landscape that is too rigid and slow to react can hinder transformation and innovation, while a dynamic, technology-open regulation can set important incentives to improve market conditions and create a clear framework for new business models. Ultimately, it will be decisive how quickly and flexibly legislators will react to technological developments in the future in order to avoid the risk of economic stagnation or unregulated proliferation.

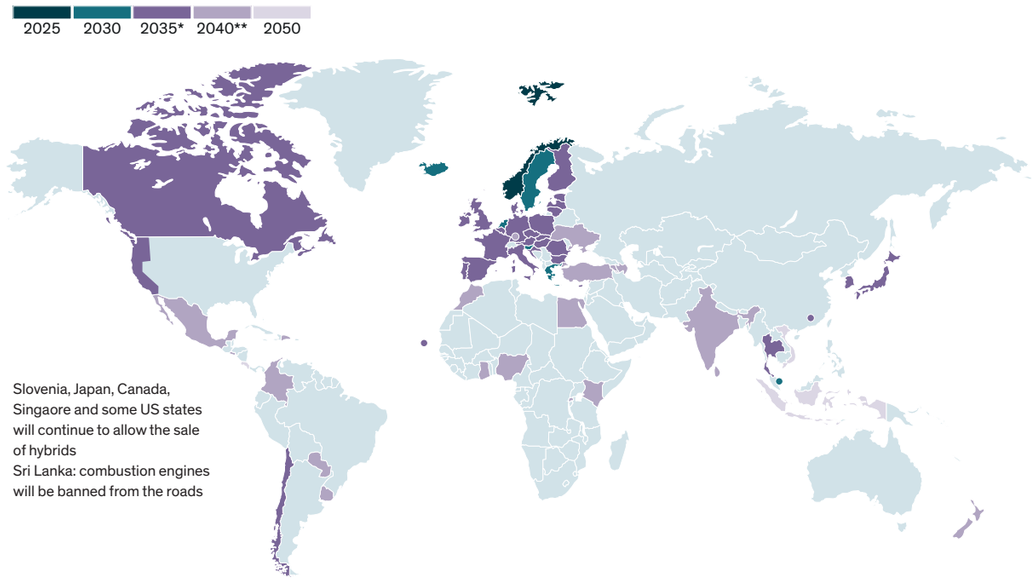
CONTEXT

HOW IS THIS TREND MANIFESTED?
The increasing regulatory complexity in the mobility industry manifests itself in a wide range of areas – from the financing of sustainable technologies to global market distortions caused by the various regulatory requirements. This complexity does not only result in enormous adjustment efforts for companies, but also has strategic effects on competitiveness, innovative strength and market access.

One example of the direct influence of regulation can be observed in aviation. Due to strict environmental regulations in the EU, in particular, the mandatory blending of sustainable aviation fuels (SAF), kerosene tax and adjustments to the EU Emissions Trading System (ETS), European airlines face higher operating costs than their international competitors. Since airlines from other regions often do not have to comply with these requirements, market distortions arise, which favour, for example, the relocation of long-haul flights to hubs such as Istanbul or Dubai. Moreover, European airlines are affected by indirect government measures: While the EU relies on emissions trading systems to make aviation more climate-friendly, airlines outside of Europe are not burdened with these additional costs. Since air traffic is global, the conditions of competition should be fair, argues, among others, Lufthansa Group, and calls for a level playing field with its main competitors from the Middle East, China, the US and Turkey. According to Lufthansa Group, the proposed EU measures in aviation would lead to a relocation of CO2 emissions and significant distortions of competition if they were not corrected.

Global phase-out of petrol cars

Approximate official targets for the complete phase-out of new petrol/diesel-powered cars, by country



Slovenia, Japan, Canada, Singaore and some US states will continue to allow the sale of hybrids
Sri Lanka: combustion engines will be banned from the roads

Source: ICCT, A2Z Coalition, Coltura, Statista-Research

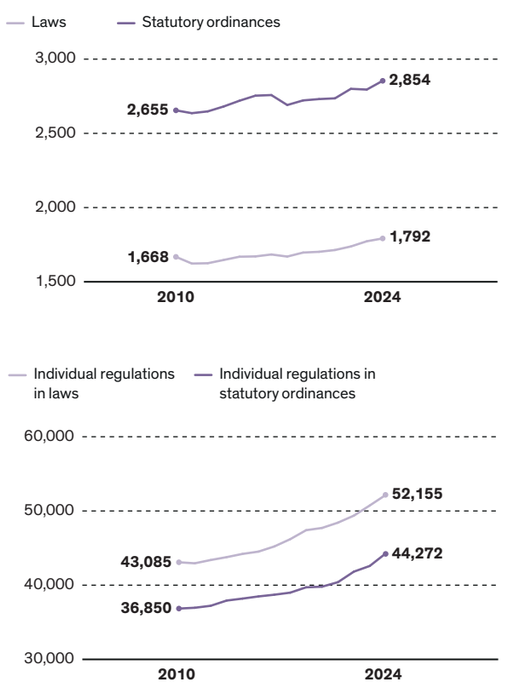
* Including EU-wide ban
** Including the signatory states of COP26 promises 2.A and 2.B

Another area in which regulation has far-reaching consequences is the financial sector. The EU taxonomy and state regulations, for example, in Germany, require banks to make their portfolios more climate-neutral, which has direct impact also on the financing of mobility projects. Some industries, such as shipping and aviation, are facing massive challenges as banks increasingly consider the financing of particularly carbon-intensive companies as high-risk. They fear that it will be more difficult for traditional industries to earn the money required to repay their loans. Apart from that, investors are less willing to entrust their money to banks that finance companies which are harmful to the climate.

However, the example of shipping shows that regulation can also be a driver of transformation. The International Maritime Organization (IMO) has established strict regulations to reduce emissions, pushing companies to switch to more sustainable fuels, such as methanol or LNG. These regulatory requirements are not only setting new standards but are also changing the entire structure of the global shipping industry by promoting alternative technologies and channelling investments into more climate-friendly infrastructure. At the same time, however, companies have to meet new certification requirements to demonstrate their compliance with these international regulations. This can result in significant costs and time delays, especially for smaller players in the industry.

Supply chains are also subject to increasingly stringent regulatory requirements. Examples include the European ban on the import of products made using forced labour and the due diligence obligations under the EU Corporate Social Responsibility Directive (CSDDD), which require companies to comply with human rights and environmental standards throughout their entire supply chain. Companies are therefore not only responsible for their own actions but must also monitor the actions of their direct and indirect suppliers. A survey among Austrian companies highlights the challenges associated therewith: Only 30 percent of the survey participants are fully familiar with the requirements of the CSDDD and the vast majority of companies do not know their indirect suppliers. Companies are required to identify risks, prevent any negative impact of their business activities and take preventive measures. They are obliged to establish detailed transparency and monitoring systems to prove that their supply chains comply with the legal requirements. This requires extensive audits, new contractual arrangements and often also a complete reorganisation of supplier relationships, which entails high administrative and financial burdens for many companies. Last but not least, the monitoring of emissions and sustainability standards with comprehensive reporting and rating systems is another factor that shows the growing influence of regulatory complexity. Companies are obliged to continuously document their environmental performance and report it in publicly accessible sustainability reports. While this is intended to create transparency and promote sustainable business models, it also significantly increases the administrative burden and poses major challenges, in particular, for smaller companies.

Number of laws, statutory ordinances and individual regulations at federal level



Source: Statista, 2024

Note: Germany, 2010 to 2024

The range of examples given shows how regulation in the various sub-areas changes the framework conditions and, thus, does not only constitute a legal or bureaucratic challenge but also a strategic core issue for companies in and around the mobility industry.

OUTLOOK

It is to be expected that, over the next years, the regulatory landscape will not only become more complex but also more dynamic and politically volatile. Companies that only comply with existing regulations today run the risk of being caught off guard by unexpected political decisions, new environmental regulations or geopolitical shifts. Those who do not deal with regulatory developments at an early stage, proactively anticipate them and integrate them into strategic decision-making processes, risk significant competitive disadvantages or even the loss of their market access. In particular, internationally operating companies have to develop a thorough understanding of the different legal frameworks and be able to dynamically adapt their strategies.

Meanwhile, regulation also offers opportunities for companies that are able to proactively adapt and position themselves as pioneers of compliant innovation. What may be a limitation to some is the opportunity to discover interesting economical potential in the new framework conditions to others. Regulatory complexity is not a side issue in mobility transition, but an essential factor, which is of central importance for the future viability of companies and entire industries. The decisive question for companies is therefore how they can use regulation to their advantage.

TREND EFFICIENT LOGISTICS

Efficient Logistics describes the optimisation of logistics processes by means of digital technologies, AI-supported systems and eco-intelligent transport strategies that increase flexibility, reduce costs and strengthen the resilience of supply chains.

EFFICIENT LOGISTICS

EFFICIENT LOGISTICS

TREND

The increased fragility of many supply chains is an indication of the interaction between mobility and megatrends such as globalisation, eco-intelligence and security. Moreover, mobility is also affected by geopolitical tensions, increased ecological and ethical demands or natural disasters while technological innovations lead to a radical transformation of transport and distribution processes. Companies are not only seeking to operate more efficiently but also to create resilient structures that can react flexibly to crises and changes. The Efficient Logistics trend describes this change and highlights the central developments that make efficient, resilient logistics possible.

One of the key drivers of this trend is digital networking. Since AI and big-data analyses enable more precise planning and control of transport flows, intelligent systems are increasingly being developed to analyse weather data, geopolitical developments, capacity bottlenecks and changes in demand in real time in order to detect disruptions and calculate alternatives early. The aim is to optimise routes, improve resource utilisation and increase delivery reliability – a key factor for companies that have to assert their position in highly volatile markets. Particularly in e-commerce, the ability to react flexibly to fluctuating order volumes is a crucial competitive advantage.

But digitalisation alone is not enough. The resilience of supply chains has become the defining issue for the industry. The Covid-19 pandemic, the war in Ukraine and ongoing (trade) conflicts have shown how dependent companies are on global supply networks. Nearshoring – i.e. the relocation of production sites and suppliers closer to the end customer market – is becoming just as important as multi-sourcing strategies, in which a specific product or service is purchased from several providers in order to avoid dependency on individual suppliers or regions. Decentralised warehousing structures and flexible logistics networks are also becoming more attractive as they offer the possibility to switch quickly to alternative supply and distribution channels in the event of a crisis.

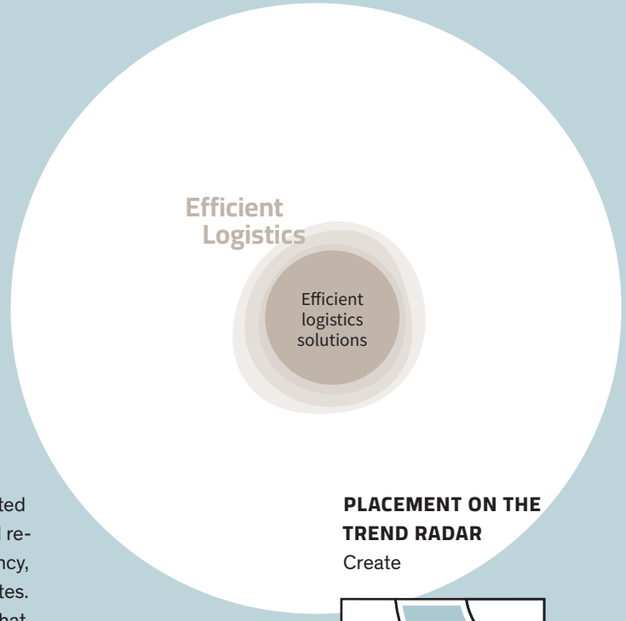
The ecological impact of logistics also plays an important role in the Efficient Logistics trend, because the transport sector is one of the main sources of CO2 emissions and customers and legislators are increasingly demanding sustainable solutions in this area. The focus here is on electrified transport fleets, alternative fuels, such as hydrogen or bio-LNG, and the increased use of rail as a means of transport. Micro depot concepts and delivery methods, such as bicycle couriers or autonomous delivery robots, also help to improve the ecological balance in logistics. Companies that reduce their CO2 emissions along the entire supply chain can benefit from an improved image, regulatory incentives and long-term cost savings.

A particularly tricky subject is what is referred to as last-mile delivery, i.e. the delivery process over the last few kilometres to the end customer. Particularly in urban areas, this part of the supply chain is often the most expensive and inefficient. While traffic jams, parking problems and environmental regulations complicate logistics, customers expect ever faster delivery times. To meet these challenges, new concepts such as parcel boxes, drone deliveries or temporary micro-hubs are being tested to relieve traffic in city centres. Moreover, autonomous vehicles and AI-supported delivery planning help to minimise delivery costs and optimise traffic flow.

Automated logistics processes are another area of innovation. Robot-assisted warehouses, in which AI-controlled machines pick and pack goods, are already part of our present. Self-driving trucks are being tested in pilot projects and promise to provide a cost-efficient and environmentally friendly transport solution in the long term, provided that the necessary infrastructures can be made available. The combination of automation, artificial intelligence and real-time data analysis has the potential to increase efficiency in the logistics industry by a few more percentage points over the coming years and can also help to alleviate labour shortages.

The Efficient Logistics trend focusses on the following identified trend concept:

➔ Efficient logistics solutions



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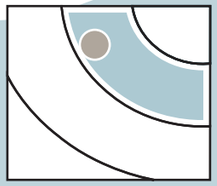


WHAT'S BEHIND THE TREND?
Efficiency in logistics can relate to various closely related aspects that aim to optimise the use of time, costs and resources. One of the central dimensions is space efficiency, which results from optimised storage and transport routes. The aim here is to move and store goods in such a way that empty runs are minimised, storage capacities are used optimally, and transport infrastructures are utilised to the best possible extent. This includes both an intelligent bundling of shipments and the best possible use of multimodal transport options combining rail, road, air and sea. Another important aspect is time efficiency, which aims to provide goods exactly when they are needed. Just-in-time supply chains and the reduction of waiting times at transshipment points are essential strategies for increasing this type of efficiency. More precise planning and real-time monitoring of supply chains help companies to identify bottlenecks at an early stage and enable them to dynamically adapt their processes.

ost efficiency is very much about making transport more economical by improving vehicle capacity utilisation, using cheaper alternatives such as trains or inland waterways, and optimising route planning. Particularly in times of rising energy prices, choosing the most economical means of transport is becoming a key factor for companies. Ecological efficiency is also increasingly coming into focus with regard to environmentally friendly logistics processes, which is improved, for example, by low-emission drive systems, energy-efficient transport infrastructures or the use of recycling and circular economy concepts within logistics. A reduced carbon footprint is becoming more and more important not only for regulatory reasons but also because companies are increasingly recognising sustainable supply chains as a competitive factor.

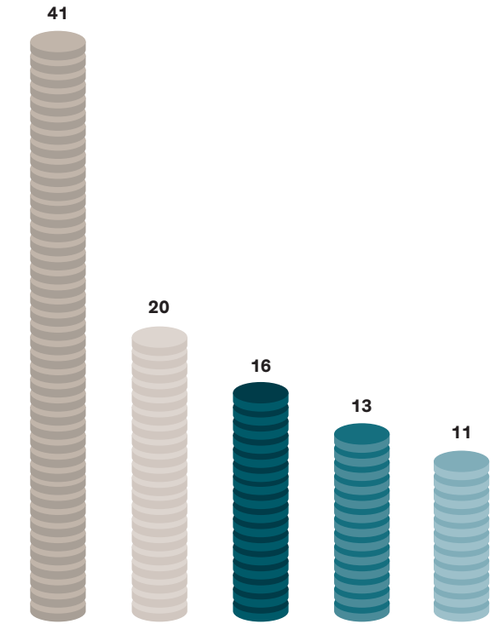
Last but not least, efficiency is also playing an increasingly important role in terms of resilience. To ensure that logistics remain efficient in the long term, supply chains must be flexible enough to react to unforeseen events. Diversification of suppliers, alternative transport routes and the use of intelligent technologies are approaches to making supply chains more resilient.

ZOOM-IN

CONTEXT

HOW IS THIS TREND MANIFESTED?
The Efficient Logistics trend is manifested in a variety of innovative tools that help companies optimise their supply chains, reduce costs and operate in a more environmentally friendly manner. Thus, for example, in early 2024, the first parcel drone took off on a scheduled flight from a tool trading company in Lüdenscheid to fly across the city to an industrial plant. Since then, up to 34 parcels have been delivered per day. The farthest drone delivery was made to the neighbouring town of Altena where it arrived after 15 minutes, whereas a car journey would have taken between 40 and 60 minutes. The start-up Morpheus Drohnenlogistik, which carries out the deliveries, has been approved for nine routes in Germany so far. Besides industrial companies, it also supplies health care facilities in regions that are difficult to reach with medical products or delivers materials, tools and spare parts to drilling platforms or wind farms. Experts consider the use of drones – for example, in express services that supply workshops and industrial companies with urgently needed spare parts overnight – an interesting option to enable fast, automated and low-CO2 transport solutions for time-critical deliveries.

Allocation of costs to individual steps in the delivery process of an e-commerce company in 2023
Worldwide, in per cent



Source: Deloitte; Cainiao Smart Logistics Network, 2023

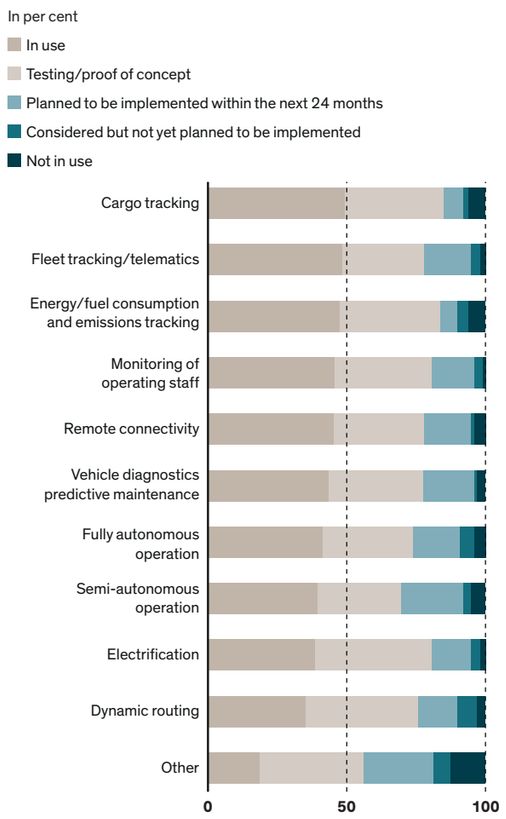
Autonomous trucks also offer great potential for increasing the efficiency of freight transport in remote regions where the freight system is facing the challenge of long distances. In the Australian iron ore mine Greater Nammuldi, which is owned by the Rio Tinto Group, for example, fifty self-driving trucks are in operation – each with a capacity of 300 tonnes. They are coordinated and monitored by the operations centre in Perth, which is about 1,500 kilometres away. Digital platforms, such as Cargonexx, Shipsta by Freightos or Shippeo, reduce the number of empty runs and enable the efficient combination of different modes of transport. Platform economy also offers vast potential as regards the fully automated execution of operational processes in logistics companies – from the negotiation and scheduling to the control of goods flows. The Silicon Economy project of the Fraunhofer Institute for Material Flow and Logistics (IML), for example, aims to develop an open-source infrastructure in this context that uses AI and automation to optimise logistics processes, creates transparency and trust in value chains and provides open-source components to promote collaboration and sustainable technologies to reduce CO2 emissions. In shipping logistics, there is also a growing emphasis on technological efficiency, in particular, when it comes to using AI-optimised routes or extensive sensor technology to remotely monitor cargo and on-board equipment, analyse real-time data and identify problems at an early stage.

The last mile of a transport route is often the most cost and emission-intensive part of the supply chain. Therefore, innovative solutions are constantly being sought also in this respect. For example, Fraunhofer IAO, veloCARRIER and evopark have developed the Park_up concept in collaboration with APCOA Parking Germany with the aim of making publicly accessible parking spaces temporarily available for logistics purposes – a kind of Airbnb for free parking spaces, which can thereby be turned into parcel transshipment points.

This allows logistics service providers to set up decentralised micro depots and shorten delivery distances especially in urban areas, where space for warehouses is hard to find and expensive. Besides other micro depot concepts, delivery robots and cargo bikes are also increasingly being used to reduce traffic and make deliveries faster and more sustainable. Goods trams, such as those in Frankfurt am Main, are being tested in combination with e-transporters and e-cargo bikes, as are innovative logistics systems such as those presented by a European research association at the Lower Saxony Research Center for Vehicle Technology (NFF) at the Technical University of Braunschweig as part of the LogiSmile project. In real traffic conditions, scientists demonstrated a complete solution for a fully autonomous logistics concept consisting of two vehicles that network with each other to independently deliver parcels. The larger vehicle is kind of a mobile intermediate storage on wheels, while the smaller one delivers parcels to the recipient and informs them by text message. In China, Alibaba reported that, by 2021, its autonomous logistics vehicle Xiaomanlv had completed already more than a million delivery orders in 52 cities. Rewe tested an autonomously-driving shopping concept in Hamburg, while the retail cooperative S Group is working with Starship Technologies to gain experience in delivering food using self-driving robots in 15 Finnish cities. More than 150,000 orders have already been processed and the expansion of the service to more than 100 stores has been initiated.

Introduction of selected digitalisation use cases among carriers

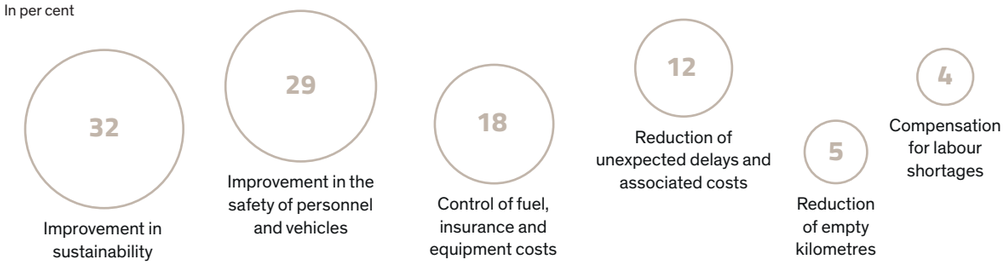
In per cent



Source: 451 Research Supply Chain Digital Transformation Survey, 2024

Key issue carriers are trying to solve with technology

In per cent



Source: 451 Research Supply Chain Digital Transformation Survey, 2024

The efforts to create an agile, environmentally friendly and resilient logistics network are being intensified in order to keep pace with the challenges of the modern world. By intelligently managing supply chains using digital technologies such as IoT, AI, real-time data and automated analytics, companies are increasingly proactively optimising their supply chains, identifying transport bottlenecks at an early stage, planning alternative routes and dynamically managing inventory levels. As a result, supply chains are becoming more efficient and more resilient to global crises and demand fluctuations.

The Green Shift will also be a key driver in logistics in the years to come. Companies will have to make their transport solutions environmentally friendly, and the creation of new political and legal frameworks will promote innovation in logistics and help to ensure that resilient transport solutions become the rule. Platform economy and sharing models will gain importance in logistics, creating digital marketplaces that offer available transport capacities in real time and enable more flexible and resource-efficient use of existing infrastructure. Joint company logistics solutions will help to avoid empty runs, make optimal use of storage space and reduce costs. These platform solutions will be particularly attractive for small and medium-sized companies, which will gain access to more efficient logistics networks through these collaborations.

Last-mile logistics will change dramatically as hyperlocal and just-in-time solutions are becoming more and more prevalent. Micro depot concepts, autonomous delivery vehicles and highly flexible supply chains will help advance even faster and more environmentally friendly delivery. Especially in urban areas, autonomous delivery robots, intelligent parcel stations and e-cargo bikes will shape the cityscape and reduce the burden of traditional delivery traffic.

OUTLOOK

TREND SUSTAINABLE FUELS

SUSTAI-NABLE FUELS

A shift towards more climate- and environmentally friendly energy sources can be observed across all mobility sectors.

TREND SUSTAINABLE FUELS

SUSTAINABLE FUELS

TREND

While the focus in road traffic is increasingly on reducing emissions through electrification, other mobility sectors such as aviation, shipping or heavy-duty road transport primarily rely on alternative fuels that are less harmful to the environment than fossil fuels. They make it possible to reduce CO2 emissions without the need to completely replace existing infrastructure and vehicles. Sustainable fuels include biofuels and synthetic fuels (e-fuels).

In aviation, sustainable aviation fuels (SAF), which are produced from biogenic residues such as used cooking oils, garden and food waste, vegetable oils and algae, or from electricity and hydrogen, are considered one of the central solution approaches. Their availability and costs, however, are currently major obstacles. Experts emphasise that the ambitious quotas, which, among others, have been set by the EU (two percent from 2025, six percent from 2030, 70 percent from 2050) and Japan (ten percent for 2030), will be difficult to achieve because of the significant challenges along the entire value chain. So far, SAF accounts for only about 0.3 percent of global aviation fuel consumption. Even with the planned investments, it is expected that only ten percent of global demand will be covered by 2030. Expanding production is a complex undertaking, as new plants require high capital expenditure, have to go through lengthy approval procedures and depend on a reliable supply of raw materials.

Another limiting factor are the high production costs, which are currently three to five times higher for SAF than for conventional kerosene. The aviation industry, which heavily relies on cost efficiency, could come under pressure as a result. Without comprehensive state funding programmes or a globally standardised CO2 price for aviation fuels, SAF will remain economically unattractive for many airlines. In addition, an increased SAF share could make ticket prices more expensive, which would have a significant impact in this highly competitive market.

Besides the costs, the limited availability of raw materials plays a crucial role. At present, a large part of the SAF production is based on biogenic residues and biomass, the global availability of which is severely limited because much of it is already used in other industries, for example, for biodiesel. A promising alternative is the production of synthetic fuels, which converts hydrogen and CO2 into aviation fuel. However, this process requires enormous amounts of renewable energy, which will make it difficult to scale up over the next few years.

In shipping, alternative fuels in the form of methanol, ammonia or biomethane are also gaining importance because they can be made compatible with existing engine technologies and significantly reduce emissions. Hydrogen is considered a particularly promising energy source for maritime and heavy-duty transport applications because it has a high energy density and can be used with zero emissions. The production of green hydrogen requires enormous amounts of renewable energy, because its manufacturing process – the electrolysis of water – achieves an efficiency level of only around 60 to 70 percent. In addition, there are high energy losses during storage, transport and conversion into usable energy, since hydrogen, as the lightest element, can only be transported at very low temperatures (-253 °C as liquid hydrogen) or under high pressure (700 bar). These processes are technically complex and costly. Liquid hydrogen requires a complex cooling and insulation infrastructure to prevent evaporation losses, which is particularly problematic in the aviation sector. Compressed gas hydrogen is stored in high-pressure tanks, which are expensive to manufacture and maintain, and transport capacity is limited. Hydrogen carriers such as LOHC (Liquid Organic Hydrogen Carrier), ammonia and methanol could be an alternative by chemically binding hydrogen, making it easier to transport. However, the subsequent reconversion requires additional energy. Pipeline transport is more efficient, but the existing infrastructure is not designed for hydrogen as the gas can embrittle materials and therefore requires special coatings and compressors.

Experts see technology as the key to competitiveness, both for fuel production and for optimising drive and storage systems. The central technological drivers include Power-to-X technologies (PtX), which is understood to include all processes that convert green electricity into chemical energy carriers for electricity storage, into electricity-based fuels for mobility or into raw materials for the chemical industry. They are categorised by intended use (e.g. power-to-fuel, power-to-chemicals or power-to-ammonia) or by the form of energy (power-to-gas, power-to-heat, power-to-liquid). PtX can be used to produce hydrogen for fuel cell vehicles and kerosene for aircrafts in a climate-friendly way.

High-performance electrolysers, which use electricity to split water into its basic components hydrogen and oxygen, are expected to increase the efficiency of hydrogen production and reduce costs in the future. In this area, progress has been made with various types of electrolysers, such as PEM (proton exchange membrane), SOEC (solid oxide electrolyser) and alkaline electrolysers. So far, water electrolysis accounts for only about 0.1 percent of global hydrogen production, but with announced and planned projects, global electrolyser capacity could reach between 175 and 420 gigawatts by 2030 – a multiple of the 1.15 gigawatts with which China is currently the global leader in hydrogen electrolysis capacity.

New storage technologies such as metal hydride storage, in which hydrogen is bound in a metal lattice structure rather than in highly compressed or liquefied form, could, from an economic and safety perspective, represent an attractive alternative to storage in form of compressed gas or liquid. Apart from that, digital control systems can be deployed to optimise hydrogen networks, connect the multitude of producers and consumers and make operations efficient. Thus, for example, blockchain can be used to transparently track origin and transport routes, or artificial intelligence can help to reduce operating costs through real-time monitoring and control. Digital twins can also facilitate the virtual modelling of plants and processes, while integrated platforms promote data exchange along the entire value chain and improve collaboration.

SUSTAINABLE FUELS

WHAT'S BEHIND THE TREND?

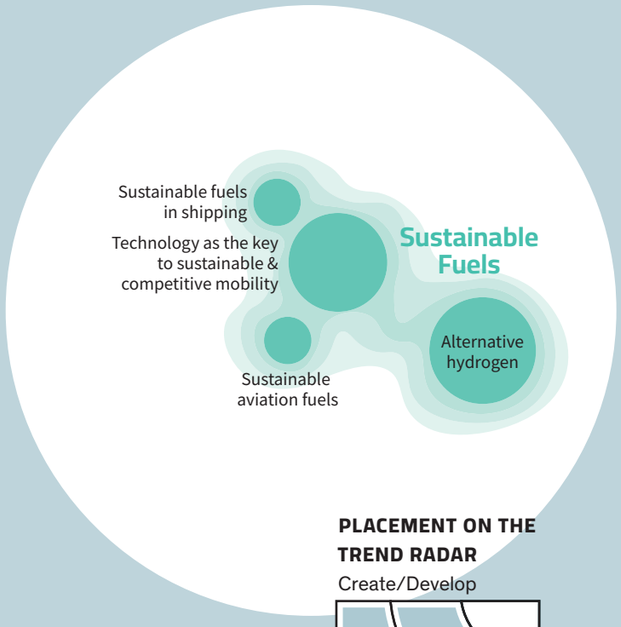
Technologies for the production of hydrogen and other alternative fuels are the dominant drivers in the Sustainable Fuels trend. Further development of processes that make the production of synthetic fuels from renewable energy sources more efficient, safer or cheaper will contribute to the long-term competitiveness of alternatives to fossil fuels, as will innovations in engine technology. As a direct energy supplier for fuel cells and as a basis for hydrogen-based fuels, hydrogen plays a dual role, offering promising possibilities, in particular, with regard to heavy-duty transport, shipping and – in the longer term – aviation.

Specifically in the areas of shipping and aviation, various energy sources other than hydrogen are being considered as alternatives to heavy fuel oil and marine diesel or kerosene. Methanol, HVO (hydrotreated vegetable oil), ammonia, which is highly toxic, or SAF are suitable as bridging technologies or beyond as they may be used in existing engines and power units.

ZOOM-IN

The Sustainable Fuels trend focusses on the following identified trend concepts:

- ➔ Sustainable fuels in shipping
- ➔ Technology as the key to sustainable & competitive mobility
- ➔ Sustainable fuels
- ➔ Alternative hydrogen



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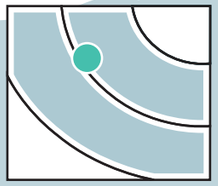


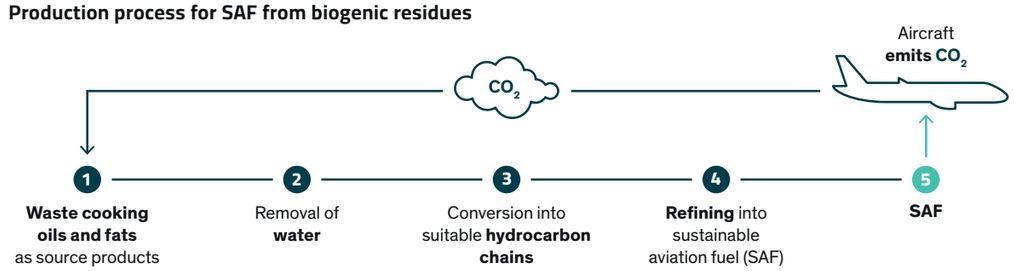
CONTEXT

HOW IS THIS TREND MANIFESTED?

With Maersk and CMA CGM, two logistics companies have joined forces in autumn 2023 to accelerate the decarbonisation of shipping. Both companies have set ambitious net-zero targets and are investing in alternative, more environmentally friendly fuels for powering container ships. Specifically, they are engaged in the development of high standards for alternative fuels such as green methanol and green methane and in ensuring the safety and bunkering of these fuels. They are also working to ensure that ports are prepared to supply these fuels and intend to intensify their collaborative development work to research alternative fuels such as ammonia.

The development of a European hydrogen market will start in Germany with the 9,000-kilometre-long hydrogen core network, which will form the backbone of the hydrogen transmission system in Germany and will be part of the European Hydrogen Backbone, connecting several member states. The EU considers this network to be the basic prerequisite for ramping up the use of renewable hydrogen in industry and transport. It is also considered important to stimulate and increase investments in the production and use of hydrogen. Another major project to promote green hydrogen economy in Europe is in the starting blocks with the expansion of the Southern Hydrogen Corridor. It is envisaged that, by the early 2030s, the H2Med Southwestern Hydrogen Corridor will connect North Africa to Europe and establish a direct pipeline connection for gaseous hydrogen. The corridor will have a total length of about 3500 to 4000 kilometres and comprise five sub-projects, including the H2Med and Hy-FEN pipeline projects, with a capacity to transport up to two million tonnes of green hydrogen per year. Germany, Algeria, Italy, Austria and Tunisia, as well as twenty companies, have signed a joint political Memorandum of Understanding to develop the corridor.

Production process for SAF from biogenic residues



Source: Lufthansa Group, 2023

Key data on the hydrogen core network

9,040 km
Total length of the approved core network

approx. 60%
consisting of converted **natural gas pipelines**

18.9 bn €
Investment costs

101 GW / 87 GW
Feed-in and **Feed-out capacity**

Source: FNB Gas, 2024

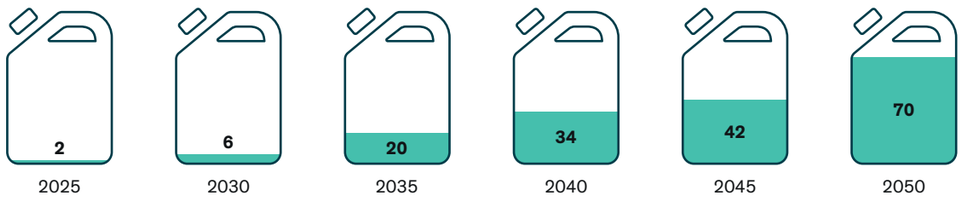
The port of Rotterdam, which is the largest container port in Europe, has set itself the goal of becoming a 'zero-emission port' by 2050. Besides the expansion of wind energy, geothermal and solar energy and the use of industrial waste heat, these efforts focus on the planning of hydrogen terminals and pipelines and logistics chains with hydrogen-powered trucks. To develop this growth area, the port is working in close cooperation with companies such as Shell and Air Liquide.

A study published in 2024 puts the spotlight on natural 'white' hydrogen, which is formed in the crust of the earth. It shows that global reserves are significantly larger than previously assumed. Geologists estimate them to be around 5.6 trillion tonnes – an amount whose energy content would exceed that of all known natural gas reserves by double. Even with a conservative extraction rate of two percent of the total amount, the predicted global hydrogen demand could be covered for about 200 years.

Minimum volume share of sustainable aviation fluids in kerosene consumption by aircraft

In the European Union, in percent

SAF share



Source: European Commission, 2024

OUTLOOK

Sustainable fuels will play an increasingly important role in mobility in the coming years, but there are major challenges that will have to be overcome before they can be used on a large scale. The impact of sustainable fuels will depend heavily on how quickly technological advances can be made to expand production capacity, increase fuel efficiency and reduce costs. Innovations in Power-to-X technologies and new storage methods, for example, could help taking essential steps towards decarbonisation, particularly in aviation, shipping and heavy-duty transport, where battery-electric solutions are often not feasible.

Scaling up sustainable fuels will require significant investment in infrastructure and development work, since, for example, existing production and transport networks are not designed for hydrogen. While political control and market design lead to an increase in demand for sustainable fuels, there are still issues regarding the implementation. In particular, in aviation and shipping, there is the risk that companies will be hesitant to switch to sustainable alternatives due to high costs and still limited availability. Apart from that, due to international competitive differences, there could be regions with less stringent environmental regulations, which continue to rely on fossil fuels, thereby distorting competition.

With targeted investments in the development of production capacities and infrastructure, pioneering regions and individual companies are pressing ahead the development of sustainable fuels. New hydrogen corridors, methanol and ammonia pilot projects, and the gradual increase in SAF blending are paving the way for sustainable fuels, albeit a long one.

Collaborative approaches, in which users, companies and political decision-makers work together and pursue common goals, create new structures that promote financial, ecological and innovative mobility solutions.

CO-CREATION FRAME-WORKS

TREND CO-CREATION FRAMEWORKS

CO-CREATION FRAMEWORKS

TREND

The mobility of the future will be shaped by cooperative and interdisciplinary collaboration between politics, companies and scientific institutions, as well as start-ups and civil society. The increasing complexity of mobility transition, driven by technological innovations, climate targets and social changes, requires a joint approach that combines different competencies, resources and perspectives. Co-creation frameworks are used to create a clear environment to structure and manage this collaboration. Within this environment, objectives, roles and mechanisms are defined to create strong collaborations and provide for their effective implementation. They help to accelerate innovation processes, harmonise interfaces between stakeholders, and shape legal and financial framework conditions.

Co-creation frameworks, such as those found in joint ventures, are characterised by flexibility, participatory structures and a systemic approach. They create a common basis for stakeholders with different interests and perspectives and promote the establishment of holistic mobility solutions. This creates potential for the more efficient use of resources, greater acceptance of innovative solutions by early involvement of various stakeholders and the possibility of generating economies of scale through synergies. In that, the forms of cooperation can vary. Cities, for example, work with technology providers and construction companies to develop infrastructure solutions in order to implement intelligent transport systems, efficient road networks or charging infrastructures for e-mobility. This is often done in the form of pilot projects or real-world laboratories that allow for practical testing of new concepts. When designing mobility services and developing new transport concepts such as ride pooling, intermodal platforms or mobility-as-a-service offerings, automotive manufacturers are working with software companies, start-ups and municipal transport companies in order to provide digital and user-focussed solutions.

Generally speaking, at macro level, co-creation frameworks are about defining political conditions and strategic guidelines, for example, in the form of laws, subsidy programmes and strategic transport planning, that facilitate innovation processes. At meso level, collaborations between companies, research institutions, municipalities, etc. ensure that new technologies and services are tested and integrated into existing mobility systems. And at micro level, specific mobility offers and infrastructures are implemented with the aim to change the use of means of transport, services and infrastructures in the long term.

WHAT'S BEHIND THE TREND?

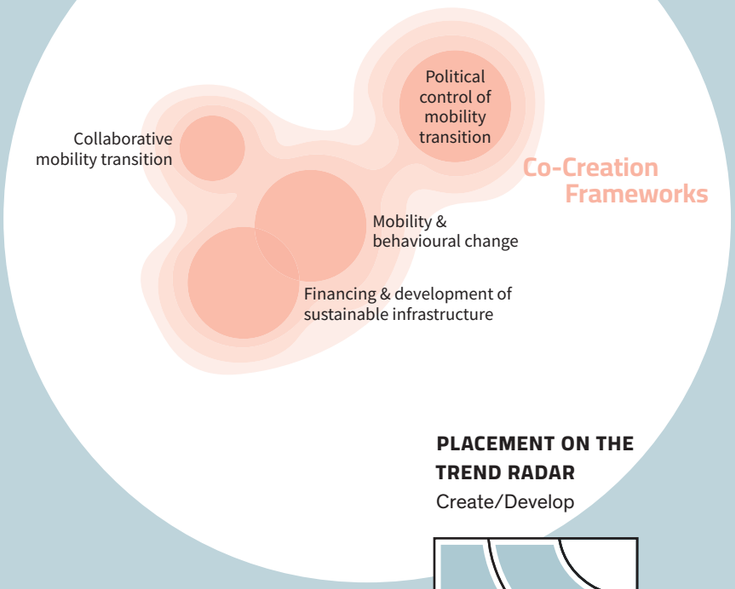
The drivers of the Co-creation Frameworks trend clearly show the holistic way in which developments in different areas interact and together create framework conditions in which different actors can play a role in the mobility transition.

The transformation of mobility is heavily influenced by government policy, with state or supranational funding programmes for environmentally friendly transport infrastructure, subsidies for low-emission vehicles and new legal frameworks that facilitate sustainable innovations. Incentives such as tax relief for public transport and e-mobility, car-sharing offers or city toll systems, as well as educational programmes for mobility education, primarily aim at raising awareness of the individual use of mobility and initiating a change in mobility behaviour.

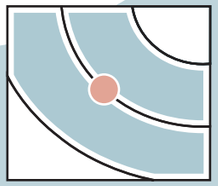
The question of financing is of great relevance as regards the development of new mobility infrastructures, and an increasing range of options is being considered besides the usual subsidies and taxes. Public and private investments, public-private partnerships, bonds or crowd funding models and, increasingly, venture capital are all being used for mobility projects. In order to develop innovative solutions for mobility transition and increase their social acceptance, the collaborative cooperation of companies such as mobility service providers with universities and NGOs, for example, in the form of living labs, in which new mobility concepts are being tested under real conditions, are coming more and more into focus.

The Co-Creation Frameworks trend focusses on the following identified trend concepts:

- ➔ Collaborative mobility transition
- ➔ Financing & development of sustainable infrastructure
- ➔ Mobility & behavioural change
- ➔ Political controlling of mobility transition



PLACEMENT ON THE TREND RADAR
Create/Develop



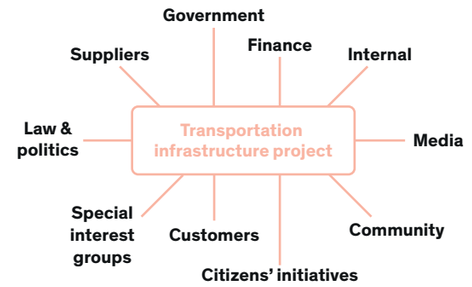
ZOOM-IN

CONTEXT

HOW IS THIS TREND MANIFESTED?

The importance of a clear framework has repeatedly been emphasised by the association CEOs for Future, which includes, among others, managers from ÖBB, DHL, Coca-Cola and McDonalds. They demand clear decisions, signals and framework conditions. An unsteady and unpredictable political course also causes uncertainty among those who are willing to invest large sums of money to promote and accelerate ecological transformation. The eighty member companies of CEOs for Future are planning around 45 billion euros in green investments over the next ten years, among other things, for projects supporting the implementation of decarbonisation, a circular economy and biodiversity. However, according to CEOs for Future, sustainability as a business model requires stability and clear action.

Overview of stakeholders of the transportation infrastructure project



Source: Stakeholder Analysis to Enrich the Systems Thinking and Modelling Methodology, 2016

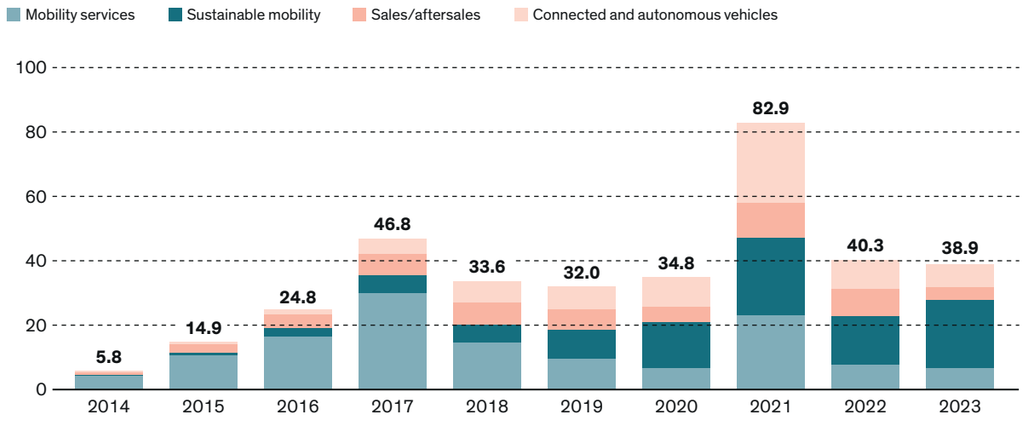
The VW subsidiary MOIA sees itself as a mobility partner for cities and is working, among others, with Hamburg and Hanover to make urban mobility demand-oriented, flexible and comfortable by establishing ride-pooling services. In the Hanseatic city, MOIA's e-shuttle fleet will be expanded in 2025 to include self-driving VW ID Buzzes, which will be equipped with thirteen cameras, nine laser measuring devices and five radars. After successful tests in Austin and Munich, autonomous ride-pooling will initially start with safety drivers and test user groups.

In the Netherlands, new and existing cycle paths are being paved with a photovoltaic road surface that generates 148 watt peak (Wp) per square metre. The Dutch provinces of North Brabant and North Holland, for example, are working with the construction company Royal BAM Group and Wattway, a solar pioneer that emerged from joint research by the transport infrastructure company Colas and the French Institute for Solar Energy (INES), to implement two such cycle paths.

Within the scope of the European MOMENTUM project (Modelling Emerging Transport Solutions for Urban Mobility), a consortium of research institutions, cities and companies, including Nommon Solutions and Technologies, the POLIS Network, the Technical University of Munich, the University of Thessaloniki, and Madrid, Leuven, Regensburg and Thessaloniki, which served as case study cities, worked on innovative data analysis methods, traffic models and planning tools. In this context, tools were developed to help city authorities simulate the impact of mobility solutions, efficiently integrate new technologies into existing transport systems and make data-based political decisions. In Switzerland, the research project "Co-Creating Mobility Hubs" was part of a multidisciplinary project by the SBB, ETH Zurich and EPF Lausanne. Together, they investigated the transformation of railway stations into mobility hubs, with a particular focus on understanding the current, and anticipating the future, social requirements of different user groups.

Investments in mobility start-ups by area of activity

Worldwide, in billions of US dollars



Source: oliverwyman.com, Statista, 2025

As part of its electric mobility strategy, Norway moved away from an approach that initially was strongly based on subsidies, which particularly benefited Tesla, and instead began to invest in sustainable mobility in a targeted manner through its sovereign wealth fund in order to generate long-term returns. The investments are subject to clear economic conditions: Companies must demonstrate a business case and provide sustainable added value for Norway. Companies that are themselves active in the mobility sector act as venture capitalists for promising developments in the course of the mobility transition. Thus, for example, BMW i Ventures specialises in innovative, rapidly scaling start-ups in the automotive sector and already holds a share in over sixty companies. According to BMW i Ventures, investments are being made in technologies that help shape the individual mobility of tomorrow, with a focus on sustainable and interdisciplinary solutions. This includes, among other things, developments in the areas of battery technology, safety, connectivity, ADAS (Advanced Driver Assistance Systems), automation, robotics, logistics and quality assurance, smart supply chain solutions for procurement management, traceability and blockchain, platform mobility, cybersecurity and quantum computing. Moreover, joint ventures, such as the one between Mercedes-Benz and BMW for the establishment and operation of a joint fast-charging network in China, are also increasingly helping to pave the way for the mobility of the future. It is expected that, by the end of 2026, the collaboration will have set up at least 1,000 stations with around 7,000 fast-charging points and the latest charging technologies.

Hamburg Hochbahn was the first German transport company to use green bonds to raise funds via the green bond market in order to realise its “Hamburg-Takt” initiative and become climate neutral itself by 2030. With its government programme for 2020 to 2024, Austria determined the framework for mobilising private capital to realign the mobility sector and achieve the Paris climate targets. By issuing green government bonds in accordance with the Green Bond Framework of the Republic of Austria, among other things, necessary investments in measures provided for in the Austrian 2030 Mobility Master Plan were made.

The successful implementation of new mobility solutions depends to a great extent on the effective cooperation of various stakeholders. In this context, important success factors include the strengthening of public-private partnerships, clear legal frameworks, tax incentives and transparent cooperation processes, as well as the creation of platforms for knowledge exchange, a targeted funding policy and the involvement of the civil society.

A decisive aspect for the further development of co-creation frameworks will be the scaling of successful pilot projects. Many innovative concepts have so far only existed in a limited framework and need to be rolled out to achieve a broad impact. However, challenges often arise, particularly with regard to the transferability of successful concepts to different regions and in terms of long-term financial viability. Standardised procedures, open data platforms and common standards are helpful to facilitate scaling.

Successful collaboration towards a mobility transition will only be achieved if people’s needs are consistently placed at the focus and they actively participate in the design process. This means that the population must be involved in the development of new mobility solutions from the outset, which could be done, for example, by participatory workshops in which people can express their wishes, concerns and ideas. Likewise, targeted feedback loops can be integrated into digital mobility offerings to continuously obtain feedback and implement improvements. Dialogues with the public, test phases or living labs, in which people can try out and evaluate new mobility solutions in everyday life, are also important measures to ensure that the designed framework conditions really do meet the users’ needs.

OUTLOOK

TREND ELECTRIFIED MOBILITY

ELECTRI-FIED MOBILITY

Electrification is increasingly finding its way into the various mobility sectors and is therefore one of the key technologies in connection with mobility.

ELECTRIFIED MOBILITY

TREND

Over the last years, electric mobility has developed from an alternative drive technology to a mainstay of global mobility transition. Electrification has already been well established, in particular, in rail transport. In Europe, for example, although only slightly more than half of the rail network (56 percent) is electrified, this covers already more than 80 percent of train kilometres travelled. Electric drive systems are particularly efficient on rails because overhead lines provide continuous energy supply and make batteries or alternative drives redundant on developed lines. However, there is a significant gap in the level of electrification between different European countries, and even those that are comparatively well positioned will have to make massive investments in the coming years if the rail network in the EU is to be electrified by 2050.

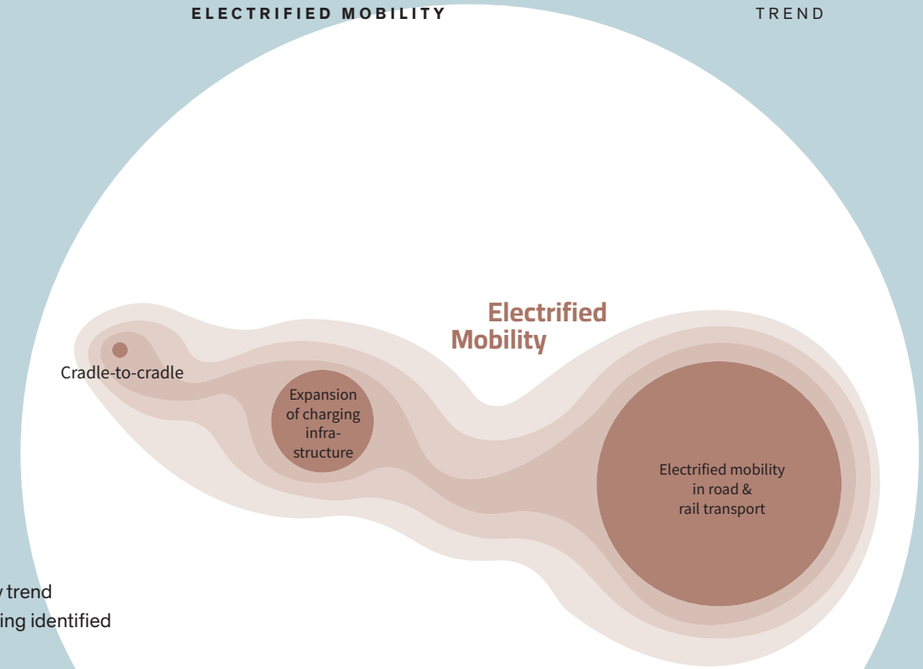
In road transport, electric drive systems are becoming established in more and more segments, such as buses, with especially the market for electric cars growing. In 2023 alone, the number of e-cars worldwide rose to almost 42 million – an increase of 14 million as compared to the preceding year. China is driving this figure massively; the Middle Kingdom accounts for around half of the electric vehicles on the road in the world, making it the undisputed leader in this area. According to forecasts by the International Energy Agency (IEA), the global stock of electric cars will grow to over 200 million by 2030, not least because the increasing economic efficiency of electric vehicles is a major driver of electrification. While the purchase price of e-cars is still higher than that of comparable combustion engine cars in some regions, the situation is already different when it comes to running costs. An analysis by ALD Automotive/Ayvens shows that, by now, combustion engines are often more expensive to operate than comparable e-cars. At the same time, environmental and climate targets play a crucial role. Also in this respect, the switch to electric mobility is a central component – especially in cities where motorised private transport is one of the main sources of air pollution. By 2035, 1.76 billion tonnes of CO_2 could be saved as a result of the increase in electric mobility.

However, electrification is still a challenge for heavy-duty transport. The weight of the batteries and the limited range of currently around 600 kilometres make it difficult to use electric trucks on a large scale. However, a pragmatic solution is emerging here: As legally required rest periods for truck drivers have to be observed, these periods may be used for charging. The expansion of the charging infrastructure is one of the most important factors for the widespread establishment of electric mobility.

Europe currently has around 900,000 public charging points, but to achieve the target of 8.8 million charging points by 2030, further extensive investment is needed. In particular, access to fast-charging stations is of central importance in order to minimise charging times, increase convenience and flexibility for users and reduce their range anxiety. The expansion is not only focused on urban areas, but increasingly also on motorways and rural regions, in order to ensure seamless coverage. In addition to the mere quantity, the technology of the charging points also plays an important role. Bidirectional charging, for example, in which electric vehicles not only absorb energy but also feed it back into the grid, could make an important contribution to stabilising the power grid, which is under increasing strain due to the growing number of electric vehicles. Intelligent charging solutions, grid expansion and storage options will have to be advanced hand in hand to manage and balance peak loads.

With the growth of electric mobility, the demand for batteries also increases exponentially. The global demand for lithium-ion and sodium-ion batteries was 1,400 gigawatt hours already in 2024, and it is expected to rise to over 8,600 gigawatt hours by 2040. This means that the demand for batteries will increase by more than sixfold in the coming years. This huge demand poses new challenges for the availability and extraction of raw materials such as lithium, cobalt and nickel, which are essential components of current battery technology and whose extraction is associated with ecological and social problems – such as high water consumption and associated scarcity, soil erosion or environmental pollution from waste and harmful substances. To counteract these problems, manufacturers are increasingly turning to cradle-to-cradle approaches that enable the recycling of used batteries and the use of sustainable materials. At the same time, companies such as Mercedes-Benz, VW, Volvo, Nio, Ford, BMW, QuantumScape or Solid Power are driving the development of alternative battery technologies. Solid-state batteries, which have a higher energy density and enable faster charging times, are seen as a major innovation and could further transform electric mobility.

ELECTRIFIED MOBILITY

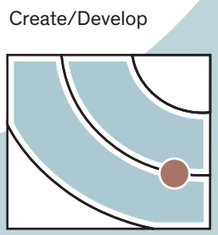


The Electrified Mobility trend focusses on the following identified trend concepts:

- ➔ Cradle-to-cradle
- ➔ Expansion of charging infrastructure
- ➔ Electric mobility in road and rail transport

PLACEMENT ON THE TREND RADAR

Create/Develop



WHAT'S BEHIND THE TREND?

The electrification of railway lines and the expansion of emission-free short-distance traffic are progressing. While high-speed trains such as the TGV, ICE or Eurostar have been electrically powered for a long time, more and more regional and commuter trains are also being converted. In global road traffic, the number of electric vehicles is growing rapidly and manufacturers are investing heavily in the further development of batteries in order to extend ranges and shorten charging times.

The majority of charging points in Europe are concentrated in a few countries, so continuous expansion remains one of the key issues. Access to fast-charging stations is increasingly being expanded so that charging processes no longer have to take more than a few minutes. Private charging solutions – for example, in underground car parks or at workplaces – are also gaining importance.

The increasing demand for batteries for electric vehicles requires efficient recycling. Companies are working on cradle-to-cradle options, for example, by reusing spent batteries as stationary energy storage devices or recovering valuable raw materials using new recycling processes. The aim is to reduce dependence on primary raw materials and minimise the environmental impact of battery production.

ZOOM-IN

CONTEXT

HOW IS THIS TREND MANIFESTED?

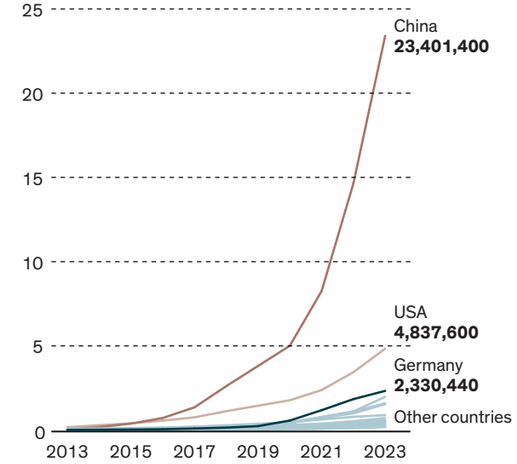
With massive investments in the electrification of transport, China has become a pioneer not only in electric cars in recent years. Particularly noteworthy is the complete conversion of the public bus fleet in Shenzhen, which began in 2009 and was completed in 2017. In the years that followed, the city's taxis, garbage trucks and other heavy-duty commercial vehicles were also converted. Starting from Shenzhen, the electrification of city buses and public transit buses in all Chinese cities grew to over 60 percent by 2022, and the goal is to convert 100 percent to e-buses by 2030. By way of comparison, Germany is expected to have electrified around 15 percent of its total bus fleet by the end of 2025, following a threefold increase in the number of e-buses in local public transport between 2018 and 2023, which was supported by the German government's funding of e-buses.

When it comes to market penetration with e-cars, Norway is considered an international role model. Here, for example, in 2024, almost 90 percent of new car registrations were for electric cars. Decisive for this success are not only financial incentives such as tax breaks and toll exemptions, but also a consistently developed charging infrastructure. The government is promoting the further expansion of fast-charging stations along motorways and in urban areas to make the use of electric cars as convenient as possible.

Tesla has undoubtedly given the e-segment an image boost and, with its Model Y and Model 3, has provided the best-selling vehicles; as the largest electric automotive manufacturer in the world, however, the Chinese competitor BYD has already overtaken the Americans. And also the by far the largest manufacturer of batteries for electric cars is based in China: CATL accounts for almost one third of the global market.

Number of electric cars in selected countries

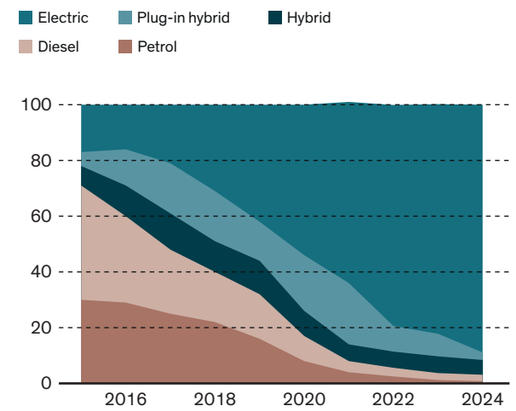
In millions



Source: Statista, 2025

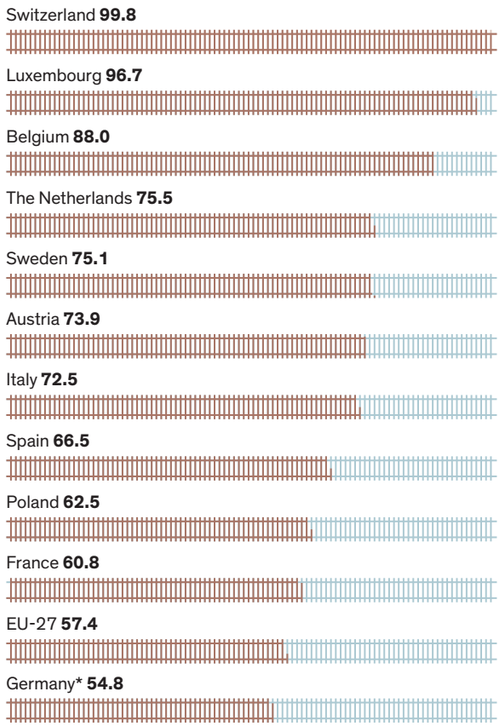
New car registrations according to drive systems in Norway

In percent



Source: Statista, 2025

Percentage of electrified lines in the state railway network in 2023



Source: Allianz pro Schiene, 2023

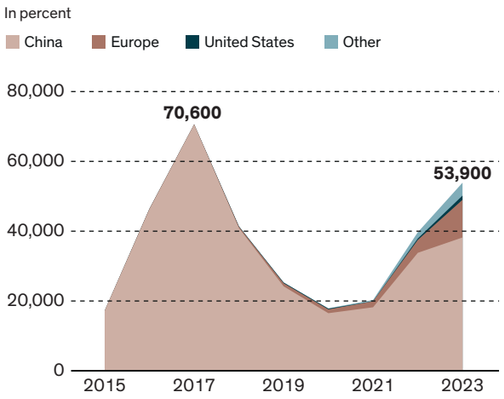
*Deutsche Bahn reports a rate of electrification of 62.3 per cent.

Number of public charging points for electric cars worldwide in selected countries in 2023

1	China	2,700,000			
2	South Korea	201,000	13	Canada	26,800
3	United States	183,000	15	Austria	17,500
4	The Netherlands	145,800	17	Switzerland	15,800
5	France	118,000	19	India	10,900
6	Germany	108,000	21	Brazil	8,700
7	United Kingdom	53,000	26	Australia	2,760

Source: IEA; Statista, 2024

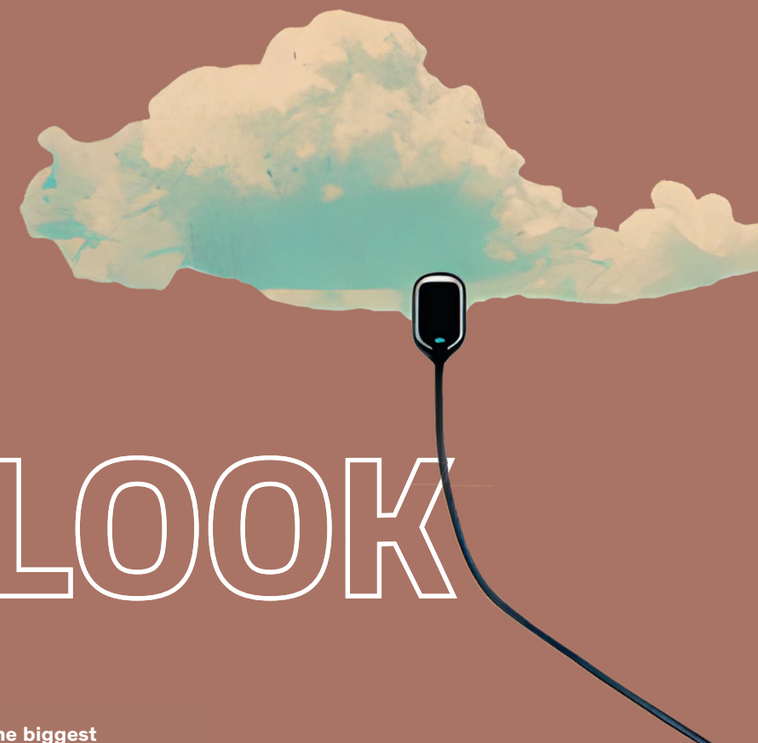
Registrations of electrified trucks by region in the years 2015 to 2023



Source: IEA, 2024

Apropos batteries: In addition to hydrogen trains, battery-powered trains are also increasingly being used on non-electrified railway lines. From summer 2026, for example, three new Mireo Plus B trains from Siemens Mobility will replace the existing diesel trains on the route between Düsseldorf and Remscheid, which will save over 2,500 tonnes of CO2 per year. They have a range of up to 120 kilometres and reach a top speed of 140 km/h.

According to a study by the European Federation for Transport and Environment, Europe has significant potential as regards the local and sustainable sourcing of materials such as cobalt, lithium, manganese and nickel from the stock of electric vehicles, used batteries and scrap from planned battery gigafactories. This could significantly reduce dependence on primary raw materials and create a more sustainable supply chain for electric vehicles. By 2030, recycled batteries should provide materials for the production of up to 2.4 million electric cars in Europe. Existing recycling capacities, however, are not sufficient to meet future demand, and various planned capacity expansions have yet to be finalised, which is why stronger political support for battery recycling is being called for. Furthermore, according to the study, a change in the composition of batteries is to be expected: cobalt and nickel content will decrease, while the use of lithium iron phosphate batteries is expected to increase. This development then will impact recycling methods and facilities, which will need to be adapted.



OUTLOOK

The electrification of mobility is one of the biggest transformations in the industry and will continue to gain importance in the coming years. While some countries have already reached the mass market, there is still great potential to be tapped in other regions. Technological innovations, political incentives and improved infrastructure will help to further establish electric mobility – with the long-term goal of making road and rail transport emission-free. Electric commercial vehicles will become increasingly competitive and dominate the market as battery costs fall, while the expansion of the charging infrastructure will be crucial for the pace of the transition to e-cars. Particularly in rural areas, major investments are still needed to ensure comprehensive coverage.

Another focus is on the circular economy: Batteries not only have to become more powerful, but also more ecologically sustainable, which is why recycling processes are being improved to recycle valuable materials and minimise environmental pollution. Apart from that, the bidirectional use of electric cars as a flexible means for storing electricity is also gaining importance. In the long term, the electrification of mobility will not only reduce emissions in transport, but will also bring about far-reaching changes in urban infrastructure, mobility behaviour and energy supply. The combination of technological advances, regulatory incentives and growing social acceptance will further advance Electrified Mobility.

TREND INCLUSIVE MOBILITY

INCLUSIVE MOBILITY

Inclusive mobility means the design of mobility systems that enable access and offer equal opportunities for all – irrespective of individual limitations, financial resources or geographical circumstances.

INCLUSIVE MOBILITY

TREND

Social justice is at the heart of the Inclusive Mobility trend, which highlights that mobility is a fundamental prerequisite for social participation. Mobility determines to a large extent how people can participate in social and economic life. However, while innovations in the mobility industry often focus on efficiency, ecological sustainability or technological advances, access to mobility, as a social factor of justice, is still given little consideration. Who can afford mobility? Who is excluded by existing systems? How can transport services be made fairer so that everyone can benefit from them? These questions are becoming increasingly important, because the answers point to essential fields of action for the future of mobility.

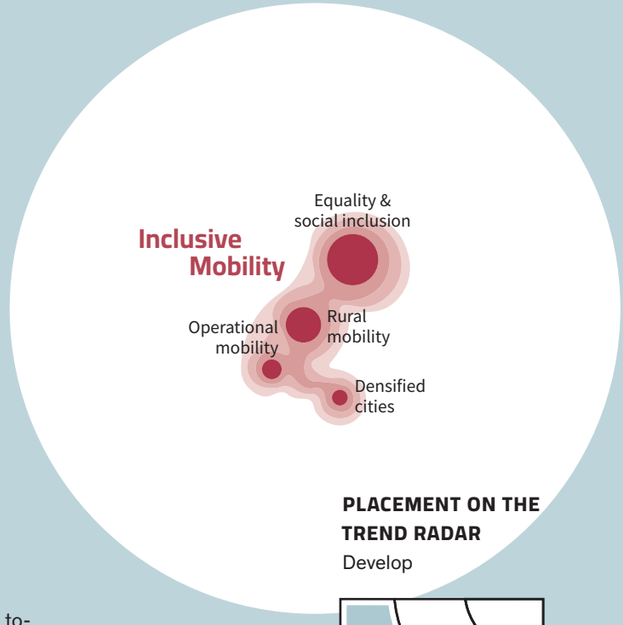
Many social groups face significant obstacles to their freedom of movement. People with disabilities, older people or low-income families often have less access to transport infrastructure. A lack of accessibility on buses and trains, insufficient service in rural areas or high costs for mobility services create an inequality that goes beyond mere locomotion – it affects access to education, work, health care and social interactions. Mobility and its stakeholders also run the risk of following the tendency to favour the majority and forgetting minorities or publicly underrepresented groups – this is an issue of social justice that can potentially be exacerbated by artificial intelligence and data-based decisions. Responsible AI and differentiated data, identified in the Megatrend of Research Connectivity, are therefore important trends for consciously avoiding disadvantages rather than digitally manifesting and exacerbating them. The massive preponderance of dominant opinions, needs, etc. in large amounts of data can lead to minorities or underrepresented points of view and needs not being adequately represented. At the same time, smaller groups with their particular needs also represent an economic potential that can be uncovered, addressed and exploited through differentiated data analysis.

Dense urban centres with well-developed public transport systems offer opportunities for a fairer distribution of mobility; still, specifically in these conurbations, tensions are also increasing: Although the well-developed infrastructure in these areas gives more people access to mobility services, new exclusions arise, for example, due to rising rents and displacement processes. In many cities, gentrification is causing affordable housing in city centres to become almost impossible, forcing people with low incomes to move to cheaper peripheral areas, suburbs or the countryside. Such regions often lack adequate public transport connections. While buses, trams and car-sharing services are easily accessible in dense city centres, the public transport connections offered in peri-urban and rural areas are often limited and infrequent. Those who live there usually have longer distances to work, to educational institutions or to health care and are more often dependent on their own car, which, due to regular costs for fuel, insurance, repairs, etc. and the financial burden resulting therefreom, in turn, increases social inequality. Moreover, obstacles to employment due to workplaces that are difficult to reach as well as social restrictions can be a burden, for example, when it is more difficult to maintain contacts, take advantage of cultural offerings or actively participate in social life for lack of mobility. A targeted expansion of flexible, needs-based transport concepts for peri-urban and rural areas will help to counteract a mobility divide in which households in outlying areas have to invest a great deal of time and money in mobility.

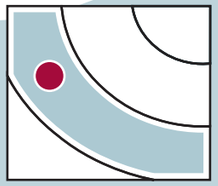
As a result of company mobility solutions, even companies whose core business has nothing to do with mobility are increasingly becoming important as mobility players. Every employer can actively contribute to improving access to mobility, for example, by providing job tickets, subsidised transport services or access to ride-sharing platforms. Not only are these measures a social and ecological lever, companies acting this way can also benefit from them themselves, for example, by greater accessibility for employees, attraction of a larger pool of applicants or reputation gains, or by including a reference to corporate mobility solutions as one piece of the jigsaw in the company's sustainability reporting.

The Inclusive Mobility trend focusses on the following identified trend concepts:

- Equality & social inclusion
- Rural mobility
- Operational mobility
- Densified cities



PLACEMENT ON THE TREND RADAR
Develop



WHAT'S BEHIND THE TREND?

Mobility planning needs to be more strongly oriented towards the special needs of different social groups. Thus, for example, equality and social inclusion mean that barrier-free infrastructure is consistently available everywhere as a matter of course – from buses with lowered entrances and tactile guidance systems for visually impaired people to voice-controlled navigation systems for people with cognitive impairments. Apart from physical accessibility, it is also important to have pricing models that provide relief for low-income households. Reduced-price subscriptions for certain social groups, such as subsidised offers for pensioners and students, are essential components of a fair mobility system. Last but not least, digitalised mobility services (without exception) increasingly have to be considered from the point of view of the digital divide – the digital gap, for example, between generations.

Increasingly dense cities are enhancing mobility, for example, when, according to the concept of the 15-minute city, all important facilities for daily life can be reached within 15 minutes. However, density also challenges cities to design their mobility networks in such a way that they are not only efficient but also socially just – for example, through a balanced distribution of space between public transport, private transport, cycle paths and pedestrian zones. Outside of dense urban centres, access to mobility remains difficult, as, to many people in outlying areas, there are often no adequate public transport connections available. Flexible solutions, such as on-demand transport, ride sharing and micro-public transport may help in this regard, but the big challenge lies in taking individual mobility needs into account while maintaining economic viability.

Through corporate mobility management, mobility budgets, subsidised job tickets, ride pooling platforms, home office, etc., employers can contribute to the mobility turnaround and support , the reduction of traffic congestion or the control of traffic flows.

ZOOM-IN

CONTEXT

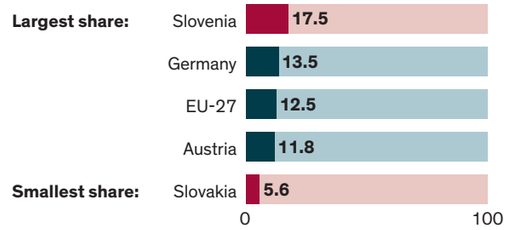
HOW IS THIS TREND MANIFESTED?

In 2013, Tallinn became the first European capital to offer its residents free local public transport. The motivation was primarily social: During the financial crisis, many people could no longer afford to buy tickets. According to the city government, the additional costs incurred by the city for the free local public transport are covered by the significant increase in the population since its introduction, including the resulting increase in tax revenue.

In the KI4autoBUS project, a consortium led by DB Regio Bus and the Fraunhofer Institute is working on the development of an AI-based solution for planning and controlling local public transport services in the Bavarian town of Bad Birnbach. Within the scope of the project, autonomous shuttles are used to increase efficiency in local public transport. The project is based on a system that processes all travel requests in real time and prioritises people with limited mobility, such as wheelchair users. The AI receives data from the scheduling system via an interface in order to retrieve the current travel requests and the positions of the shuttles and, on this basis, decides which vehicle is sent to which stop. The automated planning helps to make optimal use of the scarce resources in public transport and reduce operating costs, while, at the same time, meeting higher accessibility requirements. Especially for people with limited mobility, the project makes it easier to access public transport. The necessity of this is illustrated by the inclusion barometer for mobility from Aktion Mensch, according to which people with disabilities in Germany generally perceive the time and costs of mobility as higher than people without disabilities. Lack of accessibility and availability, just as much as barriers

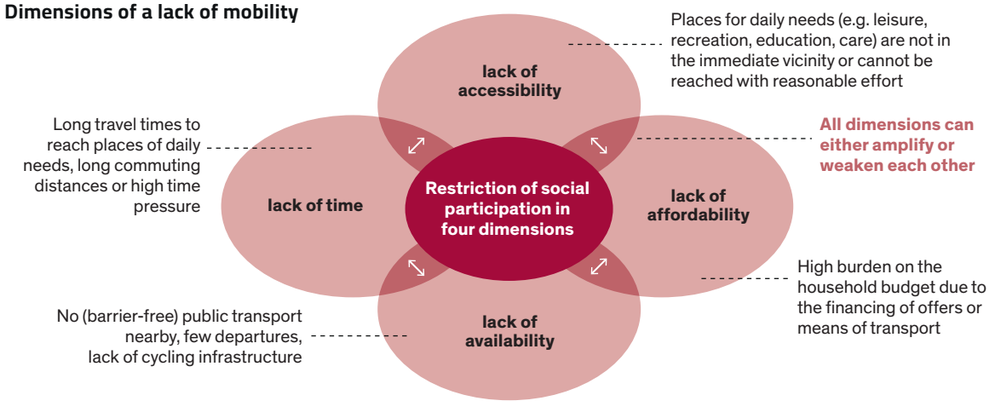
Share of transport costs in consumer spending of private households in the EU in 2022

In percent



Source: Statista, 2025

Dimensions of a lack of mobility



Source: Agora Verkehrswende, 2023

due to narrow paths or broken lifts, are a problem for people with limited mobility. As a result, many people feel insecure when travelling and are reluctant to use public transport.

Companies are increasingly taking operational mobility management into their own hands and are developing various approaches with partners. Digital solutions enable companies to measure the mobility of their employees to identify and close existing gaps in transport services. Intelligent networking of mobility services facilitates the use of public transport, reduces traffic volumes at company locations and minimises the need for parking spaces.

Incentives such as vouchers for bicycle maintenance and repair or for the company canteen can be used to motivate employees to make climate-friendly transport choices. Company carpooling centres make it easier to organise carpools, while bike, e-scooter or e-car rental services offer a flexible alternative for commuting and business trips.

Thus, the software service provider highQ, for example, has developed a corporate mobility management system for an Amazon logistics centre together with the municipalities of Achim, Ottersberg and Oyten. A corresponding mobility app and, among other things, a bicycle rental station for the last mile between the train station and the logistics centre have encouraged hundreds of employees to use public transport, which reducing traffic congestion around the site and the use of parking spaces.

The public transport company Wiener Linien also offers companies comprehensive mobility advice aimed at making the mobility of employees and customers more efficient. The objective is to make companies use tailor-made solutions to improve their mobility situation, reduce costs, for example, for business trips, enhance their attractiveness as an employer, and improve the health of their employees, while also contributing to the achievement of sustainability goals and the reduction of individual car traffic. With its advisory services, Wiener Linien intends, among other things, to help obtain clarity as regards the mobility habits within a company and to facilitate sustainability reporting in accordance with the Corporate Sustainability Reporting Directive (CSRD).

Diverse mobility needs

People with visual impairment

- large contrasts
- larger font sizes
- option to approach texts and screens

Blind people

- audible speech output
- audible announcement
- tactile information

Deaf people

- information in ÖGS/DGS/DSGS and in writing
- in case of emergency, warnings using visual signals

People with hearing impairments

- inductive hearing systems with appropriate labelling

People with learning difficulties

- simple language in written and spoken form
- alternative offers to apps

People with mental illnesses

- quiet rooms and rest areas
- areas that are free from sensory overload

People with chronic intestinal diseases

- sufficient functioning public toilet facilities

People with multiple disabilities

- consistent application of the multi-sense principle

People who use wheelchairs

- accessible ground surfaces
- folding ramps or mechanical ramps for getting into vehicles
- lifts and ramps for overcoming height differences
- information boards
- easily accessible buttons and handrails
- space to turn with a turning circle of at least 140cm

Source: Knoll 2021, VCÖ 2022

The future of mobility will not only be shaped by technological innovations. Social and political realignments are also required to ensure fair access to mobility services. Inclusive mobility is an important factor for social participation and social justice. A comprehensive mobility transition can only succeed if mobility is recognised as an essential fundamental right and its safeguarding is understood by politics, companies and mobility providers as a task requiring them to work together more closely, adapt investment strategies and create targeted incentives as well as regulatory frameworks. Data-based control systems will provide a basis on which mobility gaps can be identified in real time and socially acceptable mobility services and flows can be provided as required. This could reduce car-dependence, which is particularly high in peripheral and rural areas. Municipalities and private mobility providers are called upon to work together to develop new flexible mobility options that are economically viable and, at the same time, meet social needs.

All companies, regardless of industry, will be in greater demand as players in future-proof mobility as numerous mobility issues arise every day around the journey to work. Corporate mobility management is thus increasingly being recognised as a strategic tool.

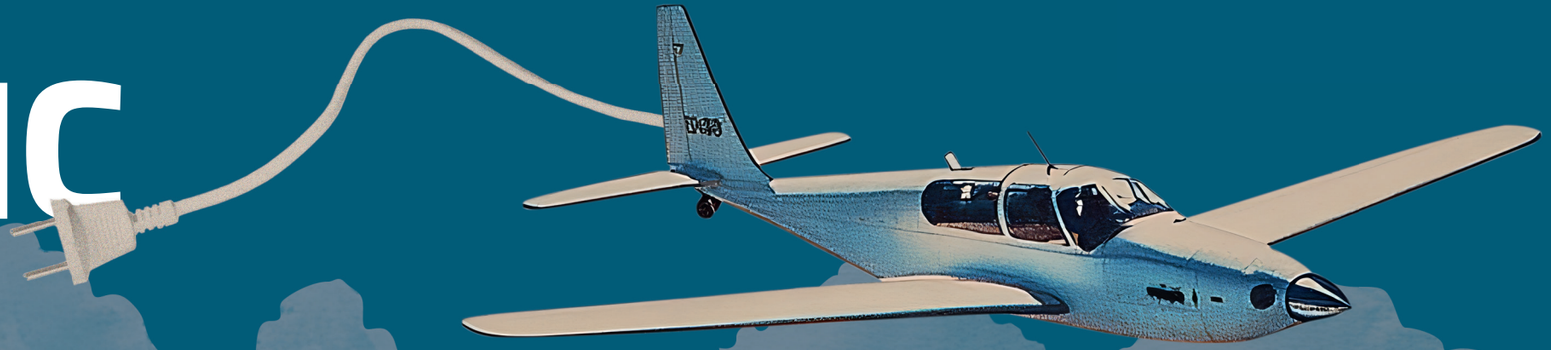
OUTLOOK

TREND ELECTRIC AVIATION

Air traffic is increasingly affected by the growing development and application of electric propulsion technologies.

AVIATION

ELECTRIC



ELECTRIC

TREND

While electric mobility on roads and rails has already picked up speed, the electrification of air traffic remains a far greater challenge, as there are fundamental differences to electric cars or trains in the specific performance requirements of aircraft. They have to transport large loads safely and reliably over long distances, without access to a supporting infrastructure. Weight, range and energy efficiency are therefore extremely critical factors. Currently, the central difficulty lies in the energy density of batteries.

While fossil fuels have a high energy density and, thus, enable long ranges, batteries are significantly heavier and require a multiple of mass for the same power: Lithium-ion batteries that are commonly used in electric cars achieve about 250 watt-hours per kilogram, whereas kerosene has an energy density of around 12,000 Wh/kg, which is about 50 times higher. This means that fully electric aircraft can currently only be sensibly used for short distances, while solutions such as hybrid propulsion or conventional or alternative fuels still have to be used for long-haul routes.

Electrification is particularly attractive for short- and medium-haul routes, as range requirements can be manageable and less energy is needed. On short routes, such as in regional air traffic or for urban shuttle connections, battery-powered aircraft could therefore become a viable option. The advantage of electric mobility is particularly apparent where there are many take-offs and landings, as electric drives are characterised by higher efficiency during repeated flight cycles. Apart from that, compared to conventional engines, maintenance costs are significantly lower since electric motors have fewer wear parts that require regular maintenance or replacement.

A particularly interesting and widely discussed part of electric aviation are eVTOLs, which stands for electric vertical take-off and landing aircraft, that are being developed primarily for urban air traffic. These aircraft offer completely new possibilities for mobility, as they do not require a conventional airport and can take off and land directly from building roofs or specially equipped hubs. Thus, they significantly reduce infrastructure dependency and open up new business areas, in particular, for air taxis or medical emergency transport.

One advantage of electric drives is considered to be the reduction of noise emissions, since conventional turbines produce significant noise levels, while electric motors are much quieter. This fuels the hope for a reduction of noise pollution in the vicinity of airports, which, in turn, could make air traffic possible in densely populated urban areas without the population being massively affected by noise. Moreover, it could have an impact on restrictions resulting from night-flight bans, longer flight routes and additional flight manoeuvres to avoid flying over certain areas at least at particular times, or noise-related take-off and landing fees. However, experts point out that, although engine noise can be reduced, other noise sources – such as propellers, mechanical components or aerodynamic effects – also exist in electric aircraft.

Whether electric aircraft are economically viable is an open question so far, because, although their operation could be more cost-efficient in the long term as maintenance and energy are cheaper than for conventional propulsion systems, initial development costs and investments in new aircraft designs, battery technologies and charging infrastructures are quite high. Furthermore, airlines would have to adapt their fleet strategies, as electric aircraft currently take longer to charge than conventional aircraft take to refuel. Government funding and regulatory incentives could accelerate the transition, still, long-term market acceptance will depend on economic viability.

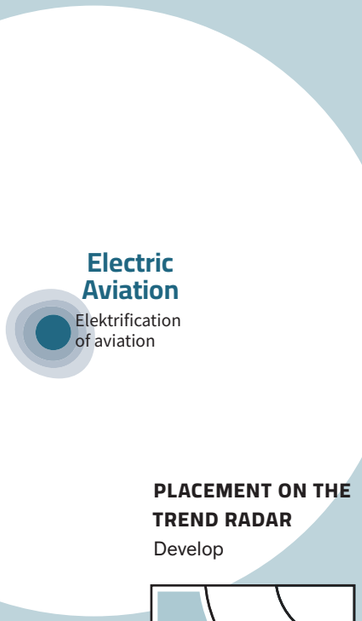
AVIATION

WHAT'S BEHIND THE TREND?

The electrification of aviation comprises various conceptions that differ in terms of their technological implementation. Fully electric aircraft rely exclusively on battery power and are particularly suitable for short-haul flights. Hybrid models combine electric drives with conventional combustion engines for use on longer distances. The focus of public attention, however, is particularly on eVTOLs, which, as electric vertical take-off aircraft, create new possibilities for urban air traffic. While these technologies are still in development, the first pilot projects, which are currently being implemented, show potential for more climate-friendly aviation.

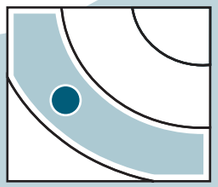
The Electric Aviation trend focusses on the following identified trend concept:

➔ Electrification of aviation



PLACEMENT ON THE TREND RADAR

Develop



ZOOM-IN

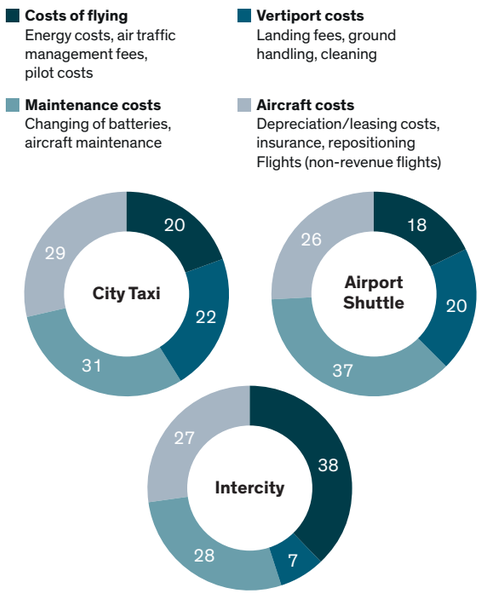
CONTEXT

HOW IS THIS TREND MANIFESTED?

Various companies and airlines have already taken the first steps to advance the electrification of aviation. One of the projects in this area is the hybrid regional aircraft ES-30 from the Swedish company Heart Aerospace, which has an electric range of 200 kilometres, a hybrid total range of up to 800 kilometres and a charging time of around 30 minutes and uses a bridging technology between conventional engines and fully electric propulsion systems. The first flight of the corresponding demo aircraft, Heart X1, is scheduled for 2025 at Plattsburgh International Airport in New York, with certification for commercial aviation to follow by 2029. A number of airlines, including Air Canada, believe this schedule is achievable; they have already ordered the ES-30 or signed letters of intent. Heart Aerospace hopes that its development will contribute to zero-emission short-haul flights and significantly lower operating costs compared

Distribution of direct operating costs by use case

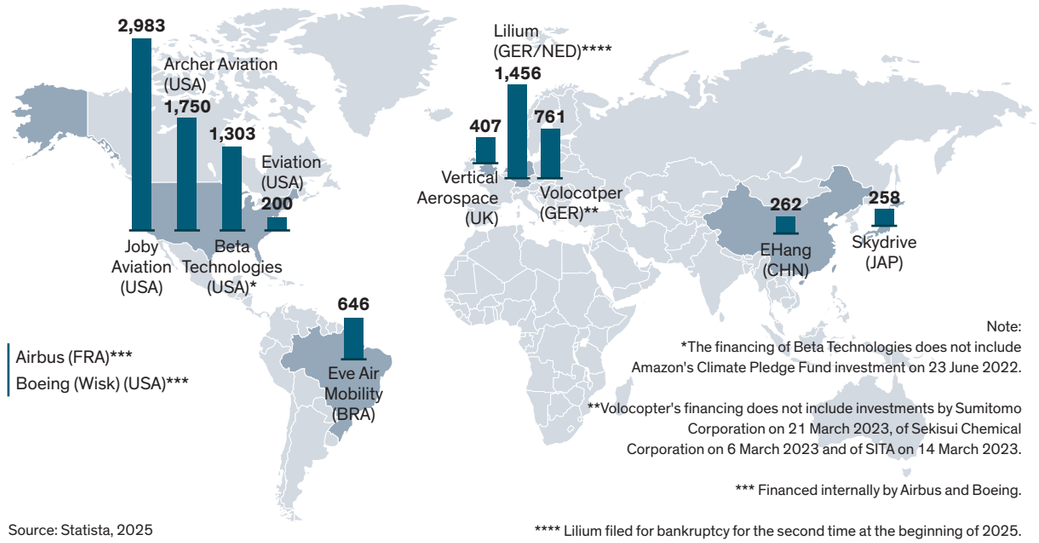
In percent



Source: German Aerospace Center, Roland Berger, 2024

The largest companies for the development and production of electric vertical take-off and landing (eVTOL) aircraft by generated capital as of December 2024

Financing in millions of US dollars



Note:
*The financing of Beta Technologies does not include Amazon's Climate Pledge Fund investment on 23 June 2022.

**Volocopter's financing does not include investments by Sumitomo Corporation on 21 March 2023, of Sekisui Chemical Corporation on 6 March 2023 and of SITA on 14 March 2023.

*** Financed internally by Airbus and Boeing.

**** Lilium filed for bankruptcy for the second time at the beginning of 2025.

Source: Statista, 2025

to conventional aircraft. According to the company's analyses, the electrification of regional aviation could lead to a 22 percent reduction in total aviation emissions by 2050.

The Dutch start-up Elysian is planning the E9X, an all-electric passenger aircraft for ninety passengers that can fly distances of up to 1,000 kilometres – a range that could cover about half of all commercial passenger flights. The design of the E9X, which is scheduled to make its maiden flight in 2033, exudes retro charm: with a compact fuselage and long wings in which the batteries are located to save space and minimise drag.

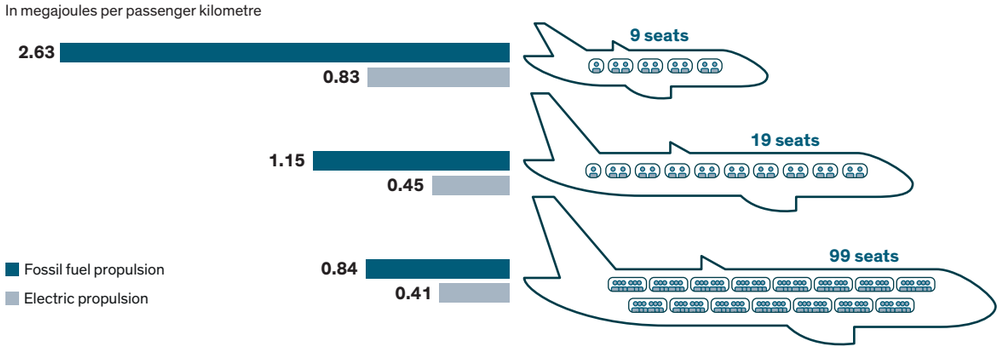
The required batteries with an energy density of 360 Wh/kg would be available; manufacturers such as Amprius and CATL have already developed batteries with up to 500 Wh/kg. Apart from that, the market for eVTOLs is also developing rapidly: Several hundred start-ups worldwide are working on an electric vertical take-off aircraft to be used as air taxis in urban areas. Countries and cities are investing heavily in the relevant technologies in order to secure leading roles. While Saudi Arabia sees eVTOLs as a game changer for the transport of pilgrims, sports fans and tourists, Dubai hopes to be able to integrate a fully developed network of air taxis into its public transport network by 2026. Even automotive manufacturers such as Toyota are investing heavily in this vision.

However, the economic turmoil faced by Lilium, Volcpoter, Eviation and amongst others highlights the problems faced by the air taxi pioneers: developing new aircraft is expensive and time-consuming. Besides this, studies by the German Aerospace Center (DLR) together with Roland Berger and the Leibniz Centre for European Economic Research (ZEW) have come to the conclusion that not only the commercial viability, but also the environmental friendliness of air taxis must be critically assessed. Initially, high operating costs and investments will mean that they are only profitable in the premium segment, and although eVTOLs, compared to combustion engines, produce fewer CO2 emissions, they consume more energy than electric cars.

In a draft resolution, the European Parliament considers electric aviation to be a promising solution for short- and medium-haul flights and emphasises the need to promote the development and introduction of electric aircraft, as electric aviation not only contributes to the decarbonisation of the transport sector but also offers economic opportunities, in particular, by creating new jobs and strengthening the competitiveness of the European aviation industry. The EU wants to support the integration of electric aircraft into commercial air traffic by targeted investments in research and development, the expansion of charging infrastructure at airports and the adaptation of regulatory frameworks. The importance of international cooperation is also emphasised in order to establish global standards and accelerate market introduction.

Energy efficiency of electric aircraft compared to aircraft powered by fossil fuels in 2022

In megajoules per passenger kilometre



Source: ICCT, 2022

Note: worldwide

OUTLOOK

The electrification of aviation will initially focus on short-haul flights. Over the next few years, battery-electric aircraft and eVTOLs could enter commercial service in selected regions of the world. A small number of powerful pioneering countries and companies are driving the development in this prestigious but economically unprofitable market. In densely populated urban areas, there are still major obstacles as regards take-off and landing sites, regulatory clarity, safety and acceptance by users and the population.

The technological development of batteries will play a key role in the electrification of aviation and it is to be expected that more powerful energy storage devices will significantly increase ranges and, thus, also open up medium distances for electric aviation. Long-haul flights, on the other hand, will continue to rely on alternative propulsion in the foreseeable future, with hybrid systems serving as an interim solution. In parallel with electrification, the use of sustainable fuels will also continue to increase. A combination of sustainable aviation fuels (SAF), hybrid propulsion and electric short-haul flights will help to lead aviation towards a more sustainable future in small steps.

The electrification of aviation is an important factor for the future of flying, even though the path towards it still holds many technological and economic challenges and its use is not suitable for all areas of aviation. However, the vision of clean and efficient aviation is a strong driver in decoupling the dream of flying from massive environmental pollution and enable new mobility concepts that fundamentally change the way we understand air traffic.

TREND INTELLIGENT TRANSPORTATION SYSTEMS

INTELLIGENT TRANSPORTATION SYSTEMS

Transport systems are becoming increasingly intelligent as they network, communicate and interact with each other.

INTELLIGENT TRANSPORTATION SYSTEMS

TREND

Influenced by the Megatrend of Connectivity, intelligent transport systems (ITS) enable more efficient and safer traffic control by artificial intelligence, real-time data and state-of-the-art communication technologies. The focus here is on vehicle-to-everything (V2X): It describes the digital real-time communication of a vehicle with various surrounding communicating traffic participants and the data transfer between them, including, for example, vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-pedestrian (V2P) communication. While V2V allows vehicles to communicate directly with each other and, thus, react quickly to braking manoeuvres, accidents or sudden obstacles, V2I enables communication between vehicles and infrastructure elements such as traffic lights or information signs, for example, to adapt traffic light sequences to traffic flows, reroute routes according to the current traffic situation or issue automated warnings about construction sites and weather events. Thanks to V2P, vehicles could slow down when children are playing at the side of the road or after detection of passengers getting off public transport.

Technological advances such as 5G networks and dedicated short-range communication (DSRC) are essential to ensure that this communication can take place in real time and with minimal latency. Stability and speed are crucial to the security of digital applications in complex traffic operations. While 5G, with its high bandwidth and reliability, enables the large-scale networking of vehicles and urban infrastructures, DSRC offers a particularly secure and stable short-range communication that works reliably even in areas with weak network coverage. Another crucial basis for ITS is the continuous collection and analysis of real time data. Sensors, cameras and the Internet of Things (IoT) capture, among other things, vehicle movements, weather conditions and traffic flows in order to generate precise forecasts. This information can be used to avoid traffic jams, reduce the use of resources in traffic and enable smarter use of existing infrastructure.

Artificial intelligence plays a major role in ITS as it is able to derive meaningful patterns from the multitude of data collected and to make automated decisions. It optimises traffic light sequences, guides autonomous vehicles safely through traffic and can prevent impending infrastructure damage and associated disruptions by proactively identifying maintenance needs. The integration of these technologies not only makes mobility systems more efficient, but also more eco-intelligent, since optimised traffic control helps to reduce emissions and make better use of resources. The implementation of these technological possibilities places high demands on the infrastructure, as such traffic systems require comprehensive digital networking, powerful data processing and reliable communication standards. Significant investments in digital traffic management systems, 5G networks and smart road infrastructure are needed to implement ITS and to realise the full potential of these technologies.

WHAT'S BEHIND THE TREND?

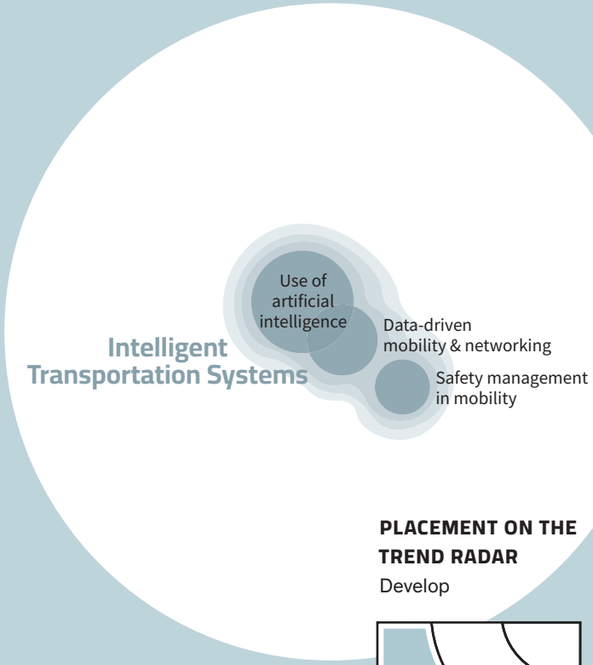
AI is at the heart of ITS and serves as a control centre for traffic optimisation. It analyses traffic data, recognises patterns and makes decisions in real time. AI-supported systems enable autonomous driving, optimise traffic light sequences and ensure more efficient use of mobility infrastructures. The use of real-time information from sensors and vehicle data can help to avoid traffic jams, minimise the risk of accidents and make mobility more efficient. Connected vehicles provide the basis for optimised traffic flows, for example, through dynamic route planning that avoids delays and helps to efficiently use the charging infrastructure.

ITS can also significantly support and improve safety management. Assistance systems such as emergency braking assistants, lane departure warning systems and pedestrian detection reduce the risk of accidents; smart camera systems and connected infrastructure recognise hazards early and can warn road users in real time.

ZOOM-IN

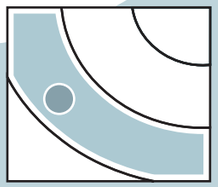
The Intelligent Transportation Systems trend focusses on the following identified trend concepts:

- ➔ Use of artificial intelligence
- ➔ Data-driven mobility & networking
- ➔ Safety management in mobility



PLACEMENT ON THE TREND RADAR

Develop



CONTEXT

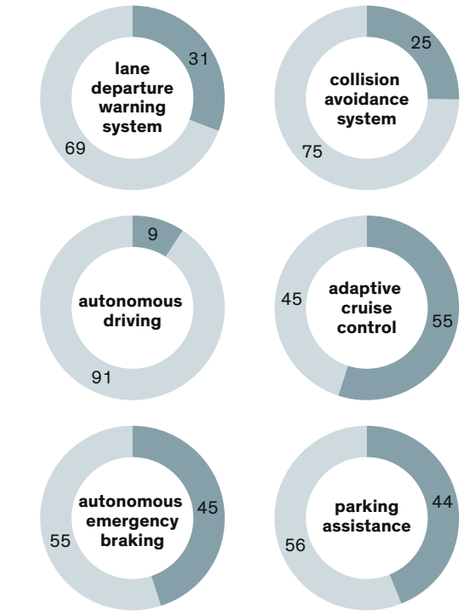
HOW IS THIS TREND MANIFESTED?

In a case study in Tokyo, Sumitomo Electric Industries demonstrated how the use of GPS-based algorithms can optimise traffic flow. By integrating real-time data from GPS systems, traffic flows were analysed and appropriate adjustments made. This approach led to more efficient traffic management and helped to reduce congestion by up to 20 percent.

Singapore is considered a pioneer because the city consistently relies on innovative technologies to make traffic safer, more efficient and more sustainable. Thus, public transport is constantly being expanded and further fully automatic, driverless mass rapid transit lines, such as the Thomson-East Coast Line (TEL) and the Jurong Region Line (JRL), are being added to improve the connection of new districts. Another model for success is intelligent traffic management: A dense network of sensors monitors traffic in real time, while dynamic signposts and traffic light sequences are adapted to traffic volume to reduce journey times and stop-start traffic. In addition to land transport, Singapore is focusing on connectivity particularly in the port of Tuas; by use of 5G technology, it is planned to be expanded into the world's largest fully automated port by 2040. The aim is to identify potential problems early on and avoid costly equipment failures with the help of predictive maintenance, drone-based monitoring and XR applications. Automated cranes and vehicles, as well as intelligent logistics systems, will be used to enable faster and more precise cargo handling. In addition, real-time tracking data will be processed even more accurately in the future, enabling berth planners to optimise occupancy and traffic flow even at peak times.

Does your car have this AI function?

In percent, rounded



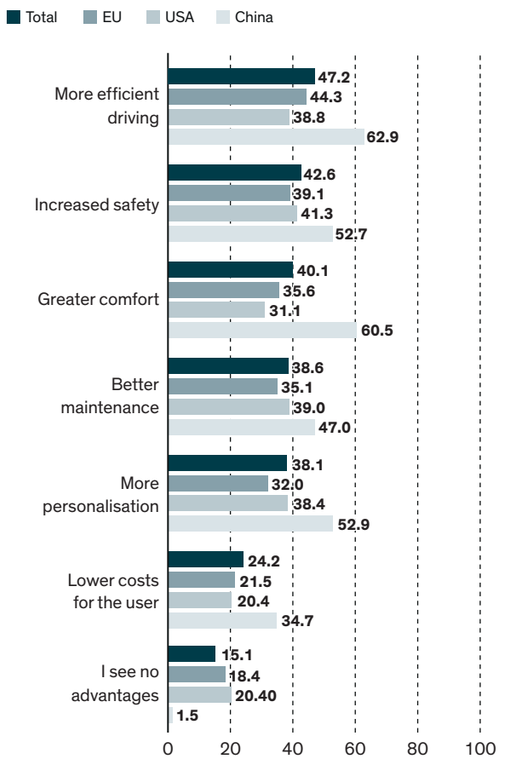
Source: Allianz Direct, 2023

For Los Angeles, where drivers spend about 95 hours a year in traffic jams, the California governor called on technology companies to use artificial intelligence to reduce gridlock. Among them is Google, which is already pursuing the Greenlight research project in 14 cities, including Seattle and Hamburg. It involves using aggregated driving trends from Google Maps, analysing thousands of intersections and modulating traffic patterns to reduce stops at red lights. According to Google, the result is that 30 percent of stops were eliminated and 10 percent of emissions were avoided. In LA, AI is already being used in cameras on buses to detect parking violations in bus lanes. The number plate is scanned, and drivers receive a warning for the first offence; for the second, they receive a fine of 250 dollars. Measures like these are intended to help improve traffic flow, especially in view of the 2028 Olympic Games in Los Angeles, which are expected to result in increased traffic.

Vehicle automation, digital signal boxes, integrated control and operating systems, sensors for environmental perception, AI in incident, capacity and traffic management – these are just a few of the numerous innovative technologies that, according to Digitale Schiene Deutschland, must interact smoothly in order to control trains in real time, drive them fully automatically and locate them precisely. Various projects help to gain experience along the way, for example, in the area of obstacle detection. Sensors such as radar, lidar, cameras, ultrasound and infrared are used to monitor the track and detect the environment. The detection of the environment is constantly being refined with the help of artificial intelligence. A data factory acts as a central platform for storing, processing and annotating such sensor data and forms the basis for training the AI models, which have to be able to identify objects reliably and accurately.

What advantages do you see in the use of artificial intelligence in cars?

In percent

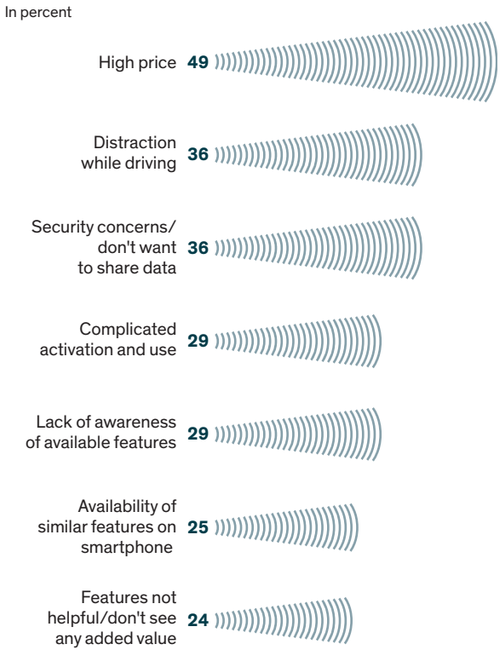


Source: Statista, 2025

Note: Europe; China; USA; 4,711 survey participants

Main concerns regarding connected car features

In percent



Source: Statista, 2025

Note: Worldwide; 2024; 19,000 survey participants in 28 countries; EQ Mobility Consumer Index

In Vienna, by combining offline traffic modelling with real-time data and algorithms, the current and future traffic situation is calculated, visualised and updated every five minutes. The software takes into account reactions to unplanned traffic delays, such as accidents, and known disruptions, such as construction sites. The city uses the data, on the one hand, to improve its mobility services, such as timetable information, on the other hand, it forms the basis for informed decisions in the control centre as regards traffic management and control.

The further development of intelligent transport systems has the potential to fundamentally change mobility concepts. One future scenario is the possibility of traffic without traffic lights, in which vehicles and infrastructure are networked in such a way that classic light signal systems become obsolete. Instead, vehicles could coordinate with each other independently through real-time communication, allowing them to pass through intersections without stopping, while AI-supported algorithms ensure optimal traffic flow control. Targeted traffic diversions via dynamic signposts can automatically and flexibly control traffic volumes to avoid congestion. Moreover, autonomous transport fleets could be intelligently controlled to minimise empty runs and optimise the utilisation of transport resources.

OUTLOOK

The widespread implementation of such visions stands and falls with the infrastructure in which high-tech vehicles operate. The expansion of 5G, sensor technology and AI-controlled traffic control systems, for example, is costly. At the same time, the collection of large amounts of data raises questions of data protection and cyber security as a large number of movement profiles are processed. The regulatory framework must be adapted to create standards and (legal) security for communication between traffic participants and infrastructure.

Given the sensitive nature of the challenges, hasty decisions are not to be expected. Through the stepwise implementation of an increasing number of intelligent actors – be they vehicles or infrastructures – an intelligent network is gradually being built up in various mobility sectors. The acceptance of, and trust in, the communication via these networks materially depends on the success of the pilot projects launched. Serious incidents would result in great public concern, which would override rational benefits and could massively delay the development of intelligent transportation systems.

TREND LIVEABLE CITIES

As life quality in cities becomes increasingly important, the many facets of urban mobility and its impacts are coming under the spotlight.

LIVEABLE CITIES

LIVEABLE

TREND

Urban life quality is perceived in many different ways. It is influenced by how people can organise their daily lives - whether they feel safe, whether they can get around quickly and conveniently, whether they have access to nature and green spaces, whether they experience social interaction, or whether environmental conditions are beneficial to their health. Attractive public spaces that invite people to linger and meet, or green spaces that are used not only as aesthetic elements but also to regulate the microclimate and provide recreation, can all improve the life quality in cities. A wide range of options for daily needs - from shopping to education, health and leisure - that are easily and quickly accessible, peace and quiet, clean air and a high level of safety also contribute to a high quality of life. One factor that influences these aspects is mobility. It can connect or divide cities. It can enable participation or create barriers. It can enliven places or stress them. The way mobility is structured is one of the factors that determines whether cities are places of well-being or places of noise, bustle and stress.

For decades, motorised private transport has marked the development of cities - with far-reaching consequences. Roads were built for cars, not for people. Still today, large areas in cities are taken up by moving traffic and, to a considerable extent, also by stationary traffic - in the form of parking spaces - thus significantly reducing the space available for other uses. Moreover, motorised traffic has a number of negative effects on the quality of life. Noise is one of the major environmental causes of health issues, with both physical and psychological effects; air pollution from exhaust fumes fuels respiratory and cardiovascular conditions. Car dependency can also exacerbate social inequalities, as people without a car or access to good public transport are restricted in their mobility. Long commutes in traffic jams or the difficulty finding a parking space also cause stress and loss of time, which affects the personal quality of life.

Active mobility - such as walking and cycling - is increasingly seen as a cornerstone of liveable cities. Walking allows for immediate social interaction and direct connection with the environment. Streets and squares with a pedestrian focus are spaces for encounters, spontaneity and diversity in urban life. They enhance the sense of security, as a lively environment discourages crime and increases social control. Cycling is a fast and environmentally friendly form of mobility that can combine both individual freedom and urban efficiency. Cities such as Amsterdam and Copenhagen have shown that consistently promoting cycling not only improves mobility, but also fundamentally changes the urban climate. Where cars used to dominate, wide cycle lanes, safe crossings and lively street cafes have transformed the cityscape.

An efficient local public transport is also essential for reachability and inclusion in cities, allowing people to travel long distances efficiently while reducing the negative impacts of traffic. Well-developed bus and rail services can significantly reduce traffic in city centres by providing an attractive alternative to the private car. The quality of local public transport is crucial here. A dense network, short waiting times, accessibility and affordable prices are crucial to people perceiving public transport as an equal or better option to the car. An efficient local public transport helps create cities with less congestion, cleaner air and a higher liveability.

How cities manage mobility is therefore crucial to the quality of life they offer those who live in them. If mobility is organised from a holistic perspective, cities can be places that not only function efficiently but also offer a high quality of life at all levels. The goal must be to understand mobility as a key component of urban development - not just as traffic planning, but as a concept that takes into account liveability, social interaction and environmental conditions equally. Liveable cities see mobility as key to enabling people to live healthy, safe and fulfilling lives in urban areas.

CITIES

WHAT'S BEHIND THE TREND?

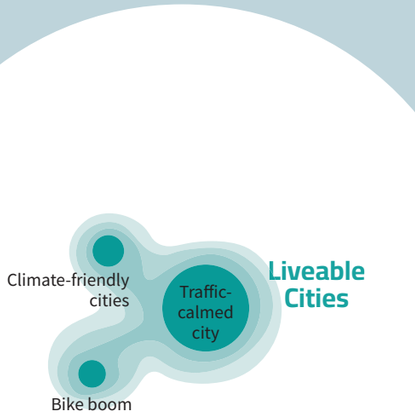
The concept of traffic-calmed cities focuses on reducing motorised private transport in order to create space for alternative uses. This is realised through measures such as car-free city centres, superblocks or 30 km/h speed limit zones. The aim is to reclaim part of the public space from vehicles and make it usable for pedestrians, cyclists and social encounters.

The development of zero-emission mobility solutions, the promotion of electric or hydrogen-powered public transport and the increased use of renewable energies all contribute to minimising the environmental impact of transport in general and in cities in particular. This is because the concentration of air pollution, a lack of fresh air corridors, increasing heat stress, a lack of green oases or sealed floors are particularly severe in urban areas.

The trend towards using the bicycle as a central means of urban transport is being driven by the development of safe cycle lanes, the integration of bike-sharing services with public transport and the increasing popularity of e-bikes. Technological, infrastructural and health aspects make the bicycle an increasingly attractive alternative to the car in the city.

The Liveable Cities trend focuses on the following identified trend concepts:

- ➔ Climate-friendly cities
- ➔ Traffic-calmed city
- ➔ Bike boom



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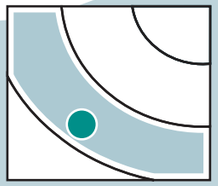


ZOOM-IN

CONTEXT

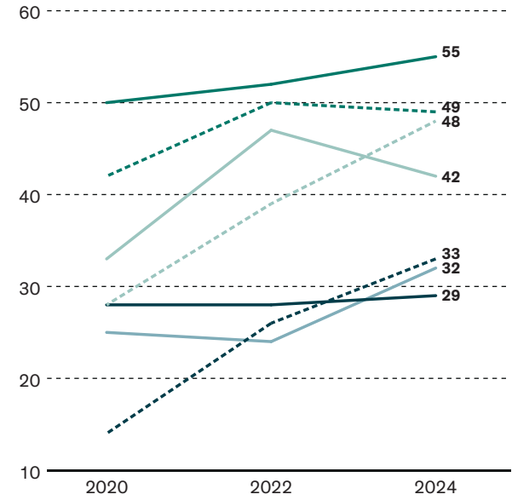
HOW IS THIS TREND MANIFESTED?

Many cities are working ambitiously to improve their quality of life through mobility initiatives and have achieved significant results. In Paris, for example, Mayor Anne Hidalgo has introduced far-reaching changes in just a few years, including the closure of streets along the banks of the Seine to traffic and the Paris Respire campaign, which celebrates a car-free day on the first Sunday of every month, when entire districts and streets are closed to motorised traffic. The network of cycle paths has been massively expanded and will soon cover more than 1500 kilometres. This exemplifies the widely (re)discovered potential of the bicycle as an everyday means of transport. It is estimated that up to 30 percent of car journeys in urban areas can be shifted to cycling. That this target is achievable is shown by the means of transport chosen in cities such as Copenhagen, Amsterdam, Groningen or in particularly bicycle-friendly German cities such as Münster, where, at 39 percent, the share of cycling in the number of journeys made has surpassed that of private motorised transport (29 percent).

Besides focusing on cycling infrastructure, the city of Paris has introduced a 30 km/h speed limit in large parts of the city, lowered the speed limit on the city motorway from 70 to 50 km/h and tripled parking fees for large cars such as SUVs. Some 50,000 parking spaces have been removed, new green spaces created and around 170,000 trees are to be planted by 2026 to transform places like the Champs-Élysées into green boulevards. According to the city administration, these changes have already contributed to a 40 percent reduction in air pollution in Paris. The French capital is also a pioneer of the 15-minute city - an urban planning concept aiming to develop urban structures in which all main facilities of daily life can be reached within 15 minutes on foot or by bicycle. Clichy-Batignolles, one of Paris‹s ÉcoQuartiers, is a prime example of green urban redevelopment in Paris. On a 54-hectare former railway area, a new district with 3,400 free and subsidised apartments, schools, cafés, gyms, supermarkets, a theatre and a centrally located, ten-hectare park including vegetable gardens, sunbathing lawns, dense planting, playgrounds and pavilions has been

What do you think are the major problems caused by traffic?

In percent



Source: Statista, 2025

Note: Germany; Ipsos; 2,500 survey participants, 16-75 years; representative; computer-assisted web interviews (CAWI)

developed since 2007. Cities like Copenhagen, Hamburg and Vienna are also planning to become 15-minute cities. Frankfurt and Düsseldorf already meet many of the requirements, and Munich‹s Werksviertel is considered an innovative urban district project. Given the immense economic potential of the 15-minute cities, the Remax real estate network expects more disadvantaged neighbourhoods to be planned and upgraded according to this concept in the future. Analyses show that, while the 15-minute city can be a good guide to tailored solutions in - especially European - cities, it has its limitations where planning has been based on car traffic from the outset. Cities such as Dallas or Atlanta, for example, where up to 70 percent of the facilities would have to be relocated to achieve the 15-minute goal, need alternative solutions.

Barcelona is another European metropolis that is emblematic of a popular concept in urban planning. Barcelona‹s Superilles concept combines several neighbouring blocks into a single unit - a superblock - and keeps motorised private transport out as much as possible. Only residents‹ vehicles, delivery vehicles, public transport and emergency vehicles are allowed to drive into a block. Pedestrians have priority and benefit from more space, safety, improved air quality, reduced noise and heat stress, and a better quality of life. The Barcelona model has already been implemented in other cities such as Vancouver and Quito.

Unfair distribution of space

58% of German citizens consider the division of traffic space in Germany to be **unfair.**

72% support the concept of **urban planning that prioritises cycling.**

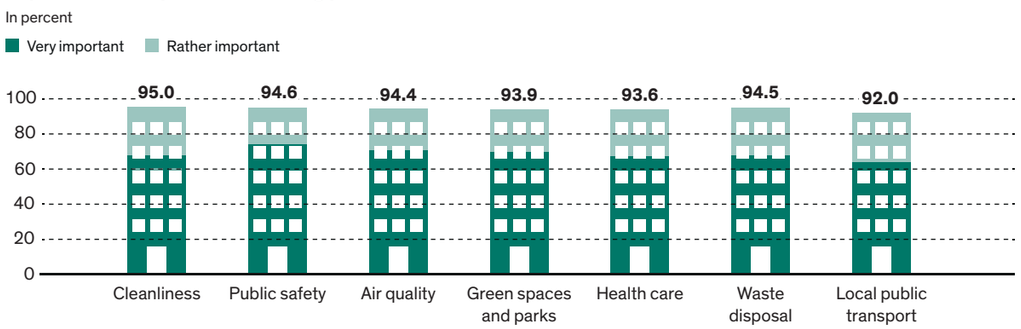
52% are opposed to the introduction of **environmental zones** in which no internal combustion engines are allowed.

Source: TÜV Mobility Studie 2024

The It‹s in the Air campaign is a good example of how widely and globally the improvement of the urban climate is being discussed, with more than thirty cities worldwide, including London, Johannesburg, Seoul, Bogotá, Stockholm and Seattle, participating with various initiatives. Car-free zones, educational programmes and public actions to promote sustainable mobility highlight the importance of clean air zones. These are urban areas where measures are taken to reduce vehicle pollution, encourage active travel such as walking, cycling and public transport, and prioritise people over cars. These zones give residents more space to breathe, walk and play, to enjoy nature and socialise. In surveys conducted in the participating cities, over 80 percent of people said that their governments should prioritise clean air. Over 90 percent support the expansion of public transport and active mobility.

Importance of aspects at the living place

In percent



Source: Statistisches Amt Basel-Stadt, 2024

OUTLOOK

In the coming years, urban mobility will change fundamentally and become not only more environmentally friendly, but also, and above all, more people-friendly. Cities face the challenge of reorganising their traffic spaces in order to use the limited urban space efficiently and, above all, fairly, since especially non-motorised road users currently perceive traffic space to be distributed unfairly.

A key focus will therefore be on reducing motorised private transport and developing and expanding mobility options that are so attractive that many city dwellers see no need for their own car. Not only for environmental and social improvements, but also - as studies increasingly show - to reap the economic benefits of reduced urban car traffic and the potential for economic growth through the use of alternative modes of transport such as bicycles, electric and cargo bikes, micro-mobility services or active mobility.

The development of the 15-minute city offers a range of new urban planning options that are tailored to the needs and realities of people‹s lives. Even if the concept cannot be implemented everywhere, the basic principles of the 15-minute city will have a significant influence on what urban mobility should achieve and enable in the coming years.

TREND MOBILITY AS A SERVICE

MOBILITY AS A SERVICE

The flexible use of different mobility services is gradually replacing the ownership of individual means of transport.

TREND MOBILITY AS A SERVICE

MOBILITY AS A SERVICE

TREND

The growing popularity of Mobility as a Service (MaaS) reflects the changing mobility behaviour of many people, who are increasingly turning away from the idea of vehicle - especially car - ownership, and instead want to use flexible, environmentally friendly and cost-efficient mobility solutions.

MaaS provides access to a range of mobility services, from local public transport to car and ride sharing, as well as micro-mobility services such as e-scooters and bike sharing. Ideally, a single intelligent platform combines all available options, enabling users to easily plan their trips and journeys, combine different means of transport and pay with a single ticket or via a subscription solution. This has the potential to increase comfort, efficiency and the motivation to choose a tailored mobility mix over the car.

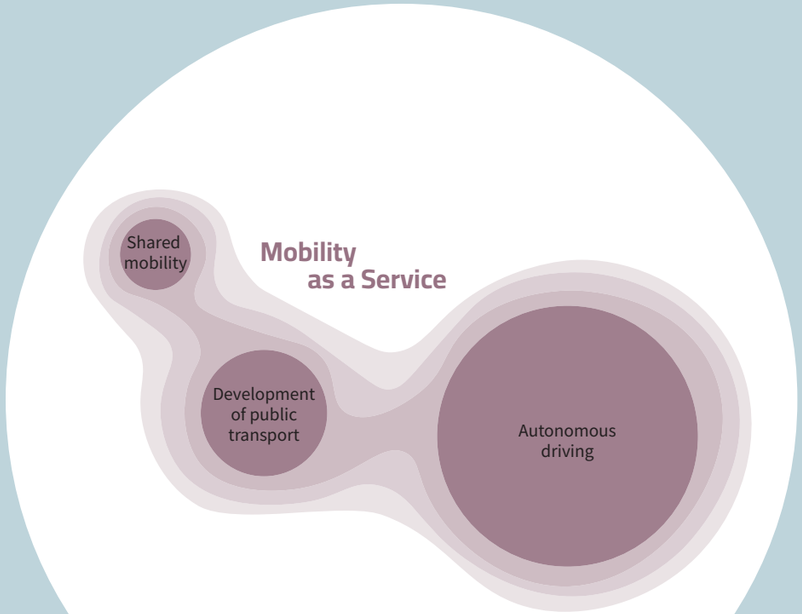
The technological basis for this new mobility concept is mainly provided by the connectivity megatrend. By combining personal routes and preferences, real-time traffic and environmental data, and various providers, intelligent routes can be calculated and optimised to get users to their destination as efficiently, quickly and sustainably as possible. Digital payment and ticketing systems facilitate access to the various modes of transport and enable seamless processing of the mobility services used.

The integration of public and private providers requires close cooperation, a clear regulatory framework and common standards to create interoperable services. Until now, many mobility providers have relied on their own platforms, apps, communication, planning and payment methods. This has fragmented the market and impeded user experience - here the local public transport operator, there one of the many e-scooter rental companies, a car-sharing provider, a taxi service - and once you cross city, state or national borders when booking or travelling, the cohesive experience often ends due to different tickets, uncoordinated timetables and gaps between modes of transport. What‹s more, successfully scaling MaaS requires a solid infrastructure, which is not equally developed everywhere.

Particularly in rural areas, there is often a lack of basic mobility options, which makes it difficult to implement appropriate concepts. The development of autonomous vehicles could therefore significantly advance the MaaS trend by closing existing gaps. In many cities and regions, public transport is reaching its limits, especially in outlying areas where frequent services are hardly economically viable. Autonomous shuttles could be an effective addition here as they offer flexible transport solutions and take people from their doorstep to central mobility hubs. This would make using public transport much easier and increase the overall attractiveness of MaaS.

Moreover, autonomous driving could strengthen a form of mobility that no longer depends on the availability of drivers. Many transport services are currently only available at certain times, leading to mobility bottlenecks, especially at night or in less frequented districts. Autonomous vehicles could overcome this shortage, as they can be used 24/7 and flexibly respond to demand. This not only ensures greater accessibility, but also helps more people to opt for alternative forms of mobility and do without their own private cars. In the long term, the elimination of human drivers will also significantly reduce the cost of on-demand mobility services and make MaaS more economically viable.

From a technological aspect, however, these vehicles must first be able to move safely and reliably in complex urban environments with many different traffic participants. Moreover, the legal framework for the operation of autonomous fleets is still uncertain in many countries. Questions of liability in case of accidents, data protection and regulatory supervision need to be resolved before autonomous mobility can be widely integrated into MaaS platforms. Furthermore, the transition to autonomous driving requires significant investment in digital infrastructures, traffic management systems and communication networks to ensure seamless connectivity between vehicles and their environment.



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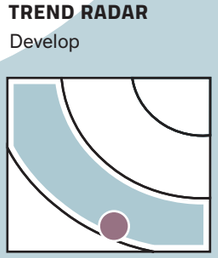


The Mobility as a Service trend focuses on the following identified trend concepts:

- ➔ Shared mobility
- ➔ Development of public transport
- ➔ Autonomous driving

WHAT'S BEHIND THE TREND?

Autonomous vehicles could provide a massive boost to MaaS in the coming years by filling gaps in time and space. At the same time, the potential savings in terms of driving personnel can reduce the cost of mobility in the long term and significantly expand access to it.

MaaS is only efficient if a well-developed public transport network serves as the backbone of the system. In many cities and regions, further action is needed to create better timing, easier booking systems and intermodal transitions. The growing acceptance of car sharing, ride hailing and micro-mobility services such as e-scooters or bike rental makes MaaS particularly attractive in urban areas. Shared vehicles reduce the need for private car ownership and contribute to a more efficient use of resources.

ZOOM-IN

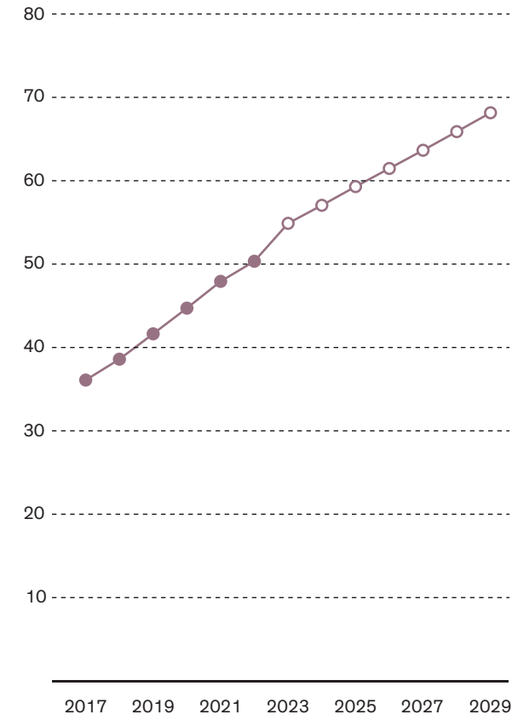
CONTEXT

HOW IS THIS TREND MANIFESTED?

With its Whim app, one of the first fully integrated MaaS solutions, Helsinki is a pioneer when it comes to booking and paying for various mobility services such as public transport, taxis, car sharing, bike sharing and e-scooters through a single app. Even though MaaS Global, the developer company founded in 2015 and considered the world‹s first Mobility-as-a-Service company, has since gone bankrupt, the established software, which is also used in Vienna, Antwerp, Turku, Tokyo, Birmingham and Switzerland, remains in place. The Dutch MaaS platform umob is transferring them to its app and building on the experience gained so far. For example, the pay-per-ride business model has proven more successful than a monthly flat-rate subscription for transport use.

Number of car-sharing users worldwide from 2017 to 2023 and forecast up to 2029

In millions

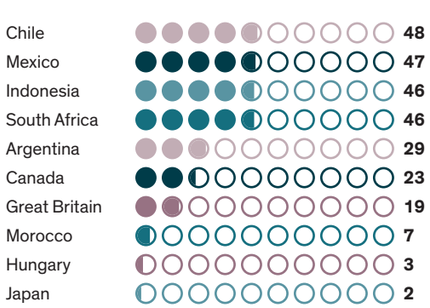


Source: Statista, 2024

The WienMobil app, for example, combines public and private mobility providers and provides a complete overview of various mobility options. The app maps local public transport in the form of underground trains, buses, trams, rental bicycles and shared taxis operated by Vienna‹s public transport operator Wiener Linien, together with real-time operating information. It also features car rental companies Europcar, Sixt and Share Now, various taxi companies, the airport bus and the state and private rail operators ÖBB and Westbahn. Nearby stops, e-charging stations, e-scooters, car parks, taxi ranks, available car- and bike-sharing vehicles, as well as Mobility Hubs, which collect various mobility services at hubs, are displayed on a shared map. Routes can be filtered by means of transport or planned as a mix. Apart from various ticket options, visitor passes including discounts for attractions and tickets for the transport museum can also be purchased through the app.

Share of ride-sharing or ride-hailing users

In percent



Source: Statista, 2024

Note: For each continent, the country with the highest and lowest value was selected from the data, as well as the Dach region

With hvv switch app, developed by Hamburger Hochbahn AG, Hamburg is one of the German cities actively promoting MaaS and combining public transport with sharing and ride-hailing services. With the app, users can book not only trains and buses, but also car-sharing services such as Miles, Share Now and Sixt share, Voi e-scooters and ride-hailing services from the ride-pooling service provider MOIA, whose autonomous shuttles are to be more closely linked to MaaS platforms in the future. Payment for various services is made using PayPal details, SEPA direct debit or credit card. Ride-hailing companies are increasingly focusing on multimodal services and expanding their range. For example, Uber is integrating Lime e-scooters or rental cars into its app. Automotive manufacturers are also embracing the trend, as Toyota is demonstrating with its KINTO brand. According to the company, it marks the transformation to a mobility company that offers a range of services, from the provision of complete vehicle and service packages for corporate and private customers to the use of data and vehicle connectivity options to develop and introduce services such as car sharing, carpools or subscriptions.

In cities with an already well-developed infrastructure, MaaS offers great potential for quickly making transport more efficient and promoting a change in the way we consume mobility. In many cases, it is not a lack of offers that is the problem, but a lack of a clear, convenient and integrated organisation and provision for users. In the long term, MaaS will not be limited to urban areas. It will create new opportunities in suburban and rural areas, providing better access for people without cars, the elderly or those with limited mobility.

An open, interoperable system that integrates both public and private mobility providers is essential for widespread deployment. In this context, data protection, fairness in pricing and the question of accessibility are becoming key issues for political decision-makers. It is essential to constructively combine different stakeholder perspectives - those of the advocates of a cultural change seeing MaaS as a means to reduce car dependency; the perspective of strong political regulation advocates who are positive that clear legal frameworks are crucial for MaaS success; and those of technological solution supporters who want to drive MaaS primarily through digital integration.

Mobility as a Service is one of the key principles of the future of mobility – autonomous driving plays a fundamental role within this trend. Once it is possible to establish autonomous fleets and thereby drastically reduce the costs of ride-hailing and sharing services, increase their availability and link them to existing public transport, it would be a decisive game changer for individual mobility.

OUTLOOK

TREND AERIAL DENSITY

AERIAL DENSITY

The growing density of air traffic calls for an optimised and coordinated use of various aircraft types.

AERIAL

TREND

Airspace is becoming more and more crowded. Aside from traditional air traffic, which is returning to pre-crisis levels following pandemic-related declines, a growing number of new players are taking to the skies. In particular, the increasing number of commercial drones is changing the scene. While especially logistics companies are testing drones for deliveries, countries like China are also setting sight on the widespread introduction of air taxis. Air traffic's growing density poses significant challenges for regulatory authorities, airspace coordinators, cities and technology companies. In particular, for traffic control, approaches are needed to ensure safe coordination between aircraft and to be able to integrate new mobility concepts into the airspace.

While conventional air traffic is growing again and the number of air passengers worldwide is expected to have risen to 5.64 billion by 2030 – an increase of around 30 percent compared to 2018 – drone traffic is also clearly on the rise. The number of commercially used drones in Germany alone almost tripled between 2019 and 2023. By 2030, the number of drones is expected to grow by a further 43 percent, with around 80,000 commercial and 332,000 private drones in circulation and potentially in German airspace. Its use is growing, particularly in the logistics industry, where air transport can make supply chains faster and more flexible. Drones are good at reaching and supplying remote locations, and smaller goods can be quickly distributed by drones across large areas such as factory sites or port facilities. For example, drones are already a valuable aid in the inspection and maintenance of wind turbines, in the monitoring of extensive agricultural areas and in rescue operations.

But what is already working well in less densely populated areas and will become increasingly established in the coming years is proving to be much more difficult in cities. Urban air mobility has been a vision of the future for decades, with deliverymen, parcels and pedestrians being projected into the air of future cities, sharing the airspace with air taxis. In fact, however, particularly urban areas pose numerous obstacles to mass individual air traffic. The dense population makes navigation difficult and take-off and landing sites are rare. The existing noise pollution in cities would be exacerbated by the additional background noise from flying objects. Test projects for eVTOLs, electrically powered aircraft that can take off and land vertically, are being widely promoted in many of the world's regions. While these developments are technologically promising, regulatory, infrastructural and economic constraints largely keep these air taxis in a niche market.

As drone traffic will be largely automated, the question is how to ensure the coexistence of manned and unmanned aircraft. As in all areas of aviation, AI will play a crucial role here. By analysing data on obstacles, weather patterns, sector configurations, air traffic bottlenecks and other factors, AI can improve air traffic management by optimising flight routes, for example, and providing air traffic controllers and pilots with information or decision-making support in critical situations. In particular, a large number of the processes involved in the fast and efficient handling of drone flights will be largely automated, including the examination of flight applications and their synchronisation with other flights. Use cases developed specifically for the project illustrated various scenarios and provided insights to ensure a safe interaction between different airspace players.

DENSITY

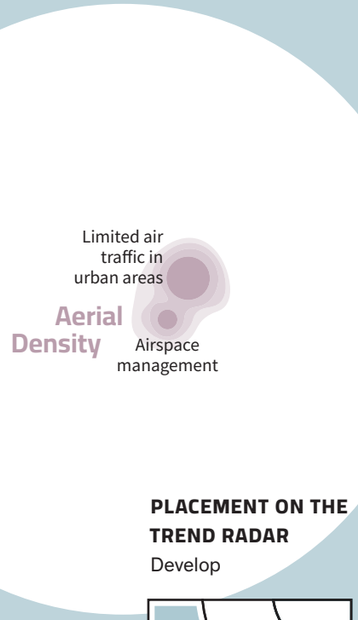
WHAT'S BEHIND THE TREND?

In dense urban areas, airspace, existing air traffic control systems and regulations are at risk of being stretched to their limits as the skies open up to the mass use of new aircraft. Strict regulations to protect the public, high safety requirements, infrastructural hurdles and, last but not least, the acceptance by the urban population are all obstacles to the development of urban air mobility.

With more aircraft in the air, competition and the need for precise control and coordination rise, for example, to ensure that air rescuers can continue to reach their destination quickly and undisturbed. New technologies are needed for airspace monitoring and collision avoidance. Also, an overcrowded airspace could lead to increased costs for use and pose an environmental issue.

The Aerial Density trend focuses on the following identified trend concepts:

- ➔ Limited air traffic in urban areas
- ➔ Airspace management



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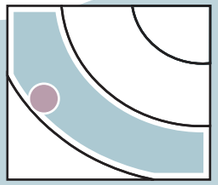


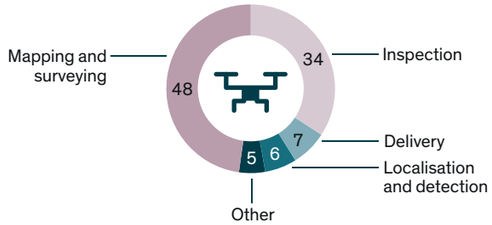
ZOOM-IN

CONTEXT

HOW IS THIS TREND MANIFESTED?

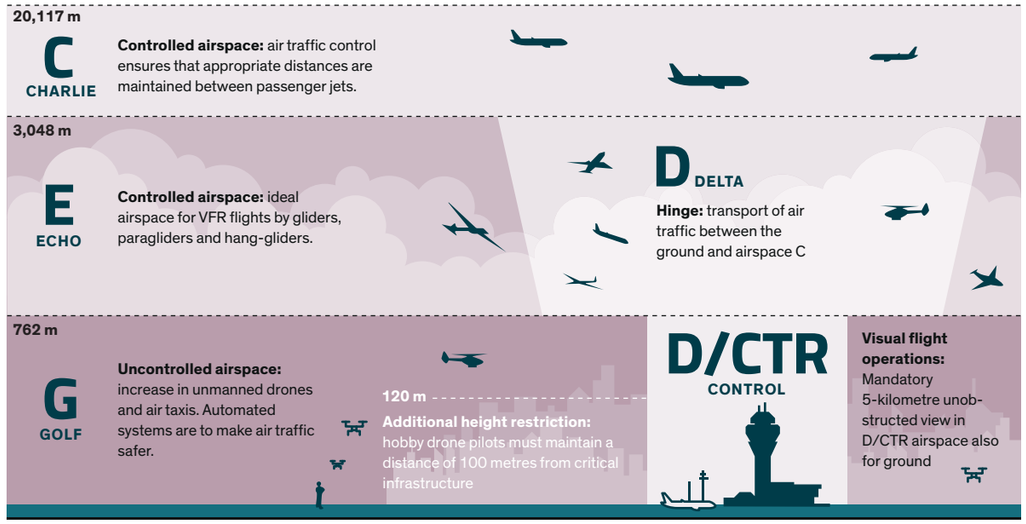
With the U-Space Regulation, the EU has created a legal and technological framework to enable the regulated operation of commercial and professional drones in urban and rural areas and to integrate them safely into the airspace. In regions with high levels of air traffic, drones benefit from a dedicated traffic system in the form of U-spaces: a defined area in the lower airspace controlled by a U-Space Service Provider (USSP). Various U-Space services ensure that drone operators are alerted to other air traffic in the vicinity of their drone (Traffic Information Service) and that there is no spatial and temporal overlap of authorised drone flights in U-Space (Flight Authorisation Service). They ensure that drone operators receive information about the airspace and possible restrictions (Geo-Awareness Service), provide identification data of the UAS and forward it to authorised users (Network Identification Service). In the Port of Hamburg, a U-Space real-world laboratory was set up over a period of seven months under the lead management of Deutsche Flugsicherung (DFS) and Droniq in which the interaction of individual airspace users, the mandatory U-Space services and the related technical, procedural and operational implementation were demonstrated. Use cases developed specifically for the project illustrated various scenarios of airspace interaction and provided insights to ensure a safe interaction between airspace users.

Number of drone uses in the global transport industry in 2021



Source: DRONEII, 2021

Who can fly where



Source: Aeroreport, 2021

The German Unmanned Aviation Association expects the German drone market to grow to over 1.7 billion euros by 2030 - an annual growth rate of 7.5 percent. This is mainly driven by the commercial sector, while the private drone market is expected to stagnate. The greatest potential in industrial applications is seen in surveying and mapping in building construction, civil engineering and road construction, where drones can be used to create 3D terrain models and aerial photographs. The Association also sees great relevance in the inspection of transport infrastructure (damage, foreign objects, vegetation, safety) and in the energy sector (inspection of safety-critical systems), for monitoring by security authorities or for inventory and transport in intra- and interlogistics.

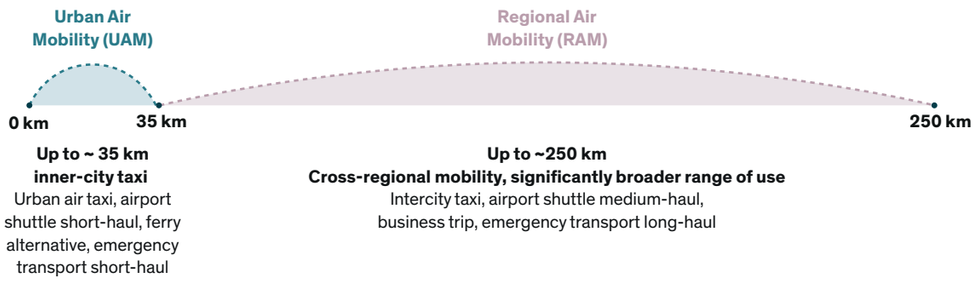
Increased attention to airspace is also driven by safety concerns. Rheinmetall and Auterion, for example, are bundling their military expertise and software skills to develop a unified operating system for unmanned drone systems. Bavaria, in particular, has become a hub for unmanned military aviation. There, for example, the start-up unicorn Helsing, Avilus and Quantum Systems are developing drones for combat, rescue or surveillance missions.

Amazon‹s drone programme Prime Air has been running for over ten years and in 2024 it received a major clearance from the Federal Aviation Administration (FAA) that allowed the model MK30 to be flown outside the operator‹s line of sight. However, residents in the drone delivery service locations in the West Valley of the Phoenix metropolitan area in Arizona and in College Station are not yet cheering the promise of under 1 hour-deliveries. Rather, they are complaining about the noise of Amazon drones and their impact on nature, such as scared away birds. They fear that their properties will lose value and express concerns about what data will be collected by the drone cameras while they are operating over residential areas and private facilities, such as swimming pools.

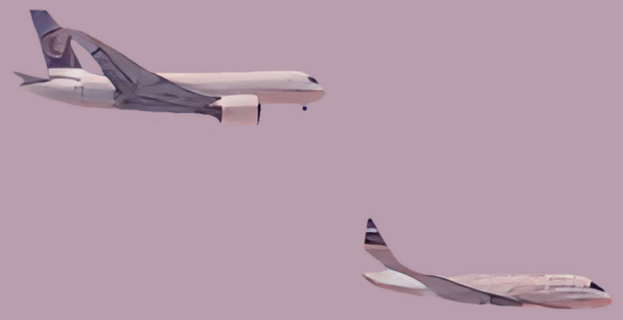
China has taken on a pioneering role in urban air mobility and has brought together more than 100 companies in the China Low Altitude Economic Alliance to work on the further development of airspace applications at low altitudes. By 2030, around 100,000 eVTOLs are expected to be used as family vehicles and taxis in China‹s major cities. Germany has also already presented a comprehensive Advanced Air Mobility (AAM) strategy to gradually expand the use of drones and eVTOLs by 2032. The first test routes are expected to be built by 2026, followed by regionally limited AAM areas by 2028. Larger routes are set to open from 2030, with nationwide operation possible by 2032.

ADAC Luftrettung, the air ambulance service of the General German Automobile Club, has already completed a two-year research project with Volocopter in the model regions of Idar-Oberstein and Dinkelsbühl to test a manned multicopter for emergency medical services. In addition to the purchase of two aircraft for research operations, an option to buy up to 150 more next-generation multicopters was also submitted.

Use cases of Advanced Air Mobility



Source: Analysis of the potential use of air taxis in Baden-Württemberg; Ministry of Transport of Baden-Württemberg, 2023



OUTLOOK

Airspace offers an exciting new realm of mobility, but the challenges of navigating it are considerable. Traffic in lower airspace will increase in the coming years and remain highly regulated, with the focus initially being on specialised applications such as medical transport and industrial deliveries.

Where space or regulation allows or facilitates it, a higher volume of drone traffic or even the operation of air taxis will be possible. Especially in countries with little regulation, such as China or Saudi Arabia, large-scale test fields could be created that serve as a basis for later implementations in Europe. However, widespread use is not foreseeable for economic, regulatory and practical reasons. Social acceptance of new forms of air mobility will play a crucial role, because without public trust in safety and environmental compatibility, they will remain interesting niche options for specialised markets.

Cybersecurity will be key to the future development of airspace and cannot be ignored, as the increasing number of airspace users can only be coordinated through intensive networking in the form of AI, sensor technology and digitalised control systems. At the same time, this creates vulnerability and raises questions about choice and dependency on technology providers.

RAIL ALIGNMENT

Standardisation and digitalisation measures are increasingly helping the rail sector to overcome capacity bottlenecks, promote interoperability and make both passenger and freight transport more efficient.

RAIL

TREND

European rail transport is characterised by a multitude of national standards making it considerably difficult to use the rail network smoothly and efficiently. In passenger transport, this starts with the often limited availability of through tickets for journeys across several countries, for which different providers and ticket shops are needed. Enforcing passenger rights, for example with regard to onward travel in the event of delay, is another issue. More significant, however, are the different signalling systems, incompatible train control technologies and uncoordinated timetables, which cause inefficiencies, delays and high operating costs. While road and air transport are largely harmonised across national borders, rail transport is marked by regulatory and technical fragmentation impeding the rail‹s competitiveness.

With every border crossing, trains literally break new ground. Over 800 national regulations, four different electricity systems and over twenty train control systems cause constantly changing operating conditions for cross-border transport. The consequences are costly and inefficient waiting times at borders, particularly for freight transport, and time-consuming operational measures such as technical inspections of wagons, changes to braking positions, brake tests and the issuing of documents. Another detail that illustrates the limitations of cross-border rail transport is the B1 level of proficiency in the national language that train drivers must have in order to be legally allowed to drive in the respective country. The current patchwork of standards results in significant delays in rail operations, and also the potential of digital optimisation measures is not yet being consistently exploited.

Harmonisation and standardisation in the rail sector are therefore crucial levers for the modernisation of rail transport. A key aspect here is the introduction of the European Train Control System (ETCS), which will replace the myriad of national train control systems in the medium term and establish a European standard. ETCS enables uniform, digital control of rail transport and can significantly increase capacity on existing lines. In Germany alone, the digitalisation of the rail network with the nationwide roll-out of ETCS is expected to provide up to 30 percent more capacity on the existing network.

In particular, high-speed connections, which usually extend across several countries, are impeded by technical and operational hurdles. They are particularly dependent on standardisation and cross-border compatibility in order to strengthen high-speed trains as an attractive alternative to short-haul air travel.

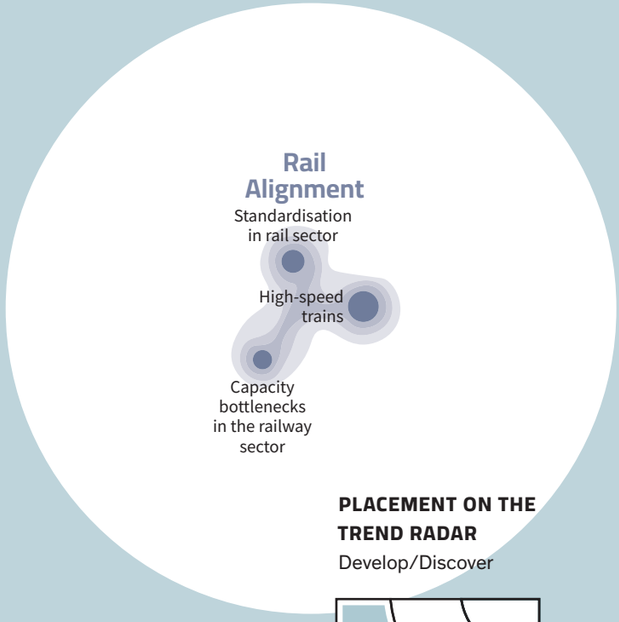
Technological innovations such as AI and digital twins are also driving progress by promoting more efficient use of infrastructure through optimised route planning. In this way, trains can be monitored in real time and delays minimised through intelligent control. Digital processes, automation and driver assistance systems can bring greater efficiency to both shunting and coupling processes and to the track. Modern information systems and sensors also enable the location of wagons, precise arrival forecasts and continuous monitoring of the condition of loads and wagons.

The modernisation of the rail system requires high levels of investment and long planning and implementation horizons. Here, national interests and existing structures collide and have to be coordinated, making rapid change more difficult. Still, experts agree: without a harmonisation of technical and operational standards, the European rail system will not be able to reach its full potential. Rail Alignment is therefore not only a technological project, but also a long-term strategic track-setting for the future of Europe’s mobility, which requires a high level of cross-border co-operation.

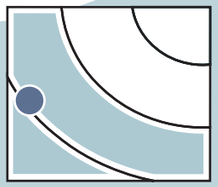
ALIGNMENT

The Rail Alignment trend focuses on the following identified trend concepts:

- ➔ Standardisation in the rail sector
- ➔ High-speed trains
- ➔ Capacity bottlenecks in the railway sector



PLACEMENT ON THE TREND RADAR
Develop/Discover



WHAT'S BEHIND THE TREND?

The standardisation of technical, regulatory and operational conditions in rail transport is essential to make cross-border rail traffic more efficient. In Europe in particular, the fragmentation of rail infrastructure is one of the biggest challenges, especially for freight transport. This is why harmonisation - for example, through standardised gauges, signalling and safety systems, and interoperable digital control and monitoring systems - offers great potential for removing barriers. High-speed trains are a major component of a modern mobility strategy, as they can offer an alternative to air travel. Particularly in Europe and Asia, high-speed connections are an essential element in making environmentally friendly mobility more competitive and shifting business and leisure travel to rail. The development of high-speed rail networks is also often a catalyst for investment in the rest of the rail infrastructure and boosts the rail transport's overall attractiveness.

Outdated infrastructure, a lack of digital networking and insufficient investment in network development are pushing the rail system‹s capacities to their limits in many countries. In many places, the infrastructure is not sufficient to meet the growing demand for passenger and freight transport. Bottlenecks at rail hubs and on major freight corridors cause delays and cancellations, damaging the image of rail and its ability to compete with other modes of transport. Overcoming these bottlenecks is key to strengthening rail transport as a reliable option for personal mobility and logistics.

ZOOM-IN

CONTEXT

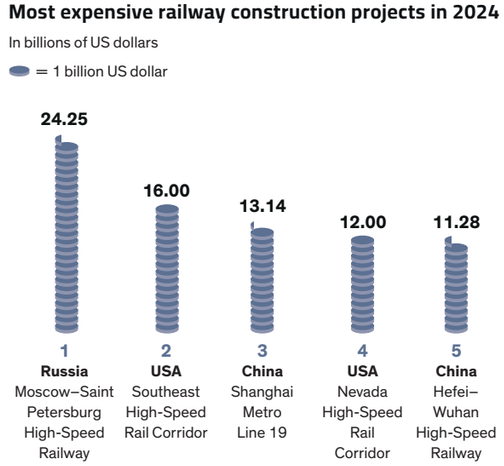
HOW IS THIS TREND MANIFESTED?

For the European Train Control System, six independent labs were set up in Europe to test new technologies and processes in the railway sector. They are to ensure that subsystems and components of the ETCS, as well as other railway control and safety systems, comply with existing standards, trains and infrastructures. Since it would be too time-consuming and expensive to test every product or system directly in real-life conditions, these labs enable fast and safe simulation under controlled conditions. They can functionally replicate the entire rail transport chain - from track-side control and signalling technology and signal boxes to infrastructure and the interface between track and train. Their modular architecture allows both software and hardware components to be tested under realistic conditions. This reduces development times and costs and ensures the smooth integration of new technologies into rail operations. In Australia, too, great efforts are being made to harmonise different gauges or signalling systems, and the interoperability of railways has been made a national priority. According to the Australian Rail Track Corporation (ARTC), the multitude of different standards has led to many critical issues affecting rail productivity and innovation. The ARTC sees significant opportunities for making Australia‹s railways more efficient through greater consistency and compatibility of technologies and systems, such as reducing the eleven signalling systems on the national rail freight network to a single one.

Europe‹s clear commitment to cross-border rail transport is also demonstrated by its plans to double it by 2030 and triple it by 2050. The European Commission‹s list of pilot projects includes a new night train from Amsterdam to

Most expensive railway construction projects in 2024

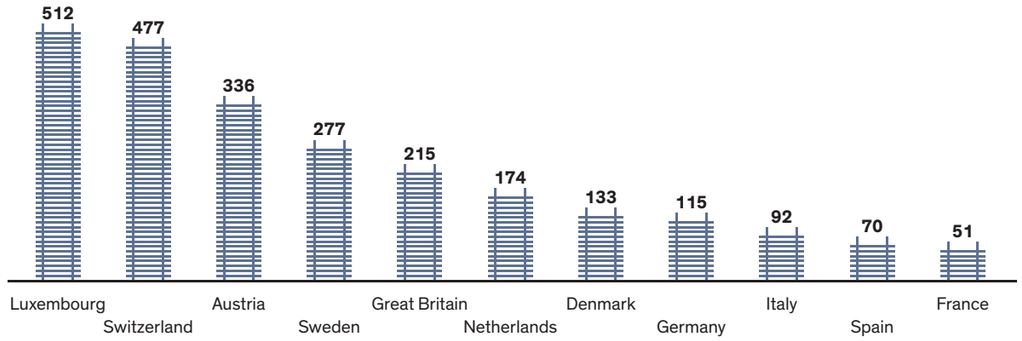
In billions of US dollars



Source: GlobalData, 2024

Investments in rail network by country

Per capita investments in rail infrastructure in 2023 in euros



Source: Statista, 2025

Barcelona and from Stockholm via Copenhagen to Berlin, as well as a connection between Austria, Hungary and Romania. The signing of a new cooperation agreement between the operators of the Channel Tunnel and the British high-speed line is also fuelling hopes of direct connections between London and Cologne or Frankfurt. Rail Baltica, which is currently under construction, promises not only a European north-south rail link from Tallinn via Riga to the Lithuanian-Polish border, but also speeds of 250 km/h on certain sections. However, it also highlights the pitfalls of such once-in-a-century projects: diverging national interests, disputes over responsibilities, delays and exploding costs.

In the future, Brightline West will operate between Rancho Cucamonga near Los Angeles and Las Vegas at speeds of up to 320 km/h. This will significantly reduce travel time from 4 hours 15 minutes (by car) to 2 hours 10 minutes, putting it on a par with air travel (1 hour flight time). With its planned high-speed line (up to 350 km/h), the United Arab Emirates aims to cut travel time between Abu Dhabi and Dubai to just 30 minutes.

Measures to increase rail capacity

Infrastructure development

- Passing loops for freight trains
- Expansion of capacity at terminals and transhipment stations
- Infrastructure for longer trains
- (Re)activation of connecting railways
- Conversion to EU technical standards

Operational optimisation

- More efficient train path coordination
- Uniform international operational processing
- Adaptation of existing passing loops
- Use of longer trains

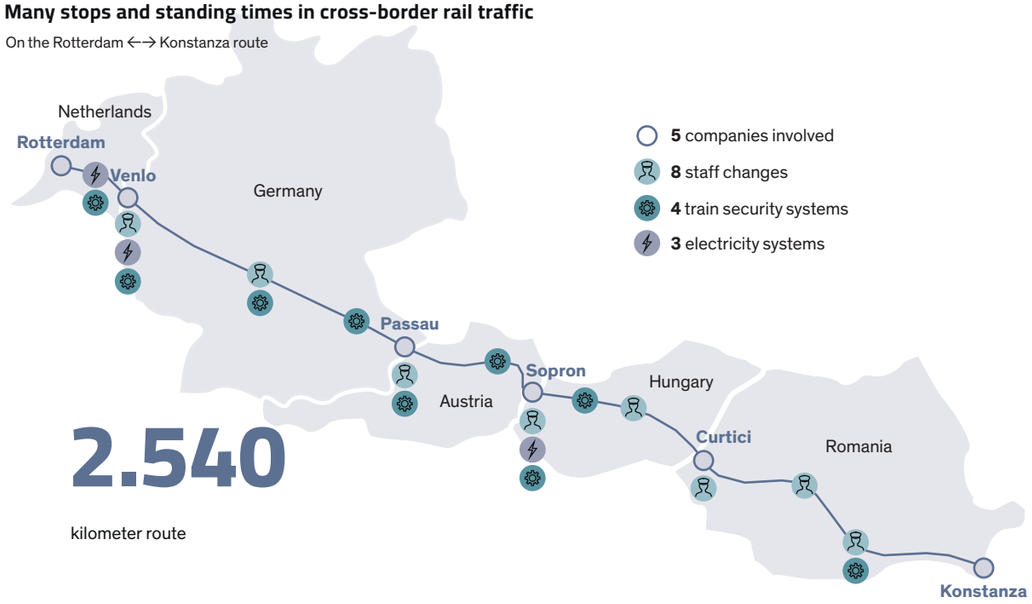
Digital automatic clutch increases …

- Line capacity through higher train loads
- Shunting capacity through faster coupling processes in marshalling yards
- Time savings through automatic brake tests

Source: VCÖ, 2024

Many stops and standing times in cross-border rail traffic

On the Rotterdam ←→ Konstanza route



Source: VCÖ, 2024

The cross-border development of Europe‹s rail transport could also be boosted by changes in security policy. Europe's upgrading to provide an effective defence independent of the US will have an impact on infrastructure such as railways as it plays an important role in transporting material, weapons and troops. Increasing digitalisation will significantly improve the capacity and efficiency of rail transport. The use of AI and digital twins will enable simulations of track usage to optimise capacity planning, optimise timetables and respond better to delays.

Great efforts are required to put the railway on a consistent track. But the long-term projects are worthwile given the benefits that can be achieved. Moreover, the pressure weighing on the rail sector makes them an urgent necessity. Missed investments, failed spatial planning and the abandonment of connecting railways have all taken their toll on the railway‹s competitiveness in freight transport. Capacity bottlenecks, inefficiencies in international operations, high shunting and terminal costs, as well as construction sites due to poor infrastructure are putting the brakes on the rail sector. The lack of harmonisation in cross-border rail transport poses a major obstacle that has to be eliminated in order to push the modal shift from road to rail, as environmental and economic benefits can only be realised in a largely harmonised rail system. The low rolling resistance of trains, for example, requires much less energy than trucks; the large mass that can be transported and the high level of safety also speak in the rail‹s favour. If external costs for accidents, congestion, air pollution, noise, habitat loss and carbon emissions from vehicle production and energy supply are considered, road freight transport causes up to four times higher costs per tonne-kilometre than rail transport.

High-speed trains have the potential to increasingly compete with short-haul flights, although higher speeds require greater distances between trains, which in turn can limit track capacity. Also, energy consumption and infrastructure wear grow disproportionately at high speeds, meaning that in the future the focus will not be on maximum speed, but on optimised driving dynamics.

In the years to come, rail transport has a lot of catching up to do in order to prevail in mobility competition and optimally play its trump cards.

OUTLOOK

TREND SEAMLESS MOBILITY

SEAMLESS MOBILITY

Networked systems where different modes of transport interact seamlessly are increasingly enabling a smooth, flexible and intuitive mobility experience.

TREND SEAMLESS MOBILITY

SEAMLESS MOBILITY

TREND

The traditional separation between individual means of transport, public transport and sharing services is gradually being replaced by an integrated mobility landscape that interconnects different services. Where mobility was long thought of from the perspective of individual transport means, the focus in the future will be on combining different services to best meet users' needs. Seamless Mobility marks this shift towards a digital and controlled ecosystem where different forms of mobility seamlessly merge.

Increasingly smooth and seamless transitions between transport modes facilitate the integration of cars, buses, trains, bicycles, sharing services, e-scooters, autonomous shuttles and other new forms of mobility into a digitally connected user-first system. This means that mobility is shifting from multiple fragmented services to a holistic, flexible and intuitive service tailored to individual needs. Crucial to this shift is the networking of different forms of mobility along seamless travel and route chains. Instead of looking at means of transport in isolation, the aim is to interlink them intelligently. Multimodal and intermodal approaches enable users to switch flexibly between different means of transport without experiencing any disruptions or obstacles in their travel experience. Technological innovations such as digital platforms for integrated booking and payment support this change by enabling simple and barrier-free use of different modes of transport and providing real-time information for efficient travel planning.

A consistent user-focussed approach is crucial here, aligning mobility options with people‹s real needs through easy accessibility, reliable travel times or high standards of comfort. Seamless Mobility also requires a new form of partnership between public and private players. Implementing intermodal mobility solutions places high demands on interface management, the timing of transport modes and the integration of data. Public transport providers, private mobility service providers and technological platforms must co-operate closely to ensure a seamless end-to-end system. The focus should not be on which means of transport is used, but on ensuring that users can travel quickly, comfortably and reliably.

Apart from passenger transport, intermodality as an optimised combination of rail, road, water and air transport options also plays a significant role in logistics. Unlike multimodal transport, in which individual freight items are moved when the mode of transport is changed, for example, when goods are removed from containers and loaded onto trucks, in intermodal transportation the goods remain in the same loading unit, which then changes the mode of transport as a whole. This is the case, for example, with piggyback transport, where a truck is loaded onto a freight train and becomes a »rolling road«, or with transportation by roll-on roll-off (RoRo) ships. The close link between intermodality in transport logistics and the standardisation of containers in the 1960s illustrates the importance of standardisation for Seamless Mobility. Only with the introduction of ISO containers and other standardised transport units has it become possible to quickly transfer entire units from ship to freight train or from train to truck, thus enabling the seamless linking of supply chains in a variety of ways.

These chains clearly show how the appropriate means of transport can be chosen and combined depending on the requirements. Ships offer cost-effective transport of large volumes, trains are particularly environmentally friendly, and trucks offer a high degree of flexibility for pre-carriage and onward carriage. However, intermodal transport also highlights the challenges associated with Seamless Mobility. These include the coordination required when goods need to be reloaded multiple times, the limited capacity of individual modes of transport, and the sometimes complex pricing when different transport providers are involved. The shift towards Seamless Mobility is a logical consequence of a mobility landscape that draws on an increasing variety of different means of transport and makes them available to users in a well-coordinated and convenient manner.

WHAT'S BEHIND THE TREND?

Mobility solutions must be consistently developed from the different user perspectives, which requires a deep understanding of the needs, expectations and limitations of different user groups. In particular, newly implemented technologies need to be developed in such a way that social aspects, justice, and accessibility are considered in addition to a technical or engineering-driven perspective.

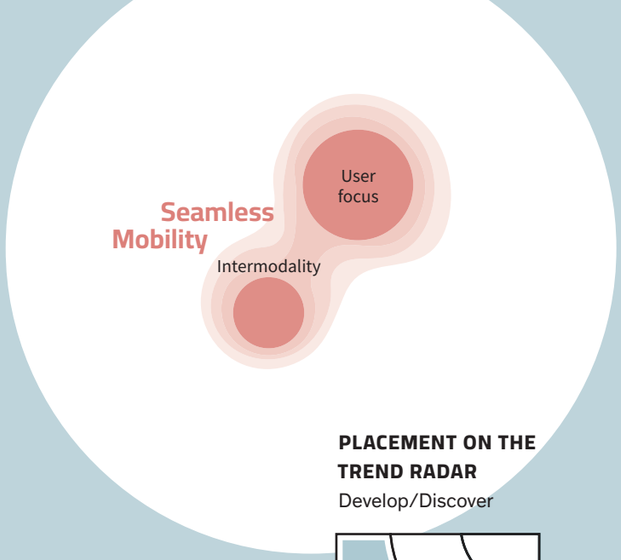
The possibility of efficiently combining different means of transport for a single journey depends strongly on whether digital platforms enable seamless planning, booking and payment. Intermodality is steadily expanding, going beyond the traditional connections between cars, buses and trains to include forms of mobility such as sharing offers, autonomous shuttles and micro-mobility.

Taken together, this will pave the way for creating a flexible, convenient and efficient mobility system that is focused on people‹s needs. Only when mobility services are standardised, personalised, accessible and digitally networked will a truly seamless experience emerge in line with the Seamless Mobility trend.

ZOOM-IN

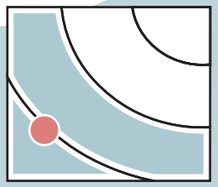
The Seamless Mobility trend combines the following identified trend concepts:

- ➔ User focus
- ➔ Intermodality



PLACEMENT ON THE TREND RADAR

Develop/Discover



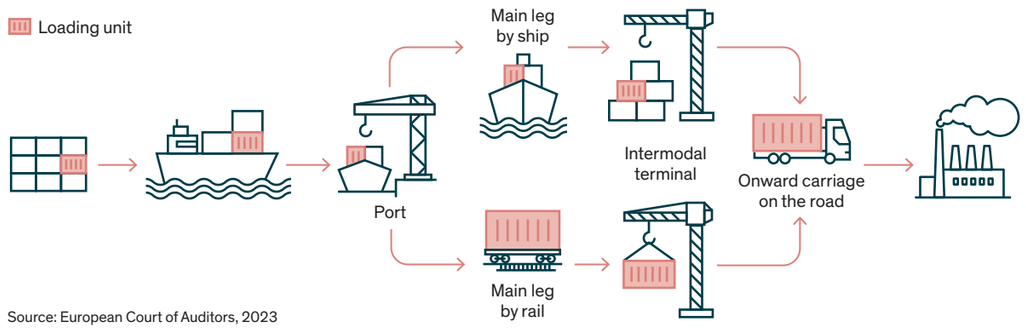
CONTEXT

HOW IS THIS TREND MANIFESTED?

Compared to the rest of Europe, Vienna offers a very affordable annual ticket for public transport (365 euros), which has proven very popular with over one million annual ticket holders. According to a study, the success of Vienna‹s public transport system is not so much due to its affordable price, but rather to the attractive services it offers. The key factors are the dense network of lines, the high frequency of services and continuous investment in expanding and intensifying public transport. These factors enable short travel times and make it more attractive to switch from private cars to public transport.

The NaMikro project was an investigation into how e-bikes and e-scooters can be used to supplement local public transport in outlying areas and small towns. In the Berlin districts of Steglitz-Zehlendorf, Tempelhof-Schöneberg and in Erkner, real-world laboratories were set up to analyse user behaviour in areas with limited local public transport coverage. The results show that sharing services are primarily used for the last mile, especially as a feeder to suburban train stations. In addition to commuting, leisure activities also play an important role. Especially during local public transport's off-peak hours, e-bikes and e-scooters are appreciated as a flexible alternative. It was also shown that station-based systems with fixed parking spaces simplify use and minimise parking violations, while virtual stations without markings tend to be more disruptive. As part of the NaMikro project, micro-mobility proved to be a valuable addition to existing local public transport services - provided that infrastructure and parking solutions are well planned and coordinated.

Example of a logistics chain in intermodal freight transport



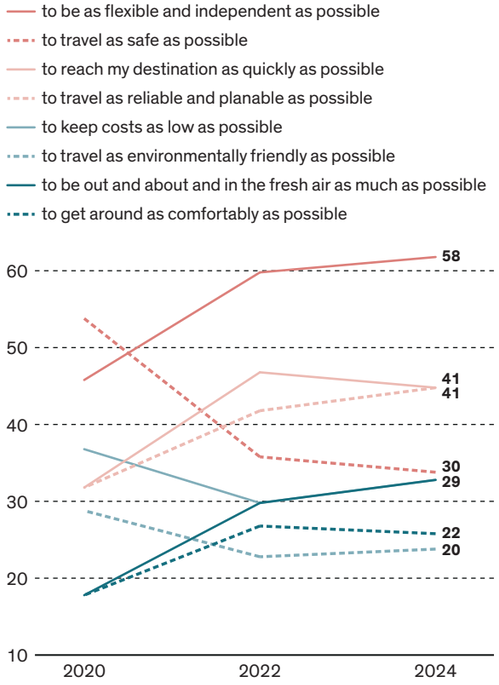
Source: European Court of Auditors, 2023

With combined freight transport, the European Commission is defining and driving a specific form of intermodal transport. The EU‹s understanding of combined freight transport, which aims to shift traffic from road to lower-emission modes, is that the main leg of the journey must be by rail or ship. Pre-carriage and onward carriage by road is possible, but should be kept to a minimum (150 kilometres linear distance between the loading or unloading point and the nearest suitable railway station, inland port or seaport).

Adherence to the requirements is rewarded with privileges such as increased permissible total weights or exemptions from driving bans on Sundays, public holidays and during holidays. However, a special report by the European Court of Auditors has revealed major pitfalls in intermodal transport: a lack of strategy between the EU and member states, regulatory hurdles and infrastructure deficits are holding it back and making it less competitive than road freight transport. The report therefore recommends the removal of regulatory barriers and targeted investments in infrastructure to make intermodal transport more efficient and attractive. Only through coordinated measures can a sustainable modal shift be achieved.

As regards my own mobility, I find it important

In percent

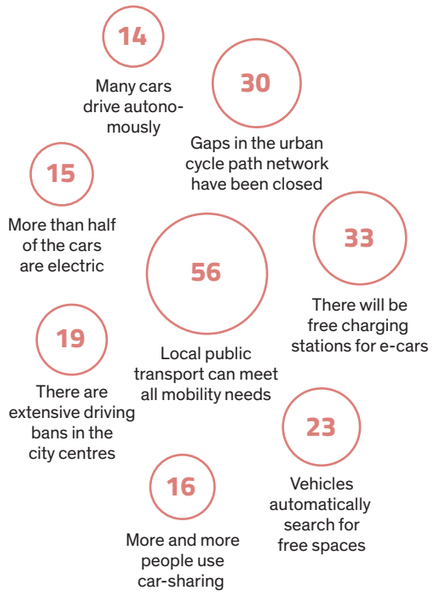


Source: TÜV, 2024

Note: Germany, 2024, 2,500 survey participants

Which of the following options do you consider desirable or worthwhile when it comes to the future of mobility?

In percent



Source: TÜV, 2024

Note: Germany, 2024 2,500 survey participants

In the future, mobility will increasingly be seen in terms of coherent experiences, or journeys, rather than individual means of transport. Integrated ticketing and platform solutions have an important role to play here, as in many cases the problem is not a lack of supply, but overcoming fragmentation. AI and data-driven mobility systems will greatly simplify optimisation, support or even take over real-time control of traffic flows, forecasting mobility needs and individual travel planning. Smooth interlinking of transport modes makes it easier for people to switch from private cars to alternatives, thus making mobility not only more efficient and user-friendly, but also more environmentally friendly.

Besides technological developments, political decisions are also needed to realise an interconnected, networked mobility landscape. In addition to technical feasibility, the social and organisational integration of Seamless Mobility is becoming increasingly important. A consistent user focus requires a shift away from traditional, infrastructure-heavy planning towards flexible, service-oriented mobility systems.

OUTLOOK

CONCL USION

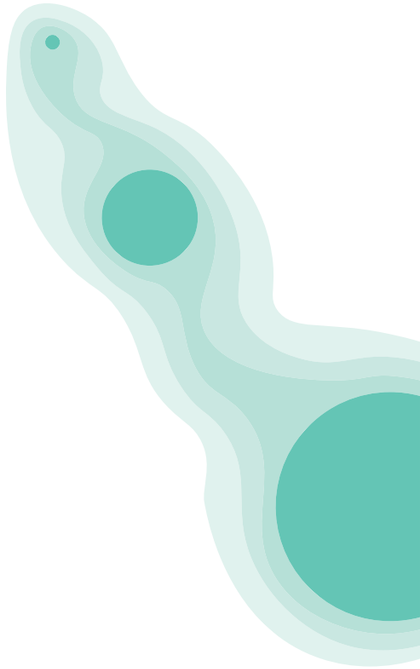
A lot is in motion in the mobility sector – not only physically, but also structurally, socially and technologically. The 14 identified sub-trends of the megatrend of mobility show that we are in the midst of numerous transitions that are strongly influenced by the megatrends of connectivity, eco-intelligence and urbanisation, and increasingly also by health and safety aspects. The interplay of these megatrends is the engine that is driving the change in mobility and taking it in new directions.

Interconnectivity is becoming crucial to making mobility efficient, flexible and resource-friendly. It is not only about digital applications, but also requires a rethink of the entire mobility system. The boundaries between public and private transport are becoming increasingly blurred, more integrated mobility networks are emerging, the service character is growing and driving new business models. With increasing urbanisation, the pressure on the mobility infrastructure in ever more densely populated cities is growing. Space is becoming a scarce commodity, and the question of how to distribute it fairly is a major challenge. Motorised private transport is gradually being pushed back, while multimodal solutions, shared mobility and active forms of transport such as cycling and walking are being actively promoted for ecological, health and mobility reasons. Mobility is a matter of individual, social and planetary health. Environmentally friendly propulsion systems, intelligent traffic control and resource-efficient infrastructures will become essential pillars for a future worth living. Apart from reducing emissions, a vehicle‹s entire life cycle - from production to use and recycling - has to come under greater focus. It also becomes clear that not everything that is technologically possible is also economically profitable and socially useful. Technological innovations must be geared to real human needs, as progress alone does not guarantee a functional and convenient mobility. Mobility is developing in a field of tension between technological feasibility, economic viability, regulatory control and social desirability.

Moreover, geopolitical and security policy developments will have a significant impact on mobility in the coming years. Changing threats, for example from military conflicts and extreme weather events, are moving the focus on the performance and resilience of mobility infrastructures. Europe needs to rethink its strategic mobility – not only for reasons of economic efficiency, but also for security policy considerations. Transport routes must be stable, resilient and flexible to enable rapid responses in the event of a crisis. Modernising and upgrading vehicles, roads, rail networks and bridges, as well as developing and expanding the use of new mobility technologies, are just as important because of increased awareness of defence capabilities as they are because of climate-related disasters, which place new demands on rescue and civil protection systems.

Public and private investments in the mobility sector are driven by many factors, including the desire and need for more environmentally friendly mobility, technological advances, economic potential and regulatory decisions, etc. As with any future-oriented topic, a systemic PELC view is needed to gain a holistic picture of future mobility, since social change arises from the subsystems of politics, economy, legitimation and community. Politics provides the framework through incentives, laws and regulations; it creates the legal, infrastructural and regulatory foundations that determine how mobility is shaped. Administrative bodies play a crucial role in implementing these political decisions, whether it be through investments in public transport, subsidies for zero-emission drives or urban development measures to promote sustainable mobility concepts. Within this framework, economy develops and delivers mobility products, services, technologies and infrastructure, and is under intense pressure to innovate. It has to develop economically viable models that meet political and social requirements. Through legitimation, social acceptance and ethical principles for mobility are defined. Science and research play a central role in the development of new mobility concepts. But also social values determine which type of mobility is considered sustainable, which infrastructures are worth promoting or how much individual freedom mobility can claim in the context of global climate targets, while mobility is also relevant as a fundamental right. The community subsystem reflects the social values and norms that shape mobility and in turn affect political and economic decisions; NGOs, social movements and public discourse have a considerable impact on which forms of mobility are socially accepted and politically promoted.

Political decisions affect the economy and vice versa. Economic success or failure can influence the legitimacy of politics. Science and education, parts of the legitimisation and the community influence both politics and the economy through research and innovation. Fundamental rights form the moral and legal basis for political and economic decisions. NGOs and the public, parts of the community, can act as a corrective to the other systems. This interplay shows that mobility cannot be considered separately, but should be understood as an interconnected system shaped by many different forces.



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POTENTIAL

IN THESE TRENDS

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Our work is based on the four dimensions of future management:

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Future management encompasses all measures and actions to maintain the future viability of organisations.

VISION

We contribute to the development of a systemic economy.

50+
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3.000+
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employees

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List of references

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list of the references we used in the research
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