

# Federal Government Report on the High-Tech Strategy 2025

The High-Tech Strategy – a successful model for Germany as a strong country of innovation



#SALMANQADIR

# Foreword

Good research, smart innovation and technological skills are the keys to opening doors. In the COVID-19 pandemic, this has meant that vaccines have been developed and brought to market at record speed thanks to good groundwork, especially from Germany. Dose by dose, and person by person, they banish the threat of contracting the disease and pave the way out of the lockdown restrictions. They open doors in the truest sense of the word and let us overcome the global coronavirus crisis step by step.

Whether it's health or climate protection, whether it's the future of energy production or mobility, whether it's questions about how we work or how we live safely and securely – through research and innovation, we are venturing into new worlds. That is the purpose of the High-Tech Strategy.

The motto of the High-Tech Strategy 2025 is "Research and innovation that benefit the people". That is why we engaged with citizens in our country to discuss their ideas and views on the future of research and innovation. All of the Federal Government ministries came together to jointly define twelve concrete missions – combating cancer, promoting digital networking for better healthcare and reducing plastic in the environment, to name a few. The results speak for themselves. The progress we have made is making tangible changes in the lives of many.

With the National Decade Against Cancer, we have succeeded for the first time in joining forces in such a way as to gain substantial grounds, ensuring that patients can benefit from the results of cancer research more quickly and closer to home in the future. Our "Data for Health", innovation initiative is shaping the digital transformation in health research, healthcare and the healthcare industry. We also analysed how plastic gets into the environment and how this can be prevented. In this way, we can significantly reduce pollution and have created the essential prerequisites for solving the global plastic problem.

Our science system has proven itself. We are the country of innovation – "Innovationsland" Germany. We are among the leading nations in Europe and worldwide when it comes to providing new answers to the questions of our time.

It is no coincidence that we hold this strong position. It is the result of a policy that consistently focuses on research and innovation. Government and the private sector have continuously increased their investments in research and development. The share of R&D in our gross domestic product rose to 3.19 per cent in 2019. That is something we can be proud of because it also shows that we are well on track towards the 3.5 per cent target.

We launched a range of research and innovation policy measures with the High-Tech Strategy 2025. Our implementation of tax incentives for research fulfilled a key requirement of the Expert Commission on Research and Innovation (EFI) and created additional innovation incentives for industry. Thanks to the Leading-Edge Cluster Competition, innovative regions have become internationally attractive hubs for cutting-edge fields. This also shows how good and how important networking between science, business and other local partners can be. Our next-generation clusters are now opening up brand-new fields of innovation and enabling their rapid application. After all, the international competition never sleeps. Global competition is increasing. We in Europe must realign ourselves following Brexit, positioning ourselves clearly with compelling offers.

Education, research and innovation are the foundation of Germany's economic strength, a foundation on which high-performance companies and their well-trained workforce can build. In order to maintain this capability, we have to continue our efforts. The annual report from the EFI certified that we are on the right track. We must now muster the strength to stay the course. Only then will we remain a country of innovation that can keep crafting the keys to the doors of new worlds.

Your Federal Ministry of Education and Research

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## 1 KEY FEATURES IN BRIEF

Germany is a country of innovation. It is one of the leading innovation nations and among the most attractive research locations worldwide. This is the result of a policy that consistently focuses on research and innovation and that aims to reinforce the long-term sustainability of Germany on a European and international level under the auspices of the High-Tech Strategy 2025. We have driven research and innovations so that they reach the people and become a resounding success. In doing so, we take a look at the entire innovation chain, from basic research as the starting point for new opportunities to the development of marketable and socially beneficial innovations.

The High-Tech Strategy 2025 is based on a holistic understanding of innovation that encompasses a broad spectrum, including technological innovations, new business models and social innovations. Fostering innovation goes hand in hand with investing in education and training to prepare people for upcoming changes. With this understanding, we are creating the necessary conditions to address the key challenges of our time in a forward-looking way and holistically design transformation processes, for instance towards a sustainable society. The High-Tech Strategy 2025 focuses on tackling the grand challenges that can be assigned to the focus areas of "Health and Care", "Sustainability, Climate Protection and Energy", "Mobility", "Urban and Rural Areas", "Safety and Security" and "Economy and work 4.0". In order to define specific transformation targets, the High-Tech Strategy 2025 follows a mission-based approach focusing on, for example, achieving substantial greenhouse gas neutrality in industry and creating sustainable circular economies. The recommendations of the Expert Commission on Research and Innovation (EFI) provide important impetus for the ongoing development of these missions.

Throughout the past year, the importance of research and innovation was impressively shown to us in a very striking way. The German research and innovation system has produced new findings on the coronavirus and the effects of the current health crisis at an impressive pace. The first test to detect the virus and the first SARS-CoV-2 vaccine approved according to international standards were developed in Germany. This would not have been possible without the good conditions we have created in recent years and shows

that science and research policy must act reliably and over the long term. During the pandemic, the Federal Government therefore placed a clear focus on education and research with the Economic Stimulus and Future Technologies Package. 60 billion euros from the Economic Stimulus and Future Technologies Package will be used for future tasks in an innovation-oriented way. In this context, the Federal Government is primarily focusing on key technologies of the future such as green hydrogen, artificial intelligence (AI) and quantum technology. This will drive the expansion of technological sovereignty in Germany and Europe.

The EFI sees these measures as positive. However, it cautions that research and innovation policy must remain a high priority in the future. The Federal Government will continue to consistently expand Germany's research strength.





As a central advisory body, the High-Tech Forum has provided a multitude of impulses for this.

Together, the government and the private sector invested 3.19 per cent of gross domestic product (GDP) in research and development in 2019 – meaning that Germany has exceeded the 3 per cent quota for the third time in a row and remains on course to reach its goal of spending 3.5 per cent of GDP on research and development by 2025. The research allowance launched by the Federal Government, which was also a recommendation by the EFI, has been creating further incentives for companies to invest in research and development since 2020.

In its Research and Innovation Strategy, the Federal Government consistently relies on further instruments such as Strategic Foresight, participatory processes and science communication. In September 2019 the new foresight process entitled “VORAUS:schau!” was launched. The foresight process is complemented by Insight – the innovation impact assessment of technologies and societal developments whose broad application is already foreseeable today. Science communication as well as opportunities for direct and indirect participation have been raised to a new level within the framework of the High-Tech Strategy 2025. The participatory process for the High-Tech Strategy 2025 and the #Innovationsland Deutschland campaign have involved new actors, and the topic of innovation was discussed in a very broad context. The innovative potential from society was also exploited with specific funding measures such as the “Society of Ideas – Competition for Social Innovation”.



The High-Tech Strategy 2025 has set the course for a culture of innovation characterised by openness, agility, foresight and trust. With the Leading-Edge Cluster Competition, innovative regions have become internationally attractive hubs for important future industries. This also shows how good and how important networking between science, business and other local partners can be. With the next-generation clusters, we are now opening up brand-new fields of innovation and enabling their rapid application. Greater attention was also given to young innovative companies. The establishment of a "Zukunfts fond" will make 10 billion euros available over the next few years and will significantly improve the financial framework conditions for young, innovative companies, an initiative which the EFI also very much welcomes. All measures at federal level mentioned in the report or in the missions or resulting from the strategy are the responsibility of the respective ministries and are financed by them within the applicable budget and financial planning (incl. posts/positions). Additional requirements for material resources and personnel are counter-financed in each respective individual budget.

## Outlook

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The past year has shown how important our continuously increasing investments in the German science and innovation system have been. The grand challenges can only be tackled with European and international cooperation. However, it is important not only to assume international responsibility, but also to avoid imbalanced dependencies. Forward-looking promotion of innovative technologies and social innovations forms the basis for creating a sustainable, greenhouse gas-neutral, resilient society in the sense of the global Sustainable Development Goals. It also ensures we maintain our technological sovereignty and remain economically successful.

Germany as a country of innovation should continue to be a leading global hub for science, research and innovation. Only in this way can we succeed in securing our prosperity and social well-being in the future and in making the lives of every individual better.



## 2 THE HIGH-TECH STRATEGY – A SUCCESSFUL MODEL FOR GERMANY AS A STRONG COUNTRY OF INNOVATION

Germany is a country of innovation. It is one of the leading innovation nations and among the most attractive research locations worldwide. This is the result of a policy that, under the umbrella of the High-Tech Strategy 2025, consistently focuses on research and innovation and strengthens Germany's long-term sustainability, as well as having an impact at a European and international level. At present, protecting health in Germany and in societies worldwide represents a particular challenge. In 2020, the emergence of the coronavirus pandemic raised immense challenges for society, and thus also for science and research, and will significantly shape future developments in our country over the next few years. And further efforts are also needed in other areas such as global climate protection, the strengthening of technological sovereignty and competitiveness in Germany and Europe, and the creation of equivalent living conditions in all

parts of Germany. Under the umbrella of the High-Tech Strategy, we have advanced important activities on research and innovation so that they reach the people and develop into a resounding success. In this process, we focus on the entire innovation chain, from basic research as the starting point for new opportunities to the development of marketable and socially beneficial innovations.



## 2.1 An adaptive research and innovation strategy: Overcoming the crisis with research and innovation

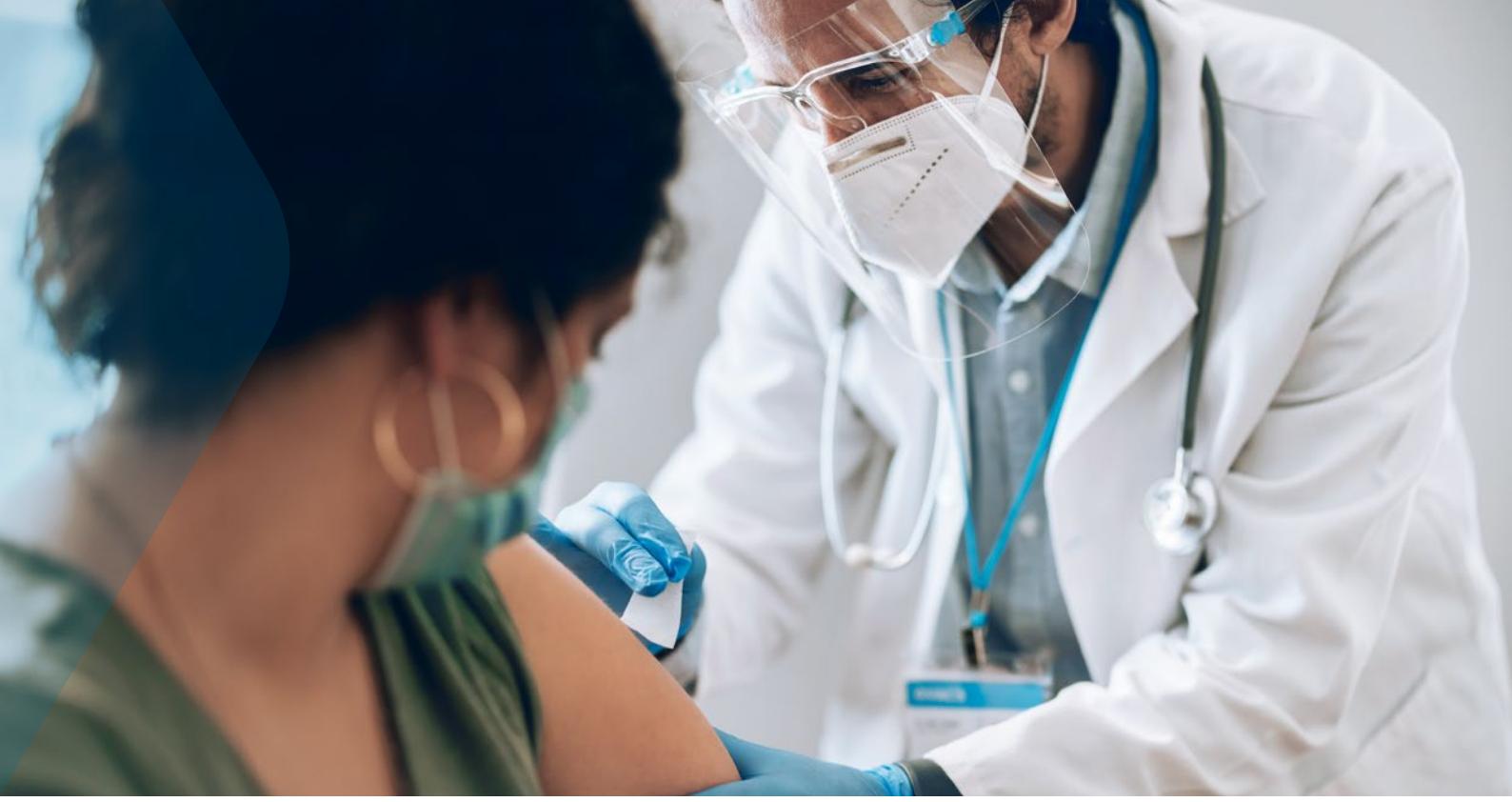
Throughout the past year, the importance of research and innovation and of global networking in this area has been brought home to us in a very striking way. And it has been shown that Germany's strength as a country of innovation is an essential foundation for overcoming the current crisis. This would not have been possible without the good framework conditions we have created in recent years under the umbrella of the High-Tech Strategy 2025. The High-Tech Strategy was designed as a learning strategy to allow for rapid and flexible responses to unforeseen events.

The German research and innovation system has proven itself during the pandemic, producing new findings on the coronavirus and the effects of the current health crisis at an impressive pace. As the Federal Government, we were able to base our measures for dealing with the pandemic and its consequences on a rapidly growing body of knowledge. The first test to detect the virus and the first SARS-CoV-2 vaccine approved according to international standards were developed in Germany. This is the success of many years of excellent research which has been particularly stimulated by our research funding.

The vaccine example in particular shows that good research and successful innovation need staying power. It was only thanks to excellently developed basic research that the virus could be decoded at all. And the biotechnology company BioNTech was able to build on this, winning the "Gründungsoffensive Biotechnologie" (GO-Bio) award and becoming a partner in a leading-edge cluster, meanwhile positioning itself as a global leader in cutting-edge mRNA technology.

This shows how crucial it is for our future viability to adopt a long-term and reliable approach to science and research policy. For this reason, the Federal Government has continuously strengthened the general financial conditions for research and innovation under the umbrella of the High-Tech Strategy. In 2019, the Federal Government, the Federal States and the private sector invested 3.19 per cent of GDP in research and development – with Germany thus exceeding the European Lisbon goal of 3 per cent for the third time in a row and consolidating its position as one of the most research-intensive economies in the world.





With its Economic Stimulus and Future Technologies Package, the Federal Government continues to place a clear focus on education, research and innovation, especially at a time of considerable slump caused by the pandemic. 60 billion euros from the Economic Stimulus and Future Technologies Package will be used for innovation to tackle future challenges in a sustainable way. In this context, the Federal Government is concentrating in particular on key enabling technologies such as green hydrogen, AI and quantum technology.

In order to ensure the effectiveness of research funding, we also decided to adjust the funding procedures, which now, for example, provide for more flexible handling of extensions to the duration of funded projects and also simplify the reporting obligations. The aim was and is to maintain research operations in times of crisis, to prevent pandemic-related discontinuation of funded research projects, and to cushion the consequences for those employed in the projects. Research and innovation policy has thus shown that it is agile and adaptable in an emergency.

The EFI has commented positively on the economic stimulus measures, especially with regard to the liquidity effect for companies and the strengthening of internal investments in research and development. Looking to the future, the Commission urges that research and innovation policy must remain a high priority even after the (acute phase of the) pandemic. The Federal Government will continue to consistently support Germany's research strength within the scope of available budgetary resources.



## 2.2 A participatory research and innovation strategy: Intensified dialogue and science communication

**Research and innovation thrive on the exchange and cooperation of the stakeholders. Participation and dialogue are essential as drivers of success, but not just for scientists. Increasingly, citizens and civil society groups are also pushing to be included as partners of science. After all, our innovation system includes not only science and industry, but also broader society. Research must enter into a stronger dialogue with civil society and take up its concerns.**

Science communication and opportunities for direct and indirect participation have been raised to a new level as part of the High-Tech Strategy 2025. This has given many new groups of actors the chance to get involved and to articulate their needs and perspectives. Raising this potential through a variety of initiatives is a key concern of the High-Tech Strategy 2025. And we want to continue strengthening this path in the future. After all, participation means not only making use of the knowledge of the many, but also creating trust, open-mindedness and acceptance for research and innovation. It makes research policy decisions more transparent and thus also more comprehensible.

The High-Tech Forum as the Federal Government's central advisory body for the implementation of the High-Tech Strategy 2025 accompanies development of the Federal Government's research policy by providing concrete recommendations for implementation and action. Experts from science, industry and civil society have brought valuable perspectives on resilience and technological sovereignty, transfer of research into application, and agile research and innovation funding.

In summer 2020, a participatory process on the High-Tech Strategy 2025 attracted new stakeholders to join the discussion on the innovation system. From the North Sea to Lusatia and the Rhineland, people from all parts of society developed a raft of good ideas for their regions at seven conferences on the following themes: a sustainable circular economy, sustainability and mobility, bio-IT and health, the use of AI in agriculture and forestry, flexible science careers, and structural change. The process was flanked by the experts of the High-Tech Forum.

Back in 2013, the Federal Government already established the central platform for citizen science in Germany "Bürger schaffen Wissen" (Citizens Create Knowledge) to present projects and offer networking and advisory services to promote and expand the joint research between citizens and science. With the advent of digitalisation, this form of direct participation in research has once again received a special boost.





Through #WirVsVirus (#UsVsVirus) and other hackathons, new forms of cooperation and open innovation spaces have been trialled and demonstrated the potential of broad participation of society. In just 48 hours, over 28,000 people worked together on over 1,500 solutions in March 2020. This resulted in 150 projects that are now being implemented. Such agile innovation spaces in and with society not only quickly generate creative ideas for meeting societal challenges, but also enable their rapid implementation into usable solutions.

The pandemic has also highlighted the importance of science communication. In the current COVID-19 pandemic, the importance of scientific work and new knowledge has become more visible and far more evident in people's everyday lives than ever before. People are interested in backgrounds, research methods and the current state of research. Science communication is of great importance in this context. Research results must be communicated in an understandable way. At the same time, the tasks and limits of scientific policy advice must be adequately communicated in order not to undermine trust in science and the acceptance of political decisions. Many scientists are extremely well equipped to present their research in a generally understandable way. This is fortunate for all sides, but it cannot be taken for granted. What is needed here is good support for the scientists who communicate their research.

For many years, the “Science Years” initiative has provided a good introductory step to engaging with science. It has succeeded in making research and innovation more transparent and tangible and has initiated debates in society. The Science Years have brought different stakeholders together and established a culture of dialogue between partners from science, politics, industry and society. This has created a fertile environment for new formats and methods of science communication. The Science Years “Seas and Oceans” and “Bioeconomy” in particular took up topics that are of interest to all generations, making them into a channel of science-driven exchange, especially for younger people. The Science Year 2022 takes this participatory focus even further. Under the working title “Nachgefragt” (Participate!) the focus will be on citizens and their questions, their ideas and their creative potential.

Through the #Innovationsland Deutschland campaign, the Federal Government placed the topic of innovation in a very broad context at the centre of its own series of events from September 2020, with regular online events such as Q&A sessions, BarCamps and workshops. This offered a wide variety of people involved in day-to-day innovation – researchers, start-up managers, school students – the opportunity to talk about their personal views on their “Innovationsland” and their own personal stories, thus contributing to opening up the scope for innovation even further.



### 3 WELL POSITIONED FOR THE FUTURE WITH RESEARCH AND INNOVATION

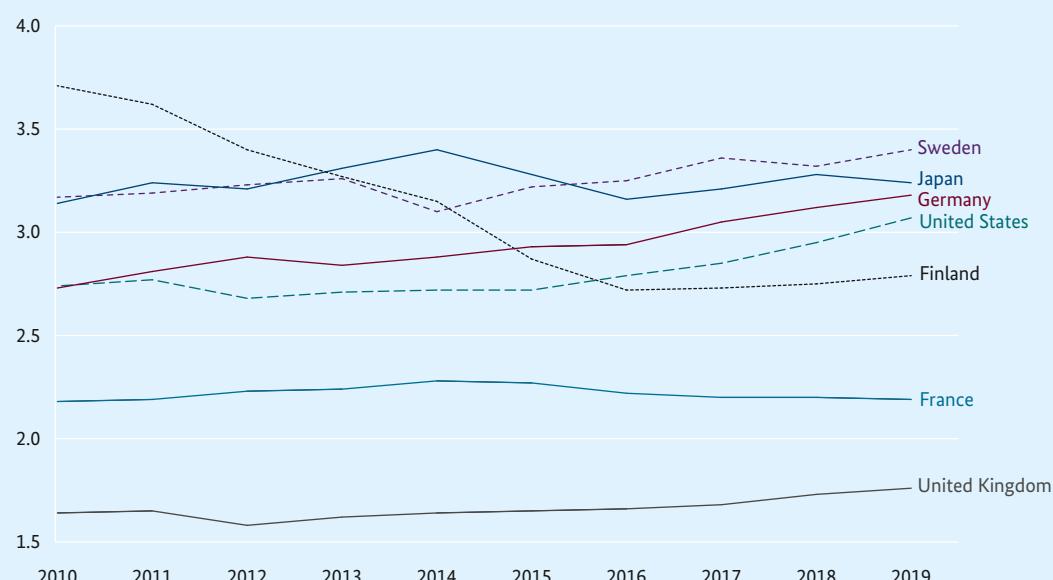
Never before has more been invested in research and development (R&D) in Germany than in recent years. In the period from 2005 to 2019, Federal expenditure on R&D increased from 9.0 billion euros to approx. 18.8 billion euros (actual). This increase in government R&D expenditure was accompanied by an increase in the R&D expenditure of the German private sector. The government and the private sector spent approximately 109.5 billion euros on R&D in 2019 (preliminary figures). This corresponds to an R&D rate of 3.19 per cent of GDP. This means that Germany continues to be among the world leaders in research spending. In addition, the number of people employed in R&D climbed by 50 per cent from 2006 to 734,000 in 2019.

Even in times of the coronavirus pandemic, together with the Federal States and industry, the Federal Government aims to increase joint spending on R&D to a total of 3.5 per cent of GDP by 2025. According to the recent Innovation Survey conducted by the ZEW – Leibniz Centre for European Economic Research, the business community expects only a moderate decline in innovation spending in 2020 compared to the previous year. At 2.2 per cent, this decline in 2020 is significantly lower than the 4.9 per cent decline in

economic output in Germany projected by the Federal Government's economic forecast in spring. Considering the tense economic situation during the pandemic, this is comparatively good news. And it shows that many companies are looking to the future despite all the current strains caused by the pandemic. However, the survey also shows that we need to expand our activities so that we do not lose small and medium-sized enterprises as innovators.

The research allowance launched by the Federal Government is a powerful instrument for creating more incentives for R&D in companies. The allowance is designed in such a way that even those SMEs are strengthened in their R&D activities that have only sporadically engaged in R&D up to now. The Federal Government's comprehensive economic stimulus programme has created an important framework for economic recovery to continue in the coming months. For the year in progress, the Federal Government expects an increase in GDP of 3.5 per cent.

**Well positioned for the future with research and innovation**  
Gross domestic expenditure on R&D in selected countries as a percentage of GDP





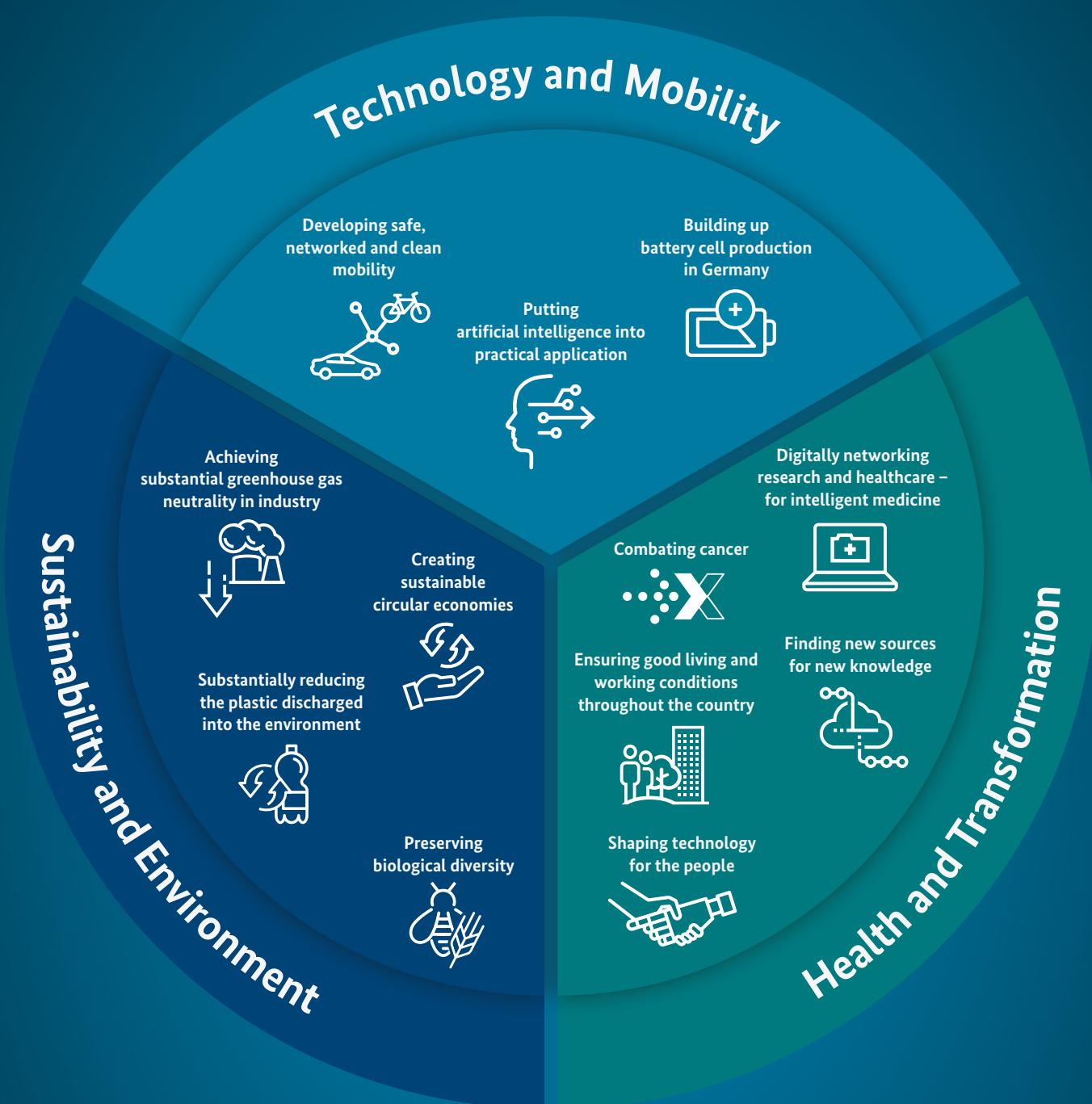
If we want to shape the future, we have to set the right course today. How useful the support of individual technologies will be for our future depends crucially on the opportunities and challenges brought about by social and technological change. In its Research and Innovation Strategy, the Federal Government therefore consistently relies on additional instruments such as strategic foresight. In September 2019, the new foresight process entitled "VORAUS:schau!" was launched to analyse which technological and societal developments might await us in the 2030s. Various in-depth foresight studies are currently being carried out, for example on future technologies around the convergence of technological and biological systems, the importance of trust in an increasingly digital world, and the emergence of a new economy of meaning. The foresight process is complemented by Insight – the innovation impact assessment of technologies and societal developments whose broad application is already foreseeable today. This new measure follows on from the earlier process of innovation and technology analysis.

As part of impact measurement, we regularly check whether decisions have proven successful and whether funding has been well invested. Evaluations are a fundamental prerequisite for evidence-based innovation policy. They provide a scientifically sound evidence base on the impact of the sectoral programmes and measures that have been implemented. On this basis, existing instruments can be optimised and further developed. The knowledge gained in this way helps to ensure that innovation policy targets are achieved in the best possible and most efficient way.

Excellent basic research at top research infrastructures continues to be the foundation of an efficient innovation landscape – the continued expansion of our knowledge is what makes application and use possible in the first place, and thus also the ability to address the grand challenges facing society. At the same time, basic research creates the knowledge base that makes an indispensable contribution to science and industry.

The High-Tech Strategy 2025 has put knowledge into effect. On the basis of this strategy, good investments have been made in a strong and internationally competitive economy, in the preservation of our natural resource base and in social cohesion.

## The missions of HTS 2025 at a glance



## 3.1 Tackling the grand challenges

Throughout the past year, the importance of research and innovation and global networking in this area has been brought home to us in a very striking way. And it has been shown that Germany's strength as a country of innovation is an essential foundation for overcoming the current crisis. This would not have been possible without the good general conditions we have created in recent years under the umbrella of the High-Tech Strategy 2025. The High-Tech Strategy was designed as a learning strategy to allow for rapid and flexible responses to unforeseen events.

The High-Tech Strategy 2025 is based on a holistic understanding of innovation that encompasses a wide range of innovations, such as technological innovations, new business models and social innovations. The promotion of innovation goes hand in hand with investments in education and training to prepare people for upcoming changes.

With this understanding, we are creating the necessary conditions for addressing the central challenges of our time in a forward-looking way and systematically shaping transformation processes, for instance towards a sustainable society.

The Federal Government's High-Tech Strategy 2025 focuses on tackling the grand challenges such as "Health and Care", "Sustainability, Climate Protection and Energy", "Mobility", "Urban and Rural Areas", "Safety and Security" and "Economy and work 4.0". In order to specify concrete transformation targets, the High-Tech Strategy 2025 follows a mission-oriented approach. This provides ambitious targets as a compass for research and innovation policy, mobilising stakeholders and uniting them behind a common goal. In particular, the clear definition of the missions and their operationalisation with a distinct focus on urgent or long-term challenges are essential for the success of the approach. The recommendations of the EFI provide important impulses for further developing the orientation of the missions within this strategy.

Data is a crucial raw material for science and industry. The Federal Government's Data Strategy aims to make Germany a pioneer for the innovative use of data and data sharing in Europe. With the aid of more than 240 measures in the Data Strategy, the Federal Government aims to better exploit the opportunities and potentials of innovative data use, create new knowledge, and strengthen data competence. The Data Strategy is an expression of European sovereignty and shared values in the age of global data traffic and international networking.

### We rely on powerful health research as the basis for medicine of the future

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Health research and the innovation system have proven to be highly innovative in the fight against the coronavirus pandemic. Firstly, health research contributes significantly to gaining knowledge as quickly as possible: health research leads to more knowledge about SARS-CoV-2; it forms the knowledge base for concepts for the prevention, diagnosis and treatment of COVID-19; and it enables the evaluation and comprehensive advancement of measures to cope with the pandemic.



Secondly, the coronavirus pandemic in Germany has already significantly changed health research itself. The unpredictability and immediacy of how the epidemic unfolded has acted as a catalyst. Within a very short period of time, a large number of structural changes have been implemented in health research, some of which had been envisaged and demanded for years, but which had been difficult to implement until now. By way of example, all German university hospitals have joined together in forming a network to coordinate and bundle their empirical expertise and research activities associated with COVID-19. All over the world, data and research results are being made available digitally and for all to see in next to real time in order to accelerate the gain in scientific knowledge.

### Preventing and curing diseases

Through the National Decade against Cancer, which was launched at the end of January 2019, the Federal Government is pushing ahead leading-edge developments to radically advance cancer research, not only to provide patients with better chances for a cure and good quality of life, but also to prevent the disease. Patients are being closely integrated in research at all levels and in all steps of the process. In this way, Germany will become a leading international hub for patient-oriented cancer research. As part of the Decade, the National Center for Tumour Diseases (NCT), for example, is being expanded from two to six locations. In addition, in 2020 a number of funding measures were released, including a funding measure on “Research on tumour heterogeneity and resistance to therapy” and one on “Prevention of colorectal cancer in younger and future generations”.



See also the mission on “**Combating cancer**” on the High-Tech Strategy 2025 website.  
(available in German)

### Bringing medical progress to patients faster

The establishment of six institutionally funded German Centres for Health Research (DZGs) about 10 years ago was a decisive step towards improving the translation of research into practice. By concentrating the forces of university and non-university research nationally and on a long-term basis, the DZGs ensure quick transfer of research results for prevention, diagnostics, therapy and care from the laboratory into practice. In March 2021, the sites for two new centres, the German Centre for Mental Health and the German Centre for Child and Adolescent Health, were selected. The centres will develop their overall concepts in the second half of 2021.

## Developing active substances, fighting infections and strengthening research on global health

The Federal Government's consistent and forward-looking funding for infection research was a major reason why we were able to respond quickly to the challenges of the SARS-CoV-2 outbreak. Thanks to a "rapid response" funding tool already established in 2016 in the wake of the Ebola epidemics, a funding measure was published as early as March 2020, followed by further targeted measures over time. More than one billion euros were allocated for research on COVID-19 and for the development of vaccines, medication and diagnostics for SARS-CoV-2 in national and international programmes until April 2021.

Since 2017, Germany is supporting the international vaccine initiative "Coalition for Epidemic Preparedness Innovations" (CEPI) as a founding member of the organisation, providing a total of 440 million euros until the end of 2021, including 350 million euros for SARS-CoV-2 vaccine development. Germany has thus so far contributed a total of 2.1 billion euros to the Access to COVID-19 Tools (ACT) Accelerator (as at April 2021), which is coordinated by the World Health Organisation (WHO) and aims to ensure equitable access to COVID-19 vaccines, therapies and diagnostics worldwide.

A nationally well-positioned, interdisciplinary research landscape and intensive European and international networking are prerequisites for efficient management of global health crises. In 2020, the Federal Government once again set priorities in the national framework through its measure for funding of junior research groups in infection research (2019) and the establishment of the interdisciplinary networking platform German Alliance for Global Health Research (GLOHRA). International networking takes place through the support of relevant research programmes (e.g. the European and Developing Clinical Trials Partnership, EDCTP), through Product Development Partnerships (PDP) in the field of neglected and poverty-related diseases, and through intensive cooperation with other funders, for example in the Global Research Collaboration for Infectious Disease Preparedness (GloPID-R).

## Digitalisation for preventive and personalised medicine

The Health Research Framework Programme, which was relaunched in 2018, has digitalisation anchored as a guiding principle permeating all fields of action in medical research. Through its innovation initiative "Data for Health", the Federal Government is demonstrating how data-based health research can improve patient care, drive medical progress, and increase Germany's innovative strength as a competitive business location.

A cornerstone of the digital transformation in medicine is the Federal Government's Medical Informatics Initiative. With this funding measure, the Federal Government has been laying the foundation for multi-site networking and reutilisation of medical data since 2016 with the aim of improving patient care. The National Steering Committee has reached joint agreements on interoperability, standards, patient consent and use of medical data between all university hospitals.

The Patient Data Protection Act of 2020 also created a research-compatible electronic health record (EHR). Insured persons can voluntarily give their consent to release their EHR data for research purposes via the Research Data Centre.



See also the mission on "**Digitally networking research and healthcare – for intelligent medicine**" on the High-Tech Strategy 2025 website (available in German).



### Nursing care technologies for the future

Nursing care of the future will be supported by assistance systems and digital solutions that are based on the needs of those requiring care, nursing caregivers and family caregivers. The Federal Government has funded “Nursing Care Innovations 2020” with a total of 45 million euros since 2015. Since 2019, “Nursing Care Innovations 2030” has focused on the use of nursing care technologies to strengthen the quality of work and life of caregivers and the quality of life of those in need of care. A total of 20 million euros will be allocated to support projects dealing with the use of robotic systems in nursing care. As part of the “Future of Care” cluster, the Nursing Innovation Centre (PIZ), the only one of its kind in Germany, has been funded with a total of 20 million euros since 2017 to investigate new technologies in everyday nursing care in clinical, inpatient and outpatient settings.

### Research for a healthy life

The funding initiative “Healthy – for a lifetime” was launched to better understand the needs of people in their different phases of life and to individualise prevention and treatment of disease even more precisely. Since 2018, specific measures for the population segments of children and young people, working people, men and women, and the elderly have been funded.

The Federal Government has further advanced research for a healthy life through its funding priority “Prevention Research”, especially with research networks in primary prevention and health promotion. Projects that investigate the medium- and long-term effects of such interventions have been funded since 2020 as part of the initiative “Quality in Health Research: Guideline for funding research strengthen the evidence base and transfer in prevention research”.



See also the mission on “**Shaping technology for the people**” on the High-Tech Strategy 2025 website (available in German).

## We are showing the way towards a sustainable way of life and economy activity

The future belongs to the generations to come. It is our responsibility to leave behind a world worth living in. The Federal Government has therefore committed itself to ambitious sustainability and climate protection goals for present and future generations. From the fight against hunger and poverty to affordable and clean energy, climate protection and the goal of liveable, sustainable cities – when the global community adopted the 2030 Agenda for Sustainable Development in 2015 under the umbrella of the United Nations, it committed itself to 17 global goals for a better future. We have nine years left to achieve them. Germany's National Sustainable Development Strategy demonstrates that the Federal Government is committed to the comprehensive implementation of the 2030 Agenda and its Global Sustainability Goals, and that it accepts this challenge as its own. With the

further development of Germany's Sustainable Development Strategy in 2021, the Federal Government acknowledges its commitment to sustainable development as the guiding principle of its actions. The importance of promoting research and innovation for the implementation of sustainable development is clarified as one of the principles for sustainable development, which is to "Use education, science and innovation as drivers of sustainable development".

By way of example, with the new FONA strategy ("Research for Sustainability"), the Federal Government is doubling research funding for climate protection and greater sustainability to four billion euros over the next five years. The motto of the strategy is "Knowledge for a future that works", and it consistently aligns R&D with goals derived from the Global Sustainability Goals. Another example is the 7th Energy Research Programme "Innovations for the Energy Transition", for which the Federal Government provides around 1.3 billion euros annually.



Among other things, the Federal Government wants to advance the energy transition through innovative technologies and strengthen technology and innovation transfer through the funding format Real-world Labs for the Energy Transition as a new pillar of energy research. This will build a sustainable, greenhouse gas emissions-free energy system in Germany and thus contribute to achieving the climate targets, which are due to be substantially raised again in response to the Federal Constitutional Court's ruling of 24 March 2021. In addition, in order to protect the civil liberties of future generations, the goal is to achieve greenhouse gas neutral emissions by 2045.

The Federal Government is also working on the transformation from a linear economy (take – make – dispose) to a resource-efficient, greenhouse gas-neutral, sustainable economy in which resources used are kept in the cycle. Basic research and applied research together with industry make important contributions to the development of sustainable and climate-friendly technologies of the future. The Federal Government is thus also supporting Germany in positioning itself on the global market as an attractive industrial location in the green-tech sector.



See also the missions on “**Creating sustainable circular economies**”, “**Achieving substantial greenhouse gas neutrality in industry**” and “**Substantially reducing the plastic discharged into the environment**” on the High-Tech Strategy 2025 website (available in German).

The establishment of the interdisciplinary Science Platform Climate Protection provides Germany with bundled scientific expertise for reviewing and updating the Climate Action Plan 2050 and its programmes of measures. In addition, the Federal Government appointed the Expert Council on Climate Issues in 2020, which, among other things, reviews the annual emissions data determined by the German Environment Agency (Umweltbundesamt – UBA) for the previous year and submits an assessment of the published data to the Federal Government and the German Bundestag.



Education for Sustainable Development (ESD) empowers people with skills for informed thinking, attitudes and behaviour, enabling them to understand the impact of their own actions on the world and to make responsible, sustainable decisions. As part of the UNESCO programmes for ESD, the Federal Government is engaged in many activities to anchor and consolidate ESD in all areas of education. The key challenge for ESD in vocational education and training (VET) is to continue to provide young people with robust training and to equip trainees with the skills to meet changing demands.

The Federal Government has defined the guidelines, goals and fields of action of its future bioeconomy policy in its National Research Strategy BioEconomy 2030. The strategy is designed to drive bio-based sustainable development within ecological limits. Germany will strengthen its role as a forerunner in the sustainable, circular bioeconomy, as well as in designing sustainable technologies and developing the jobs of tomorrow. This is because biological knowledge and sustainable technologies are the pillars of a sustainable economic system. And by sustainably producing a raw material base within ecological limits, the Federal Government is contributing in particular to climate protection.



Mitigating the loss of biodiversity is as much a challenge as combating climate change. Biodiversity is an essential fundament for human life, but it has been in decline for many years, globally and in Germany. This progressive loss of biodiversity is already threatening the economic, social and cultural livelihoods of people and their well-being. For instance, humanity depends heavily on the ecosystem services provided by insects, which play an important role as pollinators and for soil fertility, among other things. However, both the total number of insects and the diversity of insect species in Germany have declined sharply. This is confirmed by national Red Lists and numerous scientific studies, including from other EU countries. The Research Initiative for the Conservation of Biodiversity (FEdA) is creating the scientific basis to reverse the trend of biodiversity loss through concrete and comprehensive solutions. Solutions taking a scientific, ecological, social and economic perspective are proposed according to three fields of action. The Federal Government is linking research, social action and economic decisions through these priority areas in order to conserve biodiversity and thus to preserve our livelihoods and combat climate change. The National Centre for Biodiversity Monitoring will also significantly improve the database on biodiversity developments and make it more easily accessible.



See also the mission on “**Preserving biological diversity**” on the High-Tech Strategy 2025 website (available in German).

## We are strengthening intelligent and emission-free mobility

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Mobility secures our prosperity. It is a decisive economic factor and the basis for innovation. The mobility industry is undergoing a major transformation. It is no longer only shaped by the vehicle industry, but increasingly also by the IT sector. Electric vehicles are connected to the power grid, so the integration of electric mobility into the grid links the transformation of the transport sector with the conversion of the energy sector. These changes pose challenges – particularly against the background of our climate goals. But there are also many opportunities for new value creation and transformation, as well as for job creation. Answers to the challenges must be found in the big picture. Mobility needs and traffic movements, infrastructures, employment, regional structures, technical innovations and new business models must all be equally taken into account in a networked, digitalised and sustainable mobility sector. Transport transformation has been given additional impetus by the HTS mission “Developing safe, networked and clean mobility”, which focuses on mobility in urban and rural areas.



See also the mission on “**Developing safe, networked and clean mobility**” on the High-Tech Strategy 2025 website (available in German).

### **Establishing sustainable new business models**

In order to exploit the potential of digitalisation, automation and networking for climate-friendly mobility of the future, digital solutions will be made tangible and translated into new business models. A holistic approach for municipal and regional mobility systems is being tested in real-world laboratories; a broad-based stakeholder dialogue with society, business, politics and science is being established for the introduction of new technologies; and the use of AI in logistics is being strengthened to increase Germany's appeal as a business location. Road traffic-related legislation already has regulations in place today – for example in the form of experimentation clauses – that allow tests to be carried out in real traffic. If it becomes apparent that existing options for the planned trials of innovations in the real environment are insufficient, an amendment to the existing legal framework could be considered, in particular by creating new experimentation clauses.

### **Gaining a better understanding of interdependencies within the mobility system**

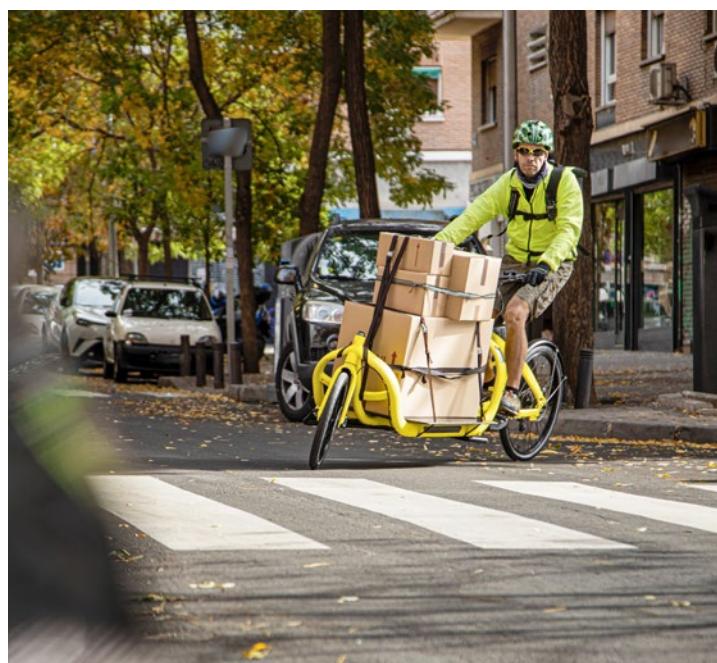
The mobility system is analysed structurally, across transport modes and sectors, and linked to societal and individual requirements. At the municipal level and in the area of integrated urban development, for example, sustainable mobility concepts are measured by the strengthening of active mobility and local public transport, the integration of new technologies (including AI applications), transport infrastructures, and the distribution of public space. In addition, formats are being developed that ensure the target-group-specific knowledge transfer into politics, economy and society as well as the networking of relevant actors.

### **Strengthening knowledge transfer in transport and mobility planning**

Funding is being provided for the practice-oriented further development of procedures and instruments for municipal control and planning in the mobility and transport sector. This can be based on findings drawn from a holistic view of the mobility system. Knowledge transfer into practice is strengthened by nationwide mobility networks and supported by access to publication of data and results. For the next generation of skilled professionals, for example, competence centres for the digital mobility sector are being established to ensure that AI competence is being developed.

### **Generating positive sustainability effects, environmental recovery and climate protection**

The environmental impact of traffic is being reduced. To this end, new digital technologies and vehicle and system technologies (lightweight construction, new drive systems) are being promoted that contribute to reducing pollutant emissions, resource consumption and land use. A long-term change in mobility behaviour towards environmentally and climate-friendly behaviour is being promoted. Federal programmes are helping municipalities to improve air quality, expand local public transport according to demand and build cycle paths, among other things.





### Enabling the real-life application of automated and connected vehicles

AI-based solutions can create the foundation for the real-life application of automated and connected vehicles. The performance of the components used in automated and connected vehicles can be significantly increased. AI-based solutions can also improve the use of demand-oriented autonomous mobility services in different areas of application. Together with car manufacturers, relevant suppliers and other providers, a consensus on the requirements and developments of future automotive components across the entire value chain is being collated to create a robust roadmap.

### Implementing integrated mobility concepts in local communities

Sustainable mobility concepts and measures are being designed on an interdisciplinary and transdisciplinary basis at the municipal level, implemented in real-world laboratories, evaluated for dissemination in other (local) contexts, and prepared for specific target groups. Insights into interactions within the mobility system are triggering sustainable change. Positive sustainability effects are being measurably taken into account in transport policy and planning. Mobility options and services in urban settings and rural regions are being improved. This is supported by a platform for the integration of all relevant mobility service providers.

### Making Germany the leading supplier and leading market for electromobility

By bundling a large number of measures and involving a variety of actors, Germany's research and innovation capacity in the field of electromobility is being significantly expanded. This includes increasing the market supply of vehicles and improving the degree of technological maturity of innovative components and infrastructure. Among other things, the focus is on the networking of research institutions, the expansion of battery research and battery cell production, and, increasingly, intelligent charging stations, as well as the transfer of research into application.



See also the mission on “**Building up battery cell production in Germany**” on the High-Tech Strategy 2025 website (available in German).

### Making German aviation fit for the future

The Federal Government is supporting developments in German aviation by means of an independent aviation research programme that has been strengthened by a total of 200 million euros for the years from 2021. This involves increasing funding for technologies in the field of hybrid-electric aircraft. The priority funding lines are for efficient, safe and economical systems and for quiet and effective alternative propulsion systems. The technology base is provided by hydrogen as an energy source and fuel cells as energy converters. At the same time, work is being done on PTL (power-to-liquid) applications to reduce the climate impact of aviation in the short term. A new crossdepartmental research initiative “Hydrogen Technologies 2050” will strategically bundle research measures on key hydrogen technologies.

## We are developing urban and rural areas to create liveable environments and sustainable regions

The different regions in Germany vary in their innovative strength and economic performance. The strong economic hubs stand in contrast to regional areas that face particular challenges of structural change. At the same time, many of these regions have specific competencies and relevant experience that can promote the creation of innovations and new value chains. This is the key to greater prosperity and quality of life in the regions concerned, as well as to strengthening Germany on the whole as a country of innovation. To achieve this, the Federal Government is relying on the power of research and innovation. As part of the High-Tech Strategy 2025, we are supporting innovation-based, sustainable and socially just structural change that actively incorporates regional know-how and the experiences of local people. The focus is on rural areas, the balance between urban and rural areas, and structurally weak regions with

differing profiles. The promotion of new technologies, creative business models and social innovations in these regions brings us a good deal closer to the goal of achieving equivalent living conditions.

The important role of research and innovation is reflected above all in the “Federal Funding System for Structural Development Regions”, which replaced the Solidarity Pact II in January last year. This is one of twelve measures with which the Federal Government is putting important conclusions from the Commission for “Equivalent Living Conditions” into practice.



See also the mission on **“Ensuring good living and working conditions throughout the country”** on the High-Tech Strategy 2025 website (available in German).



The German funding system combines more than 20 funding programmes from six different federal ministries, many of which focus on promoting research and innovation – above all the programme families “Innovation and structural transformation” and “Entrepreneurial regions”, as well as the programmes “INNO-KOM”, “ZIM” and “Innovative Communities”.

Innovation-based structural change is also being pursued for the lignite regions affected by the gradual phase-out of coal-fired power generation. Many of the measures adopted by the Federal Government and the Federal States for the Rhenish, Central German and Lusatian coal-mining areas are designed to create future-proof technology and knowledge regions. Achieving this includes establishing new research centres, setting up real-world laboratories, increasing the funding for data innovations in the field of mobility, and initiating projects for testing sustainable energy technologies. In this way, the transformation of the coal-mining regions will succeed in a way that is “sustainable” in both senses of the word.



## We are expanding safety and security research for an open and free society

The current coronavirus pandemic shows just how quickly global safety and security can change. Risks such as terrorism, organised crime or cybercrime and related attacks on internal and external security are also constantly changing – entailing new requirements for combating them.

In addition, there are challenges related to raw material and energy shortages, climate change and associated extreme weather events. The increasing complexity of energy and transport networks, the internet and telecommunications, or commodity chains for food and pharmaceuticals leads to ever-new risk potentials. The fact that the supply of sensitive and sometimes vital economic goods, for example for the supply of healthcare or pharmaceuticals, can come to a standstill has also become extremely apparent during the current pandemic. As part of the High-Tech Strategy 2025, it is therefore our declared goal to contribute to the protection of our society through innovative and feasible safety and security solutions.

The Federal Government's framework programme “Research for Civil Security 2018–2023” has made research in this area a priority of the High-Tech Strategy 2025. The programme is aimed at the protection and rescue of people, protection of critical infrastructures, and protection against crime and terrorism. The funding measure for preventing and rapidly responding to biological threats was able to make an important contribution to dealing with the coronavirus pandemic. We are well prepared for the challenges ahead, particularly in connection with digitalisation, through the use of AI for civil security solutions and through the funding of two centres of excellence for the development of autonomous systems in hostile environments (ROBDEKON in Karlsruhe and Bremen and A-DRZ in Dortmund). In order to transfer the most innovative security solutions into real-world application on a national level, a competition entitled SifoLIFE was launched for the first time to support municipalities in bringing new security solutions into practice more quickly with the help of demonstration projects.



The Federal Government has also reached important milestones in the area of IT security with the continuation of the framework research programme “Self-determined and secure in the digital world 2015–2020”. This has led the expansion and consolidation of the competence centres for IT security in Darmstadt (ATHENE), Karlsruhe (KASTEL) and Saarbrücken (CISPA). More than 30 start-up projects were initiated as part of the “StartUpSecure” measure. The focus of other funding measures included combating disinformation, the economic aspects of IT security and privacy, and IT security in autonomous driving. The pilot network for quantum communication will drive forward the demonstration of provably secure communication based on second-generation quantum technologies. The process of developing the successor programme is in the home stretch and is expected to be completed before the end of summer 2021.

## We are advancing digitalisation for strong companies and decent work

The digital transformation is fundamentally changing the way we live, work and learn at a rapid pace. The Federal Government wants to shape this change and prepare our country for the future in the best possible way. Digitalisation is a challenge for the future viability of German companies in global competition. Innovation is crucial for strengthening a country’s economic growth and competitiveness. Due to the coronavirus crisis, digitalisation is currently receiving an additional boost in practically all sectors and areas of society. This gives digitalised and digital companies a competitive advantage and also opens up new opportunities in research and education. The Federal Government is supporting this development through various programmes and through the development of digital infrastructures. The Federal Government also developed important measures in the last legislative period through its Digitalisation Strategy and outlined these measures in its implementation strategy. The goal of the joint strategic implementation of digital policy measures is to further increase the quality of life for all people in Germany, to develop economic and ecological potential, and to secure social cohesion.

Digitalisation becomes an asset when it makes our lives easier, as well as improving our quality of life and our work environment. With the “Future of Work” programme, the flagship initiative “Digital Hubs” and the funding of research and development of local climate and environmental models for future cities and regional areas, the Federal Government is creating the necessary conditions for digital applications in the areas of health, mobility, civil security and work, and for “Economy 4.0”. In this way, the Federal Government is strengthening the science and technology transfer from research into application and promoting the development of concrete solutions in order to maintain value creation and jobs in Germany. In the process, the focus of our innovation funding was expanded to include close-to-market non-technical innovations.

Established processes of value creation and work are increasingly coming under pressure to change. This is triggered by new technologies such as biotechnology and digitalisation and demands for a resource- and climate-friendly economy. The Federal Government

has therefore funded research and development within the framework of the High-Tech Strategy 2025 to be able to meet the diverse challenges with innovations that also have a social character. This has resulted in initiatives in the areas of “additive manufacturing”, “lightweight construction” and “adaptive production systems”, for “mastering and designing complex value creation systems (Advanced Systems Engineering)”. These activities were complemented by the funding priority “Digital SME – Strategies for the Digital Transformation of Business Processes”, which is strengthening knowledge transfer in particular through the further development of the “Mittelstand-Digital Centers” and facilitating digital measures in SMEs and crafts enterprises through the “Digital Jetzt” (Digital Now) programme. Funding for “Regional Centres of Excellence for Labour Research” was launched to expand research on employment and labour markets throughout Germany. It focuses on gaining new insights into shaping work of the future in research networks made up of science, industry and social partners and transferring their results via teaching at universities into operational practice in the respective





regions. The programme “Future of Value Creation – Research on Production, Services and Work” has brought together research traditions on production, services and work design, paving the way for modern value creation research that will generate the findings, methods and prototypical applications for high-quality production, services and work in Germany. The funding of research and development also opens up new opportunities to support structural change in the innovation system, the development of new business models, and the design of modern organisational forms and market services.

By implementing initiatives on “Trustworthy Electronics”, “Green ICT” and “IT Security in Industry”, the Federal Government is also promoting the sustainability and security of our future information technology.

Secure digital identities are an essential component of digital sovereignty in Germany and Europe. Almost all economic or administrative processes require the identification of a person, a company or an object. In a cross-departmental initiative in cooperation with the private sector, the Federal Government is implementing an infrastructure for digital identities and building a digital ecosystem with a broad, attractive range of applications. In addition, to strengthen our society’s trust in digitalisation, the Federal Government is jointly testing innovative solutions with technology providers, municipalities and citizens in the showcase programme “Secure Digital Identities”. Further, the Federal Government is creating data spaces that also enable new value creation, digital sovereignty and IT system security. The National Research Data Infrastructure (NFDI) is being set up as a federated system to open up data holdings from science and research in Germany and to promote the subsequent and further use of research data. Through the Research Data action plan, we are increasing data literacy in science and facilitating the sharing and further processing of research data. In particular with the establishment, operation and further development of the Gauss Centre for Supercomputing, the Federal Government is also strengthening Germany’s leading position in high-performance computing and supercomputing.

The Federal Government has driven forward the development of GAIA-X, a networked European data and infrastructure ecosystem with the highest standards of data protection, transparency, interoperability and openness, in which data can be made available, merged and shared in a secure and trustworthy environment. To this end, the Federal Government is specifically promoting the further development of basic technologies and standards, the implementation of application examples, and networking with other data infrastructures such as the National Research Data Infrastructure or the Gauss Centre for Supercomputing.



See also the mission on “**Putting artificial intelligence into practical application**” on the High-Tech Strategy 2025 website (available in German).

## 3.2 Developing Germany's future competencies

A prerequisite for maintaining Germany's innovative strength and competitiveness is the expansion of both its technological base and its skills base. Under the umbrella of the High-Tech Strategy 2025, the funding of new technologies and social innovations goes hand in hand with investments in education and training to prepare people for the changes ahead.

### The technological base

In the framework of the High-Tech Strategy 2025, the Federal Government has advanced important initiatives to maintain and expand the technological sovereignty of both Germany and Europe.

With its Artificial Intelligence (AI) Strategy and its subsequent update, the Federal Government is pursuing the goal of making Germany and Europe a leading location in the research, development and application of human-centred AI. In order to further establish and expand AI ecosystems in Germany and Europe, to strengthen the application of AI on a broad scale, and to promote responsible development oriented to the common good and an application of AI systems, the strategy and new initiatives focus on the topics of pandemic control, sustainability, and environmental and climate protection, as well as on national and international networking. The aim is to strengthen the research ecosystem, especially through the expansion, consolidation and European networking of the AI competence centres, and to establish international AI future labs in Germany, to transfer methods into application, especially through the establishment of AI application hubs, and to strengthen AI competencies at all levels, for example through the promotion of junior research groups and additional professorships for AI. As part of the Economic Stimulus and Future Technologies Package, the Federal Government has decided to increase spending on AI from 3 billion euros to 5 billion euros by 2025.



Under the umbrella concept "Research Factory for Battery Cells", the Federal Government has developed a strategic framework for battery research in Germany that describes an integrated funding approach, from materials to battery cells to production. In particular, in this context, the Federal Government initiated the establishment of a research facility for battery cell production which validates and demonstrates research results on a large scale, thus providing the scientific basis for establishing and sustainably advancing internationally leading competitive battery cell production in Germany. In parallel, the research-based development of a sustainable and competitive battery value chain in Germany is funded by the Federal Government as part of two "Important Projects of Common European Interest" (IPCEI) with up to 3 billion euros.



Another Federal Government priority is the research and application of second-generation quantum technologies. The framework programme “Quantum Technologies – from basic research to market” was already adopted in 2018, and more than 650 million euros were made available for this. Initiatives launched under this programme include in particular the areas of quantum communication, quantum sensor technologies and quantum computing. Other priorities were activities for promoting junior researchers and the development of approaches for communicating quantum technologies to the public. Through the Economic Stimulus and Future Technologies Package, the Federal Government has also provided an additional 2 billion euros to strengthen quantum technologies. In addition to increasing the funding for quantum sensor technology and communications, it has given special priority to quantum computers “Made in Germany”. The “Quantum Futur” initiative also supports providing the necessary skills base through qualification programmes.

Communication technologies are the nerve system of digitalisation. This is why, within the Economic Stimulus and Future Technologies Package, the Federal Government has formulated its aspiration of taking a leading international role as a technology provider in the development of 5G and, prospectively, 6G communication technologies. An additional 2 billion euros were made available for this purpose. The Federal Government’s measures are aimed in particular at creating a broad research base for this and at promoting transfer into practical application.

In parallel, the Federal Government has developed a specialist programme for research into communication systems.

Another key enabling technology of digitalisation is microelectronics. The Federal Government has strengthened microelectronics competencies even further in recent years, among other things by completing its investments in the Research Fab Microelectronics Germany and by providing funding of up to 1 billion euros for the implementation of the Microelectronics IPCEI. The Federal Government is specifically strengthening Germany’s and Europe’s technological sovereignty and the sustainability of microelectronics by investing 400 million euros by 2024 in the funding of research in these areas under its new framework programme for research and innovation 2021–2024 “Microelectronics. Trustworthy and sustainable. For Germany and Europe.”



The Federal Government is also supporting materials research under the framework programme “From Materials to Innovation”, which will provide about one billion euros in funding from 2015 to 2024. Current technological developments such as digitalised and bio-inspired materials research have recently been implemented in funding policy through the “Material Digital” (Digital Materials) funding activities and the ideas competition on the “Biologization of Technology”. Materials research acts as an important driver for advancing the development of other key enabling technologies, such as AI, quantum technology, battery research and medical technology, and by the same token it forms the backbone for key industrial sectors such as the chemical industry and plant and mechanical engineering. In order to make German materials research fit for the future and internationally competitive, a national materials master plan is to be jointly created with the relevant stakeholders from industry and science in Germany on the basis of an existing impulse paper.

## The skills base

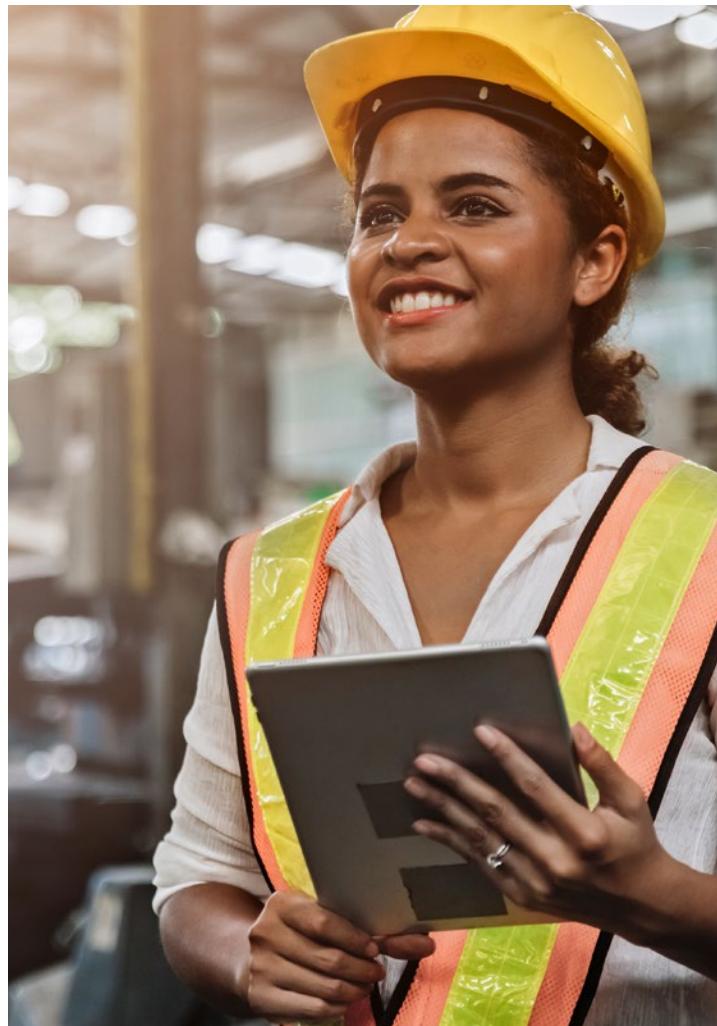
Germany is a country of bright minds. As a country of innovation, Germany is highly regarded around the world. Whether in the natural sciences, social sciences or technology, the work of German researchers is significant all over the world. It is thanks to their ideas and passion that Germany continues to be an international leader in new developments. To ensure that this remains the case, education and training must also be able to keep pace with the promotion of research and technology. Without the necessary qualifications, there will be a shortage of skilled workers in the medium and long term. It is a key concern of the High-Tech Strategy 2025 to align our education and training systems with this development and to provide and promote the necessary skills for all sectors and industries, in all areas of education and training – from school to work, from basic research to practical application.



Our recipe for success relies on the skills of the people in our country, who navigate their way through excellent vocational and academic education infrastructures. Academic and vocational education are of equal value and complement each other.

The digitalisation of schools is a cornerstone for the modernisation of education in our country. This was already on top of the agenda even before the COVID-19 crisis, as evidenced by the fact that the Federal Government has meanwhile provided a total of 6.5 billion euros in funding for the Digital Pact for Schools. The Federal Government is thus showing unprecedented commitment to schools, which are constitutionally under the jurisdiction of the Federal States. The provision of funds for infrastructure measures and digital learning tools creates the necessary conditions to increase the efficiency of digital education infrastructures. This has provided schools with the tools they need to rapidly complement the analogue with the digital. By the end of 2020, around 488 million euros had been disbursed through the Digital Pact for Schools to rapidly adapt them to the technical and infrastructural requirements. Committed sums – i.e. sums already applied for but not yet paid out – are almost twice as high at around 875 million euros. Funds already disbursed and approved amount to a total of 1.363 billion euros.

Advancing digitalisation opens up opportunities to organise work and learning more efficiently and effectively. The COVID-19 crisis is accelerating this process and increasing the pressure for change in education and training. The “Digital Education Initiative” focuses above all on creating the necessary conditions for competence development in the field of digital education. The Federal Government’s umbrella initiatives “Vocational Education 4.0” and the Digital Pact for Schools are strengthening digital education and training and its institutions. This is because digital skills are now indispensable for society and the economy for a self-determined life, professional activity and social participation. As part of the High-Tech Strategy 2025, we have therefore focused on the competencies required for using digital technologies in educational institutions.



A case in point is the special programme to promote digitalisation in inter-company vocational training centres and competence centres. In this case, the Federal Government supports these centres in acquiring modern digital equipment and in developing concepts for teaching digital content. In this way, it is contributing to modernising the training of skilled workers, especially at SMEs. This is because digitalisation has brought many changes to vocational education and training as well.



Not only is teaching and learning material being increasingly provided in a digital form, but also development and manufacturing processes or organisational and distribution systems have changed, in some cases fundamentally, thus also influencing everyday life in many professions. The Federal Ministry of Education and Research (BMBF) is providing a total of 224 million euros for this programme from 2016 to the end of 2023. Practical developments in the realm of digital vocational education and training can be offered to SMEs in particular through the programme “Digital media in vocational education and training”, the web portal “qualifizierung-digital.de”, and the transfer format “Online Roadshow”. The funding volume amounts to 152 million euros over 10 years. In addition, as part of the federal programme “Continuing Education and Training (CET) networks”, the Federal Government is supporting regional coordination offices in establishing or developing cooperation and networking structures between companies and educational and counselling institutions. The aim is to increase the number of employees participating in CET, especially those at SMEs, and to strengthen regional economic and innovation networks. The adaptation or reconception of new CET measures and formats based on the needs of companies plays an important role in this. Therefore, as part of the National Continuing

Education Strategy (NWS), the Federal Government and the Federal Employment Agency (BA) are jointly examining the development of a central entry portal for CET (NOW! – Nationale Online-Weiterbildungsplattform), which will also include existing education programmes. In spring 2021, the Federal Government also launched project funding under the innovation competition INVITE (Digital Platform for Continuing Vocational Education and Training – CVET) to design an innovative and user-centred secure digital learning space for continuing professional training.

The “Foundation for Innovation in Higher Education Teaching” is making an important contribution to the capacity for renewal and further development of higher education teaching and learning. The Foundation, jointly funded by the Federal Government and the Federal States, is intended to provide space for new ideas and approaches, to promote knowledge exchange and networking, and to strengthen the transfer of approaches that have already been tried and tested. Its first funding announcement “Strengthening higher education teaching through digitization” is intended to support promising project proposals that innovatively rethink, test and structurally embed on-campus teaching, blended learning and online teaching at higher education institutions.

The “Contract for the Future of Higher Education and Teaching” demonstrates the shared commitment of the Federal Government and the Federal States to sustainably improving the quality of higher education and teaching at universities across the nation and to maintaining study capacities in line with demand. The Federal Government alone will provide 1.88 billion euros annually for this purpose between 2021 and 2023, and 2.05 billion euros annually from 2024. The Federal States will provide additional funding at least to the amount of the federal funding provided in the respective year and in addition to their basic funding as defined in the Contract. The sustained and comprehensive funding of higher education institutions from 2021 onwards is intended in particular to expand the number of permanent higher education employees engaged in higher education and teaching. The funds of the Contract also serve the digitalisation of higher education, such as the expansion of digital teaching programmes and the development of the digital infrastructure at higher education institutes.

The coronavirus pandemic has demonstrated one thing very clearly: The ability to adjust flexibly to new circumstances and to rapidly adapt and use new knowledge is an essential prerequisite for meeting social challenges. Digitalisation and the development of new technologies and innovations are changing our work and ways of working. Being able to implement this change and to take as many people as possible along with us in the process has been and remains a core concern of the High-Tech Strategy 2025. To this end, we have further improved the general conditions and, jointly with our partners in the National Continuing Education Strategy, enhanced the culture of continuing education and training in Germany, for the benefit of workers and companies alike.

In view of the digital transformation, lifelong learning is becoming increasingly important. It is necessary to provide targeted support for education and training in Germany for all phases of life. After all, we cannot afford to lose skills.



### 3.3 Establishing an open innovation and venture culture

**It is only with an efficient innovation system that ideas become innovations and knowledge becomes value creation. This includes having a culture of innovation that provides room for creative ideas and promotes a broad spectrum of innovations, such as technical innovations, new business models and social innovations. This also includes creating the best possible conditions for the emergence of breakthrough innovations.**

The High-Tech Strategy 2025 reflects the Federal Government's commitment to fostering a venture and start-up culture, open innovation, and inter- and transdisciplinary approaches. Thus the Federal Government has created an excellent basis to promote start-ups from science and research in a more targeted and effective manner. It is crucial that researchers and students be made aware of the prospect of starting a business at an early stage and that the necessary conditions are created for them to successfully take the step towards entrepreneurship.

Within the framework of the High-Tech Strategy 2025, we have set the course for a culture of innovation characterised by openness, agility, foresight and trust. In this way, we are intensifying transfer into practical application, strengthening entrepreneurship, and utilising knowledge and innovation networks in national and international cooperation. With the High-Tech Strategy 2025, the Federal Government has set itself the goal of firmly anchoring a culture of science and technology transfer. The aim is to extensively develop novel fields of innovation with high implementation potential and to quickly transfer them into economic and social utilisation.

The Federal Government has launched the "Innovation Cluster Initiative" under the motto "Clusters4Future – Innovation Networks for Our Future" and will provide up to 450 million euros for this purpose by 2030. The aim is to bring together regional partners in innovation networks on the basis of excellent findings from basic research in central fields of technology and application. Within the framework of our new and open understanding of innovation, we have ensured that a broader concept of innovation has become established, which, in addition to technical innovations, also takes equal account of non-technical and social innovations and involves society not only as the key beneficiary of innovation policy but also as a central player in innovation. To achieve this, we have developed specific funding measures such as the "Society of Ideas – Competition for Social Innovation", which takes up innovation potential from society and taps into it through a funding programme that connects scientific pursuit of innovation development and the focus on broad impact and scalability.

A strong research and innovation location also requires a regulatory environment that invites openness to innovation. In compliance with important framework conditions, such as the precautionary principle and ethical values, the Federal Government wants to open up experimental spaces, for example, to support new forms of cooperation – between science, industry and society, between different disciplines, between users, providers and producers, and between large and small actors. We also need the legal environment to test and experiment. Therefore, the



Federal Government has decided to make greater use of experimentation clauses in specialised laws, in particular to allow for real-world laboratories. Therefore, in future as part of the departmental principle, the Federal Government wants to examine for each law whether scope can be given to innovative services by incorporating an experimentation clause. The German science system is producing many exciting, even radical new ideas. With its Open Access Strategy and its associated measures, the Federal Government aims to make these ideas more readily available. We are still too slow to actually turn these results into innovations that generate added value in Germany. With the establishment of SprinD GmbH, the Agency to Promote Breakthrough Innovation, in December 2019, the Federal Government set an important course for the creation of new scope and funding opportunities for breakthrough innovations. SprinD is intended to help radical technological innovations with game-changing potential to achieve a breakthrough and thus disruptively change markets. In addition, by establishing the Agency for Innovation in Cybersecurity GmbH (Cyber Agency), the Federal Government aims to initiate and drive groundbreaking, future-shaping innovations in the field of cybersecurity and related key technologies that create strategic advantages for internal and external security. With both the Cyber Agency and SprinD GmbH, the Federal Government is expanding the German innovation system with crucial, unique and novel components.

Another essential component of an open innovation and venture culture is the presence of young knowledge-based companies. Start-ups often bring radically new things into the world. For the Federal Government, engaging SMEs, especially start-ups, in innovation processes, for instance through the EXIST funding programme, has long been and will continue to be an integral part of its specialised programmes and horizontal measures. The establishment of a Future Fund will significantly improve the general financial conditions for young, innovative companies. Ten billion euros have been provided by the Federal Government as additional funding for start-up financing over the next ten years. In addition, the existing instruments co-financed by the Special Fund of the European Recovery Program (ERP) still have public funds of more than 4 billion euros available, which can also be used for financing commitments to young, innovative companies in the coming years.



See also the mission on “**Finding new sources for new knowledge**” on the High-Tech Strategy 2025 website (available in German).



## 4 OUTLOOK

Research and innovation are crucial for tackling societal challenges. The past year has shown just how important our continuously increasing investments in the German science and innovation system have been. An impressive case in point is the successful development in Germany of the first COVID-19 vaccine approved in Europe.

Since its first edition in 2005, the High-Tech Strategy has been the Federal Government's key umbrella strategy for research and innovation policy. We will consistently pursue the target formulated in the current High-Tech Strategy that, by 2025, together with the Federal States and the private sector we will be investing 3.5 per cent of GDP in research and development. This prioritisation is crucial for Germany's innovative strength. This is not just about coping with the short- and medium-term effects of the pandemic. Rather, at the same time we must pave the way for the mastery of long-term global challenges in the spirit of the 2030 Agenda for Sustainable Development. Considerable additional efforts are needed for our transformation into a climate-neutral, sustainable economy and society.

The grand challenges can only be tackled with European and international cooperation. However, it is important not only to assume international responsibility but also to avoid imbalanced dependencies. Forward-looking promotion of innovative technologies and social innovations forms the basis for protecting the climate and enabling a sustainable, resilient society while also ensuring that we maintain our technological sovereignty and remain economically successful. This also includes using the potential of the digital transformation and increasing citizen participation in transformation processes.

With the mission-oriented approach tested in the current legislative period, we have strengthened cross-departmental cooperation in research and innovation policy to work in a targeted manner on solving the grand challenges of our time. We will advance the orientation towards common goals and impact together with actors from science, industry, politics and society.

Germany as a country of innovation should continue to be a leading global location for science, research and innovation. Only in this way can we succeed in securing our prosperity and social well-being in the future and in making the lives of every individual better.





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