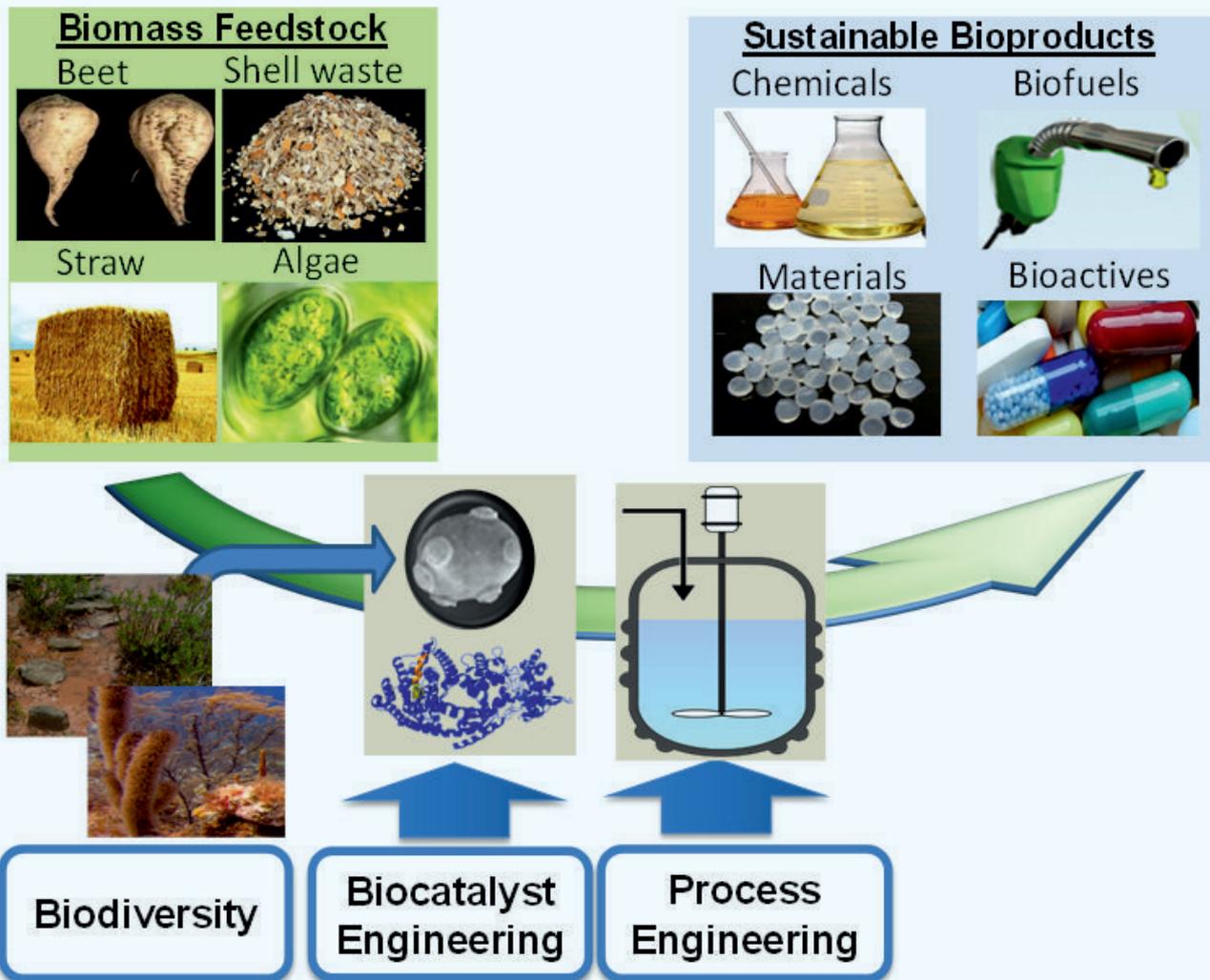


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## Industrial Biotechnology-Made in Germany: The path from policies to sustainable energy, commodity and specialty products

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# The Role of Government Research Funding in the German Industrial Biotechnology Sector

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**Abstract**

Project funding – the targeted funding of selected research projects – is a versatile tool that allows governments to stimulate research into specific topics, to encourage the formation of cooperative research networks or to accelerate the transfer of academic results into application. The German government has long offered project funding for research into industrial biotechnology, and continues to do so today. This article offers an overview of the history of funding in this field, the rationale behind it and the processes involved. The aims and concepts underlying the funding programs are discussed, including the recent shift towards the inclusion of sustainability as a major criterion. The article also outlines the administrative processes involved, including the role of advisory bodies, expert groups and strategy processes in the creation of new funding initiatives. Examples of current initiatives in industrial biotechnology illustrate the wide range of strategic aims that can be addressed with the instrument of project funding.

**ABBREVIATIONS**

**BMBF:** Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research); **BMEL:** Bundesministerium für Ernährung und Landwirtschaft (Federal Ministry of Food and Agriculture); **BMUB:** Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety); **BMWi:** Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy); **CBP:** Fraunhofer Center for Chemical-Biotechnological Processes; **NFS 2030:** Nationale Forschungsstrategie BioÖkonomie 2030 (National Research Strategy Bioeconomy 2030).

**INTRODUCTION**

Most of Germany's industries, including the chemical, pharmaceutical and engineering sectors, are overwhelmingly knowledge-driven and innovation-dependent. In view of Germany's high production and labor costs, it is vital for individual companies, and also for the German economy as a whole, to stay one step ahead of the international competition in technological terms. This is certainly true of the industrial biotechnology sector, which is both increasingly important in established industries and has become a sector in its own right.

German investment in research and development is high and has increased steadily over the past decade [1]. In 2012, Germany invested 2.98% of its gross domestic product in research; consisting of roughly one third public funding and two thirds industrial investment. This rate is somewhat higher than the 2.77% in the USA and certainly high compared to the 2.06% average in the European Union, although rates are higher in the Scandinavian countries (2.99 to 3.55%), and also, for example, in Israel (4.38%) and South Korea (4.03%) [2, 3 – final report not yet published].

Note: Throughout the article, the current names of the ministries appear

**Keywords**

- Bioeconomy
- Sustainable economic growth
- Technological advance
- Industrial development
- Government policy
- Research funding initiatives
- Industrial biotechnology

Biotechnology is a growing economic factor in Germany with over 560 dedicated biotechnology companies, generating nearly 3 billion euros revenue with more than 17,000 employees. More than 120 additional companies include some biotechnological activities in their portfolio, employing an additional 17,000 people in their biotechnology divisions (all numbers for 2012) [4]. While Germany is itself a rather biomass-poor nation, and unlikely to produce many bio-based bulk materials in future, its history of highly specialized industry can well contribute high-value products as well as processing technology for use elsewhere.

This article aims to provide an overview of biotechnology funding in Germany, highlighting some of the underlying principles and aims, explaining processes, and examining past, current and future trends. Some of it is of necessity simplified and generalized – for example, some initiatives deviate from the general model described below. The present article is meant to offer a general introduction, citing examples rather than attempting comprehensiveness, and taking a sweeping panoramic view.

**The German research funding system**

Research funding in Germany, as elsewhere, is a complex political and administrative process. Two types of public research funding can be distinguished: institutional funding and project funding. The first entails substantial baseline funding of universities and the four publicly funded research organisations (Fraunhofer-Gesellschaft zur Förderung angewandter Forschung e. V., Helmholtz-Gemeinschaft deutscher Forschungszentren, Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V., Max-Planck-Gesellschaft zur Förderung der Wissenschaften e. V.). Specialized research institutes serving public interests, such as the Robert Koch Institute, which plays a role in public health protection, also receive institutional funding.

In contrast, most of this article will be concerned with support for specified research projects. Such project funding differs from research commissioned by the government in that it offers support for the projects of others rather than defining its own projects. Research can also be commissioned, but only if it is directly relevant to government responsibilities.

As a first step in the process, a government research program is published. It details a scientific field, like biotechnology, and the overall aims, as well as specifying the funds set aside for the program. This program needs to be notified to the European Union, which verifies that it does not include subsidies which are not compatible with the European idea.

During the typical five to ten years that a research program is in effect, the government ministries publish funding initiatives within the framework it has set up. These initiatives are typically narrower in focus than the program itself and take the form of competitions. Besides scientific criteria, there may be other conditions, such as, for example, whether universities, companies or consortia containing both are eligible to apply. Determining what initiatives to set up and how to design them is obviously crucial. Experts from academia, industry and administration are usually consulted in specifically organized events (see below).

Once project proposals have been received, the selection of the projects to be funded is usually based on the recommendations of reviewers, who may be recruited from abroad to promote impartiality. Selected projects are then funded for a specified period. Depending on the risks of the project as well as the financial abilities of the grant recipient, all, or a proportion, of the costs will be funded. Large companies typically receive less than half of the total costs, while universities may receive full funding. During the funding period, progress reports must be submitted on a regular basis.

Most of the administrative processes entailed in the entire process are usually handled by project funding agencies, such as Project Management Jülich (Projekträger Jülich), in close collaboration with the ministry in question.

### **A short history of biotechnology funding in Germany**

As early as 1974, the Federal Ministry of Education and Research (BMBF) commissioned a study from the DECHEMA (Gesellschaft für chemische Technik und Biotechnologie e. V. / Society for Chemical Engineering and Biotechnology) to evaluate the potential of biotechnology [5]. This study detailed the state of knowledge and recommended many possible areas of funding on more than 150 pages [6]. This document proved popular and by 1976, three updated editions had been published. Despite this, no specific funding program for biotechnology was established at the time. A few years later, concern grew that Germany lacked know-how in modern biotechnology, and it was a strong signal when a German chemical company, Hoechst AG, invested 70 million dollars in a research cooperation with Massachusetts General Hospital in Boston, USA, in the early 1980s. The aim of this cooperation was to gain access to technology in the burgeoning field of genetics [5].

As a reaction, the German government published its first biotechnology program “Biotechnologie 1985 – 1988” [7]

which aimed to promote scientific and technological excellence, improve conditions for innovation in industry, further research and development projects in certain areas of services for the public, to assess chances and risks including ethical aspects and to support young scientists in biotechnology. Under this program, the BMBF funded four research centers for molecular biology called Genzentren (gene centers) from 1982 to 1995 in Berlin, Heidelberg, Cologne and Munich [5].

The following research program “Biotechnologie 2000” [8] had two strategic goals: facilitating access to the high innovation potential of biotechnology for various applications in industry, and strengthening preparatory research for public services such as health, environmental protection and energy supply [9]. In the BioRegio Competition, which was the first competition to fund the formation of research clusters in Germany and had a budget of 90 million euros, regions could apply with their ideas for strengthening biotechnological research and the translation of research into industrial application. Effects visible today include many companies founded at the time. From 1998, the initiative BioFuture enabled promising young academics to kick-start their careers. BioChance, which started in 1999, was aimed at newly founded biotechnology companies.

Most of these initiatives continued under the “Framework programme Biotechnology – using and shaping its opportunities” between 2001 and 2010 [10,11]. This program listed eleven “guiding principles”, such as increasing investment in research and education, promoting interdisciplinary research and internationalization, stimulating start-ups and using the opportunities of globalization. “Preventive research” focused on biological safety, animal protection and biodiversity. Under this program, BioChance was developed into BioChance Plus and then became the model for KMU-innovative (KMU = SME) which was launched in 2007. KMU-innovative was aimed at small and medium-sized enterprises (SME) – a sector of great importance to the German economy – who were eager to apply biotechnological methods but were unable to shoulder the risk using their own capital alone. This funding initiative for small and medium-sized enterprises is ongoing, with biannual application deadlines. The GO-Bio initiative has enabled entrepreneurs to realize their dream of a biotechnology start-up since 2005.

Two research programs followed in 2010: one for health [12,13] and one for bioeconomy [14,15]. The latter includes industrial biotechnology and will be introduced below.

### **Patterns and observations pertaining to funding history**

Funding steadily increased over these three programs, reflecting the increasing number of research groups, companies and techniques. The 1985-1988 program earmarked about 406 million euros\* of its total funds of over 560 million euros\* for project funding [7]. In Biotechnologie 2000 this figure subsequently increased to over 510 million euros\* for project funding out of a total of over 1 billion euros\* [8]. Ultimately, in the third program, over 800 million euros were allocated for research project funding in the years 2001 to 2005 [10,11].

The initiatives named above are only a small fraction of those that ran during the three programs listed.

Project funding can be a versatile tool: Funding has been used to establish entire research centers, to fund single projects in academia or industry as well as cooperative projects between any number of partners, to fund the establishment of networks, to aid promising young academics in establishing their own research groups, to fund start-ups at the critical early stages and to encourage international collaborations.

Considering that biotechnology had been identified as an important field for economic development, it may be surprising that no specific research program was published earlier. However, it is not the task of funding to finance every important emerging field. Many will develop excellently without such help; funding them is a waste of limited funds. Government ministries and funding agencies, besides working under financial, administrative and political constraints, therefore have to predict the development of emerging scientific fields in order to judge whether government support will be necessary.

This history suggests that project funding has had a significant impact. Germany lacked relevant know-how, but caught up once government guided funding was initiated. Generally, being risk averse can make perfect sense for an individual company or institute, but not necessarily for the national economy. Some research is undertaken more readily if companies and institutes do not have to deal with the risk alone. The aim of project funding is to provide a percentage of the cost, and thus bear a part of the risk.

### The National Research Strategy Bioeconomy 2030

The National Research Strategy Bioeconomy 2030 (NFS 2030) [14,15] was launched by the German government in November 2010 with funds of 2.4 billion euros for six years. Of these funds, 1.5 billion euros were earmarked for project funding, the rest for institutional funding and other commitments. This is nearly double the funding available for the previous program, a remarkable fact particularly since health research, included in the previous program, now has its own funding. Industrial biotechnology plays a significant role in this strategy, more prominently than it did in the earlier ones.

Bioeconomy is described in the strategy as “a natural cycle-oriented, sustainable bio-based economy that carries the promise of global food supplies that are both ample and healthy and of high quality products from renewable resources”. The two objectives are (1) to make Germany a dynamic research and innovation hub for bio-based products, energy, processes and services and (2) to meet the responsibilities for global nutrition, as well as for the protection of the climate, resources and the environment.

To meet these goals five key fields of action have been defined:

- securing global nutrition,
- ensuring sustainable agricultural production,
- producing healthy and safe foods,
- using renewable resources for industry and
- developing biomass-based energy carriers.

Note: All currency values in Deutschmark have been converted into euros and are approximate; these converted values are marked \*

Promoting interdisciplinary research, speeding up technology transfer, promoting international cooperation and intensifying the dialogue with society were defined as cross-section activities.

### Industry and sustainability in the NFS 2030: Creating an alliance

Conventionally, keeping industries competitive has been the main focus of funding, in Germany as elsewhere. Increasingly, the policies of the German government, reflecting the opinions of its populace, take into account global challenges such as threats to the environment and climate, resource depletion or social inequalities arising from population growth and poverty. The National Research Strategy Bioeconomy 2030 (NFS 2030) is no exception. The previous research program mentioned ethical aspects and environmental protection, including the idea of environmentally friendly bioprocesses, but they were clearly not the focus. In contrast, the possibility and even necessity of creating more sustainable ways of production while at the same time making industries more competitive is central to the NFS 2030. Industrial biotechnology in particular is seen to elegantly combine these two aims, which have more commonly been considered as being opposed to each other.

This concept is not entirely new, nor is it without its critics. Critics have feared that the ideas of a bioeconomy and “green” industrial processes are nothing but promises of a technological fix which detract attention from reducing consumption. They have also voiced concerns about the possibility of associated biosafety issues, biodiversity loss, increasing monocultures, land grab, and the fact that alternative uses of biomass may reduce food availability. Such dangers certainly exist. Few new processes, if any, are without risks and major transitions may produce unwanted side effects. This, however, cannot be a reason not to engage in them at all. Instead, it demands an appropriate amount of realism and vigilance to complement the hopes and enthusiasm.

It is partly an awareness of such possible conflicts that makes the NFS 2030 more than just a vision. A recent analysis comparing national strategies and policies for the bioeconomy of various countries worldwide found that “[i]n contrast to the other country policies and strategies, the German document has a clear and quiet straightforward approach with outlined visions, goals and tools to reach them. The measures are quite precise and concrete” [16]. By thinking out the approach in some detail, the NFS 2030 aims to avoid the worse pitfalls through early identification and correction of the set course if necessary.

Conflicts have already been encountered, in fields such as biosecurity or prioritization of biomass (including fuel versus food). More are undoubtedly to come. It is vital to involve the public in solving them; in fact, such involvement has been deemed invaluable for the success of the bioeconomy [17]. The German population has reservations about some biotechnological methods, in particular the genetic engineering of crops, the use of embryonic stem cells and the cloning of animals, while there are few such reservations about the medical or industrial use of biotechnology. Public discussion is encouraged, and the results are taken into account to keep improving policies and initiatives. A central role in this process can be undertaken by

advisory bodies like the Bioeconomy Council (see below). This process can be helpful in identifying conflicts early on and finding solutions that strike a balance between interests. For example, the NFS 2030 unmistakably prioritizes food production over any other use of biomass, and in consequence research using biomass from waste or by-products for industrial applications was given priority from the start.

### Inspiring, shaping and prioritizing initiatives

A long chain of funding initiatives has fleshed out Germany's biotechnology research programs, each initiative with its specific target – be it a research topic or a structural task such as, for example, encouraging start-ups. Many initiatives and other activities focused or focus on industrial biotechnology. Some of these are, in rough chronological order: Biokatalyse (Biocatalysis), mikrobielle Genomforschung (genetics of microorganisms), Bioverfahrenstechnik (biological process engineering), Aufreinigungstechnik (down-stream processing), Nachhaltige Bioproduktion (Sustainable Bioproduction), Cluster-Wettbewerb BioIndustrie2021 (Cluster Competition BioIndustry2021), ERA-Net Industrial Biotechnology, Biotechnologie2020+ (Biotechnology2020+), Strategische Allianzen (Strategic Alliances). As mentioned previously, creating initiatives is one of the most crucial steps in the entire system. Besides their own expertise, government ministries and funding agencies gather input from experts. Such consultations can take a variety of forms, a few examples of which will follow.

### Advisory bodies: The Bioeconomy Council (Bioökonomierat)

In preparation for the NFS 2030, the German government set up the Bioeconomy Council in 2009. This advisory group was appointed by the BMBF and the Federal Ministry of Food and Agriculture (BMEL) to serve as an independent advisory board, and has entered into a second working period in 2012. The members were selected in order to represent industry, academia and society as well as all relevant scientific fields. It is their task to think ahead, anticipate problems and suggest solutions. They have, so far, published about twenty documents, most of which focus on recommendations [18-32]. One of them deals exclusively with the "Contribution of industrial biotechnology to the economic change in Germany" [31] and primarily contains recommendations for public funding. They have also started a formal dialogue with the public (Bürgerdialog), the first results of which have also been published [33].

### Specialist groups: Biorefineries Roadmap

For certain topics, temporary specialist advisory groups may be established. An example of this was the working group "Biorefineries Roadmap" set up by the BMBF, BMEL, BMUB (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety) and BMWi (Federal Ministry for Economic Affairs and Energy). The 29 members combined many areas of expertise relevant to biorefineries and represented a wide range of institutions and companies. The document, published in 2012, contained detailed descriptions of different types of biorefineries and of the state of knowledge in biorefinery technology [34,35]. Besides that, it provided a lengthy but precise definition of biorefineries for the purposes of the NFS

2030: "A biorefinery is characterized by an explicitly integrative, multifunctional overall concept that uses biomass as a diverse source of raw materials for the sustainable generation of a spectrum of different intermediates and products (chemicals, materials, bioenergy/biofuels), allowing the fullest possible use of all raw material components. The co-products can also be food and/or feed. These objectives necessitate the integration of a range of different methods and technologies."

### Strategy processes: "Next generation of biotechnological processes: Biotechnology 2020+"

Strategy processes are long term, and serve to increase interdisciplinary cooperation and thinking out of the box, in order to extend what is thought to be possible and attainable. They are not only valuable for their results, but also have a wider knock-on effect through the scientific community and society as a whole. The strategy process "Biotechnology 2020+" was started in 2010 by the BMBF together with all four research organizations (Fraunhofer-Gesellschaft zur Förderung angewandter Forschung e. V., Helmholtz-Gemeinschaft deutscher Forschungszentren, Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V., Max-Planck-Gesellschaft zur Förderung der Wissenschaften e. V.) and a number of universities to encourage the development of conceptually new biotechnological production processes, such as for example cell-free processes. The first phase, completed in 2013, served to bring together a very wide field of scientists, including biologists, engineers, chemists, computer scientists, and material scientists, develop visionary concepts, assess the research and development necessary to reach these, and start implementing corresponding projects [36,37]. A research and development roadmap was written that will be revised every five years. In phase two, the four German research organizations will continue to implement research outlined in the roadmap. Additionally, projects will be funded through a dedicated funding initiative and a research award (see below).

### Selected current initiatives in industrial biotechnology

**Promoting early concepts: Initiatives accompanying the strategy process "Biotechnology 2020+":** Projects developed in the strategy process detailed above are being funded in the initiative "Enabling technologies for the next generation of biotechnological processes" (Basistechnologien für eine nächste Generation biotechnologischer Verfahren). To date, there are 35 projects with a total of 42 million euros in funding. The "Research award next generation of biotechnological processes" (Forschungspreis Nächste Generation biotechnologischer Verfahren) is awarded every two years. It highlights revolutionary research falling within the scope of the strategy process and finances a research group to work on the winning idea. Through the award, good ideas in the spirit of the strategy process but which arose outside of it can still be included. Both these initiatives fund highly innovative projects at the beginning of the value chain. The task of project funding in this context is to give cutting-edge ideas a chance even before their potential can be known. Such ideas are highly speculative and many may never make it to market, but others may prove revolutionary and lay the foundation for future processes and products.

**Research infrastructure: Fraunhofer Center for Chemical-Biotechnological Processes:** In October 2012, German chancellor Angela Merkel officially opened the Fraunhofer Center for Chemical-Biotechnological Processes (CBP) in Leuna, a facility for biorefinery research. Besides laboratories it also provides several process plants. The flexible set-up allows a wide range of techniques and methods to be applied. It includes apparatus sufficient to trial upscaling of processes to pilot scale. Researchers from the Fraunhofer-Gesellschaft and from industry can run trials there, making experimentation less cost-prohibitive. The 50 million euros in public funding came from the BMBF, the state government of Saxony-Anhalt, the BMEL und the BMUB. The CBP is also involved in the cluster BioEconomy, which is part of the “Leading-Edge Cluster Competition” (Spitzencluster-Wettbewerb) of the government, an initiative open to all technologies. Funding agencies cooperate on projects if the costs are high and the benefits are considered to be manifold. Facilitating research into biorefineries was a priority, and by making adequate facilities available such research was made more affordable. Research funding can be used to create the right conditions or infrastructure in order to level the playing field and enable more researchers and companies to examine their ideas and concepts thoroughly.

**Transfer to application: “Competition for ideas: New products for the bioeconomy”:** The “Competition for ideas: New products for the bioeconomy” (Ideenwettbewerb Neue Produkte für die Bioökonomie) invites short, informal pre-proposals detailing innovative ideas for new bio-based products. Up to 50,000 euros may be granted for an initial nine months, in which a more detailed project proposal is prepared. Beside scientific and technical detail, it must also name at least one expert with experience of commercialization in the relevant field who will act as an advisor. In a second phase, the project may then be funded up to the proof of concept with a maximum of 250,000 euros. The highly innovative projects are risky both technologically and commercially, and might have been conceived by a single researcher with no experience in commercialization. Such ideas often perish without being put to the test, take very long to make it to the application stage or fail because of insufficient understanding of market processes and administrative hurdles. Encouraging transfer to application is therefore another classic area of research project funding, in order to improve the chances that good ideas fulfill their potential.

**Fostering international cooperation: ERA-Net Industrial Biotechnology:** The present article concentrates on federal initiatives, which are for the most part national in scope, but international initiatives are also of great importance despite the higher complexity they entail. There are a number of international initiatives of relevance to industrial biotechnology, many of which have a European focus. However, some, such as “BioEconomy International” fund cooperative projects of German partners with others from a large number of countries all over the world. The European Union has a long history of biotechnology funding [38]. Several European initiatives are relevant to industrial biotechnology, such as the ERA-Nets SUSFOOD, EuroTransBio and of course Industrial Biotechnology. The ERA-Net Industrial Biotechnology was started in 2006 in order to promote cooperative projects involving partners

from several of the 13 participating countries. The European commission will fund the network until 2016 at least. Several calls have been published so far, with the fourth scheduled for early 2014. This fourth call is a unique joint initiative with the ERA-Net EuroTransBio, which funds cooperative biological research in small and medium-sized enterprises. Under the new European Framework Programme Horizon2020, which started at the beginning of this year, substantial funding in industrial biotechnology will be organized as a public-private partnership. The Joint Technology Initiative Bio-based Industries (BBI JTI) is a partnership of the Bio-based Industries Consortium (BIC) and the European Union. Together, they will set the research agenda and take all funding decisions as equal partners. This new model will hopefully lead to high financial contributions by industry – almost double the sum contributed by the EU –, a clear focus on areas of need from an industry point of view, and a comparatively low administrative effort.

**Establishing networks: “Innovation-Initiative Industrial Biotechnology”:** The “Innovation-Initiative Industrielle Biotechnologie” (Innovationsinitiative Industrielle Biotechnologie) is based on “BioIndustrie2021”, but while the earlier initiative encouraged networks of stakeholders working in related fields, the new one funds strategic alliances of dissimilar players that would not previously have considered working together. These alliances must be led by industry and aim to replace mineral oil based products with biotechnologically produced ones in order to switch to renewable resources and reduce energy consumption. Up to 100 million euros are available overall, but alliances have to contribute substantially. Five alliances are currently selected to receive funding: “Zero Carbon Footprint – functional biomass from carbon-rich wastes” (Funktionale Biomasse aus kohlenstoffreichen Abfallströmen), “Making polymers functional” (Funktionalisierung von Polymeren), “Natural Life Excellence Network”, “Techno functional proteins” (Technofunktionelle Proteine) and “Knowledge-based process intelligence – new routes towards stable bioprocesses” (Wissensbasierte Prozessintelligenz – Neue Wege zu stabilen Bioprozessen). Applications are accepted until 2015, so more alliances may well follow. Alliances serve to increase cooperation between different actors in the same fields and establish structures that will make it easier to find cooperation partners, in order to speed up and make more efficient both the exchange of knowledge and the transfer of ideas into application. These network structures are to remain in place once funding ceases. Previous initiatives, such as BioRegio, have shown this to be possible and profitable for all involved. Despite this, extensive cooperation networks, particularly between dissimilar partners, rarely form without a seed event, such as a funding initiative. As a consequence, encouraging cooperation and the establishment of networks is a recurrent theme of government funding.

## FUTURE OUTLOOK

The new focus of combining sustainability with economic progress will continue to be expressed in further funding initiatives. On 5 June 2014, a conference in Berlin will celebrate the half-way point of the NFS 2030. As part of this conference, several new funding initiatives are scheduled to be announced. This event will also mark the point in time at which first thoughts will be given to a possible subsequent research program. One

measure to aid this undertaking is an evaluation of the NFS 2030 planned for 2015. The presentation of the new program is scheduled for 2016, and it is planned to start in 2017. Industrial biotechnology is very likely to play a significant role again.

### Concluding remarks: Beyond research

Research opens up opportunities. In this particular case, research may offer opportunities to decrease dependence on fossil resources, reduce pollution, lower greenhouse gas emissions, improve quality of life, and at the same time, it may offer opportunities for businesses in the form of more efficient processes or entirely new products. However, whether these opportunities will be utilized to the full is not a scientific question; instead it is up to the public and political consensus as well as economic factors. Public discussion about the new opportunities is essential. Approaches may have to be prioritized; any undesired side effects need to be identified and discussed; chances and risks need to be weighed up. The results of these discussions then feed into the policies pertaining to applications. For the bioeconomy in Germany, discussions have begun and a first policy document delineates how the results from bioeconomy research are to be used for the benefit of society as a wider whole. It should be no surprise that industrial biotechnology is a central component of the Politikstrategie Bioökonomie (Political Strategy for Bioeconomy) [39], being seen as a promising growth market in a green economy, coupling economic prospects with a high potential for making production more sustainable. Thus, while industrial biotechnology and sustainability might at times seem to be an uneasy alliance, it can, if used judiciously, deliver substantial benefits for all. Targeted research funding can help ensure that research will continue to open up ever new opportunities so we can realize that potential.

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