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Executive Summary

Germany has the largest research system in the EU, contributing 28% of EU-27 R&D expenditure (GERD) in 2010. Despite the economic and financial crisis Germany's GERD has increased steadily, although at a lower rate, and amounted to €69.8b in 2010. Due to a concurrent increase in GDP in 2010 the percentage of GDP invested in R&D kept constant between 2009 and 2010 and stood at 2.82%. Public funding of R&D was not decreased during the crisis. The Government budget appropriations or outlays on R&D (GBAORD) rose between 2008 and 2010 by about 17% to €23b. The increase in public R&D funding offset the slight decline in R&D investments of the business sector in 2009 (BERD; -1.7%). In 2010, BERD rose again by 3.8% to €47b. More than two-thirds of R&D in Germany is performed by the business enterprise sector (67.3% in 2010).

Research and innovation policy plays a major role within the policy of the Federal Government. The prominent position of this policy area has been reinforced in July 2010 by a new white paper of the Federal Government, the **High-Tech Strategy 2020**. The strategy is a further development of the first High-Tech Strategy released in 2006.The overall goal of the new strategy is to make Germany a pioneering force in solving global challenges. For this purpose the strategy defines five priorities (fields of action): climate change and energy, health and nutrition, mobility, security, and communication. As a new element, so-called forward-looking projects are defined for each field of action that specify the scientific, technological and social objectives over a period of ten to fifteen years. The launch of this strategy has been the most important event in national R&D&I policy in the past three years. Another indicator for the importance of research and innovation policy is the fact that public funding for R&D was further increased during the financial crisis in 2008/2009.

In terms of **innovation performance**, Germany is regularly ranked in the top group of countries in international comparisons (e.g. #4 in the Innovation Union Scoreboard 2010; #4 in the Innovation Indicator 2011). Notwithstanding, the German research and innovation system shows some weaknesses and faces challenges which need to be tackled to further increase the innovation performance and to strengthen its position. If these challenges are not successfully overcome, they may create bottlenecks for the research and innovation system. This is especially critical since Germany witnesses growing competition from emerging economies, in particular from China. The Federal Government has acknowledged this general challenge in the High-Tech Strategy 2020.

The **key challenges** that Germany is confronted with in the area of research and innovation are the following:

- **Expansion of cutting-edge technologies** in order to foster further growth, to achieve a stronger innovative dynamic, and to keep pace with global technology developments. Due to a strong specialisation on medium-high-tech manufacturing, such as automotive, mechanical engineering, and chemicals, its growth potential is regarded as limited in the future. Instead, high growth rates are expected in high-tech sectors.
- **Lack of appropriate financing sources**. In particular, SMEs and high-tech start-ups face difficulties regarding financing R&D and innovation activities.

The economic and financial crisis has reinforced this situation. Improving the provision of sufficient financing for R&D and innovation projects would remove an important barrier for the business sector to increase investments in R&D.

- **Further commercial exploitation of research results** in order to realise economic value from the generated knowledge in the public sector. Utilising new research results may also contribute to the economic restructuring towards high-tech sectors.
- **Ensuring the provision of a qualified workforce** by improving the education system which exhibits weaknesses regarding several indicators compared to other countries and which is characterized by complex policy coordination. Moreover, existing resources need to be mobilised to a larger extent (women, foreign-born residents).
- **Responding to the new energy concept** which implies the nuclear phase-out until 2022. To secure the energy supply afterwards, further research and innovation activities concerning renewable electricity production are necessary. The expansion of the high-tech sector could contribute to cope with this challenge.

No major changes regarding the **main priorities in R&D&I policy** have occurred in the last three years. This also applies to the set of policy instruments in place. R&D&I policy in Germany follows a rather stable policy path. The four key priorities of research and innovation policy continue to be: (a) keeping pace with global technology trends, (b) providing funding for public and private R&D and keeping research excellence at a top international level, (c) maintaining and further improvement of the industry-science link, and (d) investing in education to strengthen the education sector and to provide qualified labour. The stability is seen as a necessary prerequisite in order to give enterprises and research organisations planning reliability and to pursue long-term oriented goals.

Nevertheless, some **shifts** in priorities and policy making have occurred. Mission-oriented approaches in technology policy are reemphasised by the definition of forward-looking projects in the High-Tech Strategy 2020. Mission-oriented measures have been implemented in German innovation policy from the beginning but received less attention during the 1990s and 2000s. Related to this approach is the aim to further intensify links between science and industry. The high importance of excellent public research and education has been emphasized by the agreement in 2009 to continue and expand the three programmes “Higher Education Pact”, “Initiative for Excellence” and “Pact for Research and Innovation”. Until 2019 funding of €18b will be allocated within these three programmes.

The priorities in R&D&I policy as also outlined in the High-Tech Strategy 2020 **correspond** well to the main challenges that Germany is confronted with in the area of research and innovation. The current policy mix addresses the challenges through a broad range of measures. The measures are well-proven and assessed as relevant and appropriate to mitigate the structural challenges. No particular imbalance between the R&D&I priorities, policy mix and challenges could be identified. However, whether the measures are sufficient to completely overcome the challenges, in particular the challenge regarding the financing of R&D in SMEs and start-ups and the new challenge due to the redefined energy policy, remains to be seen. Regarding education policy, especially structural developments such as the cooperation ban between the Federal and the state governments in education have not yet been tackled. In general, the German Federal Government is fully aware of the main challenges.

R&D&I policy offers a number of initiatives to strengthen research and innovation activities in the business sector. Nonetheless, the introduction of an alternative funding instrument, namely **tax-based incentives for R&D**, would have the potential to further mobilise private R&D investments by targeting firms conducting R&D without external project partners and stimulate non-R&D performing firms to invest in R&D. For these two groups of firms public funding is limited.

The increasing focus on promoting scientific excellence, particularly in the context of the “Initiative for Excellence”, may change to some extent the **incentive structure in science**. The current discourse on excellence and scientific competition leads to increased activities in basic research and academic publication, but provides little impetus for strengthening knowledge transfer activities. However, focusing on excellence can also indirectly promote industry-science cooperation as industry traditionally looks for the most outstanding researchers as cooperation partners (see Grimpe, 2010). Indeed, industry is involved in a significant number of collaborative projects funded through the “Initiative for Excellence” as well as through the “Pact for Research and Innovation”.

Special attention needs to be paid to **education policy** in Germany, also to ensure the supply of qualified labour. The Federal Government as well as the state government has increased the investment in higher education (foremost through the “Higher Education Pact” and the “Quality Pact for Teaching at Universities”). Various measures and initiatives are in place to strengthen the education system and mobilise human resources. Though progress has been made, further efforts are needed in primary, secondary as well as higher education, e.g., to achieve equal opportunities to access education and to increase the participation rate in tertiary education. Moreover, the existing knowledge stock of women or foreign-born residents is not yet well used and needs to be further tapped. By allowing cooperation between the Federal Government and the state governments in the school and higher education sector, the Federal Government could contribute to a larger extent to education. This adjustment would require changing the German Constitution. There is currently a debate revolving around removing the cooperation ban.

The **European dimension** of research and innovation policy has gained importance over the last decade. The relevance of European and international collaboration in research has been highlighted in the internationalisation strategy adopted in 2008 and in the High-Tech Strategy 2020 implemented in 2010, in particular in the context of solving the grand challenges. In line with this, German partners are strongly involved in projects within European initiatives. Research programmes by the Federal Government and the German Research Foundation (DFG) are further opening up to foreign entities and access to research infrastructures for the transnational scientific community is provided by opening large infrastructures. Moreover, the government takes further steps to remove formal constraints on researchers’ mobility. Overall, the strategic ERA objectives are considered and integrated into German research and innovation policy. However, as recommended by the Expert Commission on Research and Innovation (EFI, 2011) the Federal Government could intensify its role in the European coordination process and take a lead in the area of research and innovation in order to shape the ERA.

TABLE OF CONTENTS

Introduction

In terms of both population and GDP, Germany is the biggest country within the EU-27. With 81.8 million inhabitants in 2010[1], 16.3% of the EU-27 total population of 501 million live in Germany. Furthermore, Germany is responsible for 20.2% of the total Gross Domestic Product (GDP) of the EU-27 (€12,256b), having a GDP of €2,477b. Germany's GDP per capita was 24% above the EU-27 average. The years 2008 and 2009 were dominated by the economic and financial crisis. While in 2008 a moderate increase in real GDP could still be realised (+1.1%), in 2009 it sharply declined (-5.1%). But Germany recovered rapidly from the crisis and returned to growth, realising an increase of 3.7% in 2010 and of 3.0% in 2011.

Germany also has the largest research system in the EU, measured in terms of R&D expenditure (GERD). Germany's GERD was about €67.0b in 2009 and further increased to €69.8b in 2010. Thus, Germany contributes 28.4% of EU-27 R&D expenditure in 2010. The economic and financial crisis did not leave R&D activities unaffected. However, public funding of R&D was not decreased during the crisis. The GBAORD rose between 2008 and 2010 by about 17% to €23b in 2010. The increase in public R&D funding offset the slight decline in R&D investments of the business sector in 2009 (BERD; -1.7%). In 2010, BERD rose again by 3.8% to €47.0b. Although the share of private R&D has decreased slightly, the business enterprise sector still performs more than two-thirds of total R&D in Germany (67.3% in 2010).

The **research system** is grounded in a well-established university system and a large and unique non-university public research system. The non-university public research system is based on four main research organisations – Max Planck Society (MPG), Fraunhofer Society (FhG), Helmholtz Association (HGF), and Leibniz Association (WGL) – which have different missions and provide excellent research infrastructure. As indicated by data on publications and patents as well as by a range of system evaluations conducted during the last decade, the German system demonstrates a strong capacity for producing scientific and, particularly, technological knowledge. For instance, regarding the number of citations of scientific publications produced by German researchers, Germany belongs to the leading group of countries by taking second place (USA: appr. 44.7m citations between 1999 and 2009; Germany: appr. 9.4m). In terms of triadic patents, Germany contributes 12.6% of all patents from OECD countries while the share of the entire EU-27 was 30% (WR, 2010). Scientific research in Germany has a clear focus on the natural sciences and engineering, which account for about half of the research activities in universities and three quarters of those in public research organisations. Germany also performs well in the training of young scientists and scholars. 2.6 persons attained a doctoral degree per thousand population aged 25-34 years (in 2009) which is well above the EU-27 average (1.6) and the United States (1.6). The share of human resources in science and technology (HRST) of total labour force was 44.8% in 2010, which is again above the EU-27 average (40.5%).

The industrial innovation system in Germany is characterized by a strong specialisation on medium-high-tech manufacturing, such as automotive, mechanical engineering and chemicals. Within the **business enterprise sector**, the largest

[1] If not referenced otherwise, all quantitative indicators are based on Eurostat data.

demand for knowledge – as revealed by the amount of in-house R&D expenditure – is in the automotive sector which spent €14.8b for R&D (in 2010), equalling 32% of total business enterprise expenditure on R&D. Other important sectors are the electronics and electrical industry (including instruments) which spent €7.3b to finance intramural R&D (16% of total) and the chemical and pharmaceutical industries (€6.9b, 15%). A further relevant source is the mechanical engineering sector (€4.6b, 10%; Stifterverband, 2011). Overall, German enterprises are strongly oriented towards an innovation-based competitive strategy, revealed by a high share of innovating enterprises (2010: 48%) and a high share of enterprises that conduct in-house R&D (23%; Rammer et al., 2012).

Due to the federal structure, both the Federal Government and the 16 federal state (Bundesländer) governments are important players in German research and innovation policy. The **Federal Government** takes up a variety of activities in research and innovation policy and may be regarded as the main state actor in the German system. The Federal Ministry of Education and Research (BMBF) has the main responsibility for research policy. The Federal Ministry of Economics and Technology (BMWi) is responsible for innovation and technology policy as well as for some areas of R&D policy. In addition, several sectoral ministries maintain their own research institutes (Ressortforschungseinrichtungen). The **state governments'** main priority in research and innovation policy is to fund universities. In addition, they are involved in science-industry linkages and innovation programmes. Education policy lies almost exclusively within the responsibility of the individual states. There are also a number of joint activities of the federal and state governments, e.g. joint institutional funding of the four main research organisations and the programme for the Academies of Sciences. The Joint Science Conference (GWK) is the main body that coordinates research policies between the Federal Government and the state governments. Most publicly funded R&D programmes are administered and managed by a range of implementation agencies (Projektträger), with some of them located within large research centres.

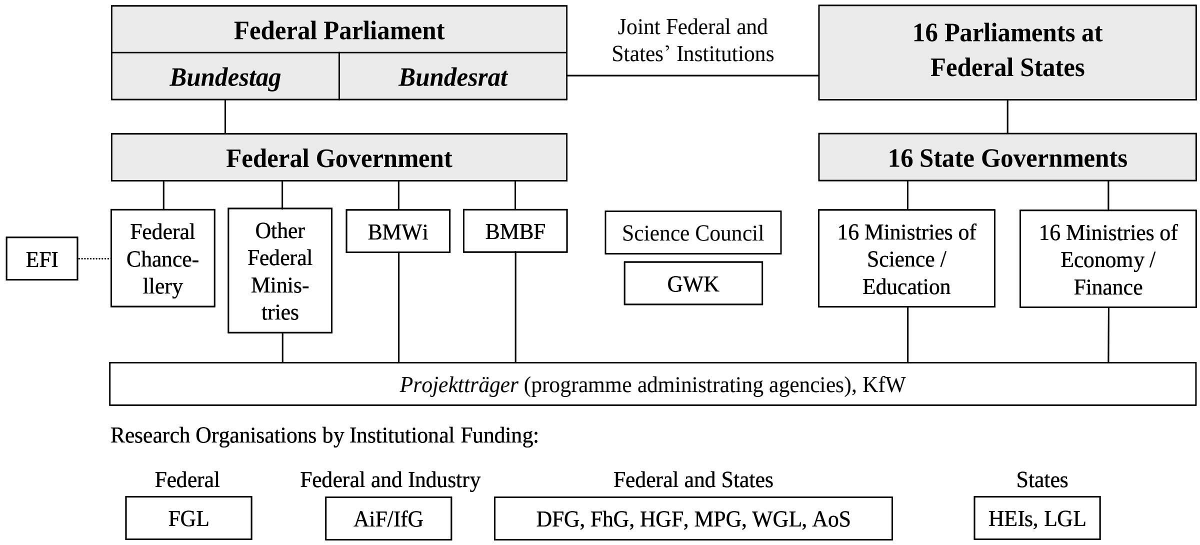
The German Science Foundation (DFG) also receives its funds from both the Federal and the state governments. It plays a central role in the funding of basic research in Germany, complementing the institutional funding for basic research with competitive project-based funding. The German Federation of Industrial Research Associations "Otto von Guericke" (AiF) deals with the promotion of applied R&D for the benefit of small and medium-sized enterprises. Within the governance of the research system, there have been no major changes in recent years among the group of main policy actors and involved institutions.

Research in Germany is conducted by a diverse spectrum of **performers**. The business enterprise sector is a strong R&D performer by international standards. Private R&D performers are responsible for 67.3% of the German R&D expenditures (2010). In particular large enterprises play an important role. Companies with more than 500 employees account for 84% of intramural R&D investments by the business sector (Stifterverband, 2011).

The 415 Higher Education Institutions (HEIs) in Germany perform 18.0% of total R&D expenditure in 2010. A unique feature in Germany is a wide range of Public Research Organisations (PROs). They performed 14.7% of total R&D expenditure, i.e. their quantitative significance in the German research system is almost comparable to that of universities. Prominent players in the public research landscape are the four large research organisations with a large number of institutes, covering the whole spectrum from basic and applied research to research services. The special role of PROs in the German research and science system is to provide long-term oriented research based on large research infrastructures (covering technical as well as data and informational infrastructure) and to offer top scientists space for concentrating on research. Another relevant block of public research performers consists of governmental research agencies and institutes (Ressortforschungseinrichtungen). These institutions provide ministries with scientific knowledge and administer sovereign tasks such as the compliance of quality and safety standards.

Despite the clear separation in statistics between HEIs on the one hand and PROs on the other, both sectors are closely interlinked in practice. In all MPG institutes and the vast majority of FhG, HGF and WGL institutes, directors of institutes are at the same time full professors at universities and hold university chairs. All four large PROs are actively engaged in graduate and post-graduate education.

Figure 1 : Organisational chart of institutions in the field of research and innovation



BMWi:	Federal Ministry of Economics and Technology	DFG:	German Research Foundation
BMBF:	Federal Ministry of Education and Research	AiF:	Association of Industrial Research Institutes
FhG:	Fraunhofer Society	IfG :	Institutes of Co-operative Industrial Research
MPG:	Max Planck Society	KfW:	KfW Banking Group - State-owned bank (80 % Federal Government, 20 % States)
WGL:	Leibniz Association	GWK:	Joint Science Conference of the Federal Government and the Federal States
AoS:	Academies of Sciences	LGL:	Länder Government Research Organisations (State Agencies, other research institutions funded through) State governments)
HEIs:	Higher Education Institutions		
FGL:	Federal Government Research Organisations (Federal Agencies)	EFI:	Expert Commission on Research and Innovation

Structural challenges faced by the national system

Germany ranks fourth in the Innovation Union Scoreboard 2010 after Sweden, Denmark, and Finland and is classified into the group of innovation leaders within EU-27 (PRO INNO Europe, 2011). Within this group, Germany exhibits the same growth rate in innovation performance as Finland and is regarded as a growth leader. Germany is also ranked fourth based on the Innovation Indicator 2011, which compares the innovation performance of 26 industrialized countries (Deutsche

Telekom Stiftung, 2011). Notwithstanding, the German research and innovation system shows some weaknesses and faces challenges which need to be tackled to further increase the innovation performance and to strengthen Germany's position. This is especially critical since Germany witnesses growing competition from emerging economies, in particular from China. The international rivalry for technologies and market leadership will further intensify. The Federal Government has acknowledged this general challenge in the High-Tech Strategy 2020.

First and foremost, maintaining international competitiveness requires a **stronger innovative dynamic** and further investment in R&D. In the last decade, the average annual growth rate of business expenditures on R&D was below the one of its peer-group including Sweden, Finland and Denmark (Innovation Union Competitiveness report by European Commission, 2011). In 2010 the business sector expenditure on R&D amounted to 1.90% of GDP which is clearly above the EU-27 average (1.23), but below the value of EU leaders such as Finland (2.69) and Sweden (2.35). The industrial innovation system in Germany is characterized by a strong specialisation on medium-high-tech manufacturing, such as automotive, mechanical engineering, and chemicals for which Germany exhibits a comparative advantage. However, the growth potential in these areas is regarded as limited in the future. Potential for high growth rates is expected in the high-tech sector which is underdeveloped in Germany (EFI, 2010). Thus, the **expansion of the high-tech sector** is important to realise further growth. This growth is also critical in order to take up new technology trends early and to keep pace with global technology developments.

An important barrier for the business sector to increase R&D investments continues to be the **lack of appropriate financing sources**. In particular, SMEs and high-tech start-ups face difficulties regarding financing R&D and innovation projects. The economic and financial crisis has reinforced this situation. Internal financing sources have decreased due to lower sales. With respect to external financing, banks have become even more cautious to finance innovation activities due to the risky nature and typically little collateral. Thus, in particular SMEs rely on public support for R&D. But public R&D support for firms is relatively small in Germany compared to other countries although the Federal Government significantly increased the budget of its main research and innovation financing programmes in 2009 and 2010. A high administrative burden might also discourage SMEs to apply for public funding. Even though the government changed the private equity law in 2008 to facilitate VC investment into firms, young high-tech firms still face a shortage of equity capital (EFI, 2011). According to the Innovation Union Scoreboard 2010 the share of VC funding has increased in Germany but remains significantly below the EU-27 average (PRO INNO Europe, 2011). The challenge for the Government is to improve access to financing sources.

The capacity for the production of scientific knowledge is grounded in a well-established university system and a large and unique non-university public research system. The importance of the latter is reflected by the share of R&D performed by the government sector (2010: 0.41% of GDP) which is the highest among EU-27 countries (EU-27 average: 0.27%; Slovenia: 0.38%; France: 0.37%). The funding for public research has been further increased in recent years, mainly due to the "Pact for Research and Innovation" and the "Initiative for Excellence". In order to strengthen the innovation system and to realise economic value, the new generated knowledge in the public sector needs to be commercially exploited. In general, industry-science links and partnerships are well-established and are by and large assessed to be effective. Fostering public-private collaboration has been an important element of the German research policy for years. Close ties between the business sector and public research is revealed by the high share of research in universities and PROs financed by industry. However, the commercialisation efforts of scientists in Germany are limited. For instance, the number of scientists that start a business is relatively low in Germany compared to the U.S. Accordingly, experts and the government still perceive an untapped potential in particular with regards to **linking research results to commercialisation**. Thus, technology and knowledge transfer mechanisms from public research should be expanded (EFI, 2010). Utilising new research results also contributes to the economic restructuring towards high-tech sectors.

An important factor for the long-term development of an innovation system is the supply of human capital. Germany exhibits weaknesses in human resources as revealed by several indicators. Though progress has been made, areas of concern are still the low share of youth with a completed upper secondary level education (a high share of students leaving school with deficiencies in basic knowledge), the low share of population with a completed tertiary education, a low participation rate in lifelong learning activities, and the low share of S&E graduates among the younger population. Germany does not only rank behind Finland, Sweden, and Denmark in this respect, but several indicators indicate a performance level even below the EU-27 average. This is partly compensated by the dual system of vocational training. This system is well established in Germany, contributes to the provision of qualified personnel for the labour market, and enjoys a high reputation (EFI, 2009). Overall, the **sufficient supply of a qualified workforce** has been a constant challenge for many years. Although there are discussions about the extent to which a lack of qualified personnel is a bottleneck for the German economy, there is consensus that a shortage is present in individual occupations/regions and that the shortage is likely to grow in the future due to demographic changes. Thus, great efforts are needed to adjust education policy. In addition, Germany needs to mobilise existing resources to a larger extent. Potentials lie in a greater participation of women, in particular in MINT-fields comprising mathematics, information technology, natural sciences and technology. In comparison to other industrialised economies, the share of women in research activities in Germany is low, in particular in the business sector (OECD, 2011). Moreover, the social selectivity regarding the access to education needs to be reduced. More effort could be made to use the potential of immigrants already living in Germany and to further attract qualified labour (EFI, 2011; Deutsche Telekom Stiftung, 2011). In general, education policy is characterized by complex policy coordination since it is within the responsibility of the individual states. The Federal Government only has few competences. In addition, adjustments in the education policy once achieved (at primary, secondary as well as tertiary level) take a long time until they have an effect.

A specific challenge for the research and innovation system in Germany constitutes the new energy policy strategy agreed on in June 2011. Due to the meltdown at the Japanese nuclear power plant of Fukushima, electricity production by nuclear power will be stopped by 2022. Thus, there is a need for research and innovation in **energy supply** to compensate the nuclear phase-out. Within the next ten years, investment in renewable electricity production is to be expanded substantially, demanding a number of innovations in this area. The expansion of the high-tech sector could contribute to cope with this challenge.

Assessment of the national innovation strategy

National research and innovation priorities

In July 2010 a new comprehensive strategy for research and innovation policy was published by the Federal Government, the **High-Tech Strategy 2020**. This has also been the most important event in national R&D&I policy in the past three years. The strategy is a further development of the first High-Tech Strategy released in 2006. The new strategy is more focused than the first one and takes a different approach. The new strategy defines five priorities (fields of action) for new technologies and innovation based on the global challenges. These priorities are climate change and energy, health and nutrition, mobility, security, and communication. The strategy continues a long-standing tradition in German innovation policy and focuses on funding new technology development in a variety of "key enabling technologies" which are important to solve the problems in the five fields and are relevant for the German economy. In addition, cross-cutting activities should ensure innovation-friendly framework conditions. As a new element, so-called forward-looking projects are defined for each field of action that specify the scientific, technological and social objectives over a period of ten to fifteen years. Accordingly, the High-Tech Strategy 2020 follows a mission-oriented policy approach. The overall goal of the High-Tech Strategy 2020 is to make Germany a pioneering force in solving global challenges.

No major changes regarding the **main priorities** in R&D&I policy have occurred in the last three years. This also applies to the set of policy instruments in place. R&D&I policy in Germany follows a rather stable path. The four key priorities of research and innovation policy continue to be: (a) keeping pace with global technology trends, (b) providing funding for public and private R&D and keeping research excellence at a top international level, (c) maintaining and further improve the industry-science link, and (d) investing in education to strengthen the education sector and to provide qualified labour.

The stability is seen as a necessary prerequisite in order to give enterprises and research organisations planning reliability and to pursue long-term oriented goals. Nevertheless, some **shifts** in priorities and policy making have occurred. Mission-oriented approaches in technology policy are reemphasised by the definition of forward-looking projects in the High-Tech Strategy 2020. Mission-oriented measures have been implemented in German innovation policy from the beginning but received less attention during the 1990s and 2000s. The goal of solving global challenges induced a more forward-looking research and innovation policy that defines medium-term objectives and stimulates private and public actors to develop ways to meet these objectives. Related to this approach is the aim to further intensify links between science and industry. This is not a new priority; it has been in the focus of R&D&I policy for many decades. For this purpose two new measures have been introduced in 2010/2011. The measure "Validation of Innovation Potentials of Scientific Research" should fill a specific gap in the transfer of scientific knowledge into commercial application by offering grants to researchers at public research organisations and universities to further investigate the commercialisation prospects of their research findings. The programme "Research Campus" provides funding for long-term oriented partnerships between universities, public research organisations and private companies. It aims at developing new technologies in areas with high technological complexity and a great potential for radical innovation. The Expert

Commission recommended supporting this type of link between science and industry (EFI, 2009). Two other instruments for establishing networks between industry and science in key technologies have been introduced in 2008 and have received increasing attention. The “Leading-Edge Cluster Competition” programme funds regional networks while the “Innovation Alliances” initiative provides public funding for large-scale, long-term projects that are critical for developing break-through technologies. The high importance of excellent public research and education has been emphasized by the agreement in 2009 to continue and expand the three programmes “Higher Education Pact”, “Initiative for Excellence”, and “Pact for Research and Innovation”. Within these three programmes funding of €18b will be allocated until 2019. Furthermore, the federal and state governments agreed on the “Qualification Initiative” in 2008 which addresses all areas of education from early-childhood education to lifelong learning and on the “Quality Pact for Teaching at Universities” in 2010 to improve the study conditions and teaching quality. €2b will be provided in the “Quality Pact for Teaching” between 2011 and 2020.

The chosen **priorities** in R&D&I policy address the main **challenges** that Germany is confronted with in the area of research and innovation, i.e. expanding cutting-edge technologies, providing sufficient funding for R&D, commercial exploitation of research results, ensuring the provision of a qualified workforce, and responding to the new energy concept through ‘green’ energy (see chapter 2).

Most programmes of the R&D&I policy are subject to **evaluations**. The following programmes have been evaluated by external reviewers recently: “Research Bonus”[2], “industrial collective research”m (IGF)[3], “Central Innovation Programme” (ZIM)[4], “EXIST”[5], “High-tech Start-up Fund”[6], and “SIGNO”[7]. Other programmes and initiatives are currently in the process of evaluation, e.g. SME Innovative, Top Clusters, ERP Start-up Fund, ERP Innovation Programme, and “Validation of Innovative Potentials of Scientific Research”. Thematic R&D programmes and sub-programmes are also evaluated. The “Initiative for Excellence” and the “Pact for Research and Innovation” are regularly monitored.[8] Programmes typically run for a specified time period with the option of prolonging. Evaluations contribute to the decision whether to extend and/or to redesign policy measures.

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[2] Astor, M., U. Glöckner, D. Riesenberg, E. Schindler (2010), Begleitende Evaluierung des BMBF-Förderinstruments „Forschungsprämie“ und „ForschungsprämieZwei“, Berlin: Prognos AG.

[3] RWI and WSF (2010), Erweiterte Erfolgskontrolle beim Programm zur Förderung der IGF im Zeitraum 2005 bis 2009, Essen: RWI.

[4] Kulicke, M., M Hufnagl, T. Brandt, C. Becker, H. Berteit, T. Grebe, M. Kirbach, T. Lübbers. (2010), Evaluierung des Programmstarts und der Durchführung des "Zentralen Innovationsprogramms Mittelstand (ZIM)", Karlsruhe and Berlin: Fraunhofer-ISI and GIB

[5] Egeln, J., M Dinges, A. Knie, D. Simon, H. Braun-Thürmann, H. Ryges, H. Gassler, S. Gottschalk, R. Hilbrich, D. Höwer, K Müller, C. Rammer, J. Schmidmayer, F. Steyer (2010), Evaluation des Existenzgründungsprogramms EXIST III, Baden-Baden: Nomos (ZEW Wirtschaftsanalysen 95).

[6] Geyer, A., T. Heimer, L. Hölscher, C. Schalast (2010), Evaluierung des High-Tech Gründerfonds, Vienna and Frankfurt: Technopolis Group and Frankfurt School of Finance & Management.

[7] Astor, M., U. Glöckner, D. Riesenberg, C. Czychowski (2010), Evaluierung des SIGNO-Förderprogramms des BMWi in seiner ganzen Breite und Tiefe, Berlin: Prognos AG and Boehmert & Boehmert.

[8] The “Initiative for Excellence” is monitored by the Institut für Forschungsinformation und Qualitätssicherung, the “Pact for Research and Innovation” by the Joint Science Conference (GWK).

Results of evaluations of research and innovation policy programmes are in general positive about the efficiency and effectiveness of the analysed measure. The main findings of the evaluations can be summarized as follows: German research and innovation policy seems to be able to deliver support measures in an efficient and user-friendly way, i.e. addressing the specific needs of the target groups of the programme. Policy programmes are generally evidence-based and designed along identified challenges and needs for public intervention. Recommendations of evaluations constantly focus on adjusting smaller programme details while being in favour of continuing the programme as such.

R&D&I policy has put in place a number of initiatives **to foster public and private R&D investments**. The measures are by and large appropriate, relevant and assessed as effective. However, an often-cited weakness in the area of public funding of business enterprise R&D is the **lack of 'indirect' measures**, in particular, the lack of tax credits for R&D (EFI, 2011). An 'indirect' support measure could complement the existing policy mix by offering a low cost access to public R&D funding especially for small enterprises. As stated in the National Reform Programme 2011, the Federal Government will integrate the decision on the introduction of a tax subsidy for R&D into the context of the development of an overall budget and tax policy concept.

Public funding for R&D also helped innovative enterprises to cope with the sharp **economic crisis** of 2008/2009 and to maintain a high level of R&D and innovation activities. Particularly, the doubling in volume of the "Central Innovation Programme" (ZIM) in 2009 and 2010 and the increased funding within the thematic programmes contributed to this positive development. The Commission of Experts for Research and Innovation (EFI) which regularly comments on progress and weaknesses in German research and innovation policy confirmed the contribution of R&D&I policy to the fast return to the growth path in Germany (EFI, 2011).

Trends in R&D funding

The years 2008 and 2009 were dominated by the economic and financial crisis. While in 2008 a moderate increase in real GDP could still be realised (+1.1%), in 2009 it sharply declined (-5.1%). But Germany recovered rapidly from the crisis and returned to growth, realising an increase of 3.7% in 2010 and of 3.0% in 2011.

Measured in terms of R&D expenditure, Germany has the largest research system in the EU. Germany's GERD was €67.0b in 2009 and further increased to €69.8b in 2010. Thus, Germany contributes significantly to EU resource mobilisation, being responsible for 28.4% of aggregate EU-27 R&D expenditure in 2010.

Despite the economic and financial crisis the total R&D expenditures increased, although at a lower rate. Public funding of R&D was not decreased during the crisis. The GBAORD increased between 2008 and 2010 by about 17% to €23b in 2010. Thereof, about €12.7b was spent by the Federal Government. The increase in public R&D funding offset the slight decrease of R&D investments by the business sector (BERD). Following a decrease of BERD by 1.7% in 2009, BERD rose by 3.8% to €47.0b in 2010. Hence, business sector R&D intensity (BERD as % of GDP) reached 1.90% in 2010. Planning data for 2011 suggest a further increase of BERD to €49.3b (Stifterverband, 2011).

Due to the decline in GDP in 2009 and the concurrent slight growth in GERD, the percentage of GDP invested in R&D increased from 2.69% in 2008 to 2.82% in 2009. In 2010, the rate remained constant (2.82%) although GDP rose again. Thus, R&D intensity in Germany is significantly above the EU average of 2.0%. Although the share of private R&D has decreased slightly, the business enterprise sector still performs more than two-thirds of total R&D in Germany (67.3% in 2010).

As agreed at the Dresden Education Summit (Dresdner Bildungsgipfel) on 22 October 2008, the goal of the Federal Government and the states is to raise spending levels for education and research to 10% of GDP by 2015. 7% are targeted for education and 3% for research. Two-thirds of the R&D target should come from the private sector and one-third from the public sector. Germany makes steady progress to achieve the 3%-target.

Table 1: Basic indicators for R&D investments in Germany

	2008	2009	2010	EU average 2010
GDP growth rate	1.1	-5.1	3.7	2,0
GERD as % of GDP	2.69	2.82	2.82[1)]	2.0
GERD per capita	809.2	817.2	853.4[1)]	490.2
GBAORD (€ million)	19,692	20,833	23,016[2)]	92,729.05
GBAORD as % of GDP	0.80	0.88	0.93[2)]	0.76
BERD (€ million)	46,073	45,275	46,980[1)]	151,125.56
BERD as % of GDP	1.86	1.91	1.90[1)]	1.23
GERD financed by abroad as % of total GERD	4.0	3.8	--	N/A[9]
R&D performed by HEIs (% of GERD)	16.7	17.6	18.0[1)]	24.2
R&D performed by PROs (% of GERD)	14.0	14.8	14.7[1)]	13.2
R&D performed by Business Enterprise sector (as % of GERD)	69.2	67.6	67.3[1)]	61.5

[1)] Estimated/provisional figure; [2)] provided by BMBF; -- not available

Source: EUROSTAT (retrieved: 22/02/2012)

The German system of public R&D funding is based on two pillars: **institutional funding and project funding**. While institutional funding is provided to cover the basic financial demands of public research institutes and universities as well as the costs of R&D in areas with low significance of third-party funding (basic research), project funding is target-oriented and has a short to medium-term focus. Based on data for 2010, about 50% of the federal R&D expenditures were spent on project funding and 42% on institutional funding. This implies a slight shift towards project

[9] 8.4 (2009), 9.04 (2005)

funding compared to 2008 (45% project funding; 44% institutional funding) since the absolute increase in project funding was larger than the increase in institutional funding.

The large majority of project funding supports very specific research areas within thematic R&D programmes ('direct project funding'; 86% in 2010; some measures are thematically open such as "Leading-Edge Cluster Competition" or some funding of innovation networks in Eastern Germany) while a small share is provided through horizontal R&D and innovation measures. Most measures focus on funding collaborative R&D and innovation projects, mainly between public (or private) research institutions/HEIs and companies, e.g. the thematic R&D programmes and the "Central Innovation Programme for SMEs" (ZIM). Hence, the lion's share of the funding is allocated using competitive measures. All public funding of business enterprise R&D is provided through subsidies. There are no tax-based incentives for R&D or innovation in Germany at present.

Sometimes, additional **funding from private sources** leverages public funding of research and innovation. An example for a public-private-partnership is the High-tech Start-up Fund which is co-financed by some large German firms, e.g. Daimler, Bosch, and Siemens.

Transnational funding in terms of funding of research and innovation in Germany by other national governments or international public organisations is rather small compared to the national budget. Examples are of course co-funding programmes through EU funds. Here, the most important source is the EU Framework Programme from which German participants receive about €0.75b per year. Other examples are the EUREKA programmes. Moreover, Germany as well as the DFG (German Research Foundation) runs a broad range of bilateral research programmes and agreements for international cooperative projects with other countries. These programmes are usually funded by sources from the governments of the participating countries (see section 2 and 7 in the Annex). The second component of transnational funding comprises German investments in research and innovation abroad. This component is also small compared to public R&D investments in Germany. Public research organisations have internationalised their activities and set up a few institutes abroad such as the Max Planck Florida Institute which was established in 2008. These institutes usually receive additional public funds from the foreign country. For universities foreign R&D investments are yet uncommon.

The **EU Structural Funds** are important for co-funding of R&D programmes run by the federal states and for co-funding investment in research and innovation infrastructures in East Germany and to a smaller extent in West Germany. In the period 2007-2013, the average annual contribution of the Structural Funds in the field of research and innovation for Germany is about €1.25b. The **European Investment Bank** (EIB) is another important EU source for funding research and innovation in Germany. The EIB made new loan commitments for research and innovation projects (particularly for fixed investment in labs or costs of large development projects) in enterprises and organisations located in Germany of approximately €3.0b (in 2008).

Evolution and analysis of the policy mixes[10]

Research and innovation policies play a major role within the national policy of the Federal Government. The prominent position of this policy area was reinforced in July 2010 by a new white paper of the Federal Government, the High-Tech Strategy 2020. It is a comprehensive, coherent and long-term strategy for research and innovation. It uses a cross-departmental approach, involving several ministries and policy areas. The strategy defines the priorities in research and innovation policy with a particular focus on the solution of the grand challenges. Another indicator for the importance of research and innovation policy is the fact that public funding for R&D was not cut during the financial crisis in 2008/2009 – in contrast the budget was further increased. This trend is expected to continue in 2012.

The research and innovation **governance** system is highly developed and stable partly due to the rather complex federal structure of the policy system. The Federal Government and the 16 federal states governments share the responsibility for research and innovation policies with a clear division of duties. The Federal Government takes up a variety of activities in research and innovation policy and may be regarded as the main state actor in the German innovation system. The federal states' main priority in research and innovation policy is to fund universities. In addition, they are involved in science-industry linkages schemes and innovation programmes. There are also several joint activities of the federal and state governments, e.g. joint institutional funding of research organisations. Education policy **-** up to the tertiary level **-** is the sole competence of the 16 federal states. Thus, education systems differ by state and coordination of education policy is cumbersome. The separation of educational competencies between the federal and the state level does not necessarily follow arguments of optimal policy allocation. In particular, the banning of cooperation in research funding of universities between the federal and the state level implemented in the reform of the federal system 2005/2006 restricts federal activities in funding basic research at universities. There is currently a debate revolving around removing the cooperation ban. Various experts call for the abolishment of the ban but the responsible 16 ministers of education and cultural affairs fear a loss of competence.

Innovation policy covers a broad **scope** of measures and activities. While the bulk of programmes focus on technological research, some measures go beyond. For example, the objective of the programme "go-innovativ" launched in 2010 is to improve innovation management in small firms. Furthermore, demand-side innovation policies are an integral part of the innovation policy mix in Germany, comprising legislation and standardisation as well as lead-market initiatives. Recently the High-Tech Strategy 2020 has reinforced the role of demand-side policies by defining five demand areas which future technology development should target. Through the instrument of so-called forward-looking projects, the link between fostering technology demand and developing technologies that are needed by future users is established and demand-side and supply-side policy approaches are aligned.[11]

[10] The policy mix is analysed along the ten features outlined in the Innovation Union self-assessment tool.

[11] For more details and examples on the role of demand-side innovation policies see chapter 3 in the TrendChart Mini Country Report/Germany, 2011.

German research and innovation policy offers a broad range of **public funding measures to strengthen research and innovation activities in the business** sector. Thematic R&D programmes are the main channel to provide financial means and comprise a large set of individual programmes and sub-programmes. They usually aim at achieving fairly specific goals in given technological fields. The majority of support measures address R&D performing firms and encourage public-private collaboration. Programmes and measures are regularly re-launched and re-designed, usually due to results of evaluations. Evaluations of German innovation policy measures are in general positive about the efficiency and effectiveness of the analysed programme. Nevertheless, the lack of R&D tax-based incentives as a continuous impetus to invest in research and innovation and as an element in research policy in Germany is often perceived as a drawback. Consequently, its introduction is frequently asked for (EFI, 2008, 2009, 2010, 2011; Deutsche Telekom Stiftung 2011). However, an introduction implies significant fiscal costs. Depending on the type of incentive, estimations for the costs vary between €460m and €5.7b (Elschner/Ernst/Spengel, 2011).

In research policy primacy is given to the **support of quality and excellence**. The selection of proposals within thematic R&D programmes is generally based on peer-review. The assessment of the proposals is purely grounded on the scientific and technical quality of research concepts and the targeted level of innovativeness. The German Research Foundation (DFG) also supports excellence in academic research. DFG offers grants for non-oriented basic research on a competitive basis according to scientific excellence and quality criteria based on peer review. Moreover, excellence in research is monitored by regular evaluations of public research organisations and university faculties. In recent years, the focus on research excellence has been further emphasized in the context of the “Initiative for Excellence” which provides funding in a competitive way according to excellence criteria, with both an institutional funding stream for universities and a project-based stream for clusters of excellence. The funding decisions are made by the Approval Committee of the Excellence Initiative, which consists, among others, of experts from foreign institutions such as MIT.

The **autonomy** of universities is rather limited in Germany (European University Association, 2009). Increased flexibility in terms of budgets which was implemented for PROs (Wissenschaftsfreiheitsgesetz) was not adopted for the universities. Overall, further autonomy in particular regarding financial and managerial aspects is required so that the universities and research institutions can develop their own goals, staffing plans and financial strategies.

Germany exhibits weaknesses in **education policy** and its ability to produce the **right mix of skills**. Ensuring sufficient supply of a qualified workforce is a constant challenge. Various measures and initiatives are in place to strengthen the education system and to mobilise human resources. For example, the continuation of the “Higher Education Pact 2020” was decided in 2009 and further expanded in 2011 to create 335,000 additional places for university entrants expected between 2011 and 2015. The national Pact for Women in MINT Professions was implemented to attract more women to courses in the so-called MINT subjects (including mathematics, information technology, natural sciences and technology). Progress has been made but further efforts are needed. One opportunity is to mobilise existing resources to a larger extent (women, foreign-born residents).

Partnerships between research and innovation stakeholders are well developed in Germany. A broad range of links between science and industry are supported, such as cooperation, clusters, networks, alliances, and most recently public-private partnerships. In addition, the German science system includes a number of organisations that are devoted to knowledge transfer with the business sector, including the Fraunhofer Society (FhG), technical universities, and universities of applied science. Most of the universities have their own knowledge transfer office. Moreover, the funding programme "SIGNO" supports universities, companies and inventors to identify inventions suitable for patenting, secure legal protection for these and exploit them commercially. Nevertheless, experts and the Government still perceive an untapped potential to link research results to commercialisation and suggest expanding technology and knowledge transfer mechanisms from public research.

Several initiatives are in place attempting to further improve the **framework conditions for private investments**. The importance of a constructive environment is also acknowledged in the High-Tech Strategy 2020. Measures range from strengthening the start-up culture to facilitating access to Venture Capital. Progress is observed. But opportunities for further improvements remain, in particular for the provision of equity to companies.

To facilitate **access to public support**, the Federal Ministry of Education and Research (BMBF) established the "Federal Research and Innovation Funding Advisory Service" as the central point of contact for any questions concerning research and innovation funding. In general, relevant information about public support programmes are accessible through the internet. Applications can also be submitted online. However, the transparency about the broad range of existing support schemes can be improved. A first approach has been undertaken by bundling programmes, e.g., within the "Central Innovation Programme" (ZIM).

The use of **public procurement** as an instrument to stimulate innovation and R&D is gaining ground in Germany. In a joint statement, six federal ministries with responsibility for a high volume of orders decided to pay more attention to innovative solutions within public procurement. Furthermore, the Law against Restraints on Competition (GWB) was modified in 2009 in such a way that public authorities can also require innovative aspects apart from social and environmental aspects in the service specifications. Overall, procurement of innovative products has increased, in particular with respect to energy efficiency. But a binding strategy for innovation-oriented procurement is not yet in sight and public procurement offers further potential.

Assessment of the policy mix

The main challenges that Germany is confronted with in the area of research and innovation, are the expansion of research in cutting-edge technologies, the provision of sufficient funding for R&D, the commercial exploitation of research results, the provision of a qualified workforce, and responding to the new energy concept through 'green' energy (see chapter 2 for more details). The current policy mix addresses these challenges through a broad range of measures.

Policy makers have introduced the **High-Tech Strategy 2020** in 2010 which outlines the research and innovation policy of the Federal Government for the coming years. The main aims of the High-Tech Strategy are to create lead markets, intensify cooperation between science and industry, and to continue to improve the general conditions for innovation. With the proposed directions and instruments, basically all structural challenges are addressed.

The Federal Government is funding **cutting-edge technologies** with numerous initiatives and measures, e.g. within thematic R&D programmes and by means of innovation alliances and top clusters. Current initiatives are embedded in the objective to create lead markets. The notion of lead markets was implemented as a new approach in the High-Tech Strategy 2020. They should contribute to the solution of the grand challenges. Changing the industry structure is challenging and takes time. While evaluations of longer existing programmes are positive, the success of newly initiated measures and the new chosen approach remain to be seen. Overall, the actions seem to be appropriate to enlarge the high-tech sector.

Finding **external sources for financing of R&D in SMEs and young high-tech firms** is a constant challenge that has been reinforced by the financial crisis. Policy makers respond to changing financing options by offering funding instruments with an increased focus on SMEs (SME innovative, ZIM). As part of the second so-called recovery package, the budget of the ZIM programme was increased substantially in 2009 and 2010. As a response to the low share of early-stage VC investments, federal VC programmes were redesigned and expanded. For example, the second "High-tech Start-up fund" (Gründerfonds II) was introduced in October 2011 with an additional investment volume of €289m. Evaluations of the programmes are positive so that they contribute to mitigate the shortage of capital. However, there is still room for further enhancements. Moreover, framework conditions for the provision of equity for firms can be improved. Among others, constraints in the legislation for foundations and endowments can be eliminated in order to use them as an additional source for funding private research (EFI, 2010; 2011).

Facilitating the knowledge exchange between science and industry enables and accelerates the commercial exploitation of research results generated by public institutions. Fostering **science-industry links** has been a policy priority in German research and innovation policy for many decades. A broad range of links are supported, including cooperations, clusters, networks, alliances, and most recently public-private partnerships. For example, the Expert Commission for Research and Innovation highlighted the "Leading-Edge Cluster Competition" as a good way to promote promising innovation clusters (EFI, 2010). The programme provides funding for clusters, comprising firms, research organisations and government authorities that aim at jointly developing and introducing innovations in a certain field of technology or sector within a region. Cluster activities may involve skill development, long-term oriented research strategies, close-to-market technology development, facilitating new business ventures and international cooperation. Moreover, entrepreneurship at universities and technology transfer activities are supported (for an overview of present measures; see section 5 in the Annex). Effective and efficient exchange of knowledge between industry and science may be regarded as one of the strengths of the German innovation system. Notwithstanding, to further extend and improve science-industry links two new measures ("Validation of Innovation Potentials of Scientific Research" and "Research Campus") were introduced in 2010/2011 - complementing existing instruments (see section 3.1).

The **education system** in Germany has to respond to the challenges of the knowledge society, but exhibits some weaknesses. Meeting the economy's **demand**

for high-skilled labour, in terms of both quantity and quality, is a constant challenge for the German education system. The government has recognized the challenge. During the first education summit in 2008, the Federal Government and the states called for an “Education Republic of Germany”. The objective of an “Education Republic” was stressed again by the new coalition, formed in 2009. Mobilising skilled workers is also a stated objective in the High-Tech Strategy 2020. The Federal Government has increased the investment in education. A number of initiatives were set up, others were updated and expanded to strengthen the education system and to mobilise human resources, such as the “Higher Education Pact“, the “Initiative for Excellence”, the “Pact for Research and Innovation”, and the “Quality Pact for Teaching at Universities”. In 2008, the federal and state governments agreed on the “Qualification Initiative” for Germany which addresses all areas of education from early-childhood education to lifelong learning. Examples are the upgrading scholarships programme which allocates grants to people with good vocational qualifications to study at a HEI, support measures for lifelong learning, and the “National Pact for Women in MINT Professions” to attract more women to courses in the so-called MINT subjects. A scholarship programme for students (Deutschlandstipendium) provides grants since summer 2011. Furthermore, actions are taken to remove barriers for third country highly qualified and highly skilled persons including the most recent bill (Blue Card) written in December 2011. Although progress is observed like growing enrolments of students at universities, further measures are necessary to improve the education system and to secure a sufficient supply of qualified workforce. Intensified efforts are needed in primary, secondary as well as higher education. For example greater efforts are necessary to achieve more social equality for access to education and to encourage young women to study mathematics, engineering and science. In order to realize the potential of women, corresponding family policy is also required, e.g. through the provision of sufficient childcare facilities and the establishment of a more family-friendly corporate culture (see chapter 1.4 in the Annex). Whether more skilled professionals will be attracted by the new bill remains to be seen. Overall, changes in the education system need a long time until they become apparent in performance indicators. Furthermore, by virtue of the federal structure legislative powers for the school and higher education sector lies in the hands of state governments. Thus, legislation, administration and financing in these areas are almost exclusively a matter of the federal states. The Federal Government has almost no competences in education policy. By removing the cooperation ban the Federal Government can contribute to a larger extent to education. There is currently a discussion revolving around the question whether a provision that allows joint action of the Federal Government and the federal states in the school sector should be incorporated in the German Constitution. For the change in the Constitution a broad consensus is needed.

In order to compensate the recently decided nuclear phase-out until 2022 and to secure the **energy supply** afterwards – for a reasonable price, research and innovation activities in renewable electricity production need to be further expanded. The Federal Government supports this field since a long time. In 2007 it launched a comprehensive package of energy and climate policy measures, the “Integrated Energy and Climate Programme” (IEKP). Among others it contains a broad range of measures, especially aiming at increasing energy efficiency and advancing the use of renewable energy. Forward-looking projects are included in the High-Tech Strategy 2020, for example the project “Intelligent restructuring of the energy supply system”. Supporting instruments of various ministries are also in place to tackle the challenge.

Their policies and activities are coordinated at the "Coordination Platform for Energy Research Policy" at the BMWi. Nevertheless, the objective is rather challenging and its achievement remains to be seen.

Overall, R&D&I policy in Germany responds to the key challenges that the German innovation system is facing. The High-Tech Strategy 2020 as well as implemented measures are relevant and seem to be appropriate to mitigate the structural challenges (EFI, 2011; Deutsche Telekom Stiftung, 2011). However, the success of the High-Tech Strategy 2020 will critically depend on its further implementation process (EFI, 2011). The potential of only recently implemented measures have not been unfolded yet and remain to be seen. Moreover, further efforts and instruments are demanded, particularly in the education system and regarding the redefined energy policy and the financing of R&D and innovation in SMEs and start-ups.

Table 2: Assessment of the policy mix

Challenges	Policy measures/actions	Assessment in terms of appropriateness, efficiency and effectiveness
Expansion of cutting-edge technologies	New approach: creation of lead markets to provide solution of the societal challenges. Various measures are directed towards cutting-edge technologies (e.g., thematic R&D programmes, innovation alliances) High-Tech Strategy 2020	Changes in industry structure are difficult to induce and take time. Programmes in place which tackle the challenge. Success of new approach remains to be seen. Actions seem to be appropriate.
Financing for R&D and innovation in SMEs and high-tech start-ups	Increased focus on SMEs in public R&D programmes ("SME innovative", "ZIM"). Expansion of the provision of VC through the "High-tech Start-up Fund II" introduced in October 2011. High-Tech Strategy 2020	Evaluations of programmes are positive. Funding focuses on grants for (cooperative) R&D projects, introduction of tax-based incentives for R&D may provide new impetus for business enterprise R&D expenditure. Framework conditions for the provision of equity could be improved further. Actions seem to be appropriate but room for further advancements

Challenges	Policy measures/actions	Assessment in terms of appropriateness, efficiency and effectiveness
Commercial exploitation of research results	Strong focus on industry-science links in R&D funding programmes for decades; support of various forms of links including cooperation, clusters, networks, alliances, partnerships. Moreover, entrepreneurship at universities and technology transfer activities are supported. "Validation of Innovation Potentials of Scientific Research" introduced in 2010; supports investigation of market potential of public research results. Establishing public-private partnerships through the "Research Campus" programme, introduced in 2011. High-Tech Strategy 2020	Overall, well-established knowledge exchange between industry and science; a broad range of existing and new programmes to further strengthen these links and to commercially exploit research results to a larger extent. Actions seem to be appropriate.
Provision of qualified workforce	Policy announced to create "Education Republic of Germany" (in 2008) Several initiatives to strengthen education system and mobilise human resources, including "Pact for Higher Education", "Initiative for Excellence", "Qualification Initiative" In December 2011 a bill has been written to further open the labour market for third country residents (Blue Card) High-Tech Strategy 2020	Initiatives have been successful as far as implemented and evaluated. But still large untapped potential (migrants, women); further opening of the labour market. Complex coordination in education policy owing to split competences. Actions seem to be appropriate but room for further advancements, particularly regarding structural developments.
Research and innovation in energy supply	A broad range of support programmes by various ministries. Integrated Energy and Climate Programme. High-Tech Strategy 2020	The objective of nuclear phase-out until 2022 is rather challenging. Actions seem to be appropriate, whether they are sufficient remains to be seen.

National policy and the European perspective

The **key challenges** that Germany is confronted with in the area of research and innovation are the following: expansion of cutting-edge technologies, provision of sufficient funding for R&D and innovation activities of SMEs and high-tech start-ups, further commercial exploitation of research results, provision of a qualified workforce, and responding to the new energy concept through 'green' energy (see chapter 2). Mastering the challenges is crucial to secure and accelerate innovative dynamics in

Germany, i.e. if these challenges are not successfully tackled they will create bottlenecks for the innovation system.

The German Federal Government has moved all three areas research, innovation and education further to the core of its growth policy (BMBF, 2010) and is fully aware of the challenges. Public investment in these areas was increased in recent years and will further increase. The **priorities in R&D&I policy** as outlined in the High-Tech Strategy 2020 as well as the current policy mix address the main challenges. No particular imbalance between the R&D&I policy actions and challenges could be identified. The measures are well proven and are assessed to be relevant and appropriate to mitigate the structural challenges. However, whether the measures are sufficient to completely overcome the challenges, in particular the challenge regarding the financing of R&D in SMEs and start-ups and the new challenge due to the redefined energy policy, remains to be seen. Regarding education policy, especially structural developments such as the cooperation ban between the Federal and the state governments in education have not yet been tackled.

Overall, R&D&I policy is rather stable and predictable due to multi-annual programmes. The **stability in R&D&I policy** in Germany which was also maintained during the economic and financial crisis is suitable since the main challenges the German research and innovation policy has to deal with, do not change dramatically on an annual base. Furthermore, the continuity and long-term orientation of policy instruments is necessary because changes in structures and the behaviour of actors take time. Although the principal research and innovation policy instruments in place remain stable, they are regularly re-designed and adjusted to respond to changing framework conditions. Nevertheless, a number of new measures that complement the existing policy mix was initiated only recently (based on the new High-Tech Strategy). Their whole potential and effects have not been unfolded yet and remain to be seen. The overall success of the High-Tech Strategy will also critically depend on its further implementation process.

R&D&I policy offers a number of initiatives to strengthen research and innovation activities in the business sector. Most measures focus on excellence, both in terms of scientific excellence in public research and 'market excellence' in applied R&D performed by enterprises or through collaborative research involving firms and public research institutions. Consequently, the R&D&I activities of enterprises have to target new products and processes that are world novelties. Firms focusing their activities on adapting existing technologies and developing customer-specific products and more efficient internal processes tend to find it difficult to receive public funding for their R&D activities, particularly if they choose to conduct R&D without external project partners. For this large group of enterprises, which comprises most of R&D-performing SMEs, alternative funding instruments are required. A **tax-based incentive for R&D** would have the potential to address a significantly larger number of enterprises by targeting firms conducting R&D without external project partners and by providing incentives for currently non R&D-performing enterprises to engage in R&D activities. More generally, tax-based incentives may provide a continuous impetus to invest in research and innovation and would complement the current policy mix for funding business R&D. Its introduction is frequently demanded by various actors. But an introduction implies significant fiscal costs. Depending on the design of the incentive, estimations for the costs vary between €460m and €5.7b (Elschner/Ernst/Spengel, 2011).

The increasing focus on promoting scientific excellence, particularly in the context of the “Initiative for Excellence”, may change to some extent the **incentive structure in science.** A recent study for the Expert Commission for Research and Innovation (see Fraunhofer-ISI et al., 2012) shows that the current discourse on excellence and scientific competition at universities leads to increased activities in basic research and academic publication, but provides little impetus for strengthening knowledge transfer activities. However, focussing on excellence can also indirectly promote industry-science cooperation as industry often looks for the most outstanding researchers as cooperation partners (see Grimpe, 2010). Indeed, there is a significant number of collaborative activities involving industry within the projects funded through the “Initiative for Excellence” as well as through the “Pact for Research and Innovation”, which provides additional funding for the four largest non-university public research organisations.

Special attention needs to be paid to **education policy** in Germany. The Federal Government as well as the state government has increased the investment in higher education (foremost through the “Higher Education Pact” and the “Quality Pact for Teaching at Universities”). In addition, various measures and initiatives are in place to strengthen the education system and mobilise human resources. Though progress has been made, greater efforts are needed in primary, secondary as well as in higher education, e.g., to achieve more social equality concerning the access to education, to increase the participation rate in tertiary education, to encourage young men and women to study mathematics, engineering and science, and to use the potential of foreign-born residents. By allowing cooperation between the Federal Government and the state governments in the school and higher education sector, the Federal Government could contribute to a larger extent to education. There is currently a debate revolving around removing the cooperation ban.

The **European dimension** of research and innovation policy has gained importance over the last decade. The relevance of European and international collaboration in research has been highlighted in the internationalisation strategy adopted in 2008 and in the High-Tech Strategy 2020 implemented in 2010. Research policy explicitly acknowledges and supports the European Research Area (ERA). Support and information are provided to mobilise German research institutions and enterprises to participate in European projects. Correspondingly, German partners are strongly involved in projects within European initiatives such as ERA-Nets, joint research programmes according to Article 185 of the Treaty of Lisbon, Joint Programming Initiatives, and Framework Programmes. At the same time, research programmes by the Federal Government and German Research Foundation (DFG) are further opening up to foreign entities and access to research infrastructures for the transnational scientific community is provided by opening large infrastructures located in Germany. Moreover, the government takes further steps to remove formal constraints on researchers’ mobility. At the administrative level, Germany contributes to improvements in coordination of R&D programmes across Europe. Overall, the strategic ERA objectives are considered and integrated into German research and innovation policy. However, as recommended by the Expert Commission on Research and Innovation (EFI, 2011) the Federal Government could intensify its role in the European coordination process and take a lead in the area of research and innovation in order to shape the ERA.

Table 3: Assessment of the national policies/measures supporting the strategic ERA objectives (derived from ERA 2020 Vision)

	ERA dimension	Main challenges at national level	Recent policy changes
1	**Labour Market for Researchers**	Increasing the attractiveness for foreign as well as German academics currently abroad to work in Germany. Main barriers include insecurity concerning career paths, small number of long term contracts, and low salaries compared to the US and Switzerland Expanding education in MINT subjects. Entrepreneurship education is underdeveloped. Potential of women not fully realized.	Agreement to continue the “Pact for Research and Innovation” in 2009 which also supports young researchers. Initiative to encourage young women’s interest in MINT subjects introduced in 2008. To strengthen a culture of entrepreneurship the initiatives “country of founders Germany” and “university of founders” were introduced in 2010. Adoption of standards on gender equality by the German Research Foundation in 2008. Paying special attention to women in the “Pact for Research and Innovation”.
2	**Cross-border cooperation**	Advancing coordination of multilateral research policies.	Adoption of the internationalisation strategy in 2008. Establishment of the “Initiative on Multilateral Research Funding” under the leadership of the DFG in 2010. Strong participation in all new multilateral joint initiatives on the European level.
3	**World class research infrastructures**	Development of national roadmap setting priorities across disciplines.	Development of a roadmap for research infrastructure by Helmholtz Association (HGF) in 2011.
4	**Research institutions**	Further financial and managerial autonomy for universities and PROs.	Since 2009 increased budget flexibility for PROs (Wissenschaftsfreiheitsgesetz), but not adopted for HEIs. Agreement on the continuation of the “Initiative for Excellence” for the period 2012 to 2017 with a total funding volume of €2.7b. Agreement on the continuation of the “Pact for Research and Innovation”.

	ERA dimension	Main challenges at national level	Recent policy changes
5	**Public-private partnerships**	Further strengthening of knowledge transfer. Recent focus on promoting research excellence may undermine knowledge transfer activities at public research.	Further strengthening of knowledge transfer and exchange by introduction of the programmes "Validation of Innovative Potential of Scientific Research (VIP)" in 2010 and "Research Campus" in 2011.
6	**Knowledge circulation across Europe**	Further internationalisation of (academic) researchers. Avoidance of brain drain, e.g., to the U.S.	Strong engagement in international projects newly initiated on the European level.
7	**International Cooperation**	Further internationalisation of some PROs. Further internationalisation to solve grand challenges.	Growing number of bi-/multilateral agreements on cooperation. First internationalisation strategy implemented in 2008. Importance of international cooperation has been highlighted in the High-Tech Strategy 2020, in particular to solve the grand challenges.

Annex: Alignment of national policies with ERA pillars / objectives

1. *Ensure an adequate supply of human resources for research and an open, attractive and competitive single European labour market for male and female researchers*

1.1 Supply of human resources for research

Germany performs well in the training of young scientists and scholars. In 2009 more than 25,000 people successfully completed a doctorate, accounting for about a quarter of the new doctorate holders in the EU-27. Put differently, 2.6 persons attained a doctoral degree per thousand population aged 25-34 years which is well above the EU-27 average (1.6) and the United States (1.6). On the other hand, the ratio of 7.5 persons employed as researchers (FTE) per thousand working population is not as remarkably (OECD, 2011). While the ratio is higher than the EU-27 average (6.5), it is significantly below Finland (15.1), Denmark (12.1) and Sweden (9.6). Similarly, the share of human resources in science and technology (HRST) in the labour force was 44.8% in 2010, which is again above the EU-27 average (40.5%) but below the shares in Finland (50.6%), Sweden (50.8%) and Denmark (51.9%). Overall, the employment perspectives in Germany rise substantially with increasing levels of education. In 2010, the unemployment rate of people having a tertiary level education (ISCED level 5 and 6) was only 3.2% compared to 7.0% for people having an education of ISCED level 3-4. The unemployment rate of those with an ISCED level 0-2 is even higher with 15.1%. The German innovation system continues to face the need to upgrade the human resource base, since the demand for university graduates in the labour market is growing.

The internationalisation in academia is increasing. The share of foreigners among doctorates awarded in Germany has grown continuously over the past decade, from 6.7% in 1997 to 14.5% in 2008. Nearly one third of foreign graduates stemmed from EU member states; 8% from China and 6% from India. In comparison, in the UK 40% of doctoral degrees were taken by foreigners in 2007. In the US, the share of foreign doctorate degree holders was 28%; the largest share of them from EU countries was German. In Germany, the share of foreign colleagues among staff scientists and artists in universities equalled 9.4% in 2008 while at non-university institutions, the share of foreign scientists and artists on the payroll reached 14.9%. With regard to professors at German institutions of higher education, the share of foreigners was 5.6% which is lower in comparison to the U.S. (10% in 2006) and Switzerland (45%). The majority of foreign researchers and scientists in Germany are from Europe, plus a sizeable share of Asian researchers (WR, 2010).

A wide range of programmes exist to enhance international mobility of researchers. Key actors are the German Academic Exchange Service (DAAD), the German Research Foundation (DFG), the Alexander von Humboldt Foundation (AvH) and for the USA, the Fulbright Commission. The DAAD is supporting foreign students and researchers coming to Germany as well as outgoing German students and researchers. It also helps to get an overview of different programmes at German universities. For example with its platform “PhDGermany” which is a database of doctoral positions, international students shall be encouraged to obtain their doctorate in Germany. The internet platform KISSWIN.de provides information and advices for national and international young scientists regarding academic careers in Germany, including funding opportunities. With the initiative “GATE-Germany” DAAD and BMBF are helping German universities to internationalise their profile. Based on a joint initiative of AvH, DAAD and DFG, GAIN has been built up which is an interdisciplinary contact and information forum for German scientists. It was established for German scientists working in North America, e.g., to provide information concerning career opportunities in Germany and to actively support their return to Germany. Similarly German scientists in the US established the “Initiative Zukunft Wissenschaft”. To attract foreign world-leading researchers, an international award for research in Germany was implemented in 2007 by the AvH (Alexander von Humboldt Professorship). The prize is endowed with up to €5m. The awardee is supposed to engage in ground-breaking research in Germany for a period of five years. In addition to the professorship the foundation has numerous measures to increase the number of international researchers at German universities as well as to support researchers to go abroad, including programmes for postdoctoral researchers, junior research group leaders and experienced researchers (Humboldt Foundation, 2011). Moreover the four large research organisations (HGF, MPG, FhG, WGL) have implemented specific programmes to attract international researchers or to exchange scientific personnel (GWK, 2011a).

1.2 Ensure that researchers across the EU benefit from open recruitment, adequate training, attractive career prospects and working conditions and barriers to cross-border mobility are removed

Career paths for PhD holders at universities are rather rigid and insecure. Short-term contracts are the norm; permanent positions are rarely available. In 2009, 83% of the full-time scientists at universities had a temporary contract. Young researchers in their qualification phase, i.e. the doctoral or postdoctoral/habilitation phase, hold the majority of limited contracts. Less than 10% of the young researchers have a permanent position. In general, the series of temporary contracts is limited to 12 years in Germany. In order to increase the attractiveness of jobs for young researchers in science and to avoid brain drain, the Federal Government introduced a new career path for post-docs towards a professorship (called Juniorprofessur) in 2002. At the end of 2009 almost 1,000 junior professorships were established. However, only about 8% of them held an actual tenure track option, i.e., promotion to a tenured professorship if specific goals are met (Federkeil/Buch, 2007). Overall, the implementation has fallen short of expectations and career prospects for this group of researchers are still uncertain due to the lack of a tenure track. To overcome the 12-year limit for temporary work contracts in universities and public research organisations, in April 2007 a new law on temporary contracts in science has entered into force. For example, the limit can be exceeded if the work is mainly linked to a third-party funded project. An additional problem arises for scholarship holders. They are usually not paying for pension schemes and thus, the period is not covered pension-wise. Regarding the portability of project grants the German Research Foundation (DFG) participates in the “Money follows Researcher scheme” by EUROHORCs and enables researchers to take the remainder of a current grant to another country. In contrast, researchers involved in research projects financed by the BMBF cannot transfer the grant since the recipient of the grant is usually the research institution.

In addition, several federal research programmes contain measures which focus on supporting promising groups of young researchers. Improved qualification and support for junior researchers in public research organisations are also an element of the “Pact for Research and Innovation”. The monitoring report of the initiative confirms that visible improvements have been reached, but suggests that more efforts should be made to implement an attractive and transparent post-doc culture in PROs (GWK, 2011a). By promoting top-class university research within the framework of the “Initiative for Excellence”, the Federal Government expects to establish internationally visible research beacons in Germany and to increase its attractiveness.

The average annual salary of a researcher in Germany was €56,132 in 2006, exceeding the EU-25 average of €37,948, as shown in the report of the European Commission on the remuneration of researchers in the public and private sector (European Commission, 2007). Taking into account the cost of living, the average salary in Germany decreases to €53,358, while the average EU-25 salary increases to €40,126. Nevertheless, Germany still keeps its position in the range of countries with high remuneration levels (€40,000-60,000). However, researchers’ salaries in Germany still lag behind those in the US (€60,156 or €62,793 when considering the cost of living) and Switzerland. Compared to the wages paid by private enterprises, the salaries are considered to be low. Moreover, the rather rigid remuneration system of the “Tarifrecht” (remuneration law of the public sector) is considered inadequate for attracting excellent researchers. In the reform concerning the remuneration of professors (“Professorenbesoldungsreformgesetz”) in 2002, for the first time limited performance components have been introduced that go beyond the stipulations of the “Tarifrecht” (Nill et al., 2009). Overall, the main barriers to the recruitment of national as well as international staff include a high insecurity concerning career paths, a relatively small number of long term contracts, and lower salaries compared to the US and Switzerland (WR, 2010). In general, transparency regarding recruitment and career perspectives can be improved as the labour market is highly diversified.

The European Charter for Researchers was signed by five German institutions, among them the German Rectors’ Conference (HRK) as the representative of Germany’s universities. The HRK recommends its members to implement the charter.

erawatch

The most recent states' higher education laws demand that vacancies are advertised internationally (depending on the importance of the position or in some cases as a general rule) and only allow exceptions in special cases. Scholarships are increasingly being advertised internationally. For example, the German Research Foundation (DFG) recommends that scholarships should be advertised internationally within the framework of its scholarship funding. This has resulted in an increasing number of applications from abroad.

The Lisbon convention on the recognition of qualifications was ratified by Germany. Germany put forward a proposal to adapt its higher education qualifications to the European Qualifications Framework. The German qualification framework proposal, launched in March 2011, aligns the higher education qualifications of its federal states to make German qualifications more easily understandable and transferable within the European Union (Deutscher Qualifikationsrahmen für lebenslanges Lernen). At the beginning of 2012 the final version should be transferred to the EC. In November 2011, the Federal Council (Bundesrat) adopted a law to further improve the assessment and validation of qualifications acquired abroad in order to use the potential of skilled foreigners already being in Germany. The 'Recognition Act' enters into force in April 2012.

1.3 Improve young people's scientific education and increase interest in research careers

Several programmes and initiatives were implemented to strengthen the education system and mobilise human resources. At the education summit in 2008, the federal and state governments agreed on the "Qualification Initiative" for Germany which addresses all areas of education from early-childhood education through to lifelong learning. Examples are the upgrading scholarships programme which allocates grants to people with particularly good vocational qualifications and work experience who wish to continue at university, support measures for lifelong learning, and the National Pact for Women in MINT Professions to attract more women to courses in the so-called MINT subjects. By 2010, 200 scholarships were allocated to the latter. With the continuation of the "Higher Education Pact 2020" in 2009 and its expansion in 2011, the Federal Government and the states decided to create 335,000 additional places for university entrants expected between 2011 and 2015. The "Initiative for Excellence" provides funding for 39 graduate schools for doctoral students in the first two rounds. Each graduate school received an average of €5.7m for a period of five years. Winners of the third round will be announced in mid-2012. With the "Quality Pact for Teaching at Universities" the study conditions and teaching quality should be improved. €2b will be provided in the quality pact between 2011 and 2020. Apart from the public programmes, there are 12 foundations and organisations (Begabtenförderungswerke) that support highly talented students, assisting 1% of all university students in 2008. The Expert Commission for Research and Education states that further measures are necessary to improve the education system (EFI, 2010) and recommends, e.g., making greater efforts to achieve more social equality for access to education. Additionally, the national scholarship programme (Deutschlandstipendium) started in 2011. It aims to support up to 8% of all students financially with €300 on a monthly basis.

The dual system of vocational training consisting of training on the job and education in vocational training schools is well established in Germany. It provides qualified personnel for the labour market and enjoys a high reputation (EFI, 2009). Vocational training is also widespread in the knowledge-intensive sector.[12]

Entrepreneurship education needs to be further developed in Germany, both in secondary as well as tertiary education (Brixy et al., 2011). To strengthen a culture of entrepreneurship, the Ministry of Economics and Technology (BMWI) started the initiative "country of founders Germany" (Gründerland Deutschland) in 2010. Among others, knowledge of business start-ups and management is taught in schools. The new competition "university of founders" has been launched within the federal programme EXIST (EXIST-Gründungskultur – Die Gründerhochschule) in which higher education institutions compete with new strategies for entrepreneurship education at their institution.

1.4 Promote equal treatment for women and men in research

[12] For an overview of the vocational education system in Germany see http://www.bmbf.de/pub/germanys_vocational_education_at_a_glance.pdf

Though increasing, the percentage of women among researchers is still rather low. Between 1992 and 2009 the proportion of female degree holders of tertiary education rose from 41% to 51%. In terms of doctorates, the share rose from 31% to 44% and from 8% to 18% for female professorships. The share of women employed as scientific staff at the four large PROs (HGF, MPG, FhG, WGL) reached 33% in 2010 whereas the proportion of women decreases, the higher the position. The share of women in leading positions was 11% in 2010, compared to 2% in 1992.

On both federal and state level special attention is paid to equal opportunities in science and research. The German Research Foundation (DFG) implemented the Standards on Gender Equality (Forschungsorientierte Gleichstellungsstandards) in 2008 which are adopted or will be adopted by all research organisations (GWK, 2011a). Besides, the “Pact for Research and Innovation” pays special attention to the promotion of women. However, there is no female quota in science.

A number of general measures aim at the reintegration of women in the labour market which also apply to researchers. In general, both men and women can take advantage of the “Elternzeit”, the possibility to leave work for up to 3 years (this can be split between the parents) with a guarantee of the previous workplace afterwards. In 2007, a new parental allowance programme (“Elterngeld”) was introduced. “Elterngeld” is a reimbursement that is paid up to 14 months to financially support the parent not working. Concerning an affordable and high quality childcare, particularly for children under the age of three, a wide gap exists. The Federal Government, the states and the municipalities have agreed to raise the number of places at childcare and day-care facilities for children under the age of three nationwide, catering for approx. 35% of these children by 2013. From 2013 on, parents will have a legal right to a childcare place. The actual implementation is far behind schedule. The achievement of this objective until 2013 is fairly unrealistic.

Overall, the academic and economic potential of women has not yet been fully realized. More efforts are required to further exploit this potential, e.g. by establishing a more family-friendly corporate and academic culture (GWK, 2011a; 2011b).

2. Facilitate cross-border cooperation, enhance merit-based competition and increase European coordination and integration of research funding

The internationalisation strategy adopted in 2008 highlights the potential of international collaborations for Germany. As outlined in the strategy funding earmarked for international cooperation should be increased. The modalities regarding the opening up of research programmes range from mere acceptance of foreign partners in research projects, without neither of any explicit selection criterion nor of funding associated, to the establishment of compulsory participation of foreign research performers and allocation of a substantial share of the funds to the latter. The degree of openness is programme-specific. For example, for BMBF-funded research projects the aim should be a participation rate of foreign partners of 20% (BMBF, 2008).

Under the leadership of the DFG, the G8 Research Councils have established the “Initiative on Multilateral Research Funding” in February 2010. Researchers of a consortium apply jointly for funding in one country. Proposals are also evaluated by one country but funding of the participating researchers is provided by their respective national funding organisation according to their normal terms and conditions for project funding. First projects have started in March 2011. Comparable to this is the existing ‘D-A-CH’ agreement between the three German-speaking funding organisations, the German Research Foundation (DFG), the Swiss National Fund (SNF) and the Austrian Research Fund (FWF).

Moreover, Germany participates intensively in multilateral joint initiatives on the European level. Germany takes part in most ERA-Nets[13], in all joint research programmes undertaken under Article 185 of the Treaty of Lisbon (European and Developing Countries Clinical Trials Partnership, Ambient Assisted Living, EUROSTARS, EMRP and Bonus), and in most Joint Programming Initiatives. German partners are also involved in European Technology Platforms (ETP) such as the ETP on Smart Systems Integration or the ETP on Photonics21 whose activities are coordinated by German partners. Through its

[13] for an overview see http://netwatch.jrc.ec.europa.eu/nw/index.cfm/info/Nets?sort=Acronym&order=ASC&status=active&CountryCode=DE&search=&Submit=Search

engagement, Germany also wants "to become a motor of European strategy development in research and innovation policy" (BMBF, 2008).

3. Develop world-class research infrastructures (including e-infrastructures) and ensure access to them

A national roadmap for research infrastructures which defines priorities across disciplines does not exist in Germany. Instead, the German Science Council (WR) regularly provides recommendations on large research infrastructures of national or international significance. Besides, the Helmholtz Association (HGF) which operates large-scale facilities and infrastructures has developed and published a roadmap for research infrastructures in 2011. In addition, infrastructure proposals are drafted by the specialist scientific communities such as the Committee for the physics of elementary particles ("Komitee für Elementarteilchenphysik"). The respective departments of the BMBF follow up the requests. So far, there is no cross-disciplinary weighing or prioritisation, but this is planned for the future. Moreover, there is no systematic integration of the states in the relevant planning processes yet (GWK, 2011b). Overall, the internationalisation strategy highlights the importance of first-class infrastructure (BMBF, 2008). Thereby, both international infrastructures in Germany as well as in other European countries are important.

Germany takes an active part in providing research infrastructures which are financed and operated jointly with other states. Major European research infrastructures reside in Germany or are scheduled for realisation such as the German Electron Synchrotron (DESY), the Facility for Antiproton and Ion Research (FAIR) and the European X-Ray Laser Project (XFEL). Several projects of the ESFRI-roadmap are being coordinated by Helmholtz centres. Information on a large number of research infrastructures can be found on the European Portal on Research Infrastructures Database.

Many of the large national infrastructures are open to foreign access. It has been realized that worldwide cooperation is the key to achieve outstanding scientific results and to foster innovation. For this reason, the Helmholtz Association provides grants within its "Initiative and Networking Fund" to strengthen its international component. With 32.7% of their users being researchers from abroad, German research infrastructures are far ahead of the rest of Europe (e.g., Italy: 14.6%, UK: 11.2%; WR, 2010) regarding their utilisation by foreign visitors. This renders Germany an essential provider of research infrastructures for the transnational scientific community.

4. Strengthen research institutions, including notably universities

Germany has a highly diversified higher education system, with about 415 higher education institutions. The two main models are universities (106) which offer a theoretical and science based education as well as possibilities to receive a PhD afterwards, whereas the universities of applied sciences (207) focus on a rather applied education and therefore do not offer all different kinds of study fields. There are special universities which focus for example on arts, music, or theology. Approximately two thirds of students are registered at universities; about 31% attend a university of applied sciences (Statistisches Bundesamt, 2011). An increasing number of universities are privately operated (about 130, in particular universities of applied sciences; BMBF, 2010). In Germany no differentiation is made between research and education universities. Moreover, in most states so-called universities of cooperative education (Berufsakademie) exist, which combine applied studies with vocational training.

The German states have strong competences in higher education. Since the related laws are introduced on state level, the laws and the resulting autonomy varies between the 16 states. Overall, the autonomy of higher education institutions is rather limited in Germany compared to other European countries (European University Association, 2009). For instance with regard to the staffing autonomy, in some states the appointment of professors has to be confirmed by the relevant state ministry. Salary costs are partially determined by the states and thus vary only marginally between professors although the salary cap was abolished. In some states, the government predetermines the number of faculties, professorship and university places. University land and buildings are in most cases not owned directly by the institutions but by the state. The implementation of tuition fees (including the amount) is decided at the state level.

The freedom of universities regarding the allocation of governmental funds is restricted. Increased flexibility in terms of budgets which was implemented for PROs (Wissenschaftsfreiheitsgesetz) has not been adopted for universities. Further autonomy in particular regarding financial and managerial aspects is required so that the universities and research institutions can develop their own goals, staffing plans and financial strategies.

For universities, block funding is provided at regional level by the 16 states and amounts to almost €19b. In recent years, in some states, a part of the block funding for universities was distributed against a set of performance criteria which includes also research performance criteria. Germany has no tradition of elite universities such as in the USA or France. Thus, a major change was that since 2006 additional funding by the Federal Government and the states has been channelled in a competitive way according to excellence criteria ("Initiative for Excellence") which aims at supporting cutting-edge research at universities to create "beacons of science" with international visibility. It consists of three project-oriented lines of funding: postgraduate schools for young scientists; clusters of excellence; funding of "Future concepts for top-class research at universities". This competition allocated additional funds from the Federal Government and the federal states of €1.9b between 2006 and 2011. The Federal Government covered 75% and the federal states 25% of the total amount. In 2009, the Federal Government and the federal states decided to extend the excellence initiative for the period 2012 to 2017 with a total funding volume of €2.7b.

For the non-university public research system, the federal and the state levels coordinate joint block funding via the Joint Science Conference (GWK). The total amount of this joint block funding (which includes also administration expenses) for the four large research organisations was about €4.8b in 2010 (GWK, 2011a). Block funding for governmental research institutes is provided by the federal ministries. Additional competitive project funding for public basic research (beyond the "Initiative for Excellence") of about €1b is provided through the German Research Foundation (DFG).

The research performance of HEIs and PROs is monitored and evaluated by various actors. The German Science Council (Wissenschaftsrat) monitors the quality and excellence of the public research system through its regular evaluations and recommendations. In previous years, the Council evaluated all federal institutions with R&D responsibilities and research institutions which applied for joint federal and state funding through the Leibniz association. Moreover, the DFG set up a specific institute for evaluation and quality assurance (IfQ). Rankings of the research quality of universities are a fairly recent phenomenon which has been particularly fostered by private not-for-profit organisations and the university rectors' conference. The Centre for Higher Education (CHE) publishes a research ranking of universities to render performance transparent. The ranking includes, among others, third-party funding, publications and citations, number of doctorates awarded, and patent applications. Every three years the DFG also publishes a university ranking based on the support received (e.g. DFG, 2009).

5. Facilitate partnerships and productive interactions between research institutions and the private sector

Effective and efficient **exchange of knowledge between industry and science** may be regarded as one of the strengths of the German innovation system. Close ties between business firms and academia are revealed by the high share of industry funding of research in universities and PROs. This high level of transfer activities is also the result of on-going policy activities. Fostering knowledge circulation has been a policy priority in German research and innovation policy for many decades, and a large number of programmes were implemented. Currently, the following initiatives may be regarded as particularly relevant to maintain and further increase industry-science links:

- Most thematic R&D programmes encourage – though not always require – the funding of cooperative research projects involving universities, PROs and the business sector. As a result, the majority of funded projects are collaborative projects (see Fier et al., 2006). Grants of the support measure "Cooperation Projects" within the "Central Innovation Programme" (ZIM) require the cooperation between SMEs or between SMEs and PROs.
- An important programme to promote interactions between research institutions and SMEs is the industrial collective research programme (Industrielle Gemeinschaftsforschung – IGF). It provides funding for cooperative industrial research that is organised through a network of more than 100 sector-specific research associations (within the framework of the AiF organisation). The actual

research work is assigned to a research institute. The results are available for all SMEs in the respective sector.

- Many thematic R&D programmes contain cluster elements such as the “Leading-Edge Cluster Competition” programme as well as “Innovation Alliances” (both introduced in 2007) which should bring larger consortia of industry and public research together to develop path-breaking innovation that needs a longer time horizon and high R&D investment. The “Leading-Edge Cluster Competition” was highlighted by the Experts Commission for Research and Innovation to be a good way to promote promising innovation clusters (EFI, 2010). The existing cluster programmes were complemented recently by the programme “Research Campus” which provides funding for the development of strategic medium to long-term public-private partnerships between universities, public research institutions and private companies. The deadline for applications was February 2012.
- The German science system includes a number of organisations that are devoted to knowledge transfer with the business sector, including
  - the Fraunhofer Society which provides applied research particularly in the fields of engineering and computer sciences,
  - technical universities linking basic to applied research in all fields of natural science and engineering, and
  - universities of applied sciences, playing a particularly prominent role in supplying industry with highly skilled personnel in the field of engineering and offering consulting and R&D services to SMEs.
- Several federal states run linkage programmes, including funding of cooperative research and voucher systems for SMEs to purchase R&D consulting services from public research organisations and universities.
- The federal programme EXIST supports entrepreneurship at universities and thus helps to promote spin-offs as a channel of knowledge exchange. Public financing schemes for high-tech start-ups (e.g. the High-tech Start-up Fund) are also important for promoting spin-offs from public research. To close the gap between academic research and commercial usability the funding programme “Validation of Innovative Potentials of Scientific Research (VIP)” was implemented in 2010. It focuses on the validation phase within the process of knowledge and technology transfer by offering grants to researchers at public research organisations and universities to further investigate the commercialisation prospects of their research findings.

The increasing focus on promoting excellence as in the “Initiative for Excellence” can also indirectly promote industry-science cooperation as industry often looks for the most outstanding researchers as cooperation partners (see Grimpe, 2010). Indeed, there is a significant number of collaborative activities involving industry within the projects funded through the “Initiative for Excellence” as well as through the “Pact for Research and Innovation”.

Economic exploitability is used as the *de facto* quality criterion for a number of public R&D support measures, mainly the pre-competitive programmes of BMBF and BMWi. In general, all publicly funded projects have to develop an implementation and exploitation plan as part of their project proposal. In addition, the results of all federal pre-competitive R&D projects are centrally accessible via a database (at TIB Hannover).

The university owns **results stemming from university research**. In 2002, the so-called “University Teachers’ Privilege” which gave ownership of the results to the professors was abolished. Since then, researchers have to notify the university in case of an invention that can be patented. The university has four months to decide whether to patent the invention or not. In the case of no decision after four months, the researcher retrieves the patent rights. The compensation for the researcher in the case of a patent application through the university is 30% of the gross income. In case a university decides to take patent rights, so-called Patent Commercialisation Agencies (“Patentverwertungsagenturen” - PVA) take care of the IP management. PVAs have been established after 2002 in each of the federal states and manage IPRs for several universities within their federal state. There are 23 PVAs today. They receive some basic funding from the Federal Government’s SIGNO programme but are expected to cover an increasing part of their costs from licensing and royalties. But the idea of self-funding of PVAs through licensing and royalties is rather unrealistic, since the vast majority of university patents do not yield any significant economic return. There is a debate on whether to reduce the number of PVAs in order to increase professional IP management and allow PVAs to better specialise by field of technology. The SIGNO programme including the supported PVAs was positively assessed by an evaluation in 2010. However, there is still room for improvements, for example regarding the skill profiles of its staff and the extension of its established networks (Prognos AG/Boehmert & Boehmert, 2010; EFI, 2009).

Knowledge transfer is organised differently between research institutions. Most of the universities have their own knowledge transfer offices. Since 2008, the funding programme SIGNO has been supporting universities as well as companies and inventors to identify inventions suitable for patenting, secure legal protection for these and exploit them commercially. Regarding public research institutions, for instance, technology transfer activities of the institutes of the Max-Planck Society are supported by a separate institute called Max Planck Innovation which currently oversees more than 1,170 inventions. Since 1979 it has managed about 3,300 inventions and closed more than 1,900 license agreements.

There are almost no government activities that directly support **researcher mobility** between the enterprise and the public research sector. Nevertheless, mobility does take place, e.g. many doctoral theses are completed in close cooperation with industry or often within industry. Mobility is facilitated by long-term oriented cooperation between (large) enterprises and institutions of higher education as well as by R&D cooperation stimulated by public programmes.

In recent years a new **governing model,** the university council (Hochschulrat) was introduced in several states such as North Rhine-Westphalia (in 2007) and Saxony (in 2009). A new feature is the involvement of external stakeholders in the council, including the business sector. Primarily, university councils have advisory functions regarding the strategic direction of the university. In some states they also elect the university's rector. Already for a long time, governing boards of public research institutions which act as advisory boards often consist of representatives of industry and business, as it is the case for institutes of the Fraunhofer Society (FhG) or Max Planck Society (MPG).

6. Enhance knowledge circulation across Europe and beyond

Germany is strongly involved in projects within European initiatives such as ERA-Nets, joint research programmes undertaken under Article 185 of the Treaty of Lisbon and Joint Programming Initiatives.

Via the Leibniz Institute for Information Infrastructure (FIZ Karlsruhe), scientific information from all over the world is made publicly available, to support the international knowledge transfer. The payable service comprises scientific and technical research and patent information. In order to facilitate cross-border collaboration in research and education the web-portal "Kooperation international" was established by the BMBF in 2002. It offers advisory services and acts as a communication platform for anyone looking for information and potential collaborations in Germany and abroad.

Access to published research is usually not restricted to German actors but accessible worldwide. However, access might not be free of charge, as for example the access to specific journals. Another barrier for access might be the language (German) since not everything is published in English.

7. Strengthen international cooperation in science and technology and the role and attractiveness of European research in the world

Scientific collaboration with other countries has a long tradition in Germany. How-ever, an explicit Government strategy on the internationalisation of research and science has only been published in 2008 (BMBF, 2008). Bilateral agreements on cooperation in education and research are in place with more than 50 countries on different levels. Agreements are tailored to the specific situation and targets of the involved countries.[14]

International scientific cooperation is coordinated by the International Bureau of the BMBF and supported by a web-based signposting and information service since 2002 (www.kooperation-international.de/en)

[14] For an overview of agreements and topics see http://www.bmbf.de/en/707.php

as well as an internet portal (www.research-in-germany.de) which provides foreign researchers and scientists with information about research opportunities in Germany.

In addition, the DFG runs a number of programmes aimed at strengthening international research cooperation, including a large number of bilateral programmes. Instruments include funding of joint research projects and the participation of German researchers in international conferences. A stronger international perspective is also one of the commitments made as part of the “Pact for Research and Innovation”. Most of the non-university research organisations (HGF, MPG, FhG, WGL) run offices outside Germany in order to stimulate international cooperation. Although assessments have confirmed that the internationalisation is well developed in Germany, further efforts to strengthen the international dimension of research are demanded by expert groups (WR, 2010; GWK, 2011a). The importance of international cooperation has also been highlighted in the High-Tech Strategy 2020, in particular to solve the grand challenges such as climate change.

References

BMBF (2008): Strengthening Germany's role in the global knowledge society, Strategy of the Federal Government for the Internationalisation of Science and Research, http://www.bmbf.de/pubRD/Internationalisierungsstrategie-English.pdf

BMBF (2010): Bundesbericht Forschung und Innovation 2010, Bonn and Berlin, http://www.bmbf.de/pub/bufi_2010.pdf

Brixy, U., Hundt, C., Sternberg, R. and Vorderwülbecke, A. (2011): Global Entrepreneurship Monitor (GEM), Länderbericht Deutschland 2010, http://www.wigeo.uni-hannover.de/fileadmin/wigeo/Geographie/Forschung/Wirtschaftsgeographie/Forschungsprojekte/laufende/GEM_2010/gem2010.pdf

Deutsche Telekom Stiftung (2011): Innovation Indicator 2011, http://www.innovationsindikator.de/der-innovationsindikator/english-summary/

EFI - Expertenkommission Forschung und Innovation (2008): Gutachten 2008, Gutachten zu Forschung, Innovation und technologischer Leistungsfähigkeit, http://www.e-fi.de/fileadmin/Gutachten/2008_engl.pdf

EFI - Expertenkommission Forschung und Innovation (2009): Gutachten 2009, Gutachten zu Forschung, Innovation und technologischer Leistungsfähigkeit, http://www.e-fi.de/fileadmin/Gutachten/2009_engl.pdf

EFI - Expertenkommission Forschung und Innovation (2010): Gutachten 2010, Gutachten zu Forschung, Innovation und technologischer Leistungsfähigkeit, http://www.e-fi.de/fileadmin/Gutachten/2010_engl.pdf

EFI - Expertenkommission Forschung und Innovation (2011): Gutachten zu Forschung, Innovation und technologischer Leistungsfähigkeit, Gutachten 2011, http://www.e-fi.de/fileadmin/EFI_2011_en_final.pdf

Elschner, C., Ernst, C. and Spengel, C. (2011): Fiskalische Kosten einer steuerlichen Förderung von Forschung und Entwicklung in Deutschland – Eine empirische Analyse verschiedener Gestaltungsoptionen, Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung - zfbf, 344-370.

European Commission (2011): Innovation Union Competitiveness report, 2011 edition, http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011/iuc2011-full-report.pdf#view=fit&pagemode=none

European University Association (2009): University Autonomy in Europe I, Explorative Study.

Federkeil, G. and Buch, F. (2007): Fünf Jahre Juniorprofessur – Zweite CHE-Befragung zum Stand der Einführung, CHE Arbeitspapier Nr. 90.

Fier, A., Aschhoff, B. and Löhlein, H. (2006), Behavioural Additionality of Public R&D Funding in Germany, in: OECD, Government R&D Funding and Company Behaviour, Measuring Behavioural Additionality, 127-149.

Fraunhofer-ISI, Joanneum Research, Stifterverband, WZB und ZEW (2012): Zur Situation der Forschung an Deutschlands Hochschulen - Aktuelle empirische Befunde. Studien zum deutschen Innovationssystem 16-2012, Berlin: Expert Commission for Research and Innovation.

Grimpe, C. (2010), Scientific Excellence and Extramural Research Grants: Beggars Can't Be Choosers?, ZEW Discussion Paper No. 10-031, Mannheim.

GWK (2011a): Pakt für Forschung und Innovation, Monitoring-Bericht 2011, Volume 23.

GWK (2011b): Equal Opportunities in Science and Research, 15th Update to the Data (2009/2010) on Women in Higher Education Institutions and Non-academic Research Establishments, Volume 24.

Humboldt Foundation (2011): Programmes for researchers, http://www.humboldt-foundation.de/web/7806.html

Nill, J., Landwehr, A., Carabias, V. and Carat, G. (2009): ERAWATCH Country Reports 2009: Analysis of policy mixes to foster R&D investment and to contribute to the ERA: Germany, JRC-IPTS, EUR 23976 EN/18.

OECD (2011): Main Science and Technology Indicators: Volume 2011/1.

PRO INNO Europe (2011): Innovation Union Scoreboard 2010, http://ec.europa.eu/enterprise/policies/innovation/files/ius/ius-2010_en.pdf

Prognos AG, Boehmert & Boehmert (2010): Evaluierung des SIGNO-Förderprogramms des BMWi in seiner ganzen Breite und Tiefe, Projektbericht im Auftrag des BMWi, http://www.signo-deutschland.de/signo-unternehmen/content/e5072/e6287/SIGNO-EvaluationAbschlussberichtApril2010_ger.pdf

Rammer, C., Aschhoff, B., Crass, D., Doherr, T., Hud, M., Köhler, C., Peters, B., Schubert, T. and Schwiebacher, F. (2012): Innovationsverhalten der deutschen Wirtschaft, Indikatorenbericht zur Innovationserhebung 2011, Bundesministerium für Bildung und Forschung. Mannheim, http://ftp.zew.de/pub/zew-docs/mip/11/mip_2011.pdf

Statistisches Bundesamt (2011): Bildung und Kultur, Studierende an Hochschulen, Wintersemester 2010/2011, Fachserie 11 Reihe 4.1, http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Publikationen/Fachveroeffentlichungen/BildungForschungKultur/Hochschulen/StudierendeHochschulenEndg2110410117004,property=file.pdf

Stifterverband - Stifterverband für die Deutsche Wissenschaft (2011): Pressekonferenz, FuE in der Wirtschaft“, Berlin, 5/12/2011, http://www.stifterverband.info/presse/pressemitteilungen/2011_12_05_forschung_und_entwicklung/fue_2011_praesentation.pdf

WR - Wissenschaftsrat (2010): Recommendations on German Science Policy in the European Research Area, No. 9866-10.

List of Abbreviations

AiF	Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von “Guericke” (German Federation of Industrial Research Associations)
AvH	Alexander von Humboldt Foundation
BERD	Business Expenditures for Research and Development
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BMWI	Bundesministerium für Wirtschaft und Technologie (Federal Ministry of Economics and Technology)
CHE	Centre for Higher Education
ERA	European Research Area
DAAD	Deutscher Akademischer Austausch Dienst (German Academic Exchange Service)
DESY	Deutsches Elektronen Synchrotron (German electron synchrotron)
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
EFI	Expertenkommission Forschung und Innovation (Experts Commission for Research and Innovation)
EIB	European Investment Bank
ERA-NET	European Research Area Network
ESFRI	European Strategy Forum on Research Infrastructures
ETP	European Technology Platform
EU	European Union
EU-27	European Union including 27 Member States
FhG	Fraunhofer-Gesellschaft (Fraunhofer Society)
FAIR	Facility for Antiproton and Ion Research
FP	European Framework Programme for Research and Technology Development
FP7	7th Framework Programme
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
GWK	Gemeinsame Wissenschaftskonferenz (Joint Science Conference)
HEI	Higher education institutions
HERD	Higher Education Expenditure on R&D
HGF	Helmholtz-Gemeinschaft Deutscher Forschungszentren (Helmholtz Association)
HRK	Hochschulrektorenkonferenz (German Rectors’ Conference)
HRST	Human Resources in Science and Technology
IGF	Industrielle Gemeinschaftsforschung (industrial collective research)
IP	Intellectual Property
ISCED	International Standard Classification of Education
MINT	Mathematics, Information technology, Natural sciences and Technology
MPG	Max-Planck-Gesellschaft (Max Planck Society)
OECD	Organisation for Economic Co-operation and Development
PRO	Public Research Organisations
PVA	Patentverwertungsagentur (patent commercialisation agency)

R&D	Research and Development
R&D&I	Research and development and Innovation
RI	Research Infrastructures
S&E	Science and Engineering
S&T	Science and technology
SME	Small and Medium Sized Enterprise
VC	Venture Capital
VIP	Validation of Innovative Potential of Scientific Research
WGL	Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (Leibniz Association)
WR	Wissenschaftsrat (German Council of Science and Humanities)
XFEL	European X-Ray Laser Project
ZIM	Zentrales Innovationsprogramm Mittelstand (Central Innovation Programme for SMEs)

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Abstract
The main objective of the ERAWATCH Annual Country Reports is to characterise and assess the performance of national research systems and related policies in a structured manner that is comparable across countries. EW Country Reports 2011 identify the structural challenges faced by national innovation systems. They further analyse and assess the ability of the policy mix in place to consistently and efficiently tackle these challenges. The annex of the reports gives an overview of the latest national policy efforts towards the enhancement of European Research Area and further assess their efficiency to achieve the targets.

These reports were originally produced in November - December 2011, focusing on policy developments over the previous twelve months. The reports were produced by the ERAWATCH Network under contract to JRC-IPTS. The analytical framework and the structure of the reports have been developed by the Institute for Prospective Technological Studies of the Joint Research Centre (JRC-IPTS) and Directorate General for Research and Innovation with contributions from ERAWATCH Network Asbl.

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