



Federal Ministry
of Education
and Research

Federal Report on Research and Innovation 2020

Short version



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Foreword

Research and innovation have a significant impact on our personal and everyday lives. This year has demonstrated the fact of this with a harsh new force. Researchers all over the world are working around the clock to develop a vaccine and medications against COVID-19. They are helping us to combat coronavirus and prevent its spread.

Every day we know more. As our knowledge base grows, we can make faster and better political and economic decisions. Cooperation in international research is saving lives every day. This highlights the advantages of the exchange of research data and the cooperation of research institutions from all over the world.

The German research and innovation system is also able to react rapidly and effectively to unforeseen events due to our consistent focus on research and innovation in recent years. In 2018, the private sector and government invested more than 3.1 per cent of Germany's economic output in research and innovation. This puts us in fourth place among the world's most research-intensive economies.

Through research and innovation, we are developing substantial solutions to the grand challenges of the present day. In this way, we can overcome the coronavirus crisis and alleviate its economic and societal consequences. But research and innovation also help us to come closer to our long-term goals: the transition to a more sustainable economy and climate protection.



A tremendous drive is now emerging in the development and roll-out of digital applications. We are heading into an era of digital sovereignty, ensuring that Germany and Europe will remain strong.

The Federal Report on Research and Innovation provides a comprehensive overview of the activities of the Federal Government and the Länder on research and innovation. It addresses key statements in the current report of the Commission of Experts for Research and Innovation.

This report provides comprehensive information to both the general public and the scientific community. For those of us in politics, it serves as a fact-based foundation for our decisions – for today and for the future.

Anja Karliczek
Member of the German Bundestag
Federal Minister of Education and Research



1 Innovation Country Germany – for decent and sustainable living conditions

Germany is a country of innovation. It is one of the leading innovation nations and among the most attractive research locations worldwide. This result has been achieved by a consistent policy focus on research and innovation that, under the umbrella of the *High-Tech Strategy 2025*, aims to reinforce the future viability of Germany and Europe. At present, the protection of health in Germany and societies worldwide represents a particular challenge. But 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 creating equivalent living conditions in all parts of Germany. Research and innovation that uphold the precautionary principle make a key contribution to this. For decent and sustainable living conditions in Germany and worldwide.

Through education, research and innovation, the Federal Government is opening up future opportunities and promoting positive innovative drive. Through the *High-Tech Strategy 2025 (HTS 2025)*, the Federal Government, in a joint effort with the Länder and the private sector, has set itself the goal of investing 3.5 per cent of gross domestic product (GDP) in research

and development (R&D) by 2025. With funds invested in R&D in 2018 amounting to 3.13 per cent of economic output, Germany is already one of the most research-intensive economies in the world. This success is also highlighted by the Commission of Experts for Research and Innovation (EFI) in its 2020 report.

Research and development expenditure in Germany

In 2018, the Federal Government and the private sector invested **105 billion euros** in research and development. This represented **3.13 per cent** of Germany's economic output.

As a powerful innovation hub, Germany is flexible and able to react rapidly and inventively to unforeseen events. The research and innovation system is currently facing large-scale challenges. As a research policy response to the global spread of novel coronavirus and the growing number of COVID-19 cases, research efforts in Germany were ramped up and accelerated at the start of 2020. The initial focus is on measures to contain the pandemic and the best possible treatment of those affected. The Federal Government continues to pursue the key component of developing vaccines, medications and testing methods. This undertaking demonstrates the enormous importance of international research cooperation, the exchange of research data, and the cooperation of institutions all over the world that are involved in research on the pandemic.

The repercussions of the pandemic impact all areas of society and will continue to be felt for some time to come. Mitigating the economic and social consequences will therefore be a key task in the near future. As the EFI points out, scientists and researchers are also feeling the effects of the crisis. The Federal Government will therefore direct more specific attention to the areas of science, research and innovation with regard to implementing further measures.

The long-term consequences of the COVID-19 pandemic are not yet foreseeable. Research and innovation play a crucial role in providing sound data and knowledge to deal with the uncertainties of the ever-changing developments in this situation. This enables us to better understand the impacts of the crisis and to develop mechanisms to effectively contain similar crises in the future. It is also important to gain a better understanding of the causes of this crisis and to gather and expand global knowledge on factors contributing to the increase in new infectious diseases. The German research and innovation system is well positioned to contribute to this.

Germany's innovative strength has many driving forces. This includes researchers who deliver excellence and creativity, and having a competitive and employment-rich economy with a broad industrial base. According to provisional estimates, the R&D workforce rose to a new peak of almost 708,000 full-time equivalents in 2018, an increase of 45 per cent since 2006, with the private sector accounting for more than 63 per cent of total R&D personnel. In terms of R&D personnel intensity, which expresses the share of R&D personnel in the total number of employed persons, Germany lies well above the EU average and ahead of China and Japan.

Employment in research and development in Germany

Almost **708,000 individuals** were employed in research and development in 2018 (full-time equivalents). Of these, more than **63 per cent** worked in the private sector.

Apart from stakeholders in public and private research, the national government and civil society are key drivers of the innovation system, as they are open to new ideas and actively participate in shaping change. All levels of government are called upon to engage, from the Federal Government and the Länder right through to the local authorities. The Federal Government has doubled its R&D expenditure since 2006. Action at EU level also supports change. In civil society, the contribution of each individual is important in all age groups and all regions. All social groups can jointly contribute to the Innovation Country Germany (Innovationsland Deutschland), for example through citizen science projects or other forms of participation. Ideas should not be confined within disciplinary silos, sectors or institutions, but should be thought of in an overarching way and communicated across a broad spectrum.

Federal Government expenditure on research and development

The Federal Government has earmarked **19.6 billion euros** for future investment in research and development (target 2019). Federal R&D expenditure has doubled compared to 2006.

Because of its innovative strength, Germany is also assuming its own responsibilities on an international level.

Germany takes its responsibility for sustainable development and climate protection very seriously. The Paris Agreement sets the framework for an ambitious German and European climate action policy with the objective of being largely greenhouse gas-neutral by the middle of the century. At the same time, a new global understanding of prosperity was established with the United Nation's *2030 Agenda for Sustainable Development*. Germany has committed itself to ambitious goals in the *National Sustainable Development Strategy (DNS)*, which is based on the 17 global sustainability goals of the 2030 Agenda.

Education, research and innovation are key to shaping a way of life and business practices that can combine competitiveness, the preservation of natural resources and social equity. In its 2020 report, for example, the EFI states that many technologies designed to support energy system transformation are in fact market-ready today, but are not able to establish themselves due to the competitive advantages held by their conventional counterparts, whose negative external impacts, such as greenhouse gas emissions, are not factored in. The EFI therefore applauds the German government's decision to adopt the *Climate Action Programme 2030*, as the climate package includes the pricing of CO₂ for the heating and transport sectors as well. The price of emission certificates will be gradually increased in order to support the diffusion of climate-friendly technologies. The Federal Government has also firmly enshrined the vision of sustainable and climate-friendly development in its innovation policy. An important goal is to strengthen structurally weak regions throughout Germany with specifically designed funding instruments and to increase their long-term innovative capacity.

The different regions of Germany vary in their innovative strength and economic efficiency: regions that are grappling with particular challenges in structural change are competing with strong economic hubs. Structurally weak regions can include rural, mountain or coastal regions, as well as former industrial centres or lignite mining areas affected by the coal phase-out and undergoing structural change. Since such regions can be found in both eastern and western Germany, the Federal Government transitioned to a nationwide support system when the Solidarity Pact expired. This step was also welcomed by the EFI. The Expert Commission came to the conclusion that eastern German companies still have some catching up to do in terms of starting up innovation activities and the commercial exploitation of innovations. However, there has been an alignment of innovation activity in key indicators. For this reason, R&D funding for structurally weak regions based on regional characteristics and not exclusively directed at eastern Germany is appropriate.

German share of global trade in research-intensive goods

Germany's share of trade in research-intensive goods worldwide was **11.5 per cent** in 2018.

There are strong international research and innovation networks which benefit from open markets, international knowledge exchange and free trade, especially within the EU. With a share of almost 11.5 per cent of total world trade in 2018, Germany is the second-largest exporter of research-intensive goods. Germany is also proving its leading international position when it comes to patent applications. With 398 patents relevant to the world market per million inhabitants in 2017, almost twice as many patent applications were filed from Germany as from the USA, for example.

Patents relevant to the world market from Germany

398 patents relevant to the world market per million inhabitants were filed in 2017 from Germany.

As a result of Germany's extensive international ties, its innovation policy environment is strongly influenced by current geopolitical events. On 1 February 2020, the United Kingdom officially left the EU. Negotiations on the future relations between the two sides are ongoing. In the second half of 2020, Germany will take over the EU Council Presidency. Here, too, the future nature of cooperation with the UK will play an important role, including in the area of research and innovation. One thing is certain: Germany will be taking on greater responsibility within the EU – especially when it comes to research and innovation. The European framework programme for research and innovation *Horizon Europe* will contribute significantly to interdisciplinary cooperation and to Europe's innovative strength.

Germany and the EU are in competition with two major economic, research and innovation locations, the USA and China. The USA and China are not only Germany's competitors but also particularly important trade and research partners. In its 2020 report, the EFI recommended that the Federal Government should work towards a level playing field with China and towards raising more awareness among German scientists of the distinctive character of research cooperations with China. To this end, the Federal Government is already conducting a review of foreign trade law with regard to investment assessment. In addition, funding projects will ensure that competences relevant to China, such as language and cultural skills, are developed and expanded at universities and research institutes.

Germany as one of the most research-intensive economies in the world

In 2018, the German economy had the **fourth-highest absolute investment** in research and development worldwide.

Much of what was a vision of the future yesterday is part of everyday life today. Research and innovation are constantly changing the world and the lives of every individual. The development of specific qualifications and continuing education can empower companies, the state and citizens alike to deal with this change. This also applies, for example, to the increasing penetration of digital applications in all areas of life, which demands training for new skills. In its 2020 report, the EFI recommends investing more in the teaching of cybersecurity skills as part of vocational education and training (VET) and at universities. This step could help better meet the increasing demand for skilled workers in this area. For this reason, the Federal Government, through *HTS 2025*, is consistently promoting future competencies like these in many fields.

Compared to other European countries, no other country spends as much on innovation as Germany. The plateauing innovator ratio in Germany – i.e. the proportion of companies that have introduced new products or new processes within a certain period of time – suggests, first of all, that a concentration of innovation activity is taking place, since corporate innovation expenditure is continuing to rise significantly. However, in order to increase the innovator ratio once again, the Federal Government is making targeted adjustments to the general framework so as to make the innovation process more open and agile and to position it more broadly overall. In its 2020 report, the EFI states, for example, that especially in eastern Germany a sufficient rate of success in mobilising companies to increase their innovation activities has not yet been achieved. The difference to western Germany may be explained in part by the fact that the economy in eastern Germany is dominated much more by small and medium-sized enterprises (SMEs). In addition to involving all areas of the economy, however, societal actors must also be more closely integrated in innovation processes in order to improve the chances of developing and introducing new sustainable products and services.

Since January 2020, the Federal Government has been providing the additional incentive of tax-based R&D funding for companies to take up research and development activities. All companies that conduct research and development and are taxable in Germany can benefit from the tax incentives for research. Funding is also available for the award of research contracts. This is particularly advantageous for SMEs and start-ups, as they are often dependent on contract research due to a lack of their own research infrastructure. In its 2020 report, the EFI welcomes the fact that the funding approach was introduced in this form.

Tax incentives for research in Germany

The new R&D allowance for enterprises engaged in research is **25 per cent** of eligible expenses.

To achieve broad participation in innovation, it is important to maintain start-up dynamism. Therefore, market-entry barriers and barriers to innovation for young companies must be reduced and new opportunities must be exploited. These are arising in part due to rapid technological change and the increasing importance of data. An open innovation culture is the key to increasing innovation dynamism. Openness means that science, business and society use experimental spaces and integrate new actors, including future users, into the innovation process. The Innovation Country Germany needs faster implementation on the ground. That requires more planning efficiency, more scope for testing, and effective experimentation clauses. The Federal Government aims to boost openness to innovation in its own actions and those of the EU; for this, innovation and precautionary measures go hand in hand. Many new solutions that have not yet been tested, or only to a small degree, are needed, especially for the transition to greater sustainability.

Start-ups in the knowledge economy in Germany

Around **21,300 enterprises** were founded in the knowledge economy in 2018.

The 2019/2020 report by the German Council of Economic Experts states that a targeted increase in innovation dynamism in Germany through a mission-oriented research and innovation policy would make an important contribution to modern industrial and economic policy. In *HTS 2025*, the Federal Government gears research and innovation to the grand challenges facing society and defines a number of missions. As an innovation policy instrument, *HTS 2025* fosters interministerial cooperation in research and innovation policy and contributes to the targeted implementation of research results. In this way, the Federal Government is increasing the drive, transfer and impact of research and innovation in many policy areas.

The measures described fall within the remit of the appropriate Federal Ministry, where they are financed under the budgetary and financial principles currently in force (including positions/permanent posts). For those measures that are neither defined in the planning nor designated as a 'priority' in the coalition agreement, the general rule is that implementation is only possible if additional financial scope is available or if corresponding direct, complete and permanent counter-financing from the relevant section of the budget is ensured.



2 Using the High-Tech Strategy to pool the strengths of the Innovation Country Germany

Since 2006, the *High-Tech Strategy* has made a major contribution to reinforcing Germany's competitive position in global innovation and to creating an environment that promotes sustainable development. The *High-Tech Strategy 2025* forms the current strategic framework of the Federal Government's research and innovation policy. It consolidates the funding of research and innovation in important future fields across all ministries and uses this funding as a key lever for shaping the response to urgent challenges. This is how knowledge is put into effect. Working jointly with the Länder and the private sector, the Federal Government has set an ambitious target for the year 2025 of investing 3.5 per cent of GDP in research and development.

The *High-Tech Strategy 2025 (HTS 2025)* of the Federal Government focuses on three major fields of action: it tackles the grand challenges for society, strengthens Germany's future competencies and establishes an open innovation and risk culture. *HTS 2025* pursues concrete goals through twelve missions, for which the science community, the private sector and civil society join forces. It covers the topics of 'Health and Care',

'Sustainability, Climate Protection and Energy', 'Mobility', 'Urban and Rural Areas', 'Safety and Security' and 'Economy and Work 4.0', and thus gears itself towards research that addresses current and future needs and is relevant to people's everyday lives. Therefore, the understanding of innovation is broad and includes technological and non-technological innovations, as well as social innovations.

The Federal Government's research and innovation policy systematically and continuously develops Germany's future competencies: through its technological base, its skills base and the participation of society. To this end, the Federal Government is funding key enabling technologies that are characteristically broad in their scope for application and thus also open up potential for disruptive innovations. At the same time, the promotion of research and technology will be closely dovetailed with education and training, which are integral to shaping digital transformation and structural change. *HTS 2025* also relies on committed and enlightened citizens who help shape change.

With *HTS 2025*, the Federal Government has created a framework to promote innovative forms of cooperation that create spaces for ideas and involve new actors in the innovation process. An open innovation and risk culture is characterised by creativity, agility and openness to new ideas. Through *HTS 2025*, the Federal Government has committed itself to achieving the greatest possible networking and cooperation. Start-ups, SMEs and users can benefit from new approaches and participation formats, as can large companies, the research landscape and civil society organisations.



2.1 Tackling the grand challenges

In the *High-Tech Strategy 2025*, the Federal Government focuses on the benefit of the people. By gearing its research and innovation funding towards the grand challenges facing society, it aims to find compelling responses to the issues of the 21st century and to the events of the current crisis. It is about finding innovative solutions that lead to tangible improvements in the here and now of people.

Health and care: Global health, personalised medical care, and combating cancer

Health research provides groundbreaking insights into health and disease. It develops new approaches to prevention and innovative diagnostic and therapeutic methods. The German research landscape is well equipped to respond to acute and global health emergencies, such as the COVID-19 pandemic that broke out at the end of 2019. The Federal Government reacted immediately to the COVID-19 outbreak and is working intensely to contain the spread of the virus and ensure the successful treatment of those affected. It is supported by the scientific expertise of its ministerial research institutions, such as, for instance, the Robert Koch Institute (RKI). So far, there is no approved antiviral treatment for the coronavirus. Germany is therefore participating in the World Health Organization's Solidarity Trials (WHO Solidarity Trials), a research undertaking on possible treatment options for coronavirus. The study is coordinated by the German Center for Infection Research (DZIF). Research for a suitable vaccine has been rigorously pursued since January 2020. In March 2020, the Coalition for Epidemic Preparedness Innovations (CEPI) received additional support of 140 million euros. CEPI has already commissioned six institutes worldwide to develop vaccines to combat COVID-19 – including the German biopharmaceutical company CureVac. Another 15 million euros were made available by the Federal Government in March 2020 to accelerate research into medications and other treatment methods. In order to achieve the most targeted and coordinated investment possible from the

research funds available worldwide, the Federal Government exchanges information with other international governmental or philanthropic funding agencies networking under the umbrella of the WHO.

The Federal Government bundles its research funding in the field of health under the *Health Research Framework Programme (2019–2028)*. This contributes to ensuring that the healthcare system of the future meets the needs of the citizens and that research successes benefit healthcare practice and thus the people. This means that new treatments will be transferred more rapidly from the laboratory to the bedside. In order for this to succeed, patients, relatives, healthcare professionals, regulatory authorities and experts from the healthcare industry are involved in the research process at an early stage. In addition, researchers and medical experts are increasingly involved in political consultation and decision-making processes.

The framework programme focuses on personalisation and digitalisation as the keys to medical progress. Digitalisation offers broader access to medical knowledge and enables better and more efficient care through the integration of digital innovations and digital networking. The application of personalised medicine in everyday medical life can prevent diseases in a more targeted manner and enable more effective treatment with fewer side effects.

The *Health Research Framework Programme* lays a reliable foundation for the players in health research in Germany over the next ten years. Nevertheless, as an adaptive programme, it is deliberately designed to be flexible and open in order to adjust research policy priorities to current scientific circumstances and relevant social developments. The establishment of two new German Centres for Health Research for child and adolescent health and for mental health is already planned.

Putting the focus on benefiting the people ultimately also means taking account of the individuality of the person and their individual circumstances and needs that may influence their health and the potential courses a disease may take. Molecular biology research and digital technologies will in future enable more precise prevention, diagnosis and therapy approaches that are personalised to each individual. For this reason, the Federal Government is intensifying its focus on personalised medical care within the health research programme. Computer-assisted linking of health-related data is also helpful in the development and individual customisation of treatment or prevention programmes. The *Personalised Medicine Action Plan* laid the foundation for systematic research funding of personalised approaches in medicine in Germany. The primacy of personalisation in health research is now well established in Germany. With the current *Health Research Framework Programme*, the Federal Government is actively involved in personalisation and digitalisation and developing them further so that they become the key to medical progress. At the same time, the aim is to address fundamental ethical, legal and economic questions and come up with new practical procedures and standards for personalised medicine right across Europe.

At the beginning of 2019, the German government launched the National Decade against Cancer to consolidate and intensify cancer research in Germany. Combined efforts will be made to bring together cancer research, research funding, healthcare, industry, society and politics in an alliance that will also systematically integrate the needs of patients. The goals are to advance prevention and early detection and in particular to reduce the number of new cancer cases. Access to high-quality oncological care must also be improved, and the prospects and quality of life of those affected must be increased. In addition, the aim is to fast-track the transfer of research results into clinical practice and promote the networking of oncological research and care. Establishing Germany as a leading location for patient-centred cancer research requires excellent scientists and staff in the healthcare system and improvements in the general framework, for example by expanding research infrastructures. The Federal Government is pursuing this by establishing further locations of the National Center for Tumor Diseases (NCT). New funding measures focusing on cancer are currently being launched, for example in the field of

medical informatics. As part of its EU Council Presidency, the German government intends to boost cancer research on a European level as well.

The COVID-19 pandemic also illustrates how essential and relevant social professions are to the system, and this relevance will continue to grow as a result of demographic change and changes in the labour market. Social professions safeguard the quality of living together and the compatibility of work and family life; this is particularly true for professions in early education and care. The Federal Government is pursuing the goal of adding value to social professions. The start of 2020 saw the launch of new nursing training courses in accordance with the Nursing Professions Act, and the Act on Good Early Childhood Education and Care came into force in 2019.

Health and care

Up to one third of the population of Germany will be 65 years old or above in 2060. In 2017, the ratio was one in five.

Sustainability, climate protection and energy: The path to CO₂-free hydrogen

In view of far-reaching ecological changes and global warming, we are facing the challenge of restructuring our economy and society in a sustainable and climate-neutral manner. The Federal Government is aware of this responsibility and, through *HTS 2025*, is guided by the model of sustainable development. It is committed to actively countering climate change and taking the necessary measures to adapt to climate change. The *2030 Agenda for Sustainable Development* adopted by the international community and the Paris Climate Change Agreement provide the political framework for action. Germany's *National Sustainable Development Strategy (DNS)* implements the United Nations' 2030 Agenda and its 17 Sustainable Development Goals (SDGs) at the national level. It formulates the commitment of the Federal Government to achieving the SDGs. The scientific oversight for implementing the SDGs is consolidated on the *Science Platform*

Sustainability 2030 (WPN). Research, innovation and transfer are important cornerstones in the implementation of the SDGs.

The goals and indicators of the DNS describe how global efforts for sustainable development should be advanced ‘within, with and through Germany’. The necessary interim steps and development paths for certain individual fields are described more specifically in other long-term strategies, such as the *Climate Action Plan 2050*. Concrete measures on how to achieve the targets described in the *Climate Action Plan 2050* were laid down in the *Climate Action Programme 2030*. The programme also contains a separate chapter on research and innovation. To support the implementation and ongoing development of the *Climate Action Plan 2050* and the *Climate Action Programme 2030*, the Federal Government has set up the Climate Protection Science Platform.

Through the programme *Research for Sustainable Development (FONA 3)*, the Federal Government is addressing key challenges such as climate change, energy system transformation, the maintenance of ecosystem viability, the circular economy, sustainable mobility and the associated social transformation processes. In line with the goals formulated in *FONA*, solutions for defined fields of action are being developed from a holistic point of view – from an ecological, economic and social perspective. Thus, through *FONA*, a significant contribution is being made to the *National Sustainable Development Strategy* and *HTS 2025*, as well as to the implementation of the *Climate Action Programme 2030* and *Agenda 2030*.

The *Climate Action Plan 2050* sets parameters for success in the Federal Government’s climate protection goal of achieving greenhouse gas neutrality by 2050. To achieve this, the transformation of the energy system into a sustainable, efficient and emission-free energy supply must be rigorously pursued. Research and development of innovative technologies and business models makes a decisive contribution to energy system transformation, as the *EFI* points out in its 2020 annual report. Green hydrogen is a key energy source of the future.

The successful decarbonisation of the energy system requires a long-term shift away from fossil fuels towards renewable energy sources. This demands an ambitious expansion of renewable energies and a further boost in energy efficiency. Green hydrogen has an important role to play in areas where direct use of renewable energies is not possible, as it can be produced in a climate-neutral way, for instance by electrolysis using renewable electricity. However, in the production and use of green hydrogen, energy efficiency must remain in focus. Green hydrogen has the potential to become the sustainable energy source of the future – for long-term storage of renewable energies with potential applications including, for instance, in power generation, for the production of alternative fuels, as a fuel or admixture to natural gas, as a raw material for industrial (especially chemical) processes, and as a reducing agent in steel production.



The Federal Government is taking the next important step with the *National Hydrogen Strategy*, which is to be adopted in 2020. In the long term, this paves the way for the Innovation Country Germany to become the world market leader in green hydrogen technologies. A general framework will be created so that research and innovation can enhance technological maturity and significantly reduce the cost of renewable hydrogen.

International cooperation between the science community and the private sector, for example with Australia, and partnerships on the African continent also play an important role. To this end, the Federal Government is making funding of more than 300 million euros available through the Energy and Climate Fund alone until 2023. An action plan will specify the implementation steps of the strategy.

With the *National Research Strategy BioEconomy 2030*, adopted in January 2020, the German government is focusing on stepping up the use of biological resources and environmentally friendly production processes in all sectors of the economy. By bringing together the previously separate research strategy and the bio-economy policy strategy, concrete measures for research, development and implementation, as well as the various players in the bioeconomy sector, can be even better linked with one another.

The Federal Government and the governments of the five northern German states (Free Hanseatic City of Bremen, Free and Hanseatic City of Hamburg, Mecklenburg-Western Pomerania, Lower Saxony and Schleswig-Holstein) have decided to establish and jointly fund the activities of the German Marine Research Alliance (DAM) in order to foster both the protection and sustainable use of coastal waters, oceans and polar regions. This is intended to initiate long-term research missions of major social relevance and to accelerate the transfer of research results.

Sustainability, climate protection and energy

Germany reduced its greenhouse gas emissions by **30.8 per cent** from 1990 to 2018. The Federal Government's goal is to reduce emissions by at least **55 per cent by 2030** compared to 1990 levels (in CO₂ equivalents).

The use of digital technologies can support and accelerate sustainable development in many areas – be it through data-driven increases in efficiency or digital innovations, for example for the circular economy or for energy system transformation. On the other hand, the increasing use of digital technologies is accompanied by steadily rising energy and resource consumption.

Designing sustainable digital technologies – from sensor systems and digital electronics to server farms and associated communication technologies – and using them to achieve sustainability goals are key priorities of current research policy. The *Action Plan 'Natural. Digital. Sustainable.'* systematically consolidates the topics of digitalisation and sustainability and will further their development.

Mobility of the future: Intelligent and sustainable transport

The challenges of future mobility must be tackled systemically. For this reason, the Federal Government is supporting diverse activities in areas ranging from future mobility technologies to social innovations. In doing so, the Federal Government takes into account the various perspectives of citizens and relevant players such as local authorities, associations, policymakers and companies. The mobility transformation can only succeed if the requirements of society are integrated into the development processes, acceptance of change is promoted, and stakeholders, business and all other actors are engaged through dialogue.

The National Platform for the Future of Mobility (NPM) is a special instrument created for this purpose. It deals with key issues concerning the future of mobility from a wide variety of perspectives, taking up the multi-stakeholder dialogue and the participation of a wide range of social actors. The NPM provides essential input for the technological and scientific design processes of innovative mobility that meets the needs of rapidly changing societies in a climate-neutral way.

Demand-oriented modern transport routes, efficient means of transport and affordable mobility are indispensable prerequisites for a dynamic economy and social participation. The mobility industry is undergoing a major upheaval. New technologies, alternative drive systems, digitalisation, increasing automation and networking will shape the mobility of the future. This should be sustainable and climate-neutral, as well as secure and networked, in order to meet people's changing and more flexible patterns of use and an increasing demand for transport, for example, freight transport. Therefore, both transport infrastructure and digital infrastructure need to be improved.

In order to meet the many and varied challenges facing modern mobility, the Federal Government has set itself research priorities that serve to improve transport infrastructure, provide sustainable and safe mobility, promote alternative drive system technologies and fuels, support automation, digital infrastructure and digital innovations, and create integrated and networked mobility.

Innovations in sustainability are put into practice through the *research agenda 'Sustainable Urban Mobility'*. Local governments are supported in jointly developing tailor-made solutions with researchers and in demonstrating the benefits of new technologies, services and approaches in practice – both in cities and in rural areas. In parallel, research projects are working on innovations for urban mobility of the future and will provide the necessary knowledge to guide long-term transition management.

The Federal Government is funding automated and connected driving, electromobility, and battery and fuel cell technologies as research-intensive key enabling technologies.

From safety and efficiency to emission-free, intelligent and innovative mobility, autonomous driving offers many opportunities. To reap the benefits, various technologies such as artificial intelligence (AI) and big data, sensor technology, electronics, human-machine interaction and IT security must be further developed and answers to fundamental social and ethical questions must be found. Since 2019, the Federal Government has therefore been consolidating the capacities and resources of R&D funding within the *Action Plan 'Automated and Connected Driving'* and is also addressing various issues through funding programmes and research projects. The aim is to promote research across the entire range of topics and to incorporate the results into the requirements of setting standards and implementing legal measures. This will reinforce the coordinated implementation of the Federal Government's *Strategy for Automated and Connected Driving (AVF Strategy)*.

Autonomous driving is part of the comprehensive development of the digitalisation of the transport system. This also includes mobility platforms that will link different mobility services, provide information for multimodal journey planning, and allow bookings

to be made, and also new mobility services such as ridesharing, ride-pooling, and vehicle-sharing services. These opportunities will only become available nationwide through digital information services. However, many of the offers are largely tailored to highly dense inner cities, but they also offer potential for rural areas. In addition, there are applications in freight transport as well as in air and sea transport. The Federal Government's goal is to actively use the opportunities offered by digitalisation and at the same time minimise the possible risks. Electromobility and the related development of battery cells are another focus of the Federal Government's mobility policy. By funding battery research and establishing battery cell production in Germany, the Federal Government is aiming to maintain technological sovereignty in another field of the future in addition to closing value chains and ultimately making a significant contribution to environmental protection. The concept framework 'Battery Research Factory' provides the strategic framework for battery research in Germany and builds on the existing structures of German battery research. Around 500 million euros are to be made available for measures within the concept framework over the next four years. In particular, the research results are to be validated and demonstrated on a large scale in a battery cell production research centre.

Shipping and rail transport are also significant links in sustainable transport chains. In 2017, the German Maritime Centre (DMZ) was founded with the financial support of the Federal Government. The DMZ sees itself as a connecting link between science, industry and politics. As a particularly environmentally friendly means of transport, rail transport, and thus rail transport research, plays a special role in the development of innovative and sustainable mobility concepts. The German Centre for Rail Traffic Research (DZSF) at the Federal Railway Authority (EBA) was launched in 2019 and deals, among other things, with complex research questions relating to the entire rail system. The *Federal Research Programme for Rail Transport*, which was drawn up in 2019, defines the priority innovation topics and the relevant research activities around rail passenger and rail freight transport, as well as rail-related infrastructure.

Innovations in sustainability are put into practice through the *Clean Air Immediate Action Programme*, the *Urban Transport Research Programme (FoPS)* and the *Sustainable Urban Mobility Research Agenda*.

The *HTS 2025* mission of developing safe, networked and clean mobility unites a wide range of ministerial activities under one umbrella strategy.

For all the challenges facing future mobility, the Federal Government is pursuing the principle of openness to technology and freedom of choice in mode of transport. At the same time, it aims to maintain the best possible transparency concerning the options for integrated and connected mobility that are available to users in the various regions. To this end, various research priorities are being pursued and linked with one another, technological approaches are being developed, and intensive knowledge transfer is taking place, for example through platforms, dialogue processes, open data policies and open access to research results. Among other things, the funding initiative *mFUND* will establish the relevant data infrastructures to promote the development of innovative digital applications in the mobility sector.

Urban and rural areas: Actively shaping structural transformation

Living conditions in Germany have improved steadily in recent years, but there are still considerable regional differences in terms of economic power, quality of life and innovation activity. It is the aim of the Federal Government to contribute to equivalent living standards throughout the country. In its 2020 report, the EFI states that even 30 years after reunification, eastern and western Germany still have not fully equalised. Compared to western German companies, eastern German companies are still lagging behind in initiating innovative projects and developing new products and services through to market maturity. Since, according to the EFI, these obstacles to innovation depend on regional characteristics which, for structural reasons, can also occur in western Germany, the EFI welcomes the transition to a nationwide financial aid scheme for structurally weak regions.

The new financial aid scheme started on 1 January 2020 and thus directly follows on from Solidarity Pact II, which expired at the end of 2019. This extends a series of support programmes which were previously restricted to eastern Germany to all structurally weak regions in both east and west. In addition, some funding measures with special eligibility conditions are given the option of providing targeted support for regional growth and innovation drivers in structurally weak regions. This will reduce the regional differences in the Innovation Country Germany and contribute to equivalent living standards.

The Federal Government's commitment in structurally weak regions will in future go far beyond traditional economic development. The nationwide support scheme combines more than 20 funding programmes and programme families. In addition to the joint task for 'Improvement of the Regional Economic Structure' (GRW), these include the *ERP Regional Funding Programme*, *ERP Capital for Start-ups*, the *Central Innovation Programme for SMEs (ZIM)*, the *Innovation Competence (INNO-KOM)* funding programme, and the suite of programmes for *Innovation & Structural Transformation*, which is open to a wide range of topics and technologies. In addition, there are programmes for the development of skilled workers, digitalisation, infrastructure and public services.

Urban and rural areas

About **40 per cent of the population** in Germany lives in structurally weak regions. Over the last ten years, the economic power of these regions – measured in terms of GDP per capita – has remained unchanged at about 80 per cent of the national average.

The Commission on 'Growth, Structural Change and Employment' was set up by the German government in 2018 with the aim of drawing up recommendations for a coal phase-out and for shaping the associated economic structural change in Germany. In order to implement the recommendations, concrete research and innovation initiatives will be implemented in the lignite regions affected by the coal phase-out – the Rhenish mining district, the Lusatian mining district and the Central German mining district – as part of the

agreed immediate action programme. Further initiatives are to follow as part of the ‘Structural Development Act’ for coal-mining regions. The measures also include establishing research facilities and competence centres and the funding of innovation initiatives. For example, structural transformation is to be promoted through model projects and real-world laboratories in areas such as the bioeconomy, hydrogen technology and digitalisation.

Safety and security: Entering an era of digital sovereignty

Information technology is an important driver of innovation in many industries. It also ensures the competitiveness of Germany as a business location. Because we are all dependent on information technology functioning reliably and securely – be it in production, energy supply, healthcare, logistics and transport, or even in the world of finance – the topic of IT security is shifting more and more into focus worldwide.

As networking increases, cyberattacks on companies, public institutions and private individuals are on the rise. People are becoming victims of identity and data theft. Industrial plants and critical infrastructures such as the electricity and water supply are becoming increasingly networked and must be secured against attacks via the Internet. The Federal Government is therefore focusing keenly on the security of the digital infrastructure. It is also devoting special attention to SMEs, which face particular challenges in terms of cybersecurity. In its 2020 report, the EFI also emphasises that low-threshold support and information services should be made available above all to SMEs. Between 2016 and 2018, every second company in Germany recorded a concrete information security incident.

In view of the constantly shifting threat landscape, the EFI’s 2020 annual report argues for the expansion of existing measures and services to meet the demand for specialists with expertise in cybersecurity, to ensure the security of digital infrastructures and to improve the information landscape. In particular, low-threshold support and information services should be made available above all to SMEs. Building up domestic and European (IT) skills and promoting and developing (open) standards and systems can also contribute to Germany’s digital sovereignty.

Innovations in cybersecurity are crucial for Germany’s technological and digital sovereignty. The Federal Government recognised the importance of cybersecurity at an early stage and defined the strategic goals of its 2016 cybersecurity policy in the *German National Cyber Security Strategy*. The Federal Government’s research framework programme for IT security *Self-Determined and Secure in the Digital World 2015–2020* bundles together all interministerial activities in IT security research. The protection of citizens is of particular importance in this context – and this includes the protection of critical infrastructures such as water and energy supply. The funded *Competence Centres for IT Security Research* located at Darmstadt, Saarbrücken and Karlsruhe are continuously engaging with new research questions and developing assessments, recommendations for action, and solutions to current cybersecurity challenges.

As a key component for the protection of citizens in cyberspace, the 2018 coalition agreement provided for the establishment of the interministerial Agency for Disruptive Innovations in Cyber Security and Key Technologies (ADIC) to ensure technological innovation leadership (digital sovereignty). In 2018, the Federal Government decided to establish a private limited company (*Agency for Innovation in Cybersecurity*) for this purpose. This *Cyber Agency* will seek solutions to cybersecurity challenges, the scope and importance of which may not yet be assessable today.

Rapid technological and social change, for example through digitalisation and globalisation, influences both the objective security situation and the subjective perception of security in Germany. On the one hand, the vulnerability of various social groups and the expectations and demands on state and non-state security actors, such as the police, fire brigade or rescue services, are subject to major changes. On the other hand, technological developments offer new opportunities, not least due to the digital transformation. The Federal Government is therefore funding civil security research that consistently uses the potential of digital transformation to protect people and critical infrastructures.

Safety and security

Between 2016 and 2018, **every second company** in Germany recorded a concrete information security incident.



Economy and work 4.0: Towards the future of work

The digital transformation is changing production and services at an unprecedented pace. Even processes and value creation structures that represent the current state of development now are facing major upheavals. Value creation is increasingly shifting to data worlds. This change affects products and services, production and work processes, company structures, working relationships and activities. On the one hand, digitalisation shows ways to efficiently use labour, raw materials, energy and capital and offers attractive opportunities in new, data-driven markets. On the other hand, this is accompanied by a change in the requirements for qualifications and competences of employees in the data economy.

The Federal Government is committed to actively shaping the technological change and the digitalised working world of tomorrow with the involvement of employees, as well as businesses and companies. The *Research Programme Innovations for Tomorrow's Production, Services and Work* focuses on designing solutions which enable production and service pro-

cesses to be developed further in an efficient and environmentally compatible manner and adapted to the new environment of the data economy. In addition, the aim is to design work to be economically and socially compatible both today and in the future so that Germany can successfully maintain its global position as a business location characterised by the social partnership approach.

An important objective of the Federal Government is to connect leading players from industry, the science and research community and civil society in order to jointly develop innovative solutions. The *Industry 4.0 Platform*, one of the world's largest networks on this topic, aims to shape the digital transformation in industry in a coordinated way. Supported by industry, associations, the science and research community, trade unions and policymakers, more than 350 experts are devoting themselves to key challenges in the areas of standardisation, security of networked systems, legal framework, technology and application scenarios, work, education and training, as well as digital business models and offers for practical transfer. The EFI suggests adapting the education system and working conditions to the digital transformation in such a way that the benefits

of technological progress can be enjoyed by all workers. As part of the *Industry 4.0 Platform*, for example, HR managers, works councils, and associations under the leadership of the IG Metall trade union are jointly developing recommendations and practical examples for the future of work in industry.

Economy and work 4.0

39 per cent of commercial enterprises in Germany use the Internet of Things (2018).

Through the programme for *The Future of Work – Innovations for the Work of Tomorrow*, the Federal Government undertakes to promote both technological and social innovations. It is conceived and implemented in close consultation with the social partners. The results of the programme are intended to provide design options as standards for the future of work. It is important that appropriate solutions are developed in particular with and for German SMEs and that all opportunities for employees and companies are used in the same way. SMEs employ around 16 million people in Germany, and four million people are in permanent employment in the craft and trades sector. This means that SMEs, crafts and trades are supporting pillars of the German economy.

The ESF federal funding programme *Centres for the Future* provides targeted support to the eastern German Länder in the digital change process, with the aim of shaping it in a socially responsible way. Qualification programmes in companies are to be reassessed and tested in order to do justice to the changed activities and requirements in all professions as a result of digitalisation, and to promote self-learning and creative competence. A 'Regional Centre for the Future' has been established in each of the eastern German Länder. These centres will make a differentiated assessment of the diverse support needs of the regions and sectors as they deal with digital and demographic change. In particular, they will respond to these needs with innovative qualification schemes at the workplace level. A higher-level 'Centre for Digital Work' supports the 'Regional Centres for the Future' by preparing the research knowledge gathered on digital and demographic change in the labour market and making it available.

2.2 Developing Germany's future competencies

Germany enjoys global recognition as an excellent location for research and innovation. In order to expand this leading position even further, important future competencies must be consistently developed. The Federal Government is systematically pursuing this task through the *High-Tech Strategy 2025*. This is because research excellence not only ensures sustainable development but also opens up new ways to solve the global challenges of tomorrow.

The technological base: Digitalisation, quantum technologies and artificial intelligence

Technological sovereignty is the prerequisite for successfully tackling the grand challenges facing society, for shaping the future in a value-driven manner, for securing and expanding prosperity and jobs, and for preserving an intact environment. This involves having the ability to formulate the requirements for key enabling technologies – including, for instance, setting standards for safety, security, reliability and sustainability – and to work towards implementing this in the global market. It is essential to appropriately coordinate competences in technology development, technology transfer and the use of technologies. Securing and expanding technological sovereignty is an important strategic goal of the Federal Government. In recent years, the Federal Government has launched a number of strategies and programmes to maintain and expand competencies in key technologies such as AI, microelectronics, IT security, battery technologies, new materials and substances, and quantum technologies.

The Federal Government's *Implementation Strategy for Digital Transformation*, presented in November 2018, builds on the *Digital Agenda 2014–2017* and places the federal ministries' priority projects within a common strategic framework. The strategy embraces five fields of action derived from the coalition agreement: 'digital skills', 'infrastructure and equipment', 'innovation and digital transformation', 'society in digital change' and 'modern state'. In addition, two cross-sectional issues

are highlighted: 'safety and security' and 'equality'. In the *Digital Strategy*, the Federal Government focuses on creating better, more sustainable ways of living, working, and doing business, scaling up digital education and training along with the relevant institutions, transforming data into knowledge and innovations, securing technological sovereignty and scientific leadership for Germany, and creating confidence and security. The federal ministries are also creating individual, ministry-specific measures to set additional digitalisation priorities.

Data is steadily growing in significance as a key factor for innovation and value creation. The ability to collect, link and analyse data is becoming a key competence for researchers, enterprises and society as a whole. It is the basis for new business models and will have a significant impact on economic structural transformation and social developments. Managing how data is handled is therefore one of the pivotal concerns of research and innovation policy. The Federal Government's goal is to gain data sovereignty, create data security, guarantee self-determination and enable the creation of value from data.

For new scientific knowledge and innovations in research and society, systematic, ongoing access to digitised data repositories is indispensable. The data collected in different ways in different places must be made available in such a way that it is systematically searchable and easy to retrieve by third parties and can be analysed and linked across the boundaries of individual databases, disciplines and countries. In order to turn scattered research data into systematically organised, scientifically usable data sets with added value for people and the environment, in November 2018 the Federal Government and the Länder agreed to establish and jointly fund a National Research Data Infrastructure (NFDI). The currently often decentralised, project-based and temporarily stored databases in science and research are to be systematically made accessible for the entire German science system as part of the NFDI. The NFDI will be developed by users and providers of research data, who will be working together in consortia to achieve this. The EFI expressly

welcomes the establishment of the NFDI as an important step towards reconciling the partially fragmented research data landscape in Germany. Subject to the provision of funds by the legislative bodies, the Federal Government and the Länder have earmarked up to 90 million euros annually in the period from 2019 to 2028 for the funding of the NFDI in its final stage of development. The funding of the first NFDI consortia is scheduled to start in autumn 2020. The NFDI is also intended to be a core element and key player in the development of the European Open Science Cloud (EOSC) and in further international cooperation.

The Federal Government, the private sector and the science and research community are striving for an efficient, competitive, secure and trusted data infrastructure for Europe. The GAIA-X project is developing the foundations to create a networked, open data infrastructure for companies and citizens alike that is in line with European values. The aim is to network decentralised infrastructure services to form a homogeneous, user-friendly system. The resulting data infrastructure is intended to increase not only the digital sovereignty of those who require cloud services but also the scalability and competitive edge of European cloud providers. For this, it is necessary to accelerate the transfer of knowledge from research to companies, enable new AI-based business models and boost medium-sized companies. In the future, GAIA-X will also be networked with international and European initiatives and activities, above all with projects of the EU Commission. The EFI supports the project's objectives, as improved data availability for German and European actors will create new innovation potential in the field of AI. However, it points out that the intended effects can only be achieved if GAIA-X is implemented quickly and with the appropriate capacity.

Quantum physics provides the technological foundation for the information society. With ever-new experiments and measurement techniques, science has now greatly increased the understanding of the properties and phenomena of quantum physics. Their contribution to the further refinement of current metrology and structuring processes means that quantum technologies are gaining significance in photonics. Conversely, photonic technologies play a key role for the second-generation quantum technologies that are now penetrating everyday life, including innovative satellite communications, quantum computing and new, precise measurement techniques.

The framework programme *Quantum Technologies – from Basic Research to Market* was adopted by the Federal Government in September 2018. This programme aims to systematically fund research in this field of the future and to advance the transfer of research results to the market. The Federal Government has earmarked a total of around 650 million euros for this purpose during this legislative period. In 2019, important initiatives were launched to achieve this. Since March 2019, a strategic initiative with the Fraunhofer Society has been pursuing the application-oriented research and development of quantum imaging and quantum sensor technologies. In October 2019, the Federal Government also launched the 'QuNet' project. The aim of the project is to develop and establish a pilot network for quantum communication in Germany, thus laying the foundation for a pan-European architecture for quantum communication. At the beginning of 2020, the Federal Government also announced a long-term initiative on quantum computing. It aims to build up user knowledge in parallel with preparing a separate hardware option for Germany and Europe. Quantum and high-performance computers can also lead to jumps in innovation in various fields of application, for example for the emerging platform economies, future logistics and mobility of the future, as these will be digitalised, connected, automated and interwoven with a multitude of Internet applications.

As a key enabling technology, AI opens up vast potential for tackling societal challenges and for achieving a sustainable, ecological and climate-friendly way of life and economy. The Federal Government is pursuing the goal of advancing the human-centred commercial and non-commercial application of AI and making this available in a wide range of possible fields. The appropriate regulatory environment should be created for the development and use of AI that meets societal norms and values.

In November 2018, the Federal Government adopted the *Artificial Intelligence Strategy*. The aim of the strategy is to put Germany at the forefront of AI research, development and application. The focus of this will be on the benefits of AI for humans and the environment. Recognising the great importance of AI and in response to growing international competition, particularly with the USA and China, the Federal Government made an additional one billion euros (expenditure and commitment appropriations) available in the 2019 and

2020 budgets. On this basis, a financial input of about three billion euros – including the use of R&D funds to achieve the 3.5 per cent target – can be obtained for implementation of the strategy up to and including 2025.

In 2019, the Federal Government already launched a series of concrete measures to implement the *Artificial Intelligence Strategy*. A total of six AI Competence Centres each form a focal point for the research, development and application of AI in their respective regions. The facilities will be further developed and networked with each other, forming the core of a national research consortium. A joint programme with the Alexander von Humboldt Foundation was launched to attract some of the world's leading scientists and researchers in AI. The first professorships are expected to be conferred in 2020. The establishment of the AI Global Futures Labs is also intended to attract top international researchers to Germany. In addition, international cooperation, including with Sweden and France, is also powering forward. High-performance computing (HPC) also has a significant role to play.

Science Year 2019 was dedicated to artificial intelligence. The action plan *Digitalisation and Artificial Intelligence in the Mobility Sector* explores an essential field of the future for society from a holistic perspective and makes the potential of AI for a mobile lifestyle directly tangible.

With these and other measures, the Federal Government is creating the prerequisites and general framework for exploiting the opportunities and potential of AI.

The Federal Government's *Blockchain Strategy*, adopted in 2019, addresses complex global technological developments and actively engages with their design. The strategy is designed to harness the opportunities offered by blockchain technology (e.g. in supply chains, logistics, customs or the energy industry) and to mobilise its potential for digital transformation. The discernible risks of these technologies are to be minimised and ideally completely eliminated from the outset. This will require developing a specific regulatory framework and, regarding research, establishing fundamental principles and conducting impact assessments.

Artificial intelligence

From 2020 to 2025, the Federal Government will spend **3 billion euros** on implementing the Artificial Intelligence Strategy.

The skills base: Vocational education and training

The development of cutting-edge technologies requires new skills and abilities, as well as state-of-the-art qualification channels. The targeted development of vocational education and training (VET) capacities in schools and vocational and academic settings creates a highly qualified skills base, which is the prerequisite for the development and use of new technologies and their innovative applications.

Ensuring the skills base is one of Germany's key tasks for the future. This task requires the involvement not only of companies and social partners, but also of policymakers and society. The Federal Government is pursuing a comprehensive and systematic approach to initial and continuing education and training through a range of interministerial initiatives.

In December 2018, the Federal Government adopted a comprehensive *Skilled Labour Strategy* in order to secure the skills base for Germany to remain a top business location. Following a three-pillar approach, the priority is to raise potential from the domestic market and within the European Union and also to intensify the recruitment of skilled workers from third countries. Innovation and education are also important fields of action in the Federal Government's *Demographic Strategy*.

Dual-sector VET plays a key role in securing Germany's skills base. In order to update the legal framework in this area, the Federal Government has adopted the Act to Modernise and Strengthen Vocational Education and Training (BBiMoG), which came into force on 1 January 2020. New provisions include the introduction of minimum pay for trainees and extended opportunities for part-time vocational training. Embedding transparent higher education levels in internationally comparable



degree titles such as Bachelor Professional and Master Professional will also increase the visibility of professional qualifications that correspond to academic qualifications. This makes it clear that vocational and academic education and training are equally important.

The Federal Government is committed to making professional advancement easier and supporting upskilling measures. To this end, it has introduced the fourth bill to amend the Promotion of Upgrading Training Assistance Act (AFBG). It envisages the most substantial service improvements since the funding of continuing vocational training was introduced.

In the Alliance for Initial and Further Education, the Federal Government is also working jointly with representatives of the Federal Employment Agency, the Länder, industry and trade unions to increase the attractiveness and quality of dual-sector VET. The aim is for more young people to find in-company training places, for more companies to be able to fill their training positions, and to increase the appeal of VET, with its modern continuing education opportunities and career paths, as an equivalent alternative to academic education. The Federal Government has set itself the goal of promoting continuing vocational education and lifelong learning. VET needs constant readjustment

and innovative reforms to respond to constant changes in the world of work and to secure the skills base. In addition to modern qualification profiles, new forms and methods of teaching and learning are also required, which will increase the long-term attractiveness of VET.

In 2019, the Federal Government launched the *National Skills Strategy (NWS)* with the participation of the social partners, the Länder and the Federal Employment Agency. The *NWS* is the content focus for the domestic pillar of the *Skilled Labour Strategy*. It pursues the goal of bundling together all the continuing education programmes of the Federal Government and the Länder and gearing them towards the needs of employees and companies. While taking account of the opportunities and challenges of digital change, the aim is to ensure that everyone in the world of work has equal opportunities for career change or advancement. The *NWS* is thus laying the foundation for a new culture of continuing education.

The Qualification Opportunities Act, which essentially came into force on 1 January 2019, opens up and expands the funding of continuing vocational education, particularly for employees in bottleneck occupations and in companies affected by structural change. The Act on the Promotion of Further Education in

Structural Change and the Further Development of Educational Support (otherwise known as the ‘Arbeit-von-morgen-Gesetz’ or Work of Tomorrow Act) was passed by the German Bundestag on 23 April 2020 and includes extending and simplifying the funding of continuing education for employees in companies particularly affected by structural change. In addition, it gives employees without vocational qualifications the legal entitlement to financial assistance in order to subsequently complete a qualification. The Act implements a key objective of the NWS: increasing the employability of individuals. The Act is still pending final debate in the Bundesrat.

The Federal Government is promoting the use of digital media in all areas of education – from the *Digital Pact for Schools* to the promotion of inclusion through digital media, including in VET, and the *Advancement through Education: Open Universities* competition jointly funded by the Federal Government and the Länder. In the interests of a forward-looking education policy, the Federal Government is also funding comparative international studies on education as well as empirical educational research.

The aim of the Federal Government’s *Implementation Strategy for Digital Transformation* is to ensure that everyone can take advantage of the opportunities offered by digitalisation. This will be achieved by investing in the digital literacy of teachers and learners and by making the education system more responsive to digital living, digital work and business, and the digital knowledge society.

In the summer of 2016, the ‘*Vocational Training 4.0*’ umbrella initiative was launched as a component of the *Digital Strategy*. It pools and promotes all the activities for structurally and substantively gearing dual-sector vocational training towards the requirements of an increasingly digitalised and networked economy.

The qualification initiative *Digital Transformation Q 4.0*, which was launched in 2019, aims to develop continuing education concepts for vocational training personnel so they will be prepared for the dual-sector education requirements that will accompany digitalisation. It focuses on the fundamental knowledge required for teaching with digital media and on the technical and social skills needed to appropriately design the content and processes of the dual-sector education programme as it undergoes digital transformation.

Competency development also depends on technology-specific measures. Well-trained researchers are needed to develop and design new technologies. Conversely, the transfer of research results into broad application requires qualified employees who can handle the new technologies and adapt them to the needs of the respective field of application. Technology and competence development must therefore be even more closely coordinated with each other. The Federal Government has therefore introduced technology-specific measures for competency development along the entire education chain in its areas of responsibility, for example in the fields of AI, microelectronics and IT security. It will intensify its support of these initiatives in the future.

Skills base

55 per cent of companies in Germany rate the skills shortage as a risk.

Societal participation: Shaping the future together

The development of a targeted research and innovation policy needs to be embedded in society through the participation of science, industry and society. To this end, the Federal Government wants to enter into dialogue with civil society, stimulate curiosity and openness for innovative developments, and give research and science the opportunity to benefit from the exchange with society and the knowledge of the many.

This is what the Futurium stands for as a place where citizens can inform themselves about cutting-edge scientific and technological developments. In addition, it should also provide them with the opportunity to take part in discussions on solutions to future challenges and to provide suggestions for foreseeable, conceivable and desirable designs for the future. Apart from the Federal Government, German research organisations, companies conducting research in Germany and research foundations are also involved in the Futurium.

The Federal Government and its various ministries are conducting consultation and agenda processes on various research topics and key technologies in order to ensure that the knowledge and funding needs of science, business and social actors are taken into account in the programme design, that research and development processes are carried out responsibly, and that the opportunities and risks of innovations and technologies are assessed. For example, an online consultation process was carried out in the course of preparing for the *Blockchain Strategy* in order to incorporate suggestions and expert opinions into the strategy, especially from associations, businesses and organisations. The comments of 158 experts formed an essential basis for identifying the challenges from the users' point of view and for the subsequent design of the strategy.

Civil society is also actively involved in agenda processes. In order to structurally anchor sustainability in all areas of education, the Federal Government has set up a participatory multistakeholder process to develop and implement the *National Action Plan on ESD* (Education for Sustainable Development). More than 300 organisations from civil society, politics, education, science and business participate on the National Platform in expert forums and partner networks. A specially established youth forum of 25 young people aged between 16 and

23 is accompanying the process. Citizens contribute their ideas through numerous events, such as the ESD Agenda Congress and an annual youth conference. Social change processes and transformations that are guided by the vision of sustainable development are key research topics in *FONA*. This priority funding for social ecological research focuses in particular on the question of how we can better involve citizens in decision-making processes.

It is already evident today that more and more people from a broad spectrum of society are becoming directly involved in research. Digitalisation opens up more opportunities for individuals to participate in citizen science projects. For example, the funding and application of open standards and open source approaches provides opportunities for civil society participation and broad knowledge transfer.

Committed citizens are actively involved in research projects by collecting and evaluating data or developing research questions in cooperation with professional scientific research partners. The online platform 'Bürger schaffen Wissen' (citizens create knowledge) offers the opportunity for networking and provides specialist information on the implementation of citizen science projects. Citizen science does two things: it encourages committed people to engage with the topics and research questions of science and get to know scientific methodology, and it gives researchers access to the 'knowledge of the many', enabling them to gear their research more strongly towards the needs of society. Participatory research projects will continue to be supported in the future. To this end, the platform published another open-topic funding guide for citizen science projects in October 2019.

The involvement of civil society actors is also an important focus of the National Decade against Cancer because health research is only successful if people actually benefit from it. The aim of the Decade against Cancer is to consistently engage civil society in oncological research topics – for example through self-help organisations or other patient groupings – and involve citizens in all phases of research, from formulation of the research question to exploitation of the research results. This means that citizens will contribute additional perspectives and expertise through this active participation.

The Federal Government is supporting this development as it resolutely continues the tradition of dialogue and expands it with new participatory formats. The expertise of prestigious Federal Government advisory bodies provides valuable guidance in the implementation and ongoing development of *HTS 2025*.

The key concern of the framework programme for *Humanities, Cultural Studies and Social Sciences*, which was updated in 2019, is that these disciplines should unfold their full potential and make a lasting contribution to the development of a sustainable society. The Federal Government has earmarked more than 700 million euros in project funding until 2025 to achieve this. This provides the framework for focusing research in the humanities and social sciences more towards practical application, for example through cooperation with partners in the field or through better communication of scientific knowledge. Another key goal of the framework programme is to provide the humanities and social sciences with scope for design and development, allowing them to set their own topics and push forward scientific developments. The third priority is to continue developing high-performance research data infrastructures.

A Research Institute for Social Cohesion (FGZ) is being established in Germany to structure the process. The groundwork for the multidisciplinary institute, which has eleven locations in ten German states, was developed in an initial concept phase, and the FGZ is expected to start its research and transfer activities in the summer of 2020. In order to strengthen social cohesion, the Federal Government is also funding research projects on fostering democracy and diversity and preventing extremism, for example projects on early distancing from religiously motivated radicalisation and on the resilience of young people in the face of conditions that promote radicalisation. The German Centre for Integration and Migration Research (DeZIM) also investigates the causes, forms, practices and consequences of social conflict dynamics for the migration society and plural democracy.



2.3 Establishing an open innovation and venture culture

Germany is on the move. Creativity, agility and openness to new ideas are the keys to shaping the society of the future and opening up new perspectives for prosperity and quality of life. For innovative results, we need innovative forms of cooperation that create spaces for thinking, bring actors together in new constellations and contribute to the effective implementation of ideas and outcomes that benefit the people. The Federal Government promotes an open innovation and risk culture in order to build bridges between science, industry and society and boost the transfer of research results into practice. Working hand in hand throughout the innovation process is the key to success, so that research can benefit the people.

Putting knowledge into effect

Through *HTS 2025*, the Federal Government is supporting the exchange of ideas, knowledge and technologies. It is helping to ensure that we pass rapidly and successfully along the often risky path that leads from discovery to exploitation. Digital technologies facilitate the creation of new knowledge and its translation into economic and social value. Open science and open innovation enable new ways of finding common ideas and new ways of accessing and sharing knowledge. With its mission of ‘Finding new sources for new knowledge’, the Federal Government is actively striving to open up science and innovation. Free digital access to scientific publications contributes to speeding up research processes, making them more efficient and open, as well as ensuring their transparency and quality through better reproducibility and fostering scientific freedom. This requires a science-friendly legal framework in copyright law that promotes open access and the free flow of knowledge. With its *Open Access Strategy*, for example, the BMBF is already ensuring that research results funded by the ministry are always published openly. The national *Open Access Strategy* aims to establish open access as a standard in scientific publishing.

The open handling of data and knowledge promotes the intra- and transdisciplinary exchange between and within the private sector, science, and departmental research institutions that is necessary to develop innovative and sustainable solutions on a holistic level. One way the Federal Government is fostering such cooperation is through an expert network that is researching urgent future challenges in the transport sector in an interdisciplinary manner across different authorities and transport modes and is offering innovative and practical solutions by integrating the science and user levels.

The Federal Government has launched targeted initiatives on other key current topics in order to accelerate the transfer of research results into application, including, for example, the establishment of a battery cell research production facility, a pilot network for quantum communication, and application hubs for AI methods.

HTS 2025 is based on an understanding of innovation that gives equal consideration to technological and social innovations. Through its current pilot funding under the *Innovation Programme for Business Models and Pioneering Solutions (IGP)*, the Federal Government is striving to open up the innovation system for ideas outside the classical research laboratory. The aim is to win over innovators in the cultural, service and creative industries, including freelancers, skilled professionals in trades and crafts, and young SMEs. At the same time, non-technological innovations are also being explicitly addressed for the first time. Social innovation includes new social practices and organisational models aimed at finding sustainable solutions to the challenges facing our society. It is a particular concern of the Federal Government to open up research funding more widely to social innovations and to focus it on important social goals. A multi-stage innovation competition is being prepared for 2020 in order to develop and guide research in social innovations.

As test rooms for innovation and regulation, real-world laboratories are renewing the Innovation Country Germany. In real-world laboratories, creative companies, administrations and researchers test such things as autonomous vehicles or new digital services and procedures in healthcare or public administrations – innovations that were unimaginable just a few years ago. The Federal Government is funding the real-world laboratories in order to test innovative technologies or business models under real conditions.

The Federal Government is also taking an equally new path in innovation policy by establishing the *Federal Agency for Disruptive Innovation (SprinD)*. It is intended to operate at the level of global innovation and provide the greatest possible scope for creative minds in ambitious R&D projects that have high disruptive innovation potential. In the future, *SprinD* will identify trends and developments with cutting-edge innovation potential at an early stage, develop them further in subsidiaries specially formed by the agency, and thus help them to achieve the breakthrough. The Federal Government intends to make around one billion euros available for this over the next ten years. Even before the agency was founded, the Federal Government launched three pilot innovation competitions on the topics of ‘Energy-efficient AI systems’, ‘Replacement organs grown in the laboratory’ and ‘World storage’.

The innovation clusters, the new flagship initiative of the Federal Government’s *HTS 2025*, make a special contribution to knowledge and technology transfer. Under the banner of ‘Clusters4Future’, this uses the regional approach to cluster funding to tie in directly with top-level research and bring science, businesses – especially from the SME sector – and other players together in the open innovation culture of a cluster. They offer an ideal environment for expanding knowledge and technology transfer through new partners in the knowledge and value chain and thus for quickly and sustainably developing emerging fields of innovation. To this end, R&D funding is being supplemented by flexible approaches to the support of innovation and will be made more open to social innovations, for example through open innovation, i.e. the involvement of citizens and users, as well as education and training or start-up support. The Federal Government has earmarked approximately 450 million euros for the first two rounds of funding.

New ideas, new knowledge and new technologies emerge daily in our diverse university landscape. The close and reciprocal exchange between universities and actors from the private sector, culture and civil society is therefore an important engine for innovation. Funding under the programme for *Strong Universities of Applied Sciences – providing fresh impetus for their regions (FH-Impuls)* supports research and innovation partnerships, primarily with SMEs, that are initiated and coordinated by universities of applied sciences in a joint research environment. In this way, research will provide stimulus for regional innovation. The joint Federal-Länder initiative *Innovative Hochschule* continues to promote the establishment and expansion of cooperation with the private sector and other social actors in a strategic and translatable way, thus scaling up the strategic role of universities in the regional innovation system.

Federal Agency for Disruptive Innovation

SprinD – the Federal Agency for Disruptive Innovation – will be funded with around **1 billion euros** over the next ten years to bring disruptive innovations more rapidly to market.

Strengthening entrepreneurial spirit: The courage to innovate

Germany is a leading location for innovation. The German economy is one of the ten most research-intensive economies in the world. Besides large companies, SMEs and especially start-ups also need to be involved in the innovation process. With its research and innovation funding under the umbrella of *HTS 2025*, the Federal Government has strengthened the innovation landscape in recent years and established viable research networks for SMEs and start-ups. However, in addition to excellent research results, entrepreneurship, courage, determination and a new entrepreneurial culture are needed in the search for new business ideas and in the development of innovative products and services. The Federal Government provides support along the way for entrepreneurs who have this courage.

SMEs are a driving force of economic development in Germany. Despite their limited human and financial resources, they carry out significant research, development and innovation activities. For this reason, the Federal Government is focusing on further increasing the innovator ratio especially among SMEs so as to activate their innovative potential, thus improving the opportunities for developing radically new, innovative products and services. The *ten-point programme 'Priority for SMEs'* supports SMEs in networking with other actors and in making research results more applicable for themselves.

The Federal Government supports the transfer of knowledge and technology between research institutions and SMEs through the *Central Innovation Programme for SMEs (ZIM)*, particularly when it comes to R&D projects with a high degree of innovation and good chances of market exploitation. Reinforcing the innovation activity of SMEs with little or no experience of funding lies at the forefront of the *Innovative SMEs initiative (KMU-innovativ)*, which is being launched for selected innovation topics. From 2020, tax incentives for R&D will serve as additional instruments to support innovation activities.

Newly founded companies – especially from within universities – creatively transform research results into new products and business models and are therefore an elementary component of every innovation ecosystem. The Federal Government's aim is to grow innovative start-ups in their early stages by providing advice and funding – including, for instance, improving their access to venture capital – thus counteracting the decline in start-up dynamism and the lack of innovative young entrepreneurs. As the EFI also notes, the *EXIST* programme in particular has contributed to positive development in the culture of entrepreneurship at German universities. The *EXIST Culture of Entrepreneurship – Entrepreneur University* competition supports universities in developing and implementing their own strategy for a university-based start-up culture and entrepreneurship. In addition, through the new *Start-UpLab@FH* funding measure, the Federal Government is specifically creating scope for practice-based research and start-ups in the spirit of scientific entrepreneurship at universities of applied sciences.

Young knowledge- and technology-based start-ups usually rely heavily on external capital, and it is often difficult for them to obtain sufficient financing for their R&D activities. Therefore, the Federal Government aims to provide additional financing instruments to support private sector involvement in the venture capital market. One example is the public-private venture capital investment firm *High-Tech Gründerfonds (HTGF)*, which invests in young, promising technology companies.

Company start-ups in the digital sector play a special role in the ongoing development of the German start-up landscape. The *Digital Innovations Start-up Competition* supports new businesses that have innovative information and communication technologies as a key component of the product or service.

Using knowledge and innovation networks: National and international cooperation

The productive capacity of innovative locations no longer depends solely on tightly integrating science and business in regional and national knowledge networks and clusters. To remain competitive and innovative, companies must share their own skills with others and expand them by incorporating international know-how without becoming dependent on others. Therefore, the Federal Government wishes to make even greater use of the potential and opportunities for Germany that lie in international cooperation and networking. International projects and networks offer Germany the opportunity to develop an even clearer definition of its role in the converging areas of business, science and education and to position German science and research more effectively on the international playing field. The European Union plays a key role in Germany's international activities.



In view of increasingly transnational processes of knowledge generation and value creation, it is essential to expand the cooperation of universities, research institutions and companies with international partners. In its current annual report, the EFI recommends placing greater emphasis on international forms of cooperation and networking in the promotion of research and innovation. German Centres for Research and Innovation play an important global role as joint showcases and points of contact at major science hubs. National funding programmes for cooperation and networking with international partners are already available today as a springboard for German SMEs to launch more intensive activities abroad. The programme for the *Internationalisation of Leading-Edge Clusters, Forward-Looking Projects and Comparable Networks* offers SMEs in particular the opportunity to participate in international partner networks, with the aim of striding forward in innovation through involvement in international research projects. Additional incentives for German SMEs to enter into international cooperations have been created through the ongoing expansion of the *ZIM* innovation programme for SMEs. The Federal Government's umbrella programme *International SMEs* helps provide SMEs with access to the value creation potential to be found in European and international cooperation and economic relations.

2.4 Outlook and ongoing development of the High-Tech Strategy

Today's political decisions should already take into account tomorrow's world and the challenges of technological and social change to come, and it is important to involve a variety of stakeholders in this process. The High-Tech Forum and the participatory process for the *High-Tech Strategy* are designed to cultivate intensive dialogue with science, industry and society on the implementation and continuing development of research and innovation policy. Innovation and technology analysis and the new foresight process also focus on questions about tomorrow's world, the opportunities and risks facing society, and the decisions that need to be taken today to answer these questions.

The High-Tech Forum and the participatory process

Since its introduction in 2006, the *High-Tech Strategy (HTS)* has been an agile strategy, i.e. it has been continuously developed and adapted to technological and social developments. This agility is also reflected in the High-Tech Forum's advisory process, which brings together stakeholders from science, business and civil society. The committee regularly publishes impulse papers outlining the results and can also propose new topics for consultation. For this purpose, stakeholders such as professional associations or the participants in the expert workshops are specifically approached and asked for their comments. As a result, the High-Tech Forum is in a position to provide advice that is timely and directly geared to the political process.

A dialogue on the future of research and innovation is being initiated between the participants and the Federal Government in a broad participatory process to further develop the current research and innovation strategy, *HTS 2025*. The starting point in terms of content is the new three-fold focus of *HTS 2025*: technologies, skilled workers, and society. After all, promoting research and technology, developing initial and continuing education, and engaging the interest and participation of society are all closely interrelated. Closely dovetailing these three areas is necessary to shape technological or social changes. The process

explicitly addresses people who work at various points in our research and innovation system or have a special connection to it, for example through their voluntary work. On the one hand, they are directly impacted by the outcomes of research and innovation policy and, on the other hand, they have special insights into the various areas of the system.

Innovation and Technology Analysis (ITA)

The Innovation and Technology Analysis (ITA) process analyses and evaluates interdisciplinary social and technological innovation topics with regard to their risks and benefits over a time horizon of about five years. The sound information base it provides contributes to a better understanding of new developments and a transparent dialogue process. Citizens are specifically involved in the impact assessment. The analysis of topics in the area of conflict between technological possibilities, social values and developments, and economic requirements supports the design of future innovation policy.

Foresight

In the course of foresight processes, descriptions of technological trends and social changes with a long time horizon are prepared with the help of experts as the basis for discussion with representatives from politics and society. This instrument of strategic foresight provides direction for policymakers, society and industry by helping to identify new topics of high strategic relevance for research and innovation policy.

The Federal Government has launched the current process of strategic foresight under the theme of values and value change in Germany. Running until 2022, various topics of future relevance will be described and examined in greater depth with the support of a Foresight Working Group made up of 17 experts from a wide range of disciplines. The foresight process covers a wide range of topics and is devoted to both



3 Strengthening excellence in science and research

The cornerstone of Germany's strong research and innovation capability is having an efficient knowledge and research system that empowers teaching and higher education and produces scientific excellence. The Federal Government is committed to achieving these goals by raising the profile of this field and pursuing excellence in it. The Federal Government will continue to promote science, research and innovation in Germany in cooperation with the Länder.

The Federal Government and the Länder have already created a great deal of momentum and perceptibly boosted the competitiveness of the German knowledge and research system through the *Pact for Research and Innovation*, the *Higher Education Pact 2020* and the *Excellence Initiative*, first adopted in the mid-2000s. Since 2007, there has been an independent funding mechanism for *Research Facilities and Large-Scale Equipment at Universities*.

In 2016, the decision was taken to expand the total funding package for universities to reinforce Germany's future viability. The measures include the *Excellence Strategy* as the permanent successor to the *Excellence Initiative*, the *Tenure-Track Programme* for early-career researchers and the joint Federal-Länder initiative *Innovative Hochschule*. In November 2018, the Federal Government and the Länder also decided to continue the programme for *Research Facilities and Large-Scale*

Equipment at Universities and to include the *National Supercomputing System* in the joint funding. The Federal Government and the Länder also support universities of applied sciences in recruiting professors through the programme ‘*FH-Personal*’ for the recruitment and professional development of professorial staff at universities of applied sciences. The *Research at Universities of Applied Sciences* programme has also made a decisive contribution to the fact that, alongside teaching, applied research has established itself nationwide as another important feature of universities of applied sciences. The required interdisciplinary research work within the universities as well as with other research partners is playing an increasingly important role in this context. In this way, the universities of applied sciences are boosting their research profile in order to increase their visibility as a powerful partner for science, business and society.

The science pacts were adopted in June 2019 as a package in three joint Federal-Länder agreements to promote Germany as a location for science and innovation. This will fund universities and non-university research institutions alike. The total funding package addresses the most important missions: higher education and teaching, research and transfer. These include the extension of the *Pact for Research and Innovation*, the *Future Contract for Strengthening Studying and Teaching in Higher Education* as the successor to the Higher Education Pact, and the joint Federal-Länder agreement *Innovation in Higher Education Teaching*.

Completion of doctorates

Women submitted around 45 per cent of overall **27,800 successfully completed doctoral degrees** in 2018.

Pact for Research and Innovation: Improving the framework

The *Pact for Research and Innovation*, which has been in place since 2005, will be extended with explicit targets to scale up support for jointly funded large research organisations until 2030. In June 2019, the Federal Government and the Länder adopted the fourth phase of the *Pact for Research and Innovation*.

This is the first time that the pact will run for a period of ten years (2021–2030). During this period, the Federal Government and the Länder aim to grant the individual research organisations an annual increase in funding of 3 per cent – subject to annual budget negotiations with the institutions and to the provision of funds by the legislative bodies. The Federal Government and the Länder will jointly carry this increase in accordance with the funding formulas specified in the agreements. Over the next ten years, the Federal Government and the Länder will invest a total of approximately 120 billion euros in the non-university research landscape and in the German Research Foundation (DFG) within the scope of available budget funds.

The pact gives the research organisations long-term financial planning security. In return, the Federal Government and the Länder have signed target agreements with them. In 2025, the results achieved will be evaluated by the Joint Science Conference (GWK), and the target agreements for the second half of the *Pact for Research and Innovation* will be further developed in collaboration with the organisations and adopted by the GWK. This planning security gives the research organisations the scope to continue refining strategic measures, expand existing instruments and develop new ones. In return, the funded organisations commit themselves to research policy goals, which they will design and implement themselves. In 2020, the EFI again expressed its approval of the increased focus on knowledge and technology transfer. This focus is demonstrated, for instance, by the fact that the new target agreements include regulations so that research organisations can develop new instruments for knowledge and technology transfer and can recognise and promote successful transfer through internal incentive instruments.

The research organisations will carry out appropriate research audits and regularly report to the GWK on the fulfilment of the objectives using meaningful indicators. The Federal Government and the Länder will assess the progress made by the organisations against the targets set in the target agreements and international benchmarks, summarising this in a monitoring report.

Non-university research

Through the extension of the *Pact for Research and Innovation*, the Federal Government and the Länder will be investing **120 billion euros** in non-university research throughout this decade.

Future Contract for Strengthening Studying and Teaching in Higher Education: Raising quality

Through the *Higher Education Pact*, which has been in place since 2007, the Federal Government and the Länder are supporting universities in creating additional study opportunities for first-year students. This is a reaction to the sharp increase in demand for study places. In June 2019, the heads of the Federal Government and the Länder adopted the new joint *Future Contract for Strengthening Studying and Teaching in Higher Education* as the successor to the *Higher Education Pact*.

The *Future Contract for Strengthening Studying and Teaching in Higher Education* represents their shared commitment to sustainably improving the quality of higher education and teaching at universities across the nation. At the same time, the supply of student places in Germany is being secured in line with demand. Almost three million students will benefit from better higher education conditions and greater teaching quality at all universities.

The financial planning security of the funding, which will be permanent from 2021 onwards, is intended to provide particular support in expanding permanent employment contracts for staff involved in higher education and teaching at universities. The EFI welcomes the sustained participation of the Federal Government in the funding of teaching as well as the planned regular review by the German Council of Science and Humanities, the results of which are to be taken into account in consultations between the Federal Government and the Länder.



Subject to the provision of funds by the legislative bodies, the Federal Government will provide 1.88 billion euros annually from 2021 to 2023 and 2.05 billion euros on a permanent basis from 2024 onwards. In addition to the basic funding of universities, the Länder will provide funds to the same amount in the same year, so that the *Future Contract for Strengthening Studying and Teaching in Higher Education* will make around 3.8 billion euros available annually until 2023 and a total of 4.1 billion euros annually from 2024 to promote higher education and teaching.

Higher education and teaching

From 2021, the Federal Government and the Länder will support higher education and teaching to the tune of **4 billion euros** per year – a reliable and long-term commitment through the new *Future Contract for Strengthening Studying and Teaching in Higher Education* and the new agreement on *Innovation in Higher Education Teaching*.

Strengthening Innovation in Higher Education Teaching

The *Quality Pact for Teaching* has made a decisive contribution to improving study conditions and the quality of teaching. In June 2019, the heads of the Federal Government and the Länder adopted the new joint agreement *Innovation in Higher Education Teaching*, which will boost the revitalisation, visibility and relevance of teaching in higher education. This is the first time that the funding of innovative teaching is being institutionally anchored.

Important objectives of the joint agreement on *Innovation in Higher Education Teaching* are to promote the ongoing development of higher education teaching and to reinforce it in the higher education system as a whole. The joint agreement will fund research-driven projects that focus primarily on promoting the strategic and structural capacity of universities in teaching and learning and that address current topic-related challenges in this area as well. In addition, it will support the organisation of transnational exchange and networking, as well as knowledge transfer. The EFI supports the goal of further improving the quality

of higher education and teaching and advocates that the experience and concepts of the universities gained from the *Quality Pact for Teaching* should also be integrated in the implementation.

The GWK has selected the Toepfer Stiftung gGmbH as the implementing institution for the organisational unit on *Innovation in Higher Education Teaching*. The new organisational unit is to use appropriate funding formats to provide incentives for university teachers and university management to continue their efforts in improving the quality of studies and teaching and supporting the exchange and networking of relevant actors.

Subject to the provision of funds by the legislative bodies, the Federal Government and the Länder will make up to 150 million euros available annually for the promotion of *Innovation in Higher Education Teaching*. Financing will initially be provided by the Federal Government alone from 2021 to 2023 and then jointly by the Federal Government (110 million euros) and the Länder (40 million euros) from 2024 onwards.

Degree qualifications

303,000 students – including around 100,000 in STEM subjects – successfully completed their studies in 2018 (first-time graduates).

Excellence Strategy: Promoting research excellence

The amendment to Article 91b of the Basic Law has given the Federal Government and the Länder new scope since 2018 to sustainably boost leading-edge research at German universities through the *Excellence Strategy*. In contrast to its precursor, the *Excellence Initiative*, the *Excellence Strategy* is not limited in duration but is instead planned for the long term. The aim is to strengthen Germany as a location for science and research in the long term and to further improve its international competitiveness.



Cutting-edge research at universities

The Federal Government and the Länder provide funding of **533 million euros** annually to support cutting-edge research at ten universities of excellence, one excellence network and 57 clusters of excellence.

The research activities of universities and their co-operation partners in cases of supra-regional importance are covered by joint funding in the *Excellence Strategy* under two funding lines: Clusters of Excellence and Universities of Excellence.

The Clusters of Excellence programme provides project-related funding for internationally competitive fields of research at universities or in university networks. In September 2018, the so-called Excellence Commission selected a total of 57 clusters of excellence for funding. The applications of 88 clusters of

excellence from 195 reviewed draft proposals had previously been approved in a two-stage procedure. Since January 2019, clusters have been funded at a total of 34 universities.

Building upon the Clusters of Excellence funding line, the second funding line, Universities of Excellence, sets out to strengthen universities or an alliance of universities as an institution and to expand their international leading position in research. As a result of the first call for proposals, funding for ten universities and one university alliance was announced in July 2019. Funding commenced in November 2019.

The *Excellence Strategy* has been allocated a total of 533 million euros per year since 2018, subject to funding from the legislative bodies. The funds are jointly provided by the Federal Government and the respective host Länder at a ratio of 75 : 25.



4 Promoting progress through internationalisation

Germany is globally networked and benefits from open markets, international exchange of knowledge and free trade, as well as from a barrier-free EU. One of the tasks for the future is to maintain and grow the openness of the German and European research and innovation system and to support free knowledge flows and mobility. Germany is also committed to scientific freedom on a global level. The Federal Government is setting strategic priorities for international research cooperation through its *Strategy for the Internationalisation of Education, Science and Research*. This focuses on both the importance of innovation and research for Germany and Germany's international responsibility.

As one of the world's leading locations for research and innovation, Germany has both the potential and the responsibility to actively shape future challenges on a global level. We are aware of our duty to contribute to finding pioneering answers to the global challenges facing our societies and economies. We also know that solutions must be found primarily in international cooperation.

Global challenges such as climate change, the increasing demand for resources and food, and global security and protection against disease cannot be tackled at national level alone but require joint international cooperation. With this in mind, the Federal Government is committed to expanding cooperation in R&D activities and finding solutions to urgent societal challenges. The international networking of all German

actors in science and research and their integration into transnational knowledge flows can make a decisive contribution to this.

International networking also ensures the competitiveness and productive efficiency of German science and industry and is therefore consistently supported by the Federal Government. The European Union will always remain the central pillar of Germany's international engagement.

Foreign scientists and researchers in Germany

In 2017, **47,500 foreign scientists and researchers** did research and taught at German universities.

German EU Council Presidency and the European Green Deal

On 1 July 2020, Germany takes over Presidency of the EU Council. In addition to dealing with the consequences of the COVID-19 pandemic, an ambitious priority topic on the agenda of the German EU Council Presidency is the repositioning of the European Research Area (ERA) to strengthen the general framework for science and innovation in Europe. The aim is also to bring negotiations to a successful conclusion on the EU research and innovation framework programme *Horizon Europe* (2021–2027), with a budget proposed by the European Commission of almost 100 billion euros, and *Erasmus+*, the EU programme for cooperation in education.

EU research funding programme Horizon 2020

Between 2014 and 2019, **7.3 billion euros** in funds from the EU research funding programme Horizon 2020 flowed to Germany.

The Federal Government is committed to integrating and linking education and research more closely together to ensure that the entire knowledge system is in a better position to successfully inform the radical technological and social changes of our time. The focus is on the challenges of sustainable development, digitalisation and the skills shortage. To this end, vocational education and training (VET) will be boosted throughout Europe. Germany, Portugal and Slovenia will coordinate the work priorities of their successive EU Council Presidencies from 2020 to 2021 as a so-called Trio Presidency. They intend to set common priorities, closely mesh initiatives and anchor them in the European agenda. Particularly in view of the UK's exit from the EU and ongoing negotiations on the future EU financial framework, joint action by member states, the European Commission and the European Parliament is needed to ensure the successful implementation of the goals set for the German EU Council Presidency in 2020.

At the end of 2019, the European Commission presented the *European Green Deal* as a strategy to achieve climate neutrality in Europe by 2050. This is backed up by a concrete investment plan. The aim is to transform the EU into a fair and prosperous society with a modern, resource-efficient and competitive economy, in which economic growth is decoupled from resource use. Other objectives are the preservation and improvement of natural capital, the health and well-being of people and protecting people against environmental risks. The transformation process will be as fair, inclusive and participatory as possible, and the people, regions and industries most affected by the challenges will be supported through activities mobilised as part of the 'Just Transition Mechanism'. In this way, broad support of civil society, businesses and public authorities at all levels will underpin the *European Green Deal*. In addition to measures in other policy areas, such as the expansion of emissions trading, research, education and innovation play an important role in the implementation of the *European Green Deal*. The Federal Government is making an important contribution to this through measures such as its *National Hydrogen Strategy*.

Knowledge and technology cooperation with China

China has emerged as one of the world's leading economic and scientific nations. Steadily rising R&D expenditure and the continuous expansion of the innovation system have resulted in China now having a large capacity for innovation. In numerous fields of technology, research is also being carried out at the highest level on a global scale, and in some areas China has already achieved technological leadership. China is also one of Germany's most important trading partners. Although the great interest of German actors from science, research and industry in China is unabated, China is being increasingly perceived as a competitor in global competition.

China and Germany have been important strategic partners in research and education for more than four decades. Both countries have stepped up cooperation over the past few decades in order to increase their innovative strength. As part of the bilateral *Scientific and Technological Cooperation (WTZ)* programme, the Federal Government is funding collaborative projects on environmental and climate research, life sciences, electromobility, digital economy (Industry 4.0), and higher education and vocational training, in addition to the exchange of students and scientists.

Scientific cooperation with China poses special challenges for German actors in science and research, for instance, due to the different administrative conditions for the work of research organisations on the ground,



cultural differences or a different understanding of the freedom of scientific research. In order to strengthen its agency in scientific and economic exchange relations with China, the Federal Government has set the development and expansion of intercultural competence on China as a high priority. It is funding eleven competence centres for this purpose at German universities. Activities include teaching language and cultural competence, German–Chinese events, joint study programmes with Chinese partner universities and student exchanges. As well as activities targeting students and employees at universities and research organisations, other measures are currently being developed to address building the competence of trainees and school students in this area. The Federal Government is also supporting German research actors in their cooperation with Chinese partners according to specific target groups. At the European level, there is a continuous exchange with China.

In addition to promoting higher education, early-career researchers, knowledge transfer and innovation, within the context of the guidelines for policy on Africa and as part of the *Africa Strategy* the Federal Government is stepping up research cooperation to implement the United Nations Sustainable Development Goals (SDGs). One focus is on adaptation to climate change. Since 2010, two regional competence centres for climate change and sustainable land management have been jointly established and expanded with African partner countries in western and southern Africa. The Federal Government is currently driving forward cooperation in the field of using green hydrogen technology as an energy source of the future, offering new opportunities for African countries as producers of green hydrogen. In addition, there are two important cross-sectional issues: digitalisation and promoting the participation of women in higher education, research and innovation.

German scientists and researchers abroad

In 2017, as many as **14,700 German scientists and researchers** were temporarily doing research and/or teaching at foreign research institutions.

Cooperation with Africa

Germany has a long tradition of scientific education and research cooperation with countries in Africa and will continue to intensify this. At the interface between education, research and innovation, the focus is on the qualification of people in order to boost economic and social participation, improve future prospects and increase sustainable development opportunities in Africa.

The Federal Government's instruments range from exploring and initiating future collaborations to implementing concrete research, innovation and education projects, developing joint funding programmes and operating joint research infrastructures.



5 Opening up new prospects through education and integration

A good education creates better prospects. It is essential for improving the opportunities and participation of every individual, as well as for the prosperity and innovative capacity of our country. From early childhood education, schooling, vocational training, and higher education to lifelong learning and continuing education – education is the key to integration and advancement and the basis for a competitive research and innovation system. Continuous advances in digitalisation, globalisation, demographic change and the need to secure our skills base are current challenges that our education system must face.

Digitalisation in education

Digitalisation poses new challenges to our education system and offers new opportunities, especially in the current pandemic crisis. Over the next few years, the Federal Government intends to make a greater contribution to ensuring that everyone can make use of the

opportunities offered by digitalisation and master the complex and rapidly evolving skills required for qualification. This will be achieved by investing in digital literacy and by making the education system more responsive to digital living, digital work and business, and the digital knowledge society. Open standards and non-discriminatory access to information and solutions will be ensured.

Through the *Digital Pact for Schools*, adopted in 2019, the Federal Government and the Länder will work together to improve the provision of schools with modern digital technology and infrastructure so they can use digital media and teach digital skills. In addition, the Federal Government and the Länder are jointly funding improvements in teacher training quality at German universities through the *National Programme to Improve the Quality of Teacher Training*. In order to meet the need for action, especially in the area of digitalisation, the Joint Science Conference (GWK) has decided to step up its activities, for instance in the area of 'Digitalisation in Teacher Education', from 2020 onwards. The aim is to provide targeted support for projects dedicated to improving the digital skills of teachers and to the use of digital media in learning contexts.

Digital Pact for Schools

The *Digital Pact for Schools* provides **5.5 billion euros** for digital infrastructures in schools in Germany and sets new incentives for digital education.

Digital media and digitalised learning opportunities in particular offer a high degree of flexibility for rapid adaptation to new developments and changing needs, and provide new and attractive access to learning and skills development for responsible use of digital media for all target groups. The joint Federal-Länder competition *Advancement through Education: Open Universities* provides fresh impetus for digital teaching and learning. The focus is on questions of how to design digital media, combining online with face-to-face learning, and also 'professional Massive Open Online Courses (pMOOCs)', which enable the education system to be opened up further on a low-threshold level, enabling all people to participate.

The flexible and dynamic dual-sector training system is basically well equipped to cope with the changes brought about by digitalisation. Nevertheless, the dynamic developments in the field of digitalisation and automation along with the increasingly digitalised and networked economy require structural and substantive adjustments. This is taken into account in the continuous modernisation of initial and continuing education regulations in line with the requirements of the world

of work. The Federal Government and the social partners in joint consensus with the Länder responsible for the school-based aspect of vocational training are working together on the development of initial and continuing education regulations.

The Federal Government is committed to decent digital work which has a positive effect on employability and supports the continuous development of opportunities for qualification and further training for a digitalised working world. As part of its *Digital Strategy*, the Federal Government is coordinating existing and new measures under the umbrella of the *Vocational Training 4.0* initiative.

At the same time, the special programme for the promotion of *Digitalisation in Inter-Company Vocational Training Centres (ÜBS) and Competence Centres* was expanded in 2019 to provide particular support to SMEs in modernising their training of skilled workers. Funding is available for the provision of digital equipment in the training workshops and teaching rooms of inter-company vocational training centres. In addition, support is given to projects run by inter-company vocational training centres in which new technology is transferred to training, new concepts are developed, and training personnel are suitably qualified. The qualification initiative *Digital Transformation Q 4.0*, which was launched in 2019, will also develop professional development concepts for vocational training personnel. The aim is to further develop media education knowledge along with the technical and social skills needed to promote a dual-sector education system that is state-of-the-art in both method and content, as it undergoes digital transformation. Digital media in particular can make an important contribution to the modernisation of vocational education. The funding programme *Digital Media in Vocational Education and Training* aims to specifically embed teaching and learning with digital media in initial and continuing VET. This includes, for example, the creation and use of e-portfolios, open educational resources (OER), and augmented reality and virtual reality concepts.

The Federal Government is focusing on digitalisation issues with its research focus on digitalisation in the education sector within the *Framework Programme for the Promotion of Empirical Educational Research*. The funding focuses on fundamental questions and conditions for the success of digitalisation processes, the requirements for their implementation, and the design of educational processes under the conditions of digital change.

Integration through education

Every fourth person living in Germany has a migrant background. In 2018, the number of people with a migrant background amounted to around 20.8 million people, representing enormous potential for the economy and society. Education is a decisive key to successful integration and the mainstay for social participation. However, children, adolescents and young adults with a migrant background still perform worse on average than their peers without a migrant background in terms of participation in education and educational success. On the other hand, increasing investment and the further development of the education system with a view to dealing with diversity are helping young people with a migrant background to catch up.

By providing targeted support, the Federal Government is fostering the integration of new immigrants and people with a migrant background who have been living in Germany for a longer period of time by intensifying language teaching and improving access to education, training, studies and work. The overall package of measures includes in particular vocational guidance, pre-vocational and in-service training, vocational education and training, and qualification programmes. Offers are also targeted at specific groups, for instance prospective trainees, training personnel, students and prospective students, people in employment or individuals without recognised qualifications or whose qualifications are low. Programmes specifically geared towards women are an important element here. The *Integration through Qualification (IQ)* programme, which is funded by the Federal Government and the ESF, provides advice on the recognition of foreign vocational qualifications and offers professional qualification programmes.

The Federal Government also specifically involves businesses in its measures so as to pave the way for immigrants to find training and work. This can be, for example, through the support of the integration initiative ‘NETWORK Businesses Integrate Refugees’ or the so-called Welcome Guides as contact partners for companies on all things to do with integrating refugees into their business operations. This is both a challenge and an opportunity for securing the skills base. Another important element in strengthening VET in its contribution to integration is the Federal Government’s support for developing partial qualifications for vocational (re)integration.

Skilled workers from abroad bring not only their qualifications but also a wide range of experience, which is an enrichment for the local economy and research. Above all, the immigration of skilled workers makes a significant contribution to filling existing skills gaps and increases innovation dynamism. For this reason, the Skilled Immigration Act, which came into force on 1 March 2020, aims to attract more skilled workers from abroad. The central tenets of the Act include improvements for third-country nationals who wish to work in occupations that require formal vocational training, and procedural improvements, for instance through the introduction of an accelerated process for skilled workers or changes to the Federal Employment Agency’s placement agreements for the recruitment of qualified skilled workers. The information portals ‘Make it in Germany’ (the central Federal Government platform for the recruitment of qualified professionals from abroad) and ‘Research in Germany’ specifically advertise for foreign skilled professionals and offer a wide range of advisory services.

Education for sustainable development

Sustainable development requires that people be able to understand the impact of their own actions on the world and make responsible, sustainable decisions. Education for Sustainable Development (ESD) pursues the goal of initiating change through education towards becoming a society that thinks and acts sustainably. ESD is therefore a key instrument for achieving the 17 Sustainable Development Goals (SDGs) of the United Nations’ 2030 Agenda. In particular, SDG 4, on quality education, stipulates that every individual

should have the opportunity to acquire the knowledge, skills, values and attitudes necessary to contribute to sustainable development.

The Federal Government is pressing ahead with the implementation of the global framework programme *Education for Sustainable Development (ESD): Towards Achieving the SDGs (ESD for 2030)*, which was adopted by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in November 2019 and will run from 2020 to 2030 in Germany. A new focus of the German ESD process will be on more closely linking sustainability and digitalisation, as well as increasing their incorporation into educational structures and programmes. The goal is to structurally embed ESD in early childhood education, schooling, VET, universities and institutions of non-formal/informal education, as well as in local communities. This programme follows on seamlessly from the Global Action Programme (GAP) on Education for Sustainable Development (ESD), under which the *National Action Plan on ESD* was adopted in 2017. Activities in ESD will continue to be expanded, along with the funding, to enable multipliers in early childhood education, youth conferences and forums. In 2020, an 'ESD Competence Agency for Local Communities' is to be established to promote the transfer of knowledge and to support local governments throughout Germany in structurally integrating ESD.

Internationalisation in education

Germany is a member of various multilateral institutions in the education sector, such as UNESCO and the OECD (Organisation for Economic Cooperation and Development). UNESCO is charged with the global coordination and successful implementation of SDG 4, on education, as part of the 2030 Agenda. The Federal Government supports UNESCO in this task, and in the various UNESCO bodies it is committed to achieving the goals of SDG 4 and of related SDGs by the year 2030. The Federal Government supports international adult education within the UNESCO framework, for instance by funding the UNESCO Institute for Lifelong Learning (UIL), based in Hamburg.

The OECD serves as a platform for the international strategic exchange of information and experience, develops globally recognised indicators, and sets global standards. So that VET systems can be evaluated and further developed on an international level as well, the Federal Government is involved in designing the OECD's education programme. To support international cooperation in the area of VET, it also funds the UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training, which is based in Bonn.

The German dual-sector VET system, in which practical in-house training in companies can reliably build on the theoretical knowledge taught in vocational schools, is a model for many countries around the world to reform their own VET systems. Dual-sector vocational training is also of crucial importance for ensuring that German companies abroad have sufficient skilled professionals with the relevant expertise.

International demand for collaboration with German VET players and for their know-how remains at a high level. The Federal Government is therefore cooperating on a global level in the field of VET with a number of partner countries in the European Union, the OECD and other industrialised, emerging, and developing countries. The Federal Government's strategy for *International Cooperation in Vocational Education and Training*, which was launched in 2013, and its formal extension from 2019 make up the framework for joint, consistent action by stakeholders in education, research, politics and industry.



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