KfW Research
Focus on Economics

The future is green – what opportunities are available to German business?

No. 355, 4 November 2021

Authors: Dr Daniel Römer, phone +49 69 7431-6326, daniel.roemer@kfw.de
Dr Volker Zimmermann, phone +49 69 7431-3725, volker.zimmermann@kfw.de
Anke Brüggemann, phone +49 69 7431-1736, anke.brueggemann@kfw.de

Things are getting serious on the climate action front. Ever since China and the US last year pledged to make their economies carbon neutral, it has become clear that the green transition is no longer academic theory but will become a reality. The next step now is to initiate the transition processes in due course in order to achieve the Paris climate targets and prevent serious tipping points. In the shadow of the coronavirus pandemic, important groundwork has been laid that has ushered in the end of the fossil fuel age and brought innovative climate-friendly technologies more into the spotlight.

Entrepreneurial success in the future will therefore have to be based on greenhouse gas-neutral processes. As a result, some established business models no longer have a future, while new, innovative solutions are about to tap into growth markets, for example in the area of sustainable mobility, where the strongest growth is expected. The technologies required here for climate neutrality are at different stages of development and some are still in the developmental or pilot phase.

For Germany, the upcoming transition means a time of profound change in any case. Whether or not the country will grow stronger or weaker as a business location is as yet unclear. But an assessment can draw upon a range of circumstantial evidence. First, a look at the current market shares of green technologies attests to a good starting position, especially in the field of circular economy but also in sustainable mobility. Another reason to be optimistic is that Germany is generally well-positioned in green technologies of the future and has a focus on many important markets of the future, with exports of green products worth some EUR 68 billion in 2018 alone. What is also evident, however, is that international competitors have caught up in recent years, especially in Asia.

In line with the stages of the innovation process, three elements are important to secure future success: First, broad support for R&D in order to enable the development of innovative technologies. Second, support for demonstration projects to make technologies scalable and ready for the market and third, a predictable regulatory framework with financial incentives that enable the diffusion of new technologies in the market and broad application. The coming years will be crucial for harnessing opportunities in the green markets of the future.

Green markets of the future are drawing nearer

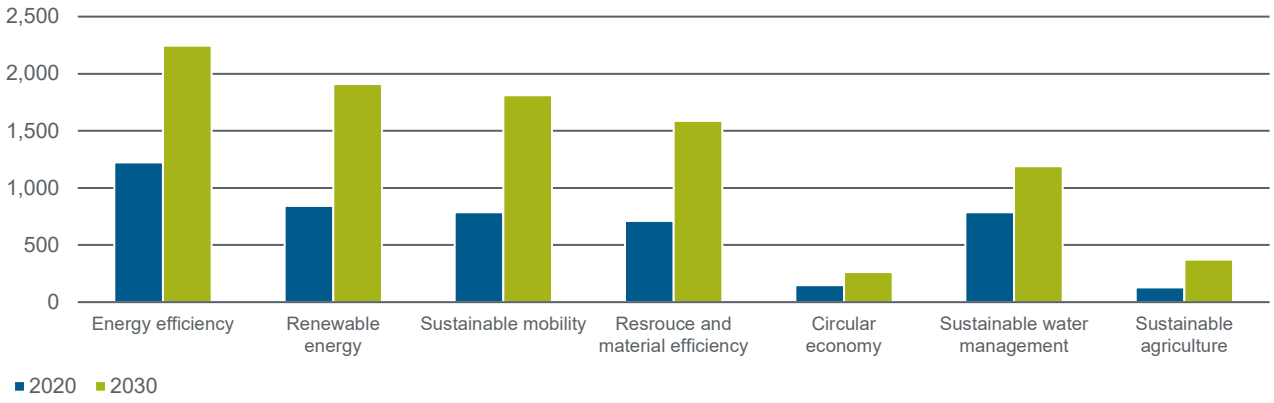
The commitments entered into under the Paris Climate Agreement of 2015 have now become specific national targets that pave the way to a greenhouse gas-neutral future. The coalition of 'net zero' states that have set themselves the goal of limiting their greenhouse gas emissions by the middle of the 21st century to levels they can absorb is growing continuously and now represents a clear majority of more than two thirds of global economic output, compared with 16% back in 2019.[1] Last year the most prominent commitments came from China (by 2060) and the US (by 2050). Most of the remaining countries are at least considering a target of climate neutrality.[2]

The European Union committed to the goal of climate neutrality by 2050 already in December 2019. With the Green Deal the EU Commission presented a roadmap that is to help low-emissions technologies achieve a breakthrough and make Europe the first climate-neutral continent by the year 2050. The 'Fit for 55' package presented by the Commission in July 2021 aims to create a supporting regulatory framework. Germany intends to reach the goal of net greenhouse gas neutrality already in 2045.

In addition to states, other organisational entities from municipalities through businesses to financial market actors are also committing to climate neutrality. Recently, two prominent asset managers committed to the goal of greenhouse gas neutrality by 2050, which in their view is a 'win-win' situation for the climate and long-term investors.[3]

These declarations of intent are no guarantee of success, of course. The net-zero targets of the different countries definitely exhibit strong variations in quality but, even so, some 60% of the declarations of intent contain specific interim goals and 44% include specific plans for target achievement.[4] Furthermore, international approaches such as carbon border adjustment mechanisms and the formation of climate clubs are being increasingly discussed.[5] Overall, these developments demonstrate that climate action is becoming increasingly established in the markets.

Figure 1: Global market volume of green lead markets today and in 2030, in EUR billion



Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2021).

Enormous potential for global growth

For businesses, this means one thing in particular: green growth markets. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) commissioned an analysis of the global market for green technologies, which also comprises the main technologies required to achieve climate neutrality.[6] The market so defined is expected to grow by 7.3% annually from EUR 4.6 trillion today to a market volume of EUR 9.4 trillion in 2030. The analysis distinguished between seven lead markets with different rates of expected growth (Figure 1).

The segment of energy efficiency accounts for the largest market volume today – and in the future. The relative growth here, however, is a rather below-average +6.3% annually. This is unsurprising because this market is relatively well-established. The strongest growth within this segment is expected in the subsegment of energy efficiency in buildings, with 11% annually.[7] In second place are energy-efficient production processes with a forecast annual growth rate of 8.3%.

The market segment with the most dynamic growth overall is that of sustainable mobility, which is growing by 8.7% a year.[8] Here, the subsegment of alternative drivetrains is growing even more significantly (+13.3%) than other subsegments such as renewable fuels (+7.6%) or transport infrastructure and traffic management (+8.1%). Given the growing number of regulations in the transport sector, these increases appear plausible. Thus, the EU Commission in its 'Fit for 55' package recently submitted a bill aimed at tightening fleet emission standards once again, which will ultimately come down to banning new internal combustion engine vehicles by 2035. Other countries are aiming for similar bans. The plans of the Chinese government are for one in two new car sales to be new energy vehicles by 2035.[9]

Renewable energy supply comprising generation, storage and efficient distribution networks is growing at a similarly rapid rate (+8.5% per year). Sustainable electricity generation is the backbone of climate neutrality, with hydropower currently making up the largest share of global market volume, 26%, even before photovoltaic (PV) systems with 24% and wind farms with 18%. In the future, however, the latter two will gain importance. According to estimates of the International Energy Agency (IEA), the installed global capacity of PV and wind farms will grow fivefold by the end of the decade from around 1,500 GW in 2020 to more than 8,000 GW in 2030. Climate action scenarios available in Germany expect installed capacity to grow threefold to fivefold by the year 2050.[10]

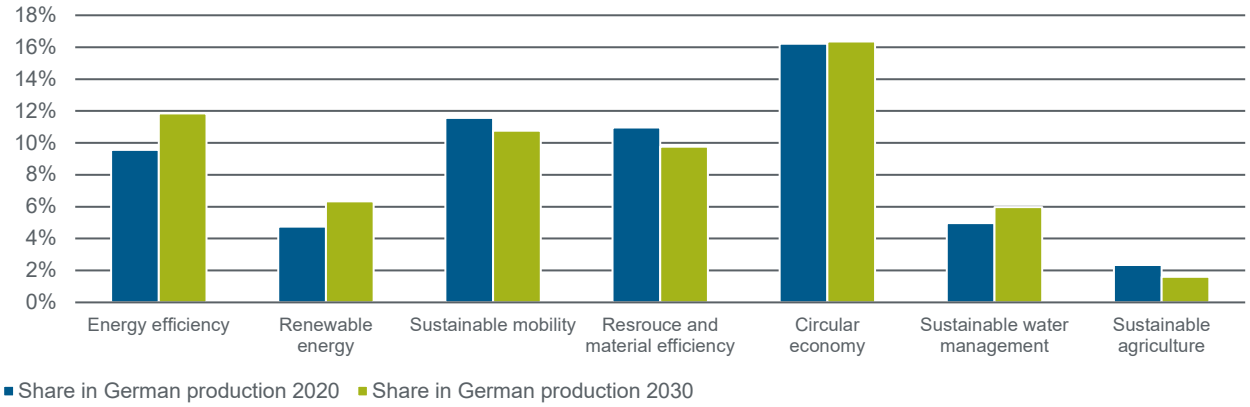
In addition, the field of energy storage technology in particular includes two segments that are still relatively small but will presumably grow very fast. One of them is electrochemical storage systems (such as batteries), which today make up only 6% of the storage market but are expected to grow by 18% a year up to 2030. Even more dynamic growth of 47% annually is expected to occur in the area of power-to-X (such as electrolysis of green hydrogen), which still accounts for less than 1% of the storage market.[11]

Germany is a major player in green markets

Germany already has a high share in these dynamically growing markets. This applies not just to overall production at German locations ('German production'), which accounted for around 8.5% of the global market for green technologies in 2020, but also with respect to all German businesses including locations abroad, which make up some 14% of green markets.[12] Both values are significantly greater than Germany's share in global economic output, which was only 4.5% in 2020[13], and they illustrate its strong position in the field of green technologies today.

Figure 2 illustrates Germany's shares in global market volume of green technologies broken down by market segments, with empirical values for the year 2020 and forecasts for the year 2030.

Figure 2: Germany's shares in global green lead markets in per cent



Source: Own calculations on the basis of BMU (2021).

Germany's market position is also reflected in exports. In 2018 German businesses exported environmental and climate-smart goods worth EUR 68 billion. That made Germany the second largest exporter of environmental and climate-smart goods, with 12% of global trade. Only China exported even more green technology goods, recording a global export share of 15% (EUR 82 billion).[14] In 2018 the climate-relevant subsegment of environmentally friendly mobility made up 25% of Germany's exports of green technologies, energy efficiency took a share of 12% and sustainable electricity generation 10% (Figure 3).

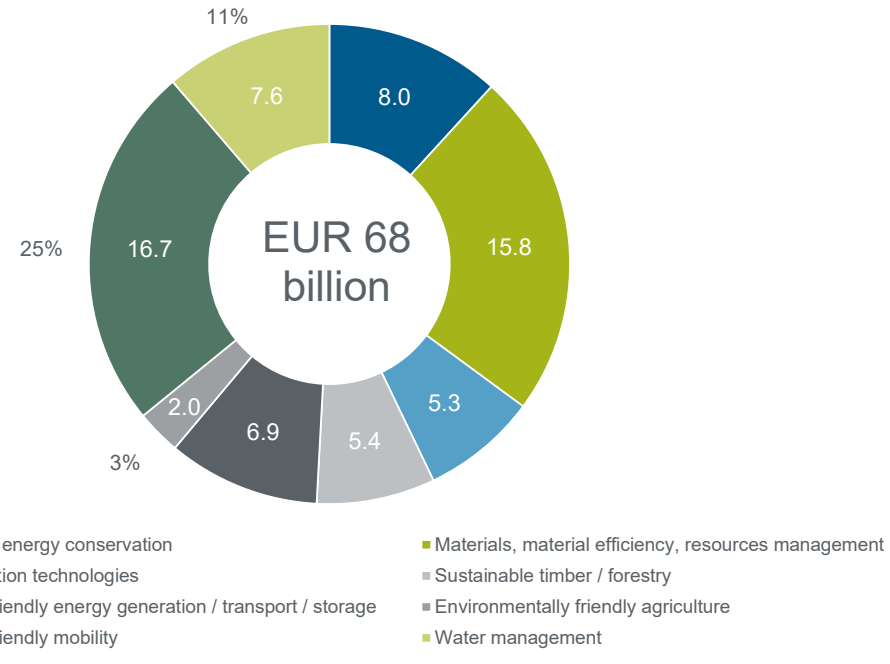
The foregoing shows that Germany is in a good starting position in international competition with environmental and climate-smart goods. Another important reason German enterprises are currently so well-positioned is that they were confronted early on with high environmental standards and ambitious climate action targets in the domestic market. The commitments of many countries to climate neutrality will lead to a significant increase in global demand for low-emissions technologies. That will generate substantial opportunities for future growth and employment for German businesses.

Climate neutrality needs considerable innovation

The goal of achieving climate neutrality by the middle of the century is ambitious and requires a deep transformation of the economy and society. Achieving this goal will require technologies that are not yet on the market, in addition to those that are already available. In order for these technologies to be available in a timely manner, substantial innovation efforts must be undertaken during this decade.

According to the IEA (2021), a large portion of the greenhouse gas emission reductions that have to be achieved by 2030 can still be reached with technologies that are already available such as heat pumps and, in part, electric automobiles.

Figure 3: German exports of environmental and climate-smart goods in 2018 (EUR 68 billion in total)



Source: Prognos (2021).

However, nearly half of the reductions that need to be achieved by 2050 will be possible only by using technologies that are still at demonstration or prototype stage – such as large-scale electrolysis of green hydrogen, new generations of batteries and negative emissions technologies such as direct air capture (DAC) or carbon capture and storage (CCS).[15] Irrespective of this, new and as yet unexplored technologies are expected to yield further breakthroughs, for example with regard to reduction potentials. Available technologies will also need to be improved, for example in order to achieve further cost reduction potentials or enhance their efficiency.

That is why no one should sit on their hands when it comes to developing and perfecting environmental technologies. This applies in particular to defending and expanding Germany's market position in climate-smart and environmental technologies.

Green technologies are a strength of Germany's innovation system

The general public is less familiar with the fact that – alongside traditional strengths such as production technologies (mechanical engineering) and automotive technologies – environmental technologies have also evolved to become one of the strengths of the German innovation system. In a study commissioned by KfW Research, the Fraunhofer Institute for System and Innovation Research (ISI) in Karlsruhe examined how well Germany is positioned in the development of technologies that can be expected to achieve high market relevance in the medium term.[16]

The study established a ranking to determine which of the examined technologies are currently evolving strongly and how large Germany's share is in their development. The ranking comprises a range of indicators for patenting activities, the production of scientific publications and trademark registrations. The result was a ranking that expresses Germany's relative strength in these technologies, in other words, which technologies are particularly promising from a German point of view.

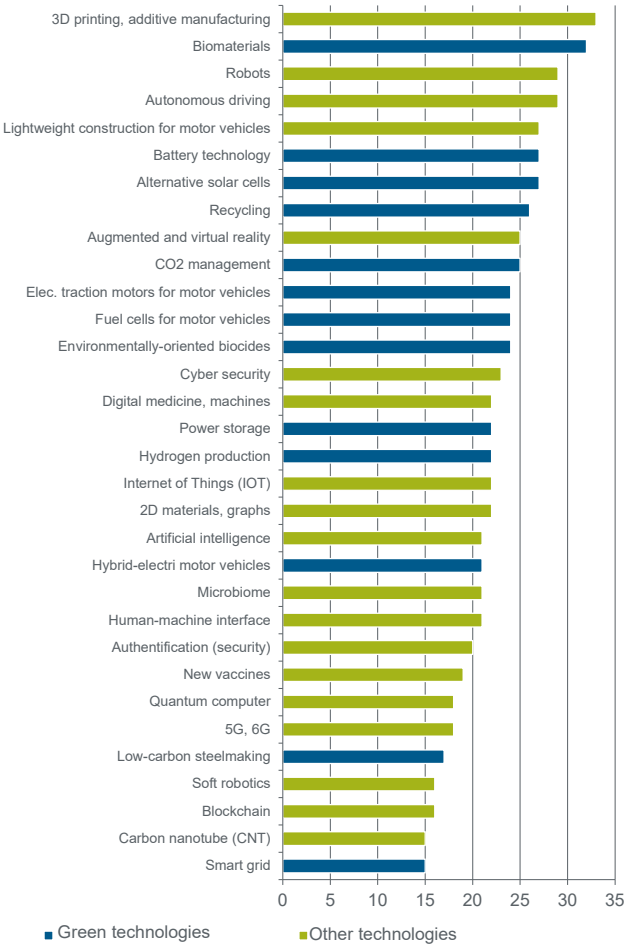
It is evident that several climate-relevant technologies are found in the top half of the ranking (Figure 4). What is particularly positive is that by and large German enterprises focus precisely on those technologies that promise the highest growth markets: from battery technology through more efficient solar cells and drive technologies for electric mobility to hydrogen production and energy storage. The conditions for advancing environmental and climate technology expertise as a promising avenue particularly for Germany are therefore exceptionally favourable.

But Germany's top technological and market position is facing increasing long-term challenges …

In order to make an economic assessment of Germany's position it is necessary to consider not just its current position but the historic development and current momentum. What this reveals is that Germany's top position in the development and marketing of high-quality technological products has been under increasing attack for some time.

Figure 4: Germany is well-positioned in the area of green technology

Index points on the basis of patents, scientific publications and trademark registrations.



Source: Schmoch et al. (2021).

For decades it has been apparent that increasingly more countries are developing capacities for developing new technologies, pursuing increasingly more ambitious R&D and innovation strategies and achieving international success. In recent decades, East Asian countries in particular have succeeded in gaining a technological foothold and offering high-quality goods and services, especially in the field of high-value technology products, which constitute traditional German strengths, for example in automotive and mechanical engineering and chemicals – as well as information and communications technologies. This growing competition is reflected in multiple indicators for the technological capabilities of most traditional technology producers and also influences the development of market shares.

... including in environmental and climate-smart technologies

Environmental and climate technology provides another corroborating example. In 1990, Germany filed almost 25% of all worldwide environmental technology patents. Even though German patent applications have since quadrupled, that share has now slipped below 15%.[17] This trend is also corroborated when we look at just the subset of patents that are of particular technological and economic importance. Germany's overall position has weakened here as well.[18] With a view to exports, it was found that as recently as in 2007, Germany was the largest exporter of climate-smart goods and has since continually lost export share, especially to China and South Korea.[19]

This trend needs to be viewed critically because technological strength has previously been an important locational advantage for Germany. This applies all the more as some of the sectors that are important for Germany, such as the automotive sector, were previously characterised by fossil fuel technologies and will have to expect sharply falling market shares already in the medium term unless they transition to innovative climate-neutral technologies. Thus, many jobs in Germany depend on whether the country can maintain world leadership in green technologies. It is the only way to create future-proof jobs and secure prosperity.

Innovation activity is increasingly concentrated in few enterprises

Extensive R&D efforts are necessary to defend a top position in technological output. Of positive note in this respect is the fact that Germany has an ambitious R&D policy and has increased R&D expenditure in relation to economic output in recent years. The country must unwaveringly continue on this path in the coming years.

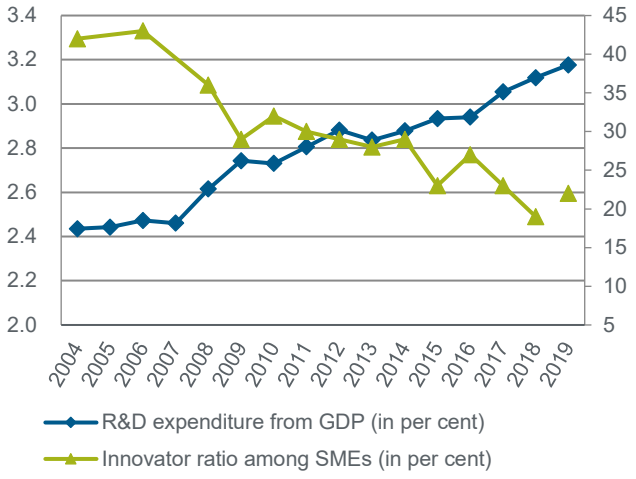
What should be viewed critically, however, is that these increases were achieved primarily by large enterprises and that overall innovation activity increasingly concentrates on fewer companies. Despite growing R&D expenditure in Germany, the innovator rate has continuously declined in the past approx. 15 years (Figure 5). But an innovative economy needs as broad a basis of innovation as possible because otherwise there will no longer be a sufficient number of highly capable suppliers, for example.

Specific challenges in environmental and climate innovations

The important role which innovative technologies play for the intended transformation and the good but not necessarily secured position of German businesses put the search for suitable supportive policy instruments into the centre of attention. The first thing to consider is that innovation in the area of environmental and climate action usually faces the problem of 'double externality'.[20] Positive external effects in the form of knowledge spillover can contribute to a situation in which proceeds from innovations do not exclusively benefit the innovating businesses but may also benefit competitors through the free use of knowledge. Furthermore, the costs of climate and environmental damage are not yet being fully internalised in the cost calculations of the parties who cause the damage (negative external effects), so that environmental and climate action technologies often have competitive disadvantages compared with conventional technologies.

Both phenomena are known in economic literature as instances of market failure and as the reason that without corrective interventions, innovation activity remains below a level that is economically desirable with respect to both development and subsequent market introduction and diffusion. That is why the state must create additional incentives for innovations in environmental and climate action by providing appropriate frameworks and support.

Figure 5: Development of innovator rate and R&D expenditure as a percentage of GDP



Note: Innovator rate in 2019 including organisational and marketing innovations

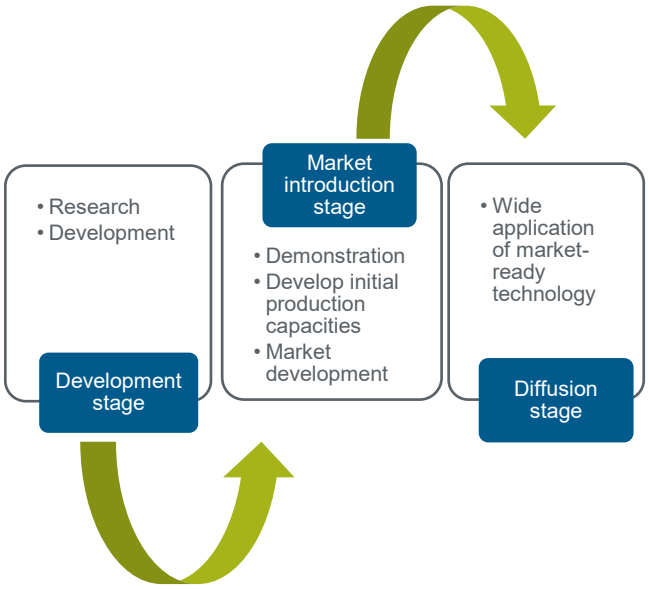
Source: OECD, KfW SME Panel

Three degrees of technological maturity are crucial to green economic policy approaches

From an economic perspective it would make sense to distinguish three stages of development or maturity of environmental and climate-smart technologies that are each shaped by specific characteristics and obstacles (Figure 6).

The **development stage** of a technology involves researching the technology with its fundamental properties and developing possible applications. A current example is negative emissions technologies for the future capture and storage of greenhouse gases from the atmosphere. This stage typically concludes with the development of a prototype. It is marked by high uncertainty about the technological and economic success of the project. For example, it is often unclear which technological pathways will ultimately succeed. This makes it difficult to finance such projects, so economic policymakers need to step in. From the perspective of promotional policy, financial support approaches with high risk assumption, such as grants and bonuses or tax incentives for R&D, as well as promotional loans for later stages in the development process are important tools.

Figure 6: Stages of the innovation process



Source: KfW Research (2021).

In the following **market introduction stage,** technologies are developed to a point where they have proven their general functioning but are not yet being broadly deployed. They are typically used in initial industrial-scale applications. A current example are electrolysers for the production of hydrogen from electricity. At this level of maturity there is much less uncertainty about success than during the development stage. Nonetheless, certain technical and economic risks remain, for example in upscaling an application, as well as problems surrounding the use of the economic return. In the field of environmental and climate technologies, state assistance in market development in the form of financial support for demonstration projects (e.g. for first-time industrial-scale applications) is an important type of aid. From the viewpoint of promotional policy, financing instruments such as loans with a grant component or subsidies, which have a lower intensity compared with R&D promotion during the development stage, would make sense. Risk assumptions can also be helpful in individual cases.

A new promotional format was created here in the field tests of the energy transition. As part of an ideas competition, viable energy technologies were tested under real-world conditions and on an industrial scale. This support serves as an incentive for the accelerated realisation of large-scale innovations for the energy transition by offsetting technological and economic risks around the state of the art and the current regulatory framework with grants.

It is also evident that newly founded businesses in innovative market segments are often the first to embrace new technologies from which they develop marketable products and services.[21] For such start-ups, financings with venture capital are suitable financing instruments that can be supported by refinancing equity providers, for example.

Finally, the **diffusion stage** of the innovation process refers to the application of new technologies across the breadth of the economy and society that ultimately enable the necessary climate and environmental benefits. Electric cars are a current example. The residual risks here can be considered low. However, the negative external effects described above typically make environmental and climate-smart technologies more cost-intensive in their acquisition and use compared with conventional technologies. Support measures that address this cost disadvantage are therefore urgently needed for the rapid diffusion of green technologies. These include, for example, a clear and rising CO_2 pricing signal or low-interest promotional loans and grants in order to reduce the increased costs of investing in green technologies. Public procurement measures and setting environmental standards using regulatory law can also help speed up market penetration.

In order to drive forward the market introduction and diffusion of new climate-smart technologies, particularly in the industrial sector, the Federal Government plans to trial what are referred to as ‘carbon contracts for difference’ in selected sectors, particularly steel and chemicals. This promotional instrument is designed to offset higher costs of operating key low-carbon technologies compared with conventional technologies. It intends to provide project-specific contributions to operating costs to offset CO_2 avoidance costs, with the amount provided usually calculated as the difference between actual CO_2 avoidance costs and the current CO_2 price of the EU Emissions Trading System. This enables efficient incentives to be set at the time of investment to promote long-term operation of innovative technologies.[22]

Conclusion

Green technologies and, hence, green innovations are increasingly moving into the spotlight. They are important not just for climate action but for the long-term viability of the economy itself because they enhance the country’s technological capabilities and thereby secure opportunities for future growth and employment.

With respect to green technologies of the future, Germany enjoys a good starting position which is coming under growing pressure from international competitors. The priority now is to secure and further expand this strong position for the future. What is important is to provide a suitable environment that enables three things to be realised: developing further innovative solutions through relevant research activities, transitioning technologies that are in the demonstration stage to market-ready, broadly viable technologies and deploying market-ready technologies on a broad scale. This calls for substantial efforts in all three areas – also in order to be able to achieve the goal of climate neutrality in the first place. The approaches can be structured as follows:

– Research and development: R&D efforts need to be ramped up to close the remaining gaps on the pathway towards a net zero emissions economy and society after 2030 – and to secure Germany’s strong competitive

position in the sector of green technologies. This applies to negative emission technologies and the development of green fuels, for example. Broad and technologically open innovation support is of special importance here.

– Market introduction: The continuing development of market-relevant technologies of the future that are on the brink of a commercial breakthrough must be further promoted. This applies in particular to the hydrogen economy, including the provision of distribution and import infrastructures as well as the next generations of (where possible, green) batteries. Promoting industrial-scale demonstration facilities is particularly important here.

– Diffusion: Enabling conditions must be created that make available technologies economically attractive enough for broad application. Examples include broader use of photovoltaic solar power and wind power, electric vehicles and technologies for increasing the energy efficiency of buildings, industry and trade. The expansion of electricity and charging infrastructure as well as local and district heating networks must also be driven forward.

The roadmap to climate neutrality is now clearly defined, as is its timeline. In this respect, green technologies are fundamentally different from other technologies for which the future can be defined more openly and the pathway to be mapped can be defined less clearly in advance. For one thing, the transition is a matter of great urgency given the looming climate impacts. For another, this also gives a clear timeframe which can enable unusual planning certainty: By around the middle of the century, vast parts of the global community will have achieved greenhouse gas neutrality. In combination with the analyses of technological pathways, this makes it possible to plan the transition with relative ease.

All of this requires extensive investment. Germany alone will have to mobilise around EUR 5 trillion to achieve climate neutrality.[23] Not only does this underscore the challenge the country faces; it also illustrates the volume in which climate-friendly technologies will now have to be rolled out in many areas. This offers potential for Germany as a leading provider of environmental and climate-smart technology to participate in the transition on the supply side as well. Politicians and businesses must now seize this opportunity. The current decade leading up to 2030 is likely to be critical – for the climate outcome and for Germany's future prosperity.

[1] Cf. Black et al. (2021): Taking Stock: A global assessment of net zero targets, Energy & Climate Intelligence Unit and Oxord Net Zero.

[2] Net Zero Tracker | Energy & Climate Intelligence Unit (eciu.net)

[3] Investors BlackRock, Vanguard join net zero effort | Reuters.

[4] Cf. Black et al. (2021): Taking Stock: A global assessment of net zero targets, Energy & Climate Intelligence Unit and Oxord Net Zero.

[5] Cf. Römer, D. and Schwartz, M. (2021): The EU's carbon border adjustment: A trade barrier or an opportunity for global climate action?, Focus on Economics No. 345, KfW Research.

[6] Cf. German Federal Ministry for the Environment (2021): GreenTech made in Germany 2021.

[7] The subsegment of passive houses is even expected to grow by 31% per year, cf. BMU (2021): Green Tech in Germany

[8] The fastest-growing market by 2030 is likely to be that of sustainable agriculture, which is set to grow by 11.3% annually. This segment plays a rather less significant role in terms of market volume, however.

[9] China's NEV sales to account for 20% of new car sales by 2025, 50% by 2035 | Reuters.

[10] Vgl. Fraunhofer ISI, Consentec GmbH (2021): Langfristszenarien für die Transformation des Energiesystems in Deutschland (*Long-term scenarios for the transformation of the energy system in Germany* – our title translation, in German). Third study on behalf of the German Federal Ministry of Economics and Agora Energiewende (2020): Klimaneutrales Deutschland (*Climate-neutral Germany* – our title translation, in German).

[11] The storage market is currently dominated by mechanical energy storage (pumped-storage power plants, compressed air storage power plants, reservoir power plants and flywheels). Power-to-X is a generic term that refers to various technical processes used to generate heat, synthetic fuels or raw materials from electricity using renewable energy.

[12] Cf. Federal Ministry for the Environment (2021): GreenTech in Germany.

[13] Cf. IMF (2021): World Economic Outlook, https://www.imf.org/external/datamapper/NGDPD@WEO/OEMDC/ADVEC/WEOWORLD/. Retrieved on 26 August 2021.

[14] Cf. Abel-Koch, J. and Ullrich, K. (2021): Low globalisation momentum requires adjustment of German companies' growth strategies, Focus on Economics No. 349, KfW Research, and Prognos (2021): Globalisierung in der Krise – Die deutschen Unternehmen brauchen neue Wachstumsstrategien (*Globalisation in crisis – German enterprises need new growth strategies* – our title translation, in German only), Basel. Study commissioned by KfW Group.

[15] For more in regard to this section see IEA (2021): Net Zero by 2050, A Roadmap for the Global Energy Sector.

[16] Cf. Schmoch, U. et. al (2021): Identifizierung und Bewertung von Zukunftstechnologien für Deutschland (*Identifying and assessing future technologies for Germany* – our title translation, in German only). Final report to KfW.

[17] Cf. German Federal Environment Agency (2020): Die Umweltwirtschaft in Deutschland. Entwicklung, Struktur und internationale Wettbewerbsfähigkeit (*Germany's environmental industry. Development, structure and international competitiveness* – our title translation, in German only)

[18] Cf. Breitinger, J., Dierks, B. und T. Rausch (2020): World class patents in cutting-edge technologies Bertelsmann Stiftung (ed.)

[19] Cf. Gehrke und Schasse (2019), S. 84.

[20] Cf. Borderstep Institut für Innovationen und Nachhaltigkeit (2017): Umweltinnovationen: Von der Nische in den Mainstream. Policy Paper im Auftrag des Umweltbundesamtes (*Environmental innovations: From the niche to the mainstream. Policy paper commissioned by the German Federal Environment Agency* – our title translation, in German only); Cf. also Nordhaus, W. (2021): The Spirit of Green, Chapter 18 'The double externality of Green Innovation' and Dechezleprêtre, A. and Popp, D. (2015), 'Fiscal and regulatory instruments for clean technology development in the European Union.'

[21] Cf. Niefert, M. and Zimmermann, V. (2009): Die Dynamik im Innovationsverhalten kleiner und mittlerer Unternehmen, SME Monitor 2009 (*The dynamics in innovative behaviour of small and medium-sized enterprises* – our title translation, in German only), p. 107–134, KfW Economic Research.

[22] Cf. Chiappinelli, O. et al (2020): Industrial Innovation: Pathways to deep decarbonisation of Industry Part 3: Policy implications, Report prepared by ICT and the German Institute for Economic Research on behalf of DG CLIMA.

[23] Much of this involves investments that are necessary anyway and now need to move towards a sustainable path. Cf. Brand, S., Römer, D. and Schwarz M. (2021): Investing EUR 5 trillion to save the climate – a surmountable challenge, Focus on Economics No 350, KfW Research.