Federal Ministry
of Food
and Agriculture

National Policy Strategy on Bioeconomy

Renewable resources and biotechnological processes as a basis for food, industry and energy

www.bmel.de

Table of Contents

Foreword

Dear Readers,

Sustainable management for the future requires responsible handling of our resources. Raw materials such as mineral oil and natural gas are running low. Extracting them is frequently only possible with great technical difficulties and risks for the environment. We are therefore increasingly focussing on a mix of raw materials from sustainably produced renewable resources. On 17 July 2013, the Federal Government adopted the National Policy Strategy for the Bioeconomy. In doing so, the Federal Government is supporting the shift to a resource-efficient economy based on renewable resources that either makes less use of fossil resources or dispenses with them entirely. This change is mainly driven by the bioeconomy.

The bioeconomy concerns different policy areas such as industrial and energy policies, agricultural, forestry and fisheries policies, climate and environmental policies and research and development policies. The National Policy Strategy for the Bioeconomy unites these different policy areas and sets a clear course for bioeconomy policy in Germany. It supports the sustainable production and use of renewable resources in the agricultural, forestry and fisheries sectors because their products are the key sources of raw materials for the bio-based economy.

The aim is to have a reliable and innovation-friendly environment that helps industry to tap into the potential of growth markets and innovative technologies. This includes new plant-breeding methods, fine and speciality chemicals produced by biotechnology or the use of algae for foodstuffs, pharmaceutics or for energy production. Industrial biotechnology as a key technology not only makes the substitution of petroleum-based products possible, but also develops new types of products that can be manufactured using renewable resources. Biotechnology is an engine driving international competitiveness and it is planned to make further advances in this technology via research and development.

The strategy also highlights opportunities for defusing conflicting aims such as the competition between food security and the use of renewable resources for industry and energy. The strategy gives important impetus in respect of the structural changes required in the transition to a sustainable bio-based economy. We can succeed in accomplishing this transition if we combine it with the safeguarding of food security and protection of the environment, climate and biodiversity. The bioeconomy must therefore contribute towards ensuring food security for a growing world population, to mitigating against climate change and to conserving soil fertility and species diversity.

The National Bioeconomy Policy Strategy sets clear targets for this. It sets the framework for sustainable economic activity with renewable resources. This means that the potential of the bioeconomy will then be used in a manner which takes into account the responsibility for future generations. The bioeconomy will thus become a key instrument in mastering the huge challenges of the 21st century!

Yours sincerely,
Christian Schmidt
Federal Minister of Food and Agriculture

Summary

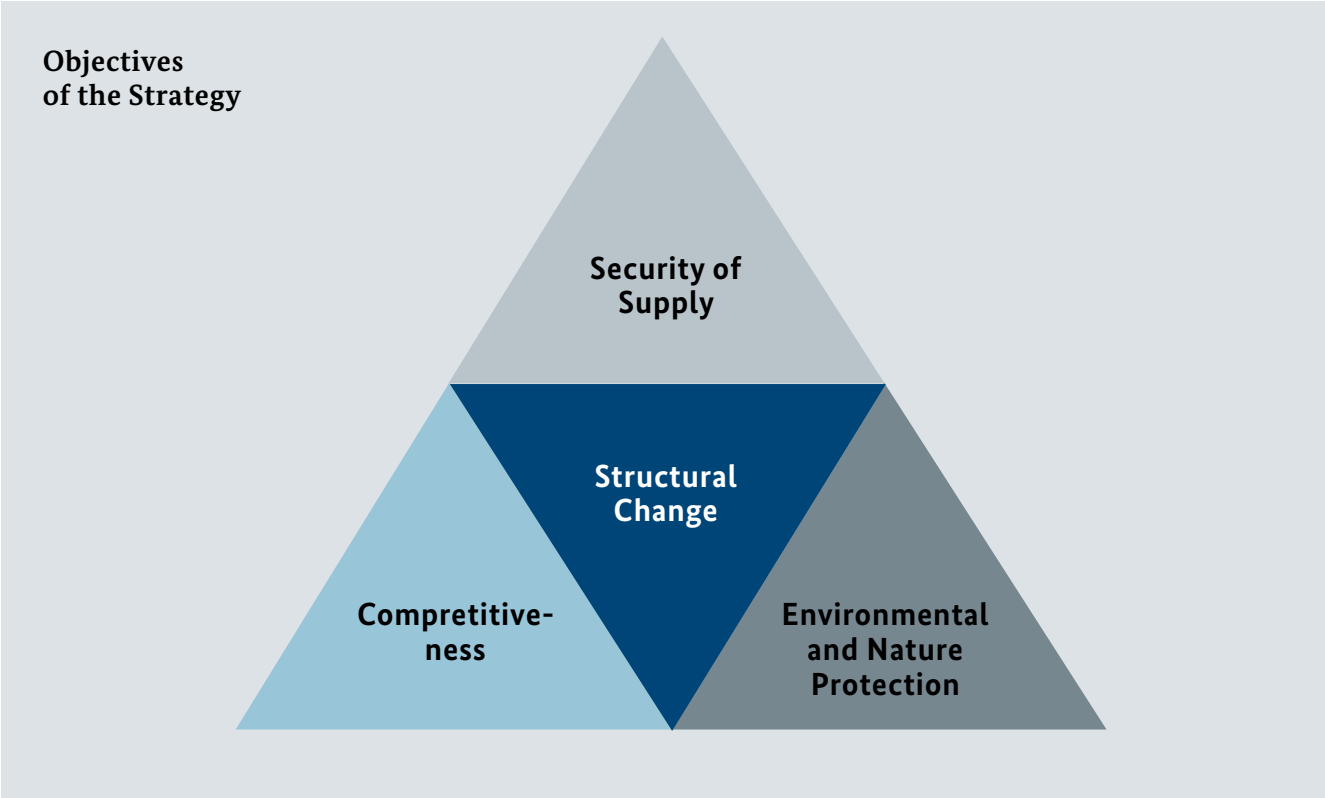
Summary

Major challenges characterise the 21st century. These include providing enough food and healthy food for a growing global population, climate change, and the loss of soil fertility and biodiversity. The "knowledge-based bioeconomy", also referred to as a "bio-based economy", offers the opportunity both to make an important contribution to mastering these challenges and simultaneously to advance the transition from an economy mainly using fossil-based raw materials to an economy based on renewable resources and efficient in terms of raw materials.

The concept of the bioeconomy takes natural cycles of materials as its point of orientation; it encompasses all sectors of the economy that produce, work and process, use, and trade with renewable resources, such as plants, animals, micro-organisms, and their derivatives. Materials used include not only raw materials produced in the agricultural, forestry and fisheries sectors, as well as in aquaculture or in microbial production; increasingly, biogenic waste materials and residual materials are also used. The bioeconomy is thus also resource-efficient recycling. The renewable resources are worked and processed to form a variety of products, also increasingly by means of industrial application of biotechnological and microbiological processes. Aside from its use for the production of materials, the use of sustainably-produced biomass also acts as a significant renewable source of energy – with preference given to using it at the end of the cascading process of use.

Biotechnology, as a key technology, is an engine driving the international competitiveness of the German economy. It gives important impetus to the structural change towards an economy based on renewable resources. Use of biotechnological methods and processes can not only substitute oil-based products; it can also enable new types of product to be developed.

The *Policy Strategy – Bioeconomy* builds upon the Federal Government's Sustainability Strategy. This dovetails with the "National Research Strategy Bioeconomy 2030 – our route towards a biobased economy", adopted in 2010, providing the foundation for innovations in the bioeconomy by means of research and development. The "Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply" (2010), the "Raw Materials Strategy" (2010), the "German Resource Efficiency Programme" (2012), the "Biorefineries Roadmap" (2012), in addition to other strategies and concepts formulated by the Federal Government, describe further points of policy orientation and conclusions with a direct effect on the bioeconomy.



The *Policy Strategy – Bioeconomy* sets priorities for advancing towards a knowledge-based bioeconomy and it highlights areas that require action. The aim is for the guiding principles, strategic approaches and measures to contribute to making use of the areas of potential for the bioeconomy in Germany, and also help to strengthen the structural transition to a biobased economy. The strategic approaches are to be further developed to match the long-term goals and to adapt to new challenges. The degree of success achieved by the strategy is to be examined in a Progress Report.

Goals and guiding principles

The structural transition towards a biobased economy can be successful only if combined with securing the supply of food and also with protecting the environment, the climate and biodiversity. These issues, together with taking social-responsibility aspects into account, are preconditions for a sustainable and internationally competitive bioeconomy. The goal of securing the availability of renewable resources and producing such resources must not be allowed to be attained at the expense of soil fertility, effective management of water resources, or climate protection. The bioeconomy is closely interlinked internationally. Decisions and developments in Germany can also have consequences in other parts of the world. Thus it must be ensured that the robustly-increasing demand for renewable resources also supports the development-policy objectives in developing countries and emerging economies.

The bioeconomy affects various specific policy areas, such as industry and energy policy, the policy on agriculture, forestry and fisheries, climate policy and environmental policy, in addition to research and development policy. In aiming to give coherent structure to policy, the political framework conditions for the bioeconomy must be arranged so that, within the limits of what is possible, a contribution is made to securing world food supplies, reducing dependence on fossil-based raw materials, protecting the climate and using the renewable resources sustainably, while safeguarding both biodiversity and the functions performed by soil. In part, these requirements give rise to conflicts between goals, which need to be resolved by means of suitable framework conditions.

For implementing the goals, the *Policy Strategy – Bioeconomy* is developing the following guiding principles, among others:

- Food security takes priority over the production of raw materials for industry and energy internationally.
- Paths of use with a higher value-adding potential must be given preference in the remainder of the work on structuring the bioeconomy's framework conditions.
- Where possible and purposeful, cascading use and coupled use of biomass should be applied.
- The aim to secure and strengthen the competitiveness of the bioeconomy in Germany and the areas of growth potential on the international markets should always be kept in sight.
- For the competitiveness of the bioeconomy it is imperative to have well-trained and well-informed specialist personnel.
- The opportunities and framework conditions for using key technologies and for effecting their transfer into commercial use need to be improved.
- The bioeconomy needs to satisfy increasingly challenging requirements from society in terms of the way in which goods are produced. This applies to the protection of the environment, the climate, nature and animals, and also to compliance with standards of social responsibility.
- The use of sustainability standards in the producer countries, especially in those with weak government leadership and weak institutions, must be expanded and appropriate efforts made to check compliance with them.
- In developing the bioeconomy there is a need for close cooperation between all those involved, from the political, economic, scientific, and environmental spheres and from society at large.

Building upon the guiding principles, the *Policy Strategy – Bioeconomy* develops strategic approaches in three cross-sectoral areas of action and five thematic areas of action, supporting these with specific measures.

A

Cross-sectoral area of action

Coherent policy framework for a sustainable bioeconomy

Page 46

Various existing and newly-emerging policies in specialist subject areas, at global, European and national level, all leave their imprint on the framework conditions that apply to the bioeconomy. There is a danger of a fragmented operating environment with incoherent framework conditions. That is why it is necessary to interlock the various areas of policy on the bioeconomy and to strive to achieve transparent, knowledge-based communication between politics, business, science and civil society. The Federal Government will call into being an "*Inter-ministerial Bioeconomy Working Group*", with the task of supporting the exchange of information and of coordinating the policies adopted by the various government departments with regard to the bioeconomy, and also of further developing this strategy. The aim is also to strengthen the interaction between the Bioeconomy Council and other consultative committees set up by the Federal Government on bioeconomy-related issues.

B

Cross-sectoral area of action

Information and dialogue within society

Page 47

For the bioeconomy, being related to a whole range of policy areas and interests, a knowledge-based dialogue carries a particular significance. The goal in providing targeted information and having a participative dialogue with the public, and with protagonists in the bioeconomy from the realms of science and business, is to contribute to formulating requirements that society places upon the development of the bioeconomy and also to strengthen open-mindedness with regard to biobased products and innovations.

C

Cross-sectoral area of action

Vocational training and apprenticeship

Page 49

For the highly-specialised and strongly-networked bioeconomy, it is a challenge to satisfy the demand for specialist personnel. It is essential to continue to build up and extend the necessary base of expertise in Germany, and to counteract the lack of well-trained specialist personnel that is to be expected due to demographic changes. Only in this way can Germany be competitive in the global competition to have the brightest and the best.

D

Thematic area of action

Sustainable production and provision of renewable resources

Page 50

Sustainable management of the agricultural areas, the forests, the seas and other bodies of water is a basic prerequisite for producing the necessary raw materials in a way that uses resources sparingly and is in harmony with the goals of protecting the environment, the climate, and nature. The demand for biomass of plant origin is rising, and the amount of utilised agricultural area is going down in Germany while, viewing the global picture, the area is only able to be increased to a limited degree: thus it is necessary to increase sustainably the yields from harvests. Accompanying this, it is highly significant to make sustainable use of aquatic resources, for securing food supplies and also microbial resources for industrial biotechnology, using micro-organisms and algae as a raw-materials source due to their variety of ingredients.

E

Thematic area of action

Growth markets, innovative technologies and products

Page 60

The Federal Government accompanies and provides support to the opening up of markets by means of reliable and innovation-friendly framework conditions, as well as through research and development. The aim is that research and innovations make use of the areas of potential that are offered by highly-promising technologies, products and markets, based on renewable resources; innovative products and processes need to be more quickly made ready for use in applications.

F

Thematic area of action

Processes and value-adding networks

Page 63

Through intelligently connected value-adding networks, it is possible to reduce further the consumption of renewable and non-renewable resources and the demands placed upon them, to improve economic viability, and to lower emissions, thus having a sparing effect on the environment and nature. Through cascading use and coupled use of biomass, raw materials can be used completely and according to their full value, in the context of recycling. Biorefineries hold out the prospect of more efficient use of the potential of biomass, compared to the current processes for using it as a source of energy and of materials.

G

Thematic area of action

Competition among uses of land

Page 66

The production of renewable resources claims areas of land that, in principle, can also be applied to other uses, such as building developments or infrastructure. The various paths of use offered by biomass (for food, and for use as a source of materials and of energy) are also competing for the land. The principle that applies in this is: securing food supplies takes priority. The requirements of protection of the environment, the climate, the soil and nature need to be taken into account. Politics influences the competitiveness of the various paths through regulatory framework conditions and a series of funding-support measures. Uniform standards of assessment are needed for assessing the various paths of use. Consistent with a sustainable expansion of renewable raw materials, directed at efficiency, it is particularly important to strengthen use of these resources as a source of materials.

H

Thematic area of action

International context

Page 70

At international level also, a balance must be struck between the competing agricultural uses of land for the priority of food security, and the use of biomass for industry and energy. At the same time, the rising demand for products of animal origin, with its associated increase in demand for feed, adds to the pressure on agricultural areas and the forests. It is equally important for a sustainable increase in agricultural productivity to be combined with an integrated rural development, and for the Right to Food to be consistently implemented, also taking into account environmental standards and standards of social responsibility in the producer countries. Internationally-recognised standards of sustainability in agriculture, forestry and fisheries serve as an important instrument in guaranteeing compliance with requirements regarding the environment and social responsibility.

Bioeconomy as an opportunity for the 21st century

1. Bioeconomy as an opportunity for the 21st century

The 21st century is characterised by major challenges. A growing global population needs to be fed sufficiently and healthily, with usable agricultural areas limited. Climate change makes it necessary to limit emissions of greenhouse gases, and the globally continuing loss of soil fertility and biodiversity demands measures to counteract these developments. The finite nature of raw materials of fossil origin, an increasing demand for raw materials, and political uncertainties: these factors will all be reflected in the market, making it essential to tap new sources of raw materials and to make use of alternatives. Thus new concepts for an enduring and safe supply of energy and raw materials, including the use of sustainably-produced biomass, take on growing significance. The knowledge-based bio-economy offers the opportunity to make an important contribution to mastering these challenges and simultaneously to strengthen Germany‘s international economic competitiveness.

The “*knowledge-based bioeconomy*” – also termed the “biobased economy” takes natural materials cycles as its point of orientation; it bases itself upon a structural transition from an economy based on finite resources of fossil origin – mainly petroleum – to an economy more strongly based on renewable resources. New knowledge gained in the life sciences and technical sciences is bringing about a deeper understanding of the global biological systems: this can lead to the sustainable use of renewable resources for the benefit of humankind and the environment. The bioeconomy spans a bridge linking technology, the economy and ecological issues, by applying biological processes and resources, further developing them and thus enhancing their performance capability, as well as making their use more efficient and sustainable. The bioeconomy not only replaces raw materials sourced from fossils; it also develops wholly new products and processes.

Bioeconomy is the knowledge-based production and use of renewable resources, in order to provide products, processes and services in all areas of the economy, within the framework of an economic system that is viable for the future[1]. The concept of the bioeconomy encompasses all economic sectors and their associated commercial services, involved in producing, working or processing, using or trading with renewable resources – such as plants, animals and micro-organisms and products made from them. This is done with the aim of making it possible to effect a transition to running the economy in a way that is increasingly independent of petroleum. Thus the knowledge-based bioeconomy can be an essential part of a viable and sustainable economic system.

Agriculture, forestry, fisheries, and aquaculture, but also the biotechnological use and conversion of biomass, in addition to biogenic waste materials and residual materials: these are the central starting points for the bioeconomy's value chains and value-adding networks, which are interlinked in a multitude of ways. Downstream sectors work and process renewable resources to form a variety of products, partly also through industrial application of biotechnological and microbiological processes, particularly in the chemical industry. This also includes food producers, and the wood, paper, construction, leather, and textile industries, as well as parts of the pharmaceutical industry and the energy sector. To that extent they are as involved in the build-up of a bioeconomy as are the associated areas of retail, distribution and commercial service sectors. It is characteristic of the bioeconomy, firstly, that the value chains of its products in the various business sectors are increasingly networked, or respectively are able to be networked, and secondly that by-products and residual materials are used in a way that yields the highest possible value. Accordingly, the bioeconomy system also attaches particular significance to recycling and waste-management processes that can avoid residual materials and waste materials, or respectively direct them to a use that derives the highest possible value from them.

Viewed as a whole, the bioeconomy is now already a significant pillar underpinning the German national economy: In 2007, across all business sectors, approximately 5 m. employees, i.e. 12.5 % of all those in employment, generated 8 % of the gross value added in Germany, corresponding to approx. € 165 bn. per year[2]. Within this, up to now the classic production systems of the food and feed sectors dominate, alongside the wood industry (including distribution and services): their share of the bioeconomy corresponded to 97 % of the employed (4.8 m. people) and 96 % (€ 159 bn.) of the gross value added in 2007. The bioeconomy has the potential to further expand this economic output, through the development and further processing of the various biomass-based raw materials – in some instances new ones – to form high-value, innovative materials and products, through increasing numbers of coupled uses and cascading uses, as well as through the optimisation and intelligent linking up of various value-adding networks.

The Coalition Treaty for the 17th legislative period states the tasks of the Federal Government with regard to the development of a bioeconomy strategy[3]: "*We see research, development and application of biotechnology as a great opportunity for Germany as a business and science location and for its international competitiveness. (...) With the support of the Bioeconomy Council, we will draw up and implement an internationally competitive strategy for advancing towards a knowledge-based bioeconomy*." The Federal Government defined the need for action to be derived from this in 2010, taking into account the recommendations of the Bioeconomy Council[4], in the "*National Research Strategy 2030 – our route towards a biobased economy*", underpinning this with a support budget totalling € 2.4 bn. for the period 2011-2016. A decisive factor in the ongoing development of the bioeconomy is the cooperation between business and science, and between partners from different countries, as well as between disciplines and institutions respectively.

The focus of the "*Policy Strategy – Bioeconomy*" is on the political options for action and strategic approaches, thus going beyond the focus of the "*National Research Strategy – BioEconomy 2030*". In particular, this includes industry policy and energy policy; agricultural, forestry and fisheries policy; and also climate and environmental policy.

1 Bioeconomic Council 2013: http://www.biooekonomierat.de/biooekonomie.html

2 Johann Heinrich von Thünen Institute 2012: Significance of biobased business to the overall national economy in Germany. Working reports from TI economics of agriculture, 08/2012.

3 Coalition Treaty between CDU, CSU and SDP, 17th legislative period.

4 Bioeconomy Council 2010: Report – "Innovation bioeconomy. Research and technology development for food security, sustainable use of resources and competitiveness".

A central issue is that of how to satisfy the globally-rising demand directed at using biomass for food, for industry and also for energy, with the associated intensifying competition for land areas to use for agriculture and forestry, while safeguarding the principle of sustainability. There are competing claims on the use of land areas for producing food and feed, for producing renewable raw materials intended for material use and for use as an energy source, and also for infrastructure and construction developments. Moreover, the requirements of environmental and nature protection can impose limitations on agriculture and forestry production. The task facing policy-makers is to create suitable framework conditions for running the economy in a sustainable, resource-efficient way that keeps sight of all these competing uses. As part of this, it is essential to take into account the concerns of protecting nature and the environment, and also the opportunities that the bioeconomy offers for protecting the climate and resources, and also for strengthening Germany as a business and science location and its competitiveness.

Possible restrictions imposed on food security and the environment by the production of renewable raw materials need to be avoided. Therefore it must be ensured that the steeply-increasing demand for such resources – and the associated demand for scarce water and land – supports the development-policy goals in the emerging economies and developing countries or respectively does not influence them negatively.

This current strategy should be viewed in the context of national concepts and strategies formulated by the Federal Government. The "*National Sustainability Strategy*", adopted in 2002 and updated on an ongoing basis, determines the course set for Germany's sustainable development, setting goals for this in all the Federal Government's political areas of action. Its success is assessed in regular Progress Reports. The "*National Research Strategy – Bioeconomy 2030*" lays the research-policy foundation for the decision to pursue a knowledge-based and internationally competitive bioeconomy. As an element of the "*High-Tech Strategy 2020 for Germany. Ideas. Innovation. Growth*" and of the project for the future[5] "Renewable raw materials as an alternative to oil", it provides important impetus in the energy and climate areas of action, as well as in the areas of health and nutrition (among others). The Federal Government, in its "*Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply*" (2010), in the "*Raw Materials Strategy*" (2010), in the "*German Resource Efficiency Programme*" (2012), and also in the "*Biorefineries Roadmap*" (2012), described points of policy orientation and conclusions with a direct effect on the bioeconomy.

Further strategies and action plans contain interfaces with the bioeconomy. In particular, these include:

- the "*National Strategy on Biological Diversity*" (2007) and, supplementary to this, the "*Agrobiodiversity Sector Strategy*",
- the "*Action Plans for the use of renewable raw materials as materials and as energy sources*" (2009/2010),
- the "*National Action Plan for Renewable Energies*" (2010),
- the strategy paper "Biofuels. Opportunities and Risks for Developing Countries" (2011),
- the "*Forest Strategy 2020*" (2011) and
- the "*Federal Government's Mobility and Fuel Strategy*" (2013).

With a view to ensuring coherence in the structuring of policy, the Policy Strategy – *Bio-Economy* builds on these concepts and strategies. It sets priorities for advancing towards a knowledge-based bio-economy and highlights areas that require action.

At European level, the European Commission has addressed the bioeconomy as a research area in "*Horizon 2020*", the new framework programme for research and innovation, and produced a bioeconomy strategy in February 2012[6]. The aim is for this to contrib-

5 http://www.bmbf.de/de/19943.php

6 European Commission 2012: Innovating for Sustainable Growth: A Bioeconomy for Europe

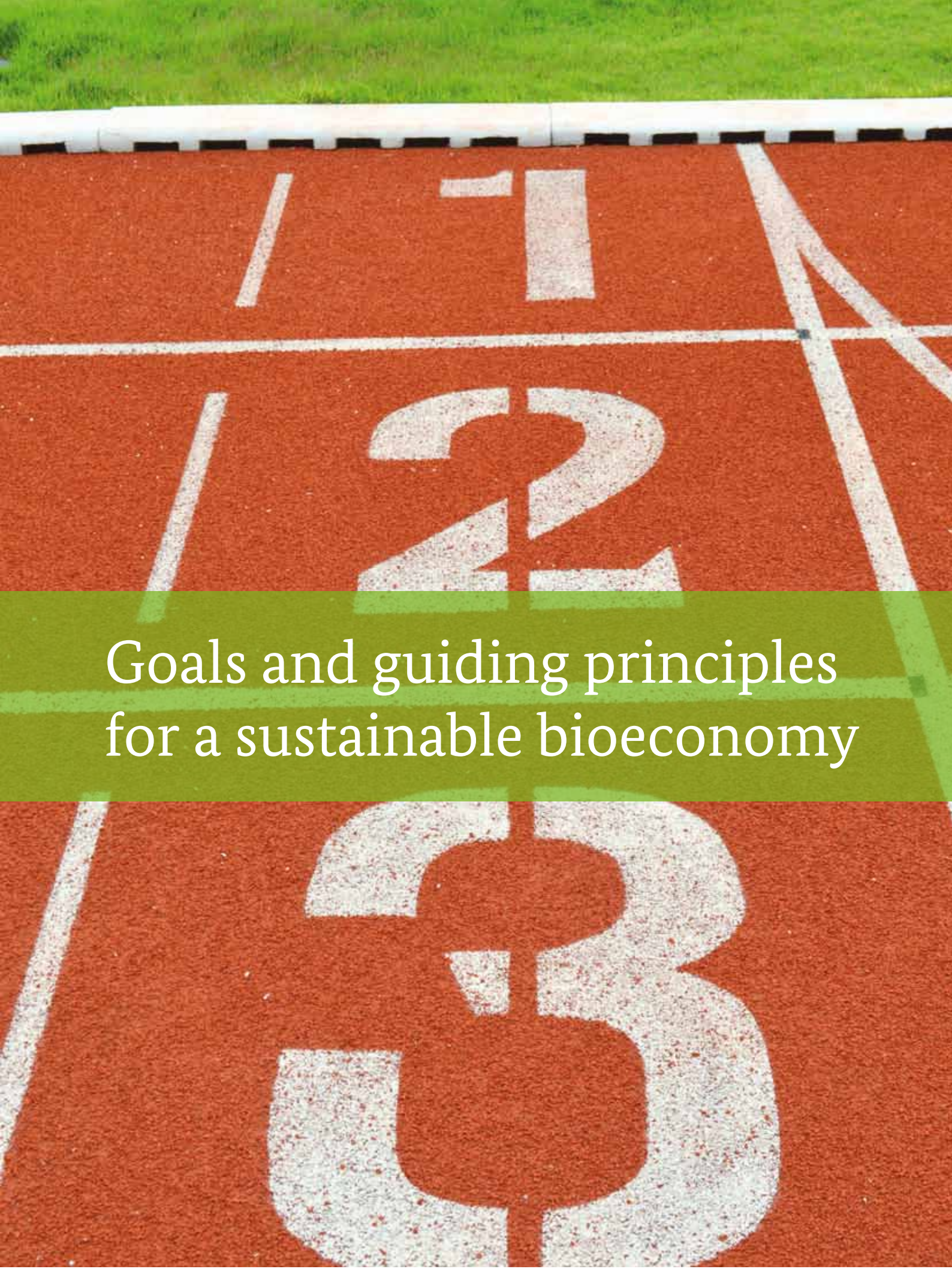
ute to implementing the goals of the "*Europe 2020*" strategy and give support to the development of an innovative, low-carbon and more resource-efficient economy which is internationally competitive. It emphasises research and innovation, but also includes measures directed at stronger networking of policies and stakeholders involved, and also at strengthening markets and competitiveness with regard to innovative products. Within the framework of an Action Plan, the Member States are called upon (among other things) to formulate national bioeconomy strategies and to establish a Bioeconomy Council. At research-policy level, the Federal Government already presented the above-mentioned "*National Research Strategy – Bioeconomy 2030*" back in 2010; it also convened a national Bioeconomy Council in 2009. Other European countries, such as the Netherlands, Denmark, Sweden and Finland, have also presented bioeconomy strategies.

Internationally, the community of states undertook an obligation at the UN sustainable-development conference, in Rio de Janeiro in June 2012, to implement the "*Green Economy*" as an important instrument in sustainable development[7]. The bioeconomy can take on a significant role in this, to the extent that it contributes to climate protection, resource efficiency, the completion of materials cycles, the conservation of biodiversity, and social inclusion. Bioeconomy strategies have been adopted in the USA and Canada; strategies of this kind are being prepared in China, South Africa, Russia, and Brazil. In 2009 the OECD reviewed the development opportunities presented by the bioeconomy and highlighted their significance for the economy and for ecology[8].

The bioeconomy can open up major areas of value-adding potential and employment potential for Germany, particularly due to the strong performance capability of the sectors of business involved, the scientific and technological lead that the country has in important areas, in addition to the climatic starting conditions and the characteristics of the soil. Integrated into its international context, the Federal Government's *Policy Strategy – Bioeconomy* describes strategic approaches and measures aimed at using the potential within the context of running the economy sustainably. The strategic approaches need to be further developed to suit the long-term goals and adapted to new challenges.

7 United Nations 2012: Report of the United Nations Conference on Sustainable Development

8 OECD 2009: The Bioeconomy to 2030. Designing a Policy Agenda



Goals and guiding principles for a sustainable bioeconomy

2. Goals and guiding principles for a sustainable bioeconomy

In its 2012 Progress Report on the "*National Sustainability Strategy*", the Federal Government highlighted that, in the future, only a sustainable way of managing the economy will keep Germany competitive compared to other countries[9]: "*Sustainable economic activity in a free market involves paying equal attention to economic success, social cohesion, the protection of natural resources, and the acceptance of social responsibility*". Taking up these premises, the current *Policy Strategy – Bioeconomy* has as its goal a sustainable and internationally competitive bioeconomy, one that contributes to the successful mastery of the challenges at national and international level. The framework conditions must be structured so as to support the following goals:

- a secure supply of high-quality food to the population in Germany; beyond this, within the scope of what is possible, a contribution towards securing the supply of food globally,
- strengthening the transition from an economy mainly based on use of fossil-based raw materials to an economy that is increasingly both efficient in terms of raw materials and also based on renewable resources,
- a supply of renewable resources, secured over the long term for sustainable and efficient use that is sparing on resources, to be used as materials and as an energy source, based on reliable framework conditions,
- sustainable use of renewable resources while conserving biodiversity and soil fertility,
- protection of the climate,
- strengthening of Germany's innovative power and its international competitiveness in business and research,
- securing and creating employment and value-added, particularly in rural areas, and
- sustainable consumption on the part of consumers, as a part of the bioeconomy's value chain.

In part, these requirements give rise to conflicts of goals. A strategically-oriented, coherent policy must bring these conflicts to light and try to defuse them by means of suitable framework conditions and through innovations. In particular, this relates to:

- competing claims to land-use for the production of food and feed, for the production of renewable raw materials for material use and as an energy source respectively, as well as for infrastructure and for building developments,
- necessary increases in production to cover a rising demand for biomass, while simultaneously environmental and nature-protection requirements are becoming more challenging,
- Conflict involved in the use of biomass in relation to the environment-protection goals,
- growing competition between material use of biomass and its use as an energy source,
- import of biomass to Germany and the avoidance of negative social, economic and environmental consequences in the producer countries, adversely affecting food security there.

The goals and the possible areas of conflict among goals lead to the following **guiding principles** being deduced for the strategic approaches and measures adopted in the *Policy Strategy – Bioeconomy* and aimed at the sustainability principle:

9 Federal Government 2012: "National Sustainability Strategy"; Progress Report 2012

Guiding principles for a sustainable bioeconomy

- In a global context as well as nationally, food security takes priority over the production of raw materials for industry and energy. Support must be given to the use of synergy effects between food production and the provision of raw materials for energy and industry.
- The paths of use for biomass should be considered in terms of their interactions and how they form networks, so as to recognise areas of potential and of competition, as well as to set priorities for political action at global, European, national and regional level.
- In the ongoing process of structuring the framework conditions for the bioeconomy, preference is to be given to paths of use that yield a higher potential for value-added while providing comparable performance with regard to other goals. This particularly applies to using waste material and residual material in the way that maximises the value gained.
- Where possible and purposeful, the objective is cascading use and coupled use of biomass. Cascades of use and intelligent linking-up of value chains or process chains respectively can improve resource efficiency, defuse possible areas of competition among paths of use and make use of innovation potential. In the bioeconomy, as elsewhere, efforts should aim at achieving a further decoupling of growth on the one hand and resource consumption on the other.
- It is essential to always keep in sight the goal of securing and strengthening the competitiveness of the bioeconomy in Germany and the areas of growth potential on the international markets.
- Well-trained and well-informed specialist personnel are an indispensable requirement for the competitiveness of the bioeconomy.
- The framework conditions for financing the development of innovative products should be improved, especially in small to medium-sized businesses.
- Where possible, impetus and incentives should be given to creativity and innovation. Improvements must be made to the opportunities and framework conditions for using key technologies and for transferring them into commercial use.
- To a decisive degree, the consumers can play their part in influencing the development of the bioeconomy. Through information and transparency, the aim is to ensure that consumers get their bearings for their purchase decisions, based on having sufficient information on sustainability aspects as well as the other factors.
- The bioeconomy needs to take into account increasingly challenging requirements placed upon the way in which goods are produced. This applies to standards governing the protection of the environment, nature, and animals, and also compliance with standards of social responsibility. The further development of production standards secures these assets and the acceptance among consumers, thereby also influencing the international competitiveness of the bioeconomy.
- There is a need to expand the application of sustainability standards in the producer countries, particularly those with weak governmental leadership and weak institutions, and work to achieve the goal of monitoring adherence to the standards.
- The synergy effects between the conservation of biodiversity and the provision of raw materials for energy and industry should be used.
- In developing the bioeconomy there is a need for tightly-knit cooperation between all stakeholders involved, from the political, economic, scientific, and environmental spheres and from society at large. What is needed is to engage the involvement and cooperation of stakeholders from the relevant groups. Regional and decentralised initiatives offer the opportunity to organise regional materials cycles and energy cycles for biobased products directly at the appropriate location.

Challenges and drivers of the bioeconomy

3. Challenges and drivers of the bioeconomy

The bioeconomy can contribute to the mastery of the challenges stated in this section. At the same time, as possible drivers of innovative capability, these challenges can open up development opportunities for a sustainable bioeconomy, engaging the creativity and innovative power of business, science and research.

Food security

The course that demographic developments are taking means that demand for food for the domestic population is on a downward trend. The projection is that, in 2030, Germany will only have approximately 77.4 m. inhabitants[10]. This amounts to 4.6 m. people fewer than in 2008, or 5.7 %. By contrast, the world population is projected to grow in the period up to 2050 from its current level of 7.0 bn. to 9.2 bn. people. The UN's Food and Agriculture Organisation (FAO[11]) estimates that, to secure food supplies, a 60 % increase in agricultural production is necessary (taking 2007 as the base year)[12]; this is because, at the same time, consumption habits are changing and, in many developing countries and emerging economies, economic development results in increasing demand for food of animal origin. FAO experts estimate that 77 % of the production increase could be attained through higher yields, 14 % of it through greater use of intermediate inputs, and 9 % of it through expanding the farming of plant-based products[13]. For this to happen, "quantum leaps" will be necessary in research, in breeding and in cultivation.

10 Statistical Offices of the Federal Government and of the Laender, 2011: Demographic Change in Germany.
11 Food and Agriculture Organisation of the United Nations
12 OECD-FAO Agricultural outlook 2012
13 Food and Agriculture Organisation of the United Nations (FAO) 2009: Proceedings of the High-Level Expert Forum on How to Feed the World 2050 (base: average of the years 2005–2007)

There are high levels of potential to boost yields, especially in Africa and in certain states in Asia and Latin America. Here, through the build-up of capacity or of competences respectively, as well as of technical and administrative infrastructure, sustainable agriculture can be intensified and the boost to productivity can be significant. Another decisive factor is the reduction of food losses. This affects the entire value chain, from harvest losses, post-harvest losses, and storage losses, through to processing, trade and consumption. The FAO concludes that globally approximately one third of food production is lost or is disposed of as waste. This corresponds to approx. 1.3 bn. t per year[14]. In Germany, industry, retail and other distribution channels, large-scale consumers and private households generate approx. 11 m. t of food waste annually[15].

Germany has a responsibility to make its contribution to securing the world's food supply. In developing countries and emerging economies, the Federal Government gives support to the development of a high-performance, sustainable agricultural sector and the build-up of an improved food-supply structure. In addition, Germany produces food for the international market. While it has at its disposal less than 1 % of the world's utilised agricultural area, it harvests 2.5 % of global production of cereals; for wheat the figure is 3.6 %. In addition there are exports of refined foods. Beyond this, Germany imports several million tons of food, fodder plants, and other renewable resources, for which the aim must be to ensure sustainable production.

It must also be borne in mind that, in the future, world agricultural prices can to an increasing degree be expected to be coupled with the development of energy prices, because the production of agricultural raw materials involves energy consumption and certain agricultural raw materials can be used either for food production or as a source of materials or of energy[16]. However, higher food prices, if they are to be expected over the longer term, can simultaneously also create incentives for expanding production and achieving improved productivity.

Finite nature of fossil-based raw materials

Fossil-based raw materials are of a finite nature. This also applies if, for instance, based on the use of innovative techniques, e.g. so-called "fracking", it proves possible to tap deposits of petroleum, natural gas, oil sand and oil shale that were not available previously. At the same time, due to the population growth and the economic development, especially in emerging countries, a continuous increase in demand is to be reckoned with.

To a large degree, Germany is dependent on imports of fossil-based resources. Alongside the sectors supplying energy, fuel and heating, this primarily applies to the chemical industry, which in many areas is reliant on raw-material sources containing carbon. For instance, important basic chemicals used for plastics, paints, cosmetics and fertilisers are produced from petroleum. By far, resources replenished by regrowth are the most important renewable source of carbon with regard to material-industrial use.

14 FAO 2011: Global Food Losses and Food Waste

15 University of Stuttgart 2012: Calculation of the quantities of food thrown away and proposals for reducing the throwaway rate with regard to food in Germany

16 Johann-Heinrich-von-Thünen-Institute 2008: Hunger – a multi-layered problem. Research Report "Global Food Security"

Protection of the climate, of biodiversity and of natural resources

It is an important challenge to minimise the burden on the air, soil, bodies of water, the climate and ecosystems, to conserve biological diversity, and also to exercise responsible management of limited resources such as soil, water and nutrients.

Germany has set itself demanding climate-protection goals. The Federal Government's energy concept (taking 1990 as the base year for comparison) provides for a 40 % lowering of greenhouse-gas emissions by 2020, and an 80 % to 95 % reduction by 2050[17]. For the period up to 2020, the aim is to raise renewable energies' share of total energy consumption[18] to 18 %, and to raise their share of gross energy consumption to 35 %; the aim is also to raise their share, by the year 2050, to 60 % of total energy consumption or respectively 80 % of electricity consumption. Therefore, over the medium to long term, a secure, sustainable and economically viable supply of raw materials and energy, accompanied by reductions in the environmental burden and in CO_2 emissions, demands – apart from the use of renewable energies from solar power, wind power, hydropower and geothermal sources – a broadening of the raw-materials base by the use of renewable resources and of CO_2 as a source of carbon.

Land-uses for cultivating biobased products influence the greenhouse-gas balance: raising CO_2 storage capacity, and also preserving and expanding the forests' potential for CO_2 reduction, reduce the burden on the atmosphere by significant amounts of CO_2. This also applies to replacing fossil-based fuels by means of using wood as an energy source and particularly as a material. Using biomass sourced from agriculture, for a bioenergy purpose or as a materials source, also avoids greenhouse-gas emissions. On the other hand, agricultural production and globally-advancing deforestation entail the emission of large quantities of greenhouse gases. Thus there is a need to conserve the function that the soils, forests, moors, grassland and wood products have in storing carbon over the longer term or respectively in replacing fossil-based resources, and indeed to expand that function, taking into account further goals, such as food security and the conservation of biodiversity. Agriculture's greenhouse-gas emissions must be kept to a minimum. At the same time, agriculture and forestry are also adversely affected by climate change. Measures directed at adaptation to climate change are necessary not solely for reasons of securing agricultural production and the ecosystems of forests, but also in order to maintain and improve the positive effects that forests have on climate protection.

Conservation and sustainable use of biological diversity, the sparing use of soil and water, and also a just participation in use of resources: these are globally important prerequisites for the future viability of agriculture, forestry and fisheries. Within the framework of the Convention on Biological Diversity, agreed in 2010 in Nagoya, the international community of states set itself the goal of halting the loss of biodiversity by 2020. To reach this goal, the "*Strategic Plan 2011–2020*" was adopted: a comprehensive and ambitious global roadmap with specific objectives, which it is now a matter of implementing consistently. The agriculture, forestry and fisheries sectors, as beneficiaries of the numerous services that the ecosystems provide, are especially challenged in this regard. The international study "The Economics of Ecosystems and Biodiversity" (TEEB) highlighted the numerous services provided by nature – the so-called ecosystem services – and showed, using examples, that investments in the protection of nature and the conservation of biological diversity are worth it in terms of the economy as a whole[19].

17 Federal Ministry of Economics and Technology, Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety, 2010: Energy Concept for an environmentally sound, reliable and affordable energy supply.

18 According to Directive 2009/28/EC of the European Parliament and of the Council: gross final energy consumption

19 TEEB 2010: The Economics of Ecosystems & Biodiversity.

Alongside the diversity of species, the genetic diversity within species of crops and farmed animals also constitutes an important part of biological diversity. In particular, it is expressed in the diversity of animal breeds and plant varieties used, the foundation for safeguarding future options for use and possibilities for adaptation to changing framework conditions and consumer wishes. Likewise, it is the basis for breeding high-performance varieties and breeds – including for uses not yet known in the context of the bioeconomy. Thus genetic diversity within species assumes a key significance in overcoming global challenges such as food security or climate change.

Research and innovation

Research and innovations lay the groundwork for the transition from the current use of renewable resources to more diverse opportunities for use, for food, industrial processes and products, and also as a biogenic energy source. They are thus a decisive driver of the bioeconomy. For instance, through biocatalytic processes in biorefineries, biobased raw materials, residual materials and waste materials hitherto mainly used in agriculture (such as straw) can be put to material use and to use as an energy source. Bioeconomic subject areas significant for research and innovation policy include efficiency of use of resources, biological production platforms, and also the coupling of technological research with socio-economic research. This is how new technologies and markets are developed successfully. Excellent science, innovation-driving key technologies such as biotechnology, highly-qualified specialist personnel, and innovative companies, can also crucially strengthen the performance capability of biomass production and also the sustainability of farming and production.

The Federal Government's "*High-Tech Strategy 2020 for Germany. Ideas. Innovation. Growth*" and the "*National Research Strategy – BioEconomy 2030*", issued in 2010 with the Federal Ministry of Education and Research in the leading role, sets clear research-policy points of emphasis in the sections on the following areas of action: "*Securing global nutrition*", "*Ensuring sustainable agricultural production*", "*Producing healthy and safe foods*", "*Using renewable raw materials for industry*" and "*Developing biomass-based energy carriers*", as well as the cross-sectoral activities "*Interdisciplinary cooperations*", "International collaborations", "*Technology transfer*" and "*Dialogue with society*". These are already being implemented by means of funding measures conducive to innovation, using suitable and in some instances also new instruments of funding support; alternatively, they are in the planning stage. Their aim is to expand strengths in science and business and to compensate both for weaknesses and also obstacles to innovation, by targeted research funding, and also to mobilise and give support to richness of ideas and the power of innovation in those areas of science and business that are relevant in terms of the bioeconomy. Networks are formed among the different research disciplines relevant to the bioeconomy – which, aside from the natural-science and engineering-science competences, also encompass economic-science and social-science competences. These networks can overcome obstacles specific to given disciplines and create new insights and knowledge, as well as creating integrated, systemic and innovative paths to solutions. The solutions keep sight of the whole range of value chains and process chains, capitalising on the bioeconomy's opportunities and areas of potential in the optimum way. In order to form efficient and successful synergies, what is needed – at national and at international level – is to dovetail pure and applied research even more closely than before, across all value-adding networks, in addition to creating higher-level research structures, e.g. by forming clusters and strategic alliances.

Growth markets, innovative technologies and products

4. Growth markets, innovative technologies and products

The bioeconomy offers a diverse range of possibilities for establishing sustainable products that are viable for the future, and for further developing specific branches of business. Alongside production in the agriculture, forestry and fisheries sectors, these are primarily the sectors engaged in the further processing of biomass by industrial means, using the latest findings in modern leading-edge technologies.

The biobased economy can build on important strengths in Germany. Primarily, these strengths are attributable to the following: the highly developed technological standard, good infrastructure, a high level of investment in research and development, and also a high-performance agriculture and forestry sector as a supplier of raw materials. Because of the German economy's extensive links and networks internationally, these strengths can be used effectively. Germany's weaknesses in this context are its limited additional potential in terms of area for agricultural and forestry development, and the high land prices associated with this. In addition, there is still scope for expansion of the processes, within and across disciplines, for providing holistic, systemic solutions.

There are areas of potential and growth opportunities for employment and value-added in the bioeconomy, both in industrial biotechnology and in renewable raw materials for material use and use as an energy source, as well as in the classic sectors of food and feed production.

Germany's strengths in the bioeconomy sector

Long-standing and solidly established base for technology and engineering, innovative strength of industry

Qualitatively high-calibre research and also innovative and globally competitive leading-edge technologies in the area of material use of renewable resources and their use as an energy source

Economy strongly positioned in international terms

Good production conditions with regard to soil, water and climate, with a high level of yield and overall performance in agriculture and forestry

Central location in Europe with large sales markets close at hand and with strong infrastructure

High quality and safety standards in production and in the finished products

High standards of protection of the environment, nature, and animals, and also of safety at the workplace

Favourable conditions for investment, by means of good infrastructure and a high degree of legal security (among other factors)

Good level of vocational training in relevant professional sectors of the bioeconomy

4.1 Industrial biotechnology

The Federal Government's "*High Tech Strategy 2020 for Germany. Ideas. Innovations. Growth*" (2010) explicitly counts biotechnology among the key technologies that are decisive for the viability of the German economy in tackling the future's challenges. Innovation-driving key technologies act as an engine for international competitiveness.

Industrial biotechnology sends out important stimulus advancing the structural transition to an economy based on renewable resources. The use of biobased raw materials and the application of modern biotechnological processes are gaining greater significance for the chemical industry. Industrial biotechnology thus creates the basis for new products and innovative processes for producing biofuels and biobased products, especially for the chemical, food, feed, paper and textile sectors. For instance, in 2007/2008 the chemical industry met no less than 13 % of its raw-material needs by using renewable raw materials: this figure equates to 2.7 m. tonnes, with an import-dependence level of 60 to 70 %[20,21].

Biotechnological processes link up the knowledge gained about biological systems with advances in molecular biology and new technical components. They can, also as partial steps within complex systems, be more efficient in energy and raw-material terms, and thus more sparing on the environment and more cost-advantageous than previously-established procedures. Accordingly, many micro-organisms bring about complex, high-yield conversions of materials at room temperature and at normal pressure, for which chemical processes require high temperatures and pressures, as well as (frequently) solvents harmful to the environment and heavy-metal catalysts.

Biotechnologically-manufactured products not only substitute petroleum-based products; they can also be commercially superior to the corresponding products from classical chemical processes, particularly due to the advantages in terms of their reaction behaviour, as well as through energy savings and reduced waste and emissions. They often constitute genuine product innovations with a highly-specific customer benefit, such as biologically-degradable plastics, and make it possible to attain significant improvements in the efficiency of manufacture. The economic and environmental advantages serve as the prerequisite for chemical processes now being replaced step-by-step by biotechnological ones. For example, this is particularly true for the chemical industry if it uses biotechnological processes and products as intermediate steps and building-blocks in the overall sequence of production activities. The future potential is very great because the diversity of nature is only in the first stages of being deciphered, in terms both of its capabilities and of the great quantity of different metabolites that the various biological systems have. Sustained research and development is required to tap the opportunities that this offers.

According to an OECD study, industrial biotechnology can point to clear growth, alongside CO_2 savings, and offers the prospect of great market potential and value-added potential[22]. In future, the chemical industry's mix of raw materials will change, and biobased raw materials will be used to a greater degree, especially in producing special chemicals and bioplastics. A study by the German National Academy of Science and Engineering estimates "*... that in 2030 biomaterials and bioenergy will account for one third of total industrial production*"[23]. Moreover, biobased raw materials' share of the value-added is much higher still. Accordingly, modern industrial biotechnology offers enormous potential for the future and can tap new markets through sustainable production processes and environmental advantages, thereby strengthening companies' competitiveness.

20 The Association of German Engineers 2013 (VCI), 2013: Data and facts – raw materials basis of the chemical industry.

21 Chemie: The sustainability initiative of the German chemical industry (2013).

22 OECD (2009): The Bioeconomy to 2030. Organisation for Economic Cooperation and Development; Industrial biotechnology's contribution to the economic transition in Germany.

23 Acatech Position: German National Academy of Science and Engineering 2012: "Acatech Position Paper: Perspectives on Biotechnology Communication"

Here are some examples for the application of biotechnological processes with growth potential:

- The economically dominant biobased products of industrial biotechnology, with the greatest long-term growth rates, include biotechnologically-manufactured fine and special chemicals, in addition to antibiotics for the pharmaceutical industry, with an estimated market value of € 20 bn.[24]. Increasingly, the following are manufactured biotechnologically: basic chemicals such as citric acid, and also fine chemicals such as amino acids, vitamins and organic acids for the food industry, including luxury foods, as well as for animal feed.

- An area of application with highly-dynamic growth and scope for expansion, one in which the chemical industry is increasingly adopting biotechnology, is that of biobased plastics and composite materials: these can tap new application opportunities and thus new markets. Such biobased polymers are used by the automotive and construction sectors, as well as the furniture and electrical industries, but also by producers of household items and sports equipment. The market for starting materials of biobased plastics – such as polylactic acid, as well as for platform chemicals or bulk chemicals, such as lactic acid and succinic acid, and other synthetic building blocks for polymer chemistry from biogenic raw materials is recording a clear growth trend[25].

- The biotechnological production of enzymes and micro-organisms – e.g. for washing powders and cleaning agents, and also for applications in the food, drink, textile and paper industries – is an important industrial sector in Germany. With a 70 % share of global enzyme production, this sector is also an economically significant area of industry in Europe, one that continues to grow.

- It may be that an area of future growth potential in the biotechnological use of plant biomass is to be found in the latter's biosynthetic capability. For example, this can be used to enrich plants with vitamins, minerals, and prebiotics. Through use of justifiable areas of innovation potential, the bringing forward of parts of the further processing or refinement respectively, and also the production of new tailor-made ingredients, by means of modern methods for breeding plants, can enhance yet further the high value-adding potential that plant biomass offers even without it.

- Industrially-manufactured essential amino acids can close a gap in animal nutrition. Natural feed, such as wheat, maize or soya, is always deficient in one or in several amino acids. While soya (for instance) almost completely covers the need for lysin and threonine, it provides only around 50 % of the required methionine quantity. Shortages like these can be balanced out by a precisely-dosed use of the amino acids needed. Use of biotechnologically-produced amino acids also benefit the environment, because it improves feed and simultaneously the animals release fewer nitrogen compounds. If amino acids are fed exclusively via proteins from traditional soya meal or fishmeal, farmed animals gain more meat — but simultaneously they discharge larger quantities of nitrogen. This raises the risk of pollution of the air and groundwater.

- The manufacture of pharmaceuticals traditionally entails heavy consumption of raw materials, solvents and energy, also producing large quantities of waste. Through the development of new procedures of synthesis and purification, by means of industrial biotechnology, pharmaceuticals such as profens, anti-rheumatic drugs and analgesics can be produced in a more efficient way that spares resources. Here the biotechnological path of synthesis can result in an increased yield, reduced raw-materials use, less waste and enhanced effectiveness, with reduced potential for side effects.

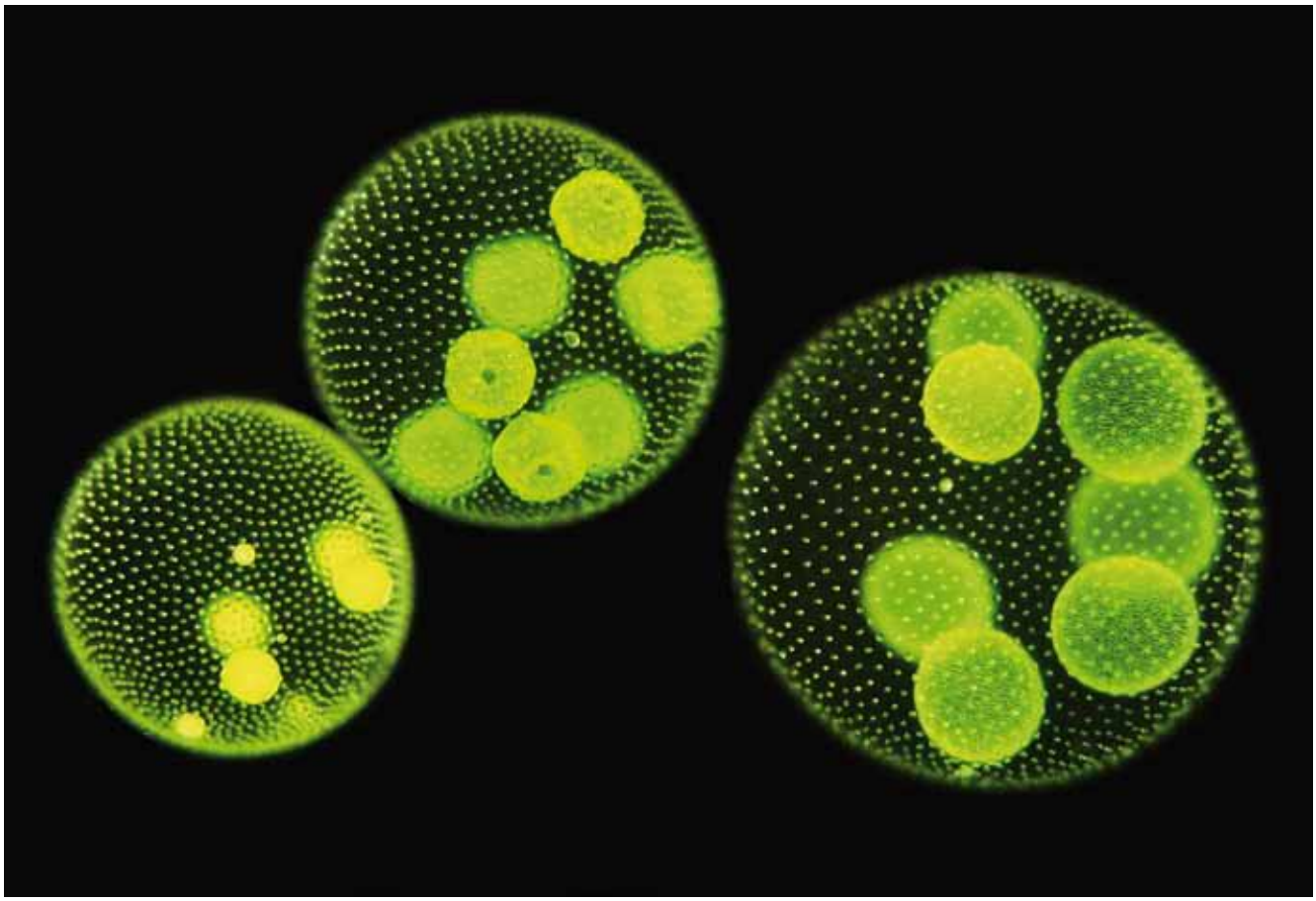
- The methods of *marine biotechnology* make living marine organisms usable for human beings. Marine organisms and parts of them, or products obtained from them, are used (among other applications) in manufacturing goods and providing services in the food, pharmaceutical, cosmetics,

24 Federal Ministry of Education and Research, 2007: White Biotechnology

25 European Bioplastics/University of Applied Sciences and Arts in Hanover, www.european-bioplastics.org

aquaculture, energy and chemical sectors. The development potential of *marine biotechnology*, one of five decisive areas of action in the European Commission's "Blue Growth" strategy, is estimated to be high[26].

Algae biotechnology as part of *marine biotechnology* has the potential to gain increasing significance, due to the numerous advantages that algae offer compared to terrestrial biobased raw material, particularly their ingredients, their rapid growth and what, in terms of plants, is a high degree of energy effectiveness. Algae have the capability to fix CO_2 and use nutrients from waste water. Subject to a sufficient supply of light or energy respectively, these properties offer the opportunity to produce algae for a variety of purposes. In this context, these phototrophic organisms form a rich range of valuable ingredients, enabling them to be put to material use or used as an energy source in the feed and food industries, the pharmaceutical and cosmetics sectors, and also in the production of biobased chemicals and biofuels. The prerequisites for this are that technical requirements that hitherto have set limits to sustainable efficient cultivation can be fulfilled and that the application is commercially viable. More research activities are also needed in order to make it economically attractive to use algae as a biofuel.



26 Master Plan – Biotechnology, Schleswig-Holstein, 2012

Biorefineries

Rich potential is attributed to biorefineries, for sustainably and efficiently using biomass as a raw material by means of an integrative and multifunctional approach. Biomass is converted into a whole spectrum of intermediate products, preproducts and final products, using various technologies in a production facility – while making as complete a use as possible of all the building blocks that constitute biomass. Because the sourcing of energy lends itself to being coupled with the material use of biomass, efficiency is boosted even further.

In 2012, a "*Biorefineries Roadmap*" was drawn up by the Federal Ministry of Food and Agriculture and the Federal Ministry of Education and Research, working in conjunction with the Federal Ministry of Economics and Technology and the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety, and also with business circles involved as well as the scientific community. Among other things, the need for action that this work ascertained affects the improvement of separation of components and the disintegration of biomass, as well as the optimisation of the processes needed for this. It is also essential to develop new and optimised conversion processes for agricultural, forestry-based and marine raw materials, and also for biogenic residual and waste materials, and yet also to formulate sustainability systems that are viable in practice, as well as to develop systems for assessment in environmental and economic terms[27].

The analysis of the potential that biorefinery concepts offer, produced in the "*Biorefineries Roadmap*", confirms the great opportunities inherent in climate protection and resource efficiency: this is because what can be expected is, firstly, alternatives that spare the environment, replacing products and energy sources currently still petroleum-based and, secondly, new kinds of products that form parts of new value chains and networks. A targeted use of the opportunities also demands early monitoring of environmental and socio-economic effects, throughout all stages of development, in order to make it possible to rapidly detect and rectify any erroneous developments, while doing justice to the requirements of sustainability.

27 Federal Ministry of Education and Research, Federal Ministry of Food and Agriculture, 2012: Biorefineries Roadmap

4.2 Biobased products and bioenergy

4.2.1 Use of biomass for production of materials

Biomass contains a complex mixture of substances, consisting of carbohydrates, fats, oils and proteins, from which chemicals can be produced by means of biotechnological processes. It offers the chemical industry what is at present its only regenerative source of carbon.

For the most part, in relation to the biomass used, material use of renewable raw materials generates a higher value-added and more employment than their use as an energy source does. Their use for materials attains a greater depth of processing and opens up the possibility of coupled use and cascading use. Related to an identical quantity of raw material or area, the employment effect resulting from material use of biomass is five to ten times as great as that for its use as an energy source; in value-added terms, the effect is four to nine times as great. It is estimated that in Germany, 60,000 to 100,000 jobs directly and indirectly result from the material use of renewable raw materials[28].

Internationally, Germany ranks among the front-runners in the material use of renewable raw materials. Yet the use of renewable raw materials for producing plastics, fibres, washing powder, cosmetics, paints and varnishes, colours for printing, adhesives, building materials, hydraulic oils and lubricants, right through to pharmaceuticals, proceeds to a large extent without state funding-support. What is primarily crucial to the use of these raw materials is economic advantages, but technological assets and the possible reduced burden on the environment are also factors.

Beyond this, the classic use of wood continues to offer growing market opportunities for the domestic forestry, wood and paper sectors. Germany's sawmill, wooden materials, paper and pulp industries rank among Europe's market leaders. The sustainable supply of wood is the basis and the engine that drives the success of the wood and forestry cluster. Around two thirds of the annual production of sawnwood is used in the building sector. Other important users of wood are the paper, cardboard, and wooden packaging materials sectors, and also furniture. The value-added in the forestry and wood cluster is at present predominantly based on coniferous wood, for which experts expect demand to rise. The next National Forest Inventory's assessment will reveal the extent to which this demand can be satisfied over the medium to long term, in view of coniferous wood's declining share in the composition of forests. As regards deciduous wood, it is mostly for technical reasons that the potential that it offers has not yet been used. The further development of "*laminated-veneer lumber*" (LVL), additional glue approvals and new authorisations for design solutions based on deciduous wood can provide approaches for competitive products or respectively for their development.

There is particular sales potential (among other areas) in the refurbishment of buildings to optimise energy use, in the targeted use of long-life wood products with corresponding CO_2 storage, and also in the area of "*Sustainable Building*"[29], making avail of wooden construction products with sustainability certificates and environmental product declarations (EPD[30]). Wood-based construction also has potential in the increase of urban areas' density, e.g. by closing gaps between construction developments and by making additions in the already existing stock of buildings. Innovative lightweight construction elements, in particular, characterised by significant weight reductions without sacrificing stability or suitability for technical processing, provide the potential for leaps of innovation in furniture-making from wood. More-developed wood-based composite materials such as "*wood-polymer composites*" or modified wood, such as thermo-wood or acetylated wood respectively, are by now attaining relevant market shares.

28 FNR (central coordinating institution for research, development and demonstration projects in the area of renewable resources): "Renewable raw materials in industry" (data do not include the wood industry).

29 BMVBS: http://www.nachhaltigesbauen.de

30 Environmental Product Declaration

Another segment with a long tradition is the production and use of **medicinal plants**; in Germany, 75 % of their use is for pharmaceuticals. Apart from this, their use in cosmetics and food supplements, as well as for spices, is gaining in significance. By far the greatest share of raw materials is imported, because many medicinal plants are not native to Germany or have hitherto not been able to be cultivated in Germany competitively. Nevertheless the sales opportunities for domestically-grown medicinal plants are good, because pharmaceutical producers prefer sources providing monitored cultivation of the product, which can readily be proved in Germany. As regards capitalising on genetic resources, primarily from developing countries and emerging economies, there are areas of potential for new products and new partnerships between industry and providers of these resources. Incentives are given for sustainable use by means of the just balancing-out of advantages that emerge from the use of these resources. This contributes to the conservation of biological diversity in situ.

In Germany and the EU as a whole, a sustainability certificate is required for biofuels in solid or liquid form, so that funding support can be applied for and obtained; conversely, there is no such certificate for the material use of biomass. Existing systems are based on the voluntary principle and participation in them is used by the companies in the context of their respective sustainability strategies.

4.2.2 Use of biomass for energy

Bioenergy is obtained from biogas as a raw material: energy crops, wood or residual materials, in particular straw, biowaste, slurry, or residual materials from biorefineries and from cascading use. In 2012, with a share of almost 65.5 % of total renewable energy consumption, bioenergy supplied by far the largest share of renewable energy in Germany; this is also because it can be used for producing both electricity and heating and also fuel, while at the same time it is storable. That bioenergy is storable is a major advantage compared to fluctuating renewable energy sources such as wind power and solar power.

The study "*Milestones 2030*", by the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety, is currently ascertaining the development potential for production of electricity, heating and fuels sourced from biomass. Taking as the basis the requirements for sustainable use of biomass, this project is identifying the technical and organisational milestones that need to be created by 2030, in order to prepare a long-term strategy for bioenergy-use up to 2050. The objective is to analyse and assess the paths leading to the provision of bioenergy, in the process of advancing towards the expansion targets, i.e. underpinning the desired energy contribution with flows of materials and technologies, and also deducing environmental, economic and regional interactions and effects associated with this. Through the many networking processes involved in the project, it is possible to put onto an ongoing basis the discussion process regarding a sustainable use of biomass, with a view to the energy strategy and the adaptation of the expansion goals for renewable energies. The use of bioenergy, with the exception of wood in parts of the market for heating, is at present strongly influenced by the structure of specific funding measures.

In the **mobility business**, where regrowing resources are by far the most important source for the use of renewable energies, biofuels would not be economically viable without public funding-support, e.g. through biofuel quotas or tax incentives, because they cannot at present compete with fossil-based fuel sources.

The current situation in biofuels is characterised by a reassessment in Germany and elsewhere in Europe and also, related to this, by an adjustment of the future paths of use and framework conditions. At the same time, new customers emerge on the market for biofuels, particularly those lacking a fuel alternative to diesel or kerosene, such as the aviation sector. The prospects for biofuel use are discussed and presented in the "*Federal Government's Mobility and Fuel Strategy*".

Biofuels can contribute to the reduction of greenhouse-gas emissions in transport. It is primarily the development of demand and the greenhouse-gas reduction that determine the branch of the transport sector in which biofuels play a given role, bearing in mind other options such as the raising of energy efficiency and also renewable alternatives.

In **electricity**, biomass accounts for 6.8 % of gross electricity consumption, and is currently the second-most-important renewable energy source behind wind power. Electricity production that is reliable and can be called off according to demand, obtained from solid, liquid or gaseous biomass, is able to balance-out the fluctuating energy sources, such as wind and photovoltaics (at 7.7 % and 4.7 % of gross electricity consumption respectively) and also to service peaks in demand. This will continue to be an essential role that bioenergy plays. In 2012, biogenic solid fuels in combined heat-and-power plants supplied 9.2 % of the quantity of regenerative electricity, primarily using wood for this purpose.

The largest renewable-energy contribution to the **heating supply** is made by biomass, at 91 %[31]. This includes solid and liquid biogenic fuels, biogas, sewage treatment gas, landfill gas and the biogenic share of waste. In turn, solid biogenic fuels, such as wood, make up the largest share by far (74.5 % in 2012). In the heating sector, solid bioenergy sources, such as pellets or firewood, already act as an economically viable alternative to fossil-based energy sources for heating. How heating production from biomass will develop is primarily dependent on the following factors: the future availability of wood from sustainable forestry resources and other solid fuels, the advances towards energy efficiency in the buildings sector, and the expansion of combined heat-and-power facilities, as well as the efficiency and the degree of effectiveness of the technology used.

In the context of numerous research and development projects, concepts and technologies are developed, aiming at **innovative use of bioenergy**, and also highly-promising products are examined in pursuit

31 Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety, 2013, "Renewable Energies 2012", first estimate, February 2013.

of sustainable bioenergy. There are several approaches under development, targeting increased efficiency in existing technology processes and also reductions of greenhouse-gas emissions, particularly through the use of raw materials that do not trigger off any changes to the use of land. Among the particularly interesting energy-based paths of use are the following: the conversion of ingredients of algae; the production of biofuels and biofuel components based on thermochemical and biotechnological routes of synthesis; and also the feeding-in of biogas or the direct use of biomethane as a transport fuel.

In this form, biomethane sourced from algae can be made available at fuel service stations, via the existing network for natural gas, in so far as the statutory quality requirements are met. Biomethane directly fed into the natural-gas network can also be used for electricity supply matched to needs in combined heat-and-power plants, where the demand is.

The Federal Government has brought numerous initiatives into being to foster highly-promising technologies, such as a variety of biorefinery concepts and products. Which forms of use and energy systems establish themselves in the market on a lasting basis, ultimately depends on the efficiency of the entire value chain, the market development, and consumer behaviour, as well as on the regulatory framework laid down in law.

Through the marketing of high-value ingredients, the production of algae-based fuel and of synthetic biofuels could become economically attractive over the long term. At present, production is not yet possible on an economically viable basis, even within the framework of the existing funding-support and with laws governing quotas; the environmental consequences also need a definitive clarification. With regard to efficiency of land-area use and avoidance of greenhouse gases, in future biomethane (in particular) and also biofuels sourced from waste materials and residual materials could play a greater role. The development of biofuels from lignocellulose is also seen as having potential. Another option is provided by the development of synthetic biofuels by means of thermochemical conversion procedures. These innovative fuels enable a broad spectrum of biogenic raw materials and residual materials to be used. In principle, it is conceivable to use these fuels in vehicles from private cars, trucks and ships' engines, through to aircraft engines. If efforts to convert this potential into practical solutions are successful, innovative fuels could contribute to the future supply of energy in the mobility sector.

Via combined heat-and-power processes, electricity that is fed into the grid can be produced using wood in biomass-based CHP facilities. Wooden pellets made from wood shavings are more homogeneous and carry a greater energy load than traditional firewood or wood chips. Modern technology enables the pellets supplied by truck from the storage unit to be transported automatically into the furnace. Because of the growing use of wood in small combustion plants, the total emitted freight has increased continuously in recent years. As a precaution against environmental damage and to protect the public against harm to their health caused by fine dust, challenging threshold values for emissions were established for small combustion plants, in the amendment to the 1st Federal Immission Protection Ordinance (Novelle der 1. Bundesimmissionsschutzverordnung) that came into force on 1 March 2010. Filter technologies and improvements to boiler technology contribute to achieving compliance with the requirements of immission protection in terms of heat production. In addition, thermochemical routes of conversion, such as pyrolysis or gasification, provide innovative alternatives to combustion.

There is continuing research into plants as an energy source, and the search is in progress for optimisation possibilities in the chain of conversion. Alongside the further development of conventional crops, new plants and alternative systems of farming are in the focus of attention. It is desirable to increase or respectively to maintain biodiversity, and because with regard to energy crops the entire biomass is of interest, it is not imperative that they grow in a single-variety or single-species environment. Thus, apart from the established energy crops such as maize, rape or cereals, highly-promising alternatives for sourcing energy include Sorghum sudanense, millet and Silphium perfoliatum. Over the medium-term, mixtures of wild plants could be added to this, when the challenge is to obtain sufficient yield and adhere to environmental requirements.

4.3 Food and feed

There are also areas of potential and growth opportunities to be had in the classic sectors of food and feed production. The German agriculture and food sector produces a great diversity of foods which hold their own in international competition, primarily due to high-calibre ingredients, the convincing quality of the processing, and the use of modern technology. This can be used as the basis for tapping new areas of sales potential. This is particularly true for the export of highly-refined food and feed with a high level of value-added, produced in conformity with the requirements of sustainable agricultural production. In the context of the positive economic development, particularly in emerging economies, robust economic demand is emerging for more highly-refined products.

New market opportunities are offered by increased farming of protein crops for human nutrition and as animal feed, for which research and development projects play a supporting role.

Market potential in horticulture, including fruit farming, is provided by (among other things) the use of chemical-synthetic aromas, flavourings and ingredients, through appropriate substances sourced from natural raw materials (fruit and vegetables), but also the increasing market significance of functional plants (field copses, perennial herbaceous plants, and grasses) in urban areas.

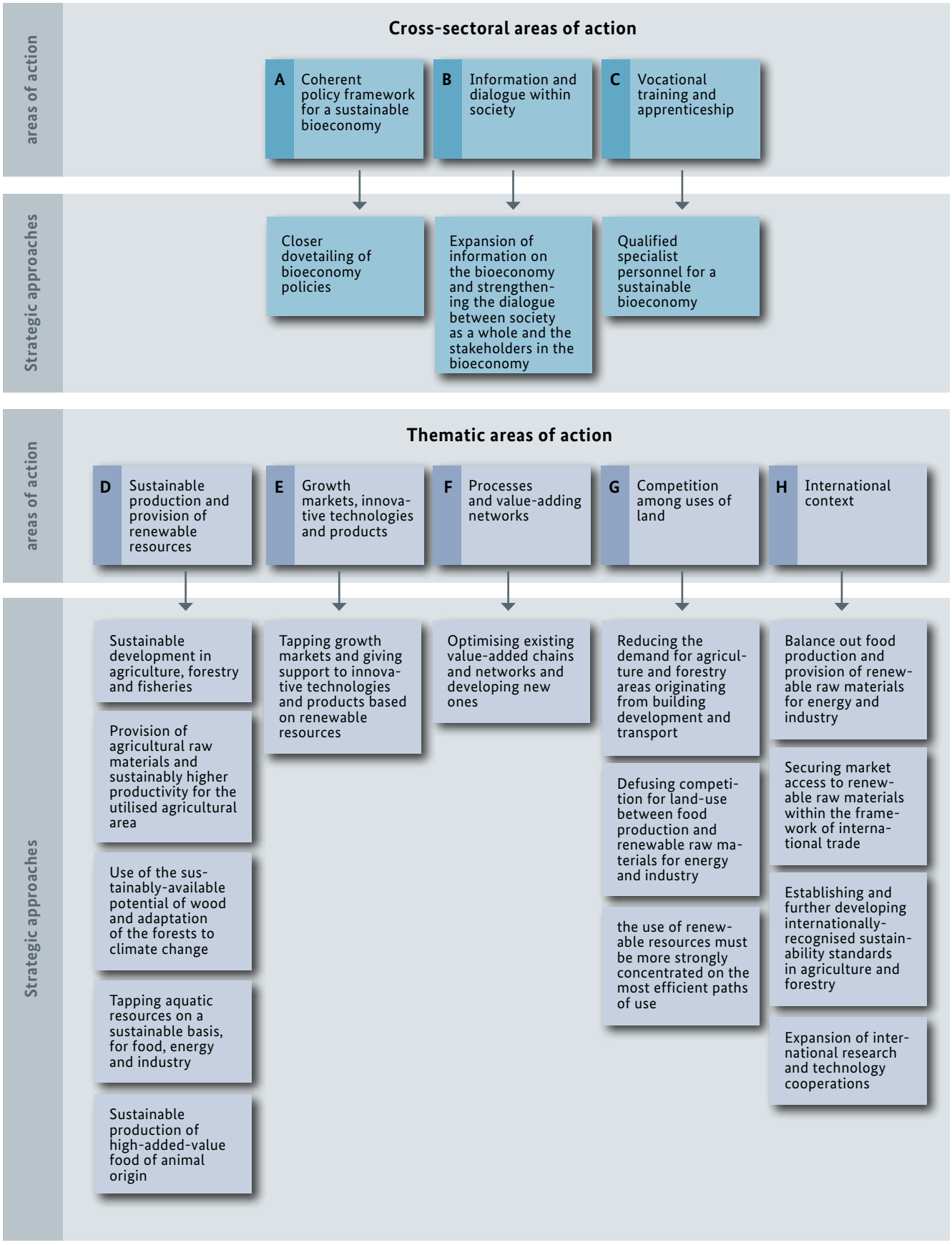
Farming high-calibre food in urban areas – so-called "*urban/vertical farming*" – will gain in significance due to the growing demand for food produced locally and regionally. Indeed, this form of farming can tap additional areas or resources for the bioeconomy. For example, residual materials and waste materials generated locally and usable for energy needs can be used in "*urban/vertical farming*", as can waste heat. If the energy-efficiency and recycling-related technological challenges are overcome that in some respects still exist today, this new form of farming offers the potential to contribute to food security, not least because of the possibility of producing all year round, independently of the weather.

Fish and other aquatic organisms are bred with the aid of highly-sophisticated aquaculture technology in complex facilities, which include heated water tanks and reuse the cleaned water. By using the waste heat from biogas facilities, aquaculture recycling units are becoming increasingly economically attractive; this means that in the future, less expensive fish (such as tilapia) can be produced on a larger scale. There are currently facilities in the experimental stage which bring together plant cultivation, hydroculture and aquaculture. These systems, referred to as "*aquaponics*", can reuse nutrients, metabolites, CO_2 and water, in largely self-contained units, reaching a high level of combined production of fish and plants (e.g. tilapia, tomatoes). German research institutions play a leading role in the development of "*aquaponics*", which could reach significance, in Germany as elsewhere, in the context of "*urban/vertical farming*" systems.

There are currently 39 recycling units in Germany, producing around 1,700 t of fish annually, and recording annual growth rates of more than 10 %. High-priced fish are cultivated, such as eel, catfish, sturgeon and caviar, as well as pet fish and fish for stocking.

Areas of action, strategic approaches and measures

5. Areas of action, strategic approaches and measures



The plan is for the goals of the *Policy Strategy – Bioeconomy* to be implemented through strategic approaches and, as far as possible, operational measures. The measures are financed via an adjustment of priorities within the budgetary resources available, taking into account the budget-consolidation requirements in the context of the national budget. The strategic approaches are allocated to three superordinate cross-sectoral areas of action, as well as to five thematic areas of action. One area of action can include several strategic approaches.

The current and future measures are arranged in such a way as to support the development of a sustainable bioeconomy in Germany and can be examined in the context of a Progress Report.

5.1 Cross-sectoral areas of action

A *Coherent policy framework for a sustainable bioeconomy*

A1 Closer dovetailing of bioeconomy policies

Strategic approach

The bioeconomy has an impact on a wide spectrum of existing or newly emerging policies at global, European or national level. Thus there is the danger of a fragmented policy environment with incoherent framework conditions and possible conflicts between goals.

- Solutions need to be found to the conflicts of goals between globally rising demand for biomass and the goals set in other policy areas, having a limiting effect on supply.
- Efforts to foster bioenergy and other non-food products must always bear in mind those products' competitive situation relative to food production.
- The fostering of research and the policies supporting knowledge-transfer should go hand in hand with the conversion of research results into processes and use in industrial facilities.

A close communication between politics, business, science and civil society, as well as the preparation of policy decisions based on interdisciplinary estimates of the consequences of policies, contribute to ensuring that various areas of policy are dovetailed and also to minimising or eliminating conflicts of goals at an early stage.

Measures

- ***Establishing an "Inter-Ministerial Working Group on the Bioeconomy"***: An *"Inter-Ministerial Working Group on the Bioeconomy"* is being established with the aim of supporting the exchange of information and the policy coordination between the various ministries of the Federal Government with regard to the bioeconomy and also to further develop the bioeconomy strategy. The Working Group is to draw up a Progress Report to this end and examine further questions, such as the monitoring and implementation of an impact assessment, taking into account the aspects for the overall economy. The Working Group is to conduct an open dialogue with the Federal Government's Bioeconomy Council, give support to the exchange of views with parliament and act as a link with the various *Laender* (Federal States). It is to be integrated into the coordination of public-relations work relating to the bioeconomy.

- ***Closer dovetailing of the Federal Government's advisory committees:*** The Federal Government's advisory committees are to more closely dovetail their work in formulating opinions on matters that also affect the bioeconomy. An important advisory committee of the Federal Government is the Bioeconomy Council. Its interdisciplinary composition means that it creates an important foundation for the further development and establishment of a bioeconomy in Germany, based on well-founded recommendations with regard to political, scientific, economic and environmental framework conditions. Beyond this, other advisory committees also draw up recommendations on bioeconomy-related topics: these include the Federal Ministry of Food and Agriculture Scientific Advisory Boards on Agricultural Policy and on Forestry Policy respectively, in addition to the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety's German Advisory Council on the Environment. The aim is to strengthen the exchange of information and views on bioeconomy matters between the Bioeconomy Council and other Federal Government advisory committees.

- ***Supporting a coherent EU and international bioeconomy policy:*** The Federal Government gives support to the Bioeconomy Strategy of the European Commission and its implementation, by committing its efforts to a coherent structuring of the political framework conditions at European and also at international level.

B *Information and dialogue within society*

B1 Expansion of information on the bioeconomy and strengthening the dialogue between society as a whole and the stakeholders in the bioeconomy

Strategic approach

Production processes in the bioeconomy affect citizens in a whole variety of ways and as consumers they use that sector's products. Thus, when making use of the innovation potential, citizens' interests must be taken into account because the bioeconomy cannot be made into a reality without them and their demand. In overcoming the challenges facing the bioeconomy, there is a need to strive for a broad consensus within society. A knowledge-based dialogue on controversial issues or conflicts between goals is particularly significant for a business sector that relates to such a variety of policy areas and interests.

A participative dialogue with the public, initiated by stakeholders in the bioeconomy from the realms of science and business, as well as targeted information and communication, contribute to formulating requirements that society places upon the development of the bioeconomy, and also to strengthening open-mindedness with regard to biobased products and innovations. In this way, the bioeconomy's benefit for the individual and society can be made clearer and support can be given to the transfer of new scientific findings into practical use.

Measures

Information initiatives

- ***Information – bioeconomy:*** Ongoing measures by the Federal Government to promote public information on and understanding of bioeconomy issues. For instance, the initiative *"New products: made from nature"*, by the Federal Ministry of Food and Agriculture, emphasising the material use of renewable raw materials: the goal is for multipliers, the general public, and the business community to be informed about biobased business, its interconnected issues, its significance, and the opportunities that it presents.

- ***Information about sustainable consumption:*** The Federal Ministry of Food and Agriculture is strengthening its communication aimed at supporting sustainable food consumption. Alongside recommendations for healthy and varied nutrition, a central role here is taken by aspects of sustainable food production.

- ***Information project on sustainability:*** Between 2013 and 2015, the Federal Ministry of Food and Agriculture is conducting an information project on *"Sustainability in Forest Management"*. The aim is to make the general public aware of the contribution that sustainable forestry management, and wood as a renewable raw material, make to society.

- ***Better product information for customers:*** In addition to the established, first and best-known environmental symbol of merit – the "Blue Angel" – which has been setting standards for environment-friendly products and services since 1978, the Federal Government State Secretary's Committee on Sustainable Development adopted a resolution in January 2013: this makes a commitment to develop a methodology for product labelling with regard to sustainability, and to establish such product labelling. The objective in this is to enable consumers, companies and governments to have better product information. The project *"Quality check – sustainability standard"* is intended to support this aim. The project's objective is to develop an internationally-acknowledged methodology of comparison, enabling the performance capability of sustainability standards to be compared and assessed. The Federal Ministry of Labour and Social

Affairs, the Federal Ministry of Food and Agriculture, and the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety jointly form the management body running this three-year project.

- ***Initiatives against food waste:*** In the context of the *"Too good for the bin"* initiative, the Federal Ministry of Food and Agriculture is engaging in consumer information and the building of awareness, aimed at reducing waste in Germany. Likewise, as part of the national waste-avoidance programme being drawn up under the guidance of the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety, to promote implementation of the Recycling Act (Kreislaufwirtschaftsgesetz), measures are planned to reduce levels of discarded food and food waste.

Dialogue in society

- ***The Federal Government's dialogue with business, science and civil society, regarding the bioeconomy:*** In order to improve the exchange of information and the coordination of activities, an improvement is to be made to the Federal Government's dialogue regarding the bioeconomy, with business, science, and civil society, and also with the Laender (Federal States). The Federal Government conducts regular stakeholder events, in order to establish and advance the bioeconomy as a topic discussed with professional subject specialists and interested parties in society as a whole. For example, the Federal Ministry of Education and Research will conduct a stakeholder event, as part of the interim evaluation of the *"National Research Strategy – Bioeconomy 2030"*, to gather in feedback and stimulus for the process of implementing, extending and further developing the research strategy.

- ***Intensifying the dialogue to promote an innovation-friendly climate and on determining how best to deal with conflicting goals:*** The participative dialogue with society is being intensified, through the business and science communities; this is in order to create an innovation-friendly climate within society and business, one that takes the public at large as its point of orientation. The Bioeconomy Council convened by the Federal Government intends to draw up a communication strategy in this regard. The Federal Ministry of Economics and Technology is conducting a series of workshops, with an accompanying study, on open-mindedness to technology and innovation-friendliness in German society. It is also the Federal Government's intention (among other things) to engage in dialogue events to address the conflicts of goals referred to in Chapter 2.

C Vocational training and apprenticeship

C1 Qualified specialist personnel for a sustainable bioeconomy

Strategic approach

The knowledge-based bioeconomy is an area that is both highly networked and also highly specialised in individual sub-areas, one that can employ modern technology to create a whole range of innovations and jobs, by developing and dovetailing many different natural sciences and technical sciences. Thus it is a challenge to meet the demand for specialist personnel. Germany needs to further build up and expand the expertise necessary for a bioeconomy, and to counteract the shortage of well-trained specialist personnel that is to be expected because of the demographic trends; it must also be successful in the global competition for the brightest and the best; for these reasons, the Bioeconomy Council recommends the following:

"... new training programmes and funding-support measures, particularly interdisciplinary research programmes (...) which help to motivate graduates from the programmes to have self-belief in daring to cross interdisciplinary boundaries and, in doing so, to move with assurance both in the academic world and in the private business sector."[32]

Measures

- ***International Bioeconomy Network:*** At the University of Hohenheim, the Federal Ministry of Education and Research and the German Academic Exchange Service (DAAD) are fostering the internationalisation of research and teaching at institutes of higher education, with grants, summer schools and scientific congresses; this is part of the funding-support programme *"Strategic partnership and thematic networks"*, with bioeconomy as the point of emphasis in the research;the framework for this initiative is an international network for students, doctoral candidates and researchers with five partner universities from Denmark, Canada, Brazil and Mexico.[33]

- ***Cooperation models or also public-private partnership models:*** The Federal Government, the Laender, university-based and institutional research establishments are working together on cooperation models and also public-private partnership models, arranged in a variety of ways: these include the Bioeconomy Science Center at the Forschungszentrum Jülich[34] and the *"Plant-based bioeconomy"* science campus in Halle; initiatives also include the establishment of the *"Pharmaceutical Biotechnology"* course at Biberach University of Applied Sciences.

- ***Integrating bioeconomic aspects into vocational training:*** The Federal Institute for Vocational Education and Training (BIBB) is deliberating how to integrate bioeconomic aspects into vocational training. With a BIBB model-testing programme financed by the Federal Ministry of Education and Research, the aim is to systematically integrate "Vocational training for sustainable development" into initial and advanced vocational training, and consistently use it as a modernising strategy in vocational training[35].

32 Bioeconomy Council 2013: Bioeconomy Council's Key-Issues Paper – Points of Emphasis 2013–2016
33 https://www.uni-hohenheim.de/news/neues-internationales-netzwerk-universitaet-hohenheim-erhaelt-daad-foerderung-2
34 http://www.biosc.de
35 http://bbne.bibb.de/de/nh_52475.htm

5.2 Thematic areas of action

D *Sustainable production and provision of renewable resources*

D1 Sustainable development in agriculture, forestry and fisheries

Strategic approach

Natural resources form the basis for the bioeconomy. Sustainable management of agricultural and forestry areas, and also of seas and other bodies of water, acts as the basic prerequisite for providing most of the raw materials in the bioeconomy. It is only by sparing resources and thus operating resource-efficiently that the necessary increase in agricultural production can be harmonised on a lasting basis with the protection of the environment, of the climate and of nature. This demands efforts that take into account all the factors involved in the production systems, including location-specific requirements and the aspects of sustainability.

The political and statutory framework conditions are being development on an ongoing basis, aiming to achieve sustainable agriculture that is adapted to the local environment's characteristics. After 2013, as part of the further development of the Common Agriculture Policy (CAP), ecological-adaptation requirements are being introduced as a component in relation to the direct payments ("*Greening*") for agricultural enterprises. After the change, businesses applying for direct payments must comply with stipulations regarding both the proportion of land accounted for by crops and also the conservation of permanent pasture; each farm must use a minimum share of the arable areas for environmental purposes ("*ecological focus areas*"). In this context, areas used for agricultural production can also be acknowledged as ecological focus areas that have a clear benefit to the environment.

Consistent with the goal of efficient allocation of resources, the market orientation on which the CAP has embarked will be continued.

The agricultural sector must be appropriately involved in climate-protection policy and the agreed national reduction goals, making its contribution to securing natural resources and safeguarding biodiversity. To support this process, further development of the environmental measures for agriculture, jointly fostered by the EU, the Federal Government and the *Laender*, takes on major significance.

Forests are of great importance as an economic factor, a supplier of raw materials, a habitat for flora and

fauna, a store of carbon, and a place where people find recreation. Forestry now pursues the aim of securing forests' rich variety of benefits, to the economy, the environment and society as a whole, for this and future generations. This is a challenging goal and efforts to achieve it in Germany adopt the integrative approach for sustainable and multi-functional forestry. In the context of the Federal Government's Forestry Strategy 2020, approaches to solutions were drawn up which are aimed at ensuring internal coordination among the broad range of requirements that the forest must meet and also at resolving any conflicts of goals between protection and use of the forests. For this, it is necessary to mobilise the existing and sustainably usable potential in terms of raw materials. Short-rotation plantations not forming part of forests can also contribute to the supply of wood. At national and at EU level, additional restrictions imposed on forestry for nature-protection or environmental reasons must be weighed up with the achievable sustainable benefit in mind, taking into account ecological, economic, social and climate-relevant aspects.

In the fishery sector, the connection between resource efficiency and sustainability is particularly evident. The management of fish stocks, based on the principle of maximum long-term yield and on the precautionary principle, not only secures vigorous stocks of fish and the best-possible supply to consumers: at the same time it is the foundation for a sustainable and economically viable development of the fishery industry. Therefore the Common Fisheries Policy's (CFP) measures particularly serve the purpose of building up fish stocks again, in so far as they are still overfished at present, and of managing them sustainably.

Measures

- ***Appropriate implementation of the CAP:*** Under the Irish Presidency of the Council of the European Union, a political agreement was reached among the EU institutions, concerning reform of the Common Agricultural Policy, taking effect in 2014. The Federal Government commits itself to an appropriate, administratively viable structuring of the process of greening the direct payments. This entails ensuring that the selection from the list of possible ecological focus areas also includes those that guarantee an environmentally advantageous agricultural use. Building upon decisions relating to greening and to the structuring of the CAP's second pillar, the funding-support measures in the Joint Task for the Improvement of Agricultural Structures and Coastal Protection[36] are developed further and the funding priorities are set. In this, effectiveness and efficiency of the measures are taken into account with regard to the environment, the climate and biodiversity.

- ***Options for action to foster climate protection in the agriculture and forestry sectors:*** The Federal Ministry of Food and Agriculture gives support to the national climate-protection goals, by drawing up options for action that agriculture and forestry can take. Part of this involves identifying and assessing these actions' effects on Germany's inventory of greenhouse gases.

- ***Implementing the package of measures aimed at sustainable use of plant-protection products:*** The "*National Action Plan for Sustainable Use of Plant-Protection Products*" was adopted by the Federal Cabinet on 10 April 2013 and will be implemented over the next ten years. It includes quantitative requirements, goals, measures to take and schedules for reducing the risks of using plant-protection products. Also part of this is the fostering and further development of integrated plant protection and (taking the average from 1996-2005 as the start) the 30 % reduction by 2023 of the risks that use of plant-protection products entail for the balance of nature.

- ***Implementing the recommendations for action regarding the effectiveness of the national Fertiliser Ordinance (Düngeverordnung):*** An evaluation group led by the Johann Heinrich von Thünen Institute examined the Fertiliser Ordinance (Düngeverordnung) in terms of its effectiveness. The evaluation group submitted a final report on this, with recommendations for action which are being integrated into an amendment of the existing Fertiliser Ordinance, closely coordinated with the European Commission and the Laender. Among other things, the changes are to relate to ascer-

36 Federal Government/Länder Joint Task for the Improvement of Agricultural Structures and Coastal Protection

tainment of the demand for fertiliser, restrictions regarding soil and location, prohibition periods, the duration of storage for volatile organic fertilisers, the mode of application to the land, as well as upper limits regarding application of remnants of biogas digestate on the land.

- ***Implementing the measures in the Forest Strategy 2020:*** In order to internally coordinate the wide range of requirements regarding forests and contribute to forests' sustainable use, approaches to solutions were drawn up within the framework of the Forest Strategy 2020 which are to be implemented consistently by all relevant stakeholders. The measures are aimed at climate protection and adaptation of the forests to climate change, securing and expanding the value added, efficient use of raw materials, biodiversity and nature protection in the forest, structuring of the forest and hunting, soil protection, water management, recreation, tourism, research and education, and also public information.

- ***Network for sustainability certification:*** Since the end of 2011, the Federal Ministry of Food and Agriculture has been fostering the network "Sustainability certification of the raw-materials base for the material use (of biomass)" (INRO). In the network, companies, R&D establishments, certification offices and NGOs work together in a multi-stakeholder process. The project goal is to draw up the subject-specialist foundations according to which the industry voluntarily obliges itself to engage in sustainability certification of the raw-materials base applied to the material use of biomass.

- ***Elaborating a strategy for the future of horticulture:*** In order to strengthen horticulture, the Federal Ministry of Food and Agriculture is preparing a "Strategy for the future of horticulture". Via the Federal Ministry of Food and Agriculture innovation programme, support is given to (among other things) the development of technologies for greenhouse-based production that is sparing on resources (reduced energy needs, increased efficiency, use of robots).

- ***Research into sustainable farming of energy crops:*** With intensified research into energy crops, the Federal Government is giving support to further improvements with regard to the sustainability of production systems. In addition, funding-support is given to the introduction of new energy crops and farming systems, right through to the scientific accompaniment of the transition into practice: the aim is to develop alternatives to farming maize, the hitherto-dominant crop. The focus in the Ministry of Food, Agriculture and Consumer Protection's funding-support activities is on plant production, agricultural technology and logistical topics, and also in some instances on cultivation and phytomedicine-related topics; also examined are suitable measures aimed at evaluating new crop species, to contribute to the enhancement of agricultural biodiversity, a resource that is an important building block in the bioeconomy.

- ***Establishing a networking unit – the "German Innovation Partnership for Agriculture":*** The German Innovation Partnership for Agriculture was founded in April 2012, in implementation of the European initiative to promote innovation partnership – "*Agricultural Productivity and Sustainability*". The essential element is a networking unit at the Federal Office for Agriculture and Food (BLE). The whole process is to be run from this base, from the idea to the trying-out of innovative techniques and processes in demonstration farms. The following are partners involved, among others: the German Agricultural Society, the Rationalisation Curatorium for Agriculture (Rationalisierungs-Kuratorium für Landwirtschaft) and the bank Landwirtschaftliche Rentenbank.

D2 Provision of agricultural raw materials and sustainably higher productivity for the utilised agricultural area[37]

Strategic approach

To cover the growing demand for biomass of plant origin, while the amount of utilised agricultural area in Germany is declining, it is essential to increase the yields from harvests sustainably. To do this, apart from using modern methods of cultivation, efficiency improvements are needed, particularly regarding the use of energy, fertiliser and plant-protection products, while simultaneously reducing demands made on natural resources – namely biodiversity, land and water – and services provided by ecosystems are safeguarded. Emissions per product unit must be minimised. Alongside plant cultivation and other technical progress, the enrichment and long-term storage of carbon can be a suitable means of boosting area productivity, contributing to climate protection.

In Germany, until ten years ago, increases in hectare yield for the main crops averaged at approximately 1 to 2 % annually, due to the ongoing development of processes for working the soil, fertiliser, plant protection and agricultural technology, as well as intensive efforts regarding cultivation. There has been a distinct slowing-down trend in evidence over the last decade. The challenge is to accelerate progress again in enhancing yields through research and development, and simultaneously to raise productivity relative to the totality of production factors and taking sustainability into account. Beyond this, the objective is to diversify the species of plants used.

37 Productivity growth means an increase in output while the use of all production factors (labour, land, capital and intermediate inputs) is the same, or a reduction in the use of the production factors while attaining the same output from production. "Sustainable productivity growth means that per output unit – measured at the end of the respective value chain – less of the overall bundle of natural resources is used. In this context, social aspects and issues of animal welfare must also be taken into account." (Scientific Advisory Board on Agricultural Policy at the BMEL, Opinion "Food Security and Sustainable Productivity Growth", 2012)

Because of its soil characteristics, its water-management arrangements and climatic conditions, Germany is one of the world's most fertile agricultural regions. Conflicts between production and the environment can be reduced and productivity enhanced by breeding and farming of plant varieties adapted to their location and efficient in terms of use of nutrients and water: these offer high stable yield potential due to improved resistance and raised tolerance to abiotic and biotic stress. Progressive farming methods, maintaining and improving the foil fertility, can also contribute to this. Thus Germany can take up a top position internationally in the practical implementation of "precision farming" and production methods that spare the soil.

For the purpose of subsequent processing, biomass can be modified or respectively tailor-made as soon as it emerges, and refined in terms of ingredients. Instruments for this are the selection of suitable plants and farming methods, as well as the use of modern methods of cultivation. The collection, processing, cataloguing, conservation and provision of genetic material by means of gene banks used for breeding and research is an absolute prerequisite for using genetic diversity in order to attain advances in breeding.

Because of the expected increase in dry periods and other extreme weather conditions in the context of climate change, accompanied by the simultaneous shift in and extension of vegetation periods, irrigation and highly-effective use of water take on increasing importance. Maintaining humus contents that are adapted to their location, or respectively increasing them over the long term where they are reduced, also contributes to maintaining and improving the soil's capacity to store water. Increasingly scarce precipitation water and rising water prices will necessitate the introduction or respectively the wider dissemination of water-saving technologies, which can simultaneously reduce energy consumption.

Measures

- ***Investments in innovative research and development for the purpose of expanding the performance potential of crops:*** The performance potential of crops is to be further expanded through investments in innovative research and development. The development and application of new technologies in plant breeding (e.g. high-throughput phenotyping – "*smart breeding*") is one of the Federal Government's points of emphasis in its funding-support activity. With funding-support measures such as "*Plant biotechnology of the future*" and "*PLANT-KBBE – Transnational Plant Alliance for Novel Technologies – towards implementing the Knowledge-Based Bio-Economy in Europe*", the Federal Ministry of Education and Research and the Federal Ministry of Food and Agriculture support innovations in research into breeding. The purpose is to optimise the increase in yield and the stability of crop yields, as well as optimising the generation and selection of quality characteristics, and the sustainable farming of crops. Flanking this activity, the German plant-phenotyping network is developing high-throughput phenotyping units for scientific experiments undertaken by academia and industry. Against the background of the international wheat-research initiative, under way in the context of the G20 action plan on food-price volatility and agriculture, provision is also made for the Federal Ministry of Food and Agriculture to strengthen national breeding research, with emphasis placed on breeding of wheat hybrids. Through the evaluation of the "*Genome Analysis of the Plant Biological System*" (GABI), supported by funding, the Federal Ministry of Education and Research will draw up a future orientation for funding support and for instruments of funding in this activity area. The foundation for these activities is access to a wide base of genetic resources, secured by the Federal Ministry of Education and Research and the Federal Ministry of Food and Agriculture, through their activities aimed at safeguarding and sustainable use of genetic resources.

- ***Strengthened fostering of research and development along the value chain:*** The Federal Government is strengthening its fostering of research and development along the value chain, in collaboration with business partners, from the breeding to the farming and through to products' use. Crop rotations that maintain and improve soil fertility are to be extended to include plant species which were neglected in terms of breeding over the last decades because of limited competitiveness, but which nevertheless offer the prospect of being very beneficial. One example is the Federal Ministry of Education and Research's development initiative "*Innovative plant-breeding in the farming system*"; this examines advantages and disadvantages of plant-breeding innovations in various farming systems.

- ***Research into precision farming:*** The Federal Ministry of Food and Agriculture is strengthening research into precision farming. The goal is to develop energy-saving processes for improving the effectiveness of use of fertiliser and plant-protection products, and simultaneously to reduce environmental risks which can emerge due to the use of plant-protection products.

- ***Strengthening soil research:*** The Federal Ministry of Education and Research is planning to provide funding-support to a project on "*Soil as a sustainable resource for the bioeconomy*", in order to sustainably guarantee food security with regard to all forms of use of plant-based biomass, and also to maintain and improve the long-term economic performance capability of soils used for agriculture. To develop for various locations measures that are adapted and that function sustainably, the necessary scientific foundations need to be elaborated or respectively extended and validated.

- ***Adaptation to climate change:*** The Federal Government is fostering concepts for water-resources management – including the improvement or respectively restoration of soils' storage capacity – and for the further development and improvement of irrigation measures in regions with increasing dry periods in the vegetation time. In order to produce estimates for the future occurrence of extreme-weather situations and their effects on German agriculture and forestry, the Federal Ministry of Food and Agriculture initiated the research project "*Extreme-weather situations relevant to agriculture and possibilities for risk management systems*". In this context, adaptation measures are to be developed, both for individual farming businesses and also for public risk management and policies.

D3 Use of the sustainably-available potential of wood and adaptation of the forests to climate change

Strategic approach

The area of forest in Germany has increased by almost 10 % over the last four decades. Because the growth of wood has also exceeded use, the stocks of wood have risen continuously. Beyond this, over the last years, particularly due to the increased level of use, the build-up of stocks has slowed down, also because of the forests being relatively old. From 2002 to 2008, approx. 90 % of the additional growth was used[38]. The Federal Government's Forest Strategy 2020 recommends that the existing and sustainably available raw-materials potential is mobilised to a greater degree, due to the positive climate-protection effects of using wood. As part of this, the forest is to be maintained as a CO_2 sink. Activities referred to in the *Charter for Wood Promotion* continue to be consistently implemented. In terms of non-forest resources, the following wood can contribute to the bioeconomy's raw-materials base: wood produced in short-rotation plantations located on utilised agricultural areas; recycling wood; wood intended for landscape-maintenance uses; and wood imported from sustainable and legal forestry operations. The significance of targeted information and specialist consultation provided to the owners of forests will continue to grow.

Climate change influences both the forest as an ecosystem and also sustainable wood production. The forests need to be adapted to climate change, to continue to secure both their function for use, protection and recreation, and also the role that wood and the forest play in protecting the climate.

38 The latest figures will not be available before the 3rd National Forest Inventory completes its work

Measures

- ***Fostering projects and activities within the framework of the Federal Government's Forest Climate Fund:*** The purpose of the Forest Climate Fund's activities in fostering developments is to tap and optimise use of the potential that the forest and wood offer for CO_2 reduction, energy, and substitution, and also to give support to the German forests' adaptation to climate change.

- ***Expanding international cooperation in the context of checking suitability for cultivating non-indigenous species of trees:*** The Federal Ministry of Food and Agriculture gives its support to improved international cooperation in the area of checking non-indigenous tree species in terms of their suitability for cultivation and their effects on biodiversity. The background is the adaptation of forests to climate change and the increase in biomass yields.

- ***Giving support to the development of short-rotation plantations:*** In order to make use of additional potential for wood not sourced in forests, it is being examined whether it is appropriate to support the development of short-rotation plantations, primarily on arable areas producing threshold-level yields and on degraded land areas, e.g. areas formerly used for mining.

- ***Supporting developing countries and emerging economies in forest protection and sustainable use:*** The Federal Government supports developing countries and emerging economies in maintaining their forests, implementing sustainable use of forests and associated trade in wood products for material use and as an energy source, as well as applying credible certification that has a broad-ranging effect.

D4 Tapping aquatic resources on a sustainable basis, for food, energy and industry

Strategic approach

The target of the fisheries policy is to manage fish stocks sustainably, according to the principle of maximum long-term yield. Through replenishment plans and management plans spanning many years, as well as restrictions on catch quantities and also on resources committed to catch operations, activities are directed to attaining the maximum long-term yield from all stocks. By-catches reduce the productive fish stocks, make it harder to estimate the stock situation, damage the marine ecosystems and threaten seabirds, marine mammals and other marine organisms. Therefore by-catches need to be reduced.

Industrial biotechnology processes that use aquatic micro-organisms and algae for their diverse ingredients (as a source of raw materials) are of growing interest as a resource-efficient use of biomass.

Measures

- ***Commitment to sustainable fishing:*** At international level, the Federal Government commits its efforts to further measures aimed at sustainable fishing and at raising the reproductive capability of the fish stocks: in the context of the Common Fisheries Policy reform, it emphatically advocates measures aimed at reducing by-catches – e.g. by improving the selection capabilities of equipment used for catching or by temporary prohibitions on catch activity – and also by introducing, stage-by-stage, bans on throwback of caught material by commercial fishing operations.

- ***Fostering the expansion of sustainable aquaculture and polyculture:*** The Federal Government gives support to the expansion of sustainable aquaculture and polyculture and also to the intensified use of these activities' value-added potential; this support is provided through suitable measures in the context of the forthcoming fisheries policy reform, including the reform of the Common Organisation of the Market and the proposal for a European Maritime and Fisheries Fund. To reinforce marine aquaculture, it is necessary to strengthen research and development and to improve research coordination in the area of sustainable aquaculture and polyculture.

- ***Developing and using algae as a sustainable resource:*** The Federal Government is giving its support to the development of potential offered by algae and other aquatic resources, in measures forming part of research initiatives. Accordingly, a consortium led by the *Forschungszentrum Jülich* will examine and test the economic and environmental feasibility of biokerosene produced from micro-algae.

D5 Sustainable production of high-added-value food of animal origin

Strategic approach

A diversification of farming of animals, involving a targeted use of the genetic potential, and also keeping the animals in ways that are sustainable as well as appropriate both to the respective species and to the location, make it possible to further increase the value-added to be generated in the future by the farming of animals, and to improve the management of resources. The use of modern animal-breeding methods (e.g. genetic selection) renders it easier to take into account heredity characteristics which are also important for adaptation to changed environmental conditions. The existing genetic diversity within breeds of farmed animals is used to optimise production processes in product-refinement activity, taking animal-welfare factors into account.

Measures

- ***Optimising the conditions for keeping farmed animals:*** Development of technologies for online monitoring both of parameters that are specific to the individual animal, metabolic, immunological, and physiological, and also of environmental factors for the purpose of simultaneously managing conditions for keeping animals, whereby these conditions are appropriate to demand, to the animal, and to the environment.
- ***Breeding of high-performance, robust farmed animals with good resistance to illness:*** The development and use of new efficient breeding and reproduction technologies, accepted by consumers, are advancing the breeding of high-performance, robust farmed animals with good resistance to illness, and also the breeding of farmed animals that generate less methane.
- ***Europe-wide networking among research partners:*** In the context of ERA-Net "*ANIHWA – Animal Health and Welfare*", the Federal Government is supporting the bundling and networking of technological and scientific areas of competence among European research partners, in order to engage in strategic planning and structuring of joint research programmes to combat the most important illnesses among animals.

E *Growth markets, innovative technologies and products*

E1 Tapping growth markets and giving support to innovative technologies and products based on renewable resources

Strategic approach

The question of which products are produced in Germany and on what scale is decided through competition among business locations, according to the principle of comparative costs. It is the business community's task to use areas of potential in growth markets. The Federal Government accompanies this process through reliable framework conditions that are conducive to innovation, giving support to research and development.

Within the bioeconomy, it is particularly high-value segments with volume that still remains low which offer expansion potential for enhancing value-added. This includes more highly-refined products in the value chain, such as fine chemicals and speciality chemicals, active substances and functional ingredients for medicinal, nutritional, cosmetic and agro-chemical applications, biopolymers, bioplastics and also basic chemicals. The potential offered by highly-promising technologies, products and markets, based on renewable resources (see Section 4: Growth markets, innovative technologies and products) should be expanded, based on research and innovations. Appropriate research activities are being carried out by the Federal Government in the context of its "*National Research Strategy – Bioeconomy 2030*".

Due to increasing global demand for food, there is considerable market potential in high-value food and feed, despite the expected decline in domestic demand for food. The use of biobased raw materials, coupled with the use of biotechnical processes and the targeted improvement of industrially-used biological systems, is gaining in significance, particularly for the chemical industry.

Measures

- ***Fostering research and development on renewable raw materials:*** The Federal Government is giving support to research and development via the Federal Ministry of Food and Agriculture "*Renewable Raw Materials*" programme, and also the programme for fostering the optimisation of biomass-use as an energy source, run by the Fed-

eral Ministry of the Environment, Nature Conservation, Building and Nuclear Safety. The aim is to bring innovative products and processes to market readiness more quickly. Current areas of emphasis in the "*Renewable Raw Material*" programme to foster development with regard to use for energy are the production of second-generation fuels, efficiency improvement in biogas-production and the breeding and farming of energy crops, in order to diversify the range of energy crops (among other reasons). The programme fostering material use of renewable resources and their use as an energy source has these points of emphasis: biotechnological and chemical processes and products, including integrated material use and energy-source use in biorefineries, as well as research and development on biobased materials.

In the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety's programme for fostering the use of biomass as energy, the focus is primarily on the following: climate-policy aspects, climate-protection effects and the testing out and validation (in terms of viability in practice) of technologies and optimisations of procedures and processes that have relevance as demonstration projects / pilot projects.

The funding-support initiatives "*BioEnergy 2021 – Research for the use of biomass*" and "*BioProFi – Bioenergy – Process-Oriented Research and Innovation*", set up by the Federal Ministry of Education and Research, primarily address issues of basic research for a sustainable use of biomass as an energy source, avoiding negative influences on the ecosystem and, in particular, on biodiversity.

- ***Improving the framework conditions for venture capital directed to young and innovative companies:*** The Federal Ministry of Economics and Technology has newly set up economic-support funds – such as the "High-Tech Gründerfonds" start-up fund – or, as in the case of the ERP/ EIF umbrella fund – significantly extended them. In future, the Business Angels are being given support by the venture-capital investment bonus (for the years 2013 to 2015, funds totalling € 150 m. are being provided). In addition, the Federal Ministry of Economics and Technology, together with the EIF and the banks LfA Förderbank Bayern and the NRW.BANK, has set up a joint umbrella fund, the mezzanine umbrella fund for Germany (MDD), by means of which a total of € 200 m. of EU, Federal Government and *Laender* financial resources are being directed to the fostering of Germany's small to medium-sized business sector. Beyond this, with the Federal Ministry of Economics and Technology's "*Central Innovation Program SME*" (Small to Medium-Sized Enterprises), which is open in terms of the technology involved, it is making available a cross-sectoral fostering programme that can be beneficially applied in building up a bioeconomy.

- ***Fostering of innovative agriculture and food-sector products:*** In the framework of the "*Fostering of Innovation Programme*", the Federal Ministry of Food and Agriculture actively supports the development of innovative, internationally competitive products, processes and services that are based on newly-acquired knowledge. Among other things, the aim of the programme is to give support to sustainable agriculture production, and food production more broadly, while sparing the resources that form life's natural foundations. The programme includes giving support to research, development and demonstration projects with the aim of making innovative technical and non-technical products able to compete in the market. Also included in this are projects to enhance innovation capability, including knowledge transfer, studies of framework conditions for innovations, both in society at large and in terms of the law, as well as the identification of future areas for innovation.

- ***Fostering industrial-biotechnology innovations:*** The Federal Ministry of Education and Research is strengthening innovations in industrial biotechnology, particularly by fostering research and development alliances led by companies, and through activities directed at the conversion of research results into commercial practice. The goal is to validate new scientific knowledge and to accelerate efficient technology transfer into various markets. In drawing together individual entrepreneurial interests in pursuit of a convergent objective, under the leadership of a strategic alliance, the necessary impetus is given to activate and implement a far-reaching innovation process.

  Beyond this, in the context of the Federal Ministry of Education and Research's long-term strategy process "*Biotechnology 2020+*", the challenge is to develop visions and activities that convert into reality the "*next generation of biotechnological production processes*". The strategy process is accompanied by funding-support measures for implementing the points of emphasis identified in the research. The focus in this is on new kinds of interdisciplinary approaches to research from the engineering sciences and biosciences.

- ***Fostering of research, development and technology transfer by small to medium-sized enterprises (SMEs), as well as by scientists:*** The implementation of a broad-based effort to foster SMEs, stated in the catalogue of measures for supporting the bioeconomy, is made possible by the Federal Ministry of Education and Research in its programme "*SME-innovative: Biotechnology – Bio-opportunity*". The aim in this is to initiate help in absorbing the risks that companies face in an early R&D phase of their activities, and also to support technology transfer between science and business, as well as to strengthen cooperation between companies.

  With the Company-Formation Offensive for Biotechnology (GO-Bio), the Federal Ministry of Education and Research provides the possibility for scientists from institutes of higher education, non-university research institutions, companies and clinics to further develop research topics offering high innovation potential so as to bring them to the commercial-application stage. The primary goal of the transfer of results is for companies to be founded in the biotechnology sector, counteracting the declining number of new-company formations in the high-tech sector, as well as the scarcity of private risk capital.

- ***Expanding growth markets in the area of innovative wood products:*** Based on the *Forestry Strategy 2020* and the national *Charter for Wood Promotion* 2004 to 2014, the Federal Ministry of Food and Agriculture is formulating measures to take, such as the provision of consumer information on outstanding deciduous-wood products. Measures in the biomass action plan, aimed at expanding bioenergy, as well as areas of action in the action plan for material use of renewable raw materials, likewise contain measures aimed at expanding the growth markets in the wood sector. Likewise, the forest climate fund that is planned envisages fostering CO_2-reducing measures by increasing the carbon pool of wood products.

- ***Sustainably tapping and using microbial resources:*** The Federal Ministry of Education and Research is fostering efforts to tap the potential offered by microbial resources, through a variety of suitable funding-support measures in the context of the "*Industrial use of renewable raw materials*" area of action, forming part of the "*National Research Strategy – Bioeconomy 2030*".

- ***Support to export of biobased products and technologies:*** The range of instruments made available for export promotion by the Federal Government, particularly by the Federal Ministry of Economics and Technology, as well as the programme of foreign trade fairs and the "*Renewable energies*" export initiative, is also open for German providers of biobased products and technologies.

- ***Further development of norms, standards and life-cycle analyses:*** The Federal Government commits itself to a further development of norms, standards and life-cycle analyses on biobased products, supporting the implementation of sustainability initiatives by the business community in the area of use of biomass. A factor to bear in mind in this is the implications for small companies who are to be given support in implementing the standards and criteria. Among other things, there needs to be a development or improvement of clear, unambiguous national, European and international standards for biological degradability, biobased carbon content, usability and sustainability.

- ***Fostering the potential for value-added offered by functional green plants:*** Support is to be provided to efforts to tap into the regional potential for value-added offered by functional green plants, primarily in urban settings, while safeguarding nature and the landscape, i.e. while conserving biological diversity, protecting the balance of nature's functional and performance capability, and maintaining the recreational value provided. Approaches to be mentioned here are research and development with, for example, a screening of the plant species which are candidates and also with examinations of plant use with regard to restoration work on land areas (e.g. soil contamination, heavy metals) as well as the implementation of model projects.

- ***Urban/vertical farming concepts:*** The Federal Government is providing support to analyses of the intensified use of inner-urban areas for agricultural or horticultural production. Building upon this, viable concepts are to be developed and tested for establishing urban farming or vertical farming systems that can contribute (among other things) to enhancing the availability of renewable resources.

F *Processes and value-adding networks*

F1 Optimising existing value-added chains and networks and developing new ones

Strategic approach

Through optimisation of individual value chains and through interconnecting these chains intelligently, it is possible both to reduce resource consumption and the use of non-regenerating raw materials, to tap potential for innovation and value-added, and also to improve the economic effectiveness of production. Beyond this, opportunities exist for developing new regional value chains, also based on new raw-material sources: ideally, these evolve into value-adding networks.

Where possible and purposeful, the objective is cascading use and coupled use of biomass. The by-products emerging as renewable resources are processed must be utilised in such a way that as a complete and as high-value a use is made of them as is possible, and simultaneously waste is reduced to a minimum. In many instances, synergies exist between various paths of biomass use. For example, feed products are generated as by-products when plant oil is made, or the production of cereals generates straw which (in some instances) can be used as a material or as an energy source. There are already many instances of coupled production: in modern cereal mills and oil mills, sugar factories and biodiesel and bioethanol facilities. A further example of coupled production is the biorefinery (see Chapter 4). Biorefineries offer the prospect of a more efficient use of biomass, for sourcing materials and energy, than processes currently being operated. Thus the further development of this technology, taking sustainability requirements into account, is an important milestone on the path to the expansion of the bioeconomy.

Alongside the ongoing technological development, there needs to be an improvement in the starting conditions for establishing more biorefinery demonstration facilities, the aim in this being to effect as rapid as possible a transfer into industrial-scale operations. A basic prerequisite for this, also with a view to purposeful use of tight private and public research budgets, is a rigorous environmental and economic classification of the biorefinery concepts. To this end, gaps in knowledge and in available data need to be closed. Thus, apart from the ongoing technological development, it is essential to carry out projects that, beyond the "*Biorefineries Roadmap*", take as their subject the deepening economic and environmental assessment of biorefinery concepts, both compared to one another and also compared to other paths of use for biomass. For instance, within the framework of "*Horizon 2020*", public-private partnerships are initiated; these focus on biomass production, biorefineries and product innovations that build up value-adding networks at European level.

Many bioeconomy companies already have methods for assessing the sustainability of their production processes; this is in order to identify weak spots and

to promote their products in relation to consumers. However, these methods are often not comparable; indeed sometimes they are not even transparent. What is necessary is to apply uniform processes for calculation and assessment, which are transparent and reliable and which are elaborated jointly by politicians, science, business and civil society. The objective is to reach reliable assessments of the sustainability of production processes and products and also to enable consumers to choose in favour of a sustainable product.

Value chains, especially in the food sector, need to be optimised so as to minimise losses in the chain from production and via transport, storage, processing and marketing, through to consumption.

Measures

- ***Fostering the leading-edge cluster competition BioEconomy:*** Since 2012, in the context of the competition among leading-edge clusters, the Federal Ministry of Education and Research has been fostering the "*BioEconomy*" cluster. The purpose of coupled production and cascading use in the lignocellulose biorefinery is the maximum value-added from beech wood. This connects the industry sectors relevant for the bioeconomy – such as the chemical industry, the paper and pulp industry, agriculture and forestry, the energy sector, as well as mechanical engineering and process engineering in eastern Germany – reflecting for the first time the entire innovation and value chain, spanning a variety of industries. The plan envisages funding-support to this cluster, amounting to € 40 m. over five years.

- ***Fostering innovative procedures and products involved in cascading use and coupled use:*** Cascading use and coupled use of biomass are to be strengthened through the further development of innovative procedures and products: this is in the context both of the funding-support programme "*Renewable Raw Materials*", run by the Federal Ministry of Food and Agriculture, and also of the "*National Research Strategy – BioEconomy 2030*"; another element of this is to check existing rulings for obstacles to cascading use.

  Cascading use of waste wood and biowaste is also to be increased. Approaches to pursue this include, for instance, checking incentive systems for increasing what continues to be a low recycling rate in the context of waste wood (currently well below 20 %), and the construction of anaerobic digester units as pre-treatment facilities for composting. The cascading use of biowaste, with anaerobic digestion and subsequent composting, is already taken into account in the Renewable Energy Sources Act (EEG)[39], with special rulings on remuneration. The monitoring, within the context of the Renewable Energy Sources Act (EEG), must examine the extent to which the framework conditions, improved by the Renewable Energy Sources Act 2012 (EEG), have indeed successfully fostered the desired cascading use – firstly use as an energy source for making biogas, and then material use for producing compost.

- ***Fostering initiatives to recover phosphorus:*** The Federal Ministry of Food and Agriculture and the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety give their support, within the rulings stated in the law governing fertiliser and waste-management, to initiatives aimed at recovery of phosphorus, primarily from sewage sludge that is not directly used as fertiliser. Supplementing this, the intention is also to check further options for the recovery of nutrients from upstream operations. The plan is for this recovery activity to include other nutrients and carbon. The improvement of availability of plant-sourced phosphorus of fertiliser can also make an important contribution to saving global phosphorus resources.

- ***Fostering international scientific collaboration:*** The Federal Government is fostering international and European collaboration in science and research, within the scope of bilateral and multilateral projects with German participation, aimed at developing new value chains and networks and optimising existing ones. Examples to mention here include the bilateral cooperation projects with Brazil and Russia respectively, initiated by the Federal Ministry of Education and Research. This Ministry is fostering further international partnerships, in the context of "*Bioeconomy International*" – on a preferred basis with Argentina, Brazil, Canada, Chile, Malaysia, Russia and Vietnam – in R&D activities that serve as model projects on relevant bioeconomic topics. Alongside technological issues and development goals,

39 Renewable Energy Sources Act

The bio-factory of the future for climate protection and resource efficiency

Examples of funding support:

Biorefinery Research Centre Leuna and the leading-edge cluster "BioEconomy" – a network involving the complete use of wood

Embedded in the chemical-industry hub at Leuna in Saxony Anhalt, a modern biorefinery-research centre was opened in 2012, with cooperation partners from business and science.

At the **CBP – the Fraunhofer Center for Chemical-Biotechnological Processes**, under the scientific management of the Fraunhofer Society, the focus is on the integrated material use of plant oils, the pulping of lignocellulose made from wood, and the production of new technical enzymes; this is in order to use all parts of various plants – particularly those not used in the food chain – for the production of chemicals, fuels, electricity and heating. The Fraunhofer CBP seeks to close a gap between laboratory and industrial implementation, by testing the feasibility and economic viability of biotechnological and chemical processes for using renewable raw materials on an industrial scale. The costs, over € 50 m., are borne by the Government of the Land of Saxony Anhalt, the Federal Ministry of Education and Research, the Federal Ministry of Food and Agriculture, and the Federal Ministry of the Environment, Nature Conservation, Building and Reactor Safety.

The CBP also forms the core of the **leading-edge cluster "*Bio-Economy*"** in eastern Germany, which proved successful in the Federal Ministry of Education and Research's leading-edge cluster competition at the beginning of 2012. In this cluster, set to receive € 40 m. of funding in the period up to 2017, 60 partners from the region around Leuna group together their forces to develop technical processes for the sustainable use of biobased raw materials, and also to scale these processes up and apply them; this is in order to produce a broad portfolio of innovative, high-value products from the wood-processing sector to the chemical industry. Thus, for instance, the plan is for local beechwood to be made available more cost-competitively through an optimised dovetailing of wood processing and logistics operations. It is also planned to build up new, biobased value-adding networks by dovetailing operations that involve the chemicals, paper, pulp, automotive, construction and textile sectors. Coupled production and cascading use in the lignocellulose biorefinery are to make it possible to extract the maximum value-added from beechwood. An important aspect of this is management of electricity sourced from biomaterial, spanning across clusters, as well as the development, scaling-up and industrial implementation of production processes. Among the cluster partners are companies such as Linde, Total and Vattenfall, SMEs such as Homatherm, in addition to the Fraunhofer Center for Chemical-Biotechnological Processes (CBP) and the German Biomass Research Centre in Leipzig.

Fostering research and development on biorefineries: In addition, the Federal Government is also fostering the development of research and technology on biorefineries, (inter alia) in the framework of the "*Renewable Raw Materials*" programme set up by the Federal Ministry of Food and Agriculture, and the "*National Research Strategy – BioEconomy 2030*", principally run by the Federal Ministry of Education and Research.
Sources: National Research Strategy – BioEconomy 2030 (Federal Ministry of Education and Research, 2010); Biorefineries Roadmap (Federal Ministry of Education and Research/Federal Ministry of Food and Agriculture, 2012); White Biotechnology (Federal Ministry of Education and Research, 2012)

socioeconomic matters are also of significance in this regard.

- ***Fostering initiatives for sustainable food production and also sustainable food consumption:*** In the context of the European ERANet initiative SUSFOOD (SUStainable FOOD production and consumption), the Federal Ministry of Education and Research and the Federal Ministry of Food and Agriculture are fostering projects aimed at sustainable food production and also at a reduced environmental burden, reduced waste, food security, and high quality of food in order to enhance life quality. Further goals of this funding-support initiative are sustainable consumer behaviour, as well as improvement of the competitiveness of Europe's food industry, and also economic growth, primarily of small and medium-sized enterprises in trade and industry.

G *Competition among uses of land*

G1 Reducing the demand for agriculture and forestry areas originating from building development and transport

Strategic approach

A goal of the Federal Government's sustainability strategy is to limit the growth in area claimed by building development and transport projects, from the current 81-hectare (ha) level to 30 ha by the year 2020[40]. Depending on how quickly this increase can be slowed down, an additional total-area requirement of 200,000 to 500,000 ha for building development and transport is to be expected up to the year 2030. Taking as the basis an approx. 50 % share of this total area accounted for by utilised agricultural area, the resulting loss to be expected is at least 100,000 to 250,000 ha of farmed land.

Measures

- ***Development of a concept for reducing claims made on agricultural areas by non-agricultural use:*** The Federal Ministry of Food and Agriculture has drawn up a comprehensive concept for limiting non-agricultural claims to what is currently agricultural land. To this end, an open dialogue was conducted on the topic of "*Claims made on land areas*", with the participation of the Laender and representatives of agriculture and the food industry, the municipalities, organisations engaged in safeguarding the environment and nature, the scientific community, and investors. A catalogue of measures was submitted and the process of implementing them was begun. The platform initiated by the Federal Ministry of Food and Agriculture – "*Protection of soil as a natural resource – legal rulings and intelligent area management*" (begun in mid-2012) will accompany this process in a targeted way, grouping resources as well as managing its link-up with the current Federal Government-Laender joint working process – part of the sustainability strategy – on the issue of reducing the claims made on use of land.

- ***Introduction of standards governing the quality of compensation measures in terms of specialist expertise on nature-protection matters:*** The Federal Government views the Compensation Directive (Kompensationsverordnung) as an important instrument of implementation for the ruling that governs interventions, making them work effectively and in a uniform way nationwide. This highlights three needs: the need to secure the quality of balancing measures taken by nature-protection specialists; the need to assert effectively the agricultural-structure issues; and the need to reduce claims made on use of agricultural areas.

40 Four-year average

G2 Defusing competition for land-use between food production and renewable raw materials for energy and industry

Strategic approach

The Federal Government has set itself demanding goals in terms of the expansion of the renewable energies. It is working towards an increase in renewable energies' share of final energy consumption, from 12.6 % in 2012 to 30 % in 2030, with the target being 60 % for 2050. According to the "*National Biomass Action Plan*", the objective is to expand the use of bioenergy in heating, electricity and fuel.

Per unit of land area, food production (particularly in the case of highly-refined products) usually generates greater value-adding effects and employment effects than bioenergy production based on energy crops. In future, the various biomass raw materials can be further processed, by means of coupled use and cascading use (among other options), to generate high-value products for food and feed, or industrial- material use, as well as for sourcing bioenergy.

Likewise, with regard to use of biomass for materials, the Federal Government is aiming to further expand activities, because this promises a substantial potential for value-added and employment, for protection of the environment and the climate, as well as for saving fossil fuels. However, the background for the ambitious goals for farming renewable raw materials in Germany is low residual-materials potential and an area potential that can only be expanded to a limited degree. This intensifies the competition for scarce resources, particularly for scarce land and biomass. The following can contribute to defusing conflicts of goals, in terms of competing claims on land-use: process-efficiency enhancements achieved through microbial production; or raw-materials and residual-materials potential not yet used, involving innovative biotechnological processes in coupled use or cascading use or in biorefineries. In this area also, suitable framework conditions need to be created, taking into account conditions of competition for the various paths of use.

A coherent policy for a sustainable bioeconomy needs to find a balance between the competing claims to agricultural areas used for food production and for production of renewable raw materials. Such a policy must take into account the requirements for protecting the environment, the soil, nature and the climate. The principle that applies is that securing food supplies takes priority. The framework conditions must be arranged so that agricultural areas in Germany – taking into account competitiveness and international markets – are available for a sufficient

supply of food at appropriate prices. Beyond this, available areas can be used for supplying raw materials and energy, with bioenergy increasingly taking as its orientation point the demands of competitiveness. Ultimately it is primarily the relative prices that decide concerning use in the food, feed, energy or industry sector.

The Federal Government is endeavouring to reduce competition for areas of land and for its use. Approaches particularly suitable for this are those that improve the production and availability of renewable resources as a whole (Area of Action C), which improve the efficiency of its use, and which also aim to increase the use of residual products and by-products not usable for food (Area of Action D). Among others, the following measures supplement those stated.

Measures

- ***Reviewing the Renewable Energy Sources Act (EEG):*** As part of the monitoring for the Renewable Energy Sources Act (EEG), the funding-support is also reviewed in the area of bioenergy, in terms of its climate-protection efficiency, the CO_2 avoidance costs, and the development of competition among uses of area.

- ***Using greenhouse-gas reduction as the assessment basis when considering funding-support to biofuels:*** Funding-support in the biofuels sector takes as its assessment basis the associated reduction in greenhouse gases. Starting in 2015, the petroleum sector's current obligation to bring biofuels onto the market via energy quotas will be replaced by so-called decarbonisation. This policy stipulates that the petroleum producers reduce greenhouse-gas emissions resulting from fuel combustion by using an increasing proportion of biofuels. A 7 % greenhouse-gas reduction is envisaged for the period up to 2020. The Federal Government's energy concept (of September 2010) makes provision for these greenhouse-gas-reduction quotas to become more demanding step-by-step over the long term. A prerequisite for this is a suitable ruling to avoid indirect changes to land-use: this is currently being formulated at European level. With regard to the target that at least 10 % of the transport sector's final energy must be obtained from renewable sources by 2020, the European Commission has proposed limiting the deductibility of 1st-generation biofuels to 5 %. In this way, there would be a reduction both of funding-support to 1st-generation biofuels, which have very high CO_2 avoidance costs, and also of the risk of indirect changes to land-use.

- ***Mobility and fuel strategy:*** The prospects for a sustainable use of biofuel, one that is viable in the future, are also taken up in the Federal Government's *Mobility and Fuel Strategy*; this presents fuel options, drive technologies and infrastructure which can contribute to more efficiency and reduced CO_2 emissions.

- ***Permanent exchange of views and ideas on the transition in energy sourcing:*** The conversion of energy supply in Germany is a task facing everyone in society. Proposals, recommendations, scenarios and options for the energy transition which are developed in research need to be discussed and coordinated jointly among the scientific, business and political communities, and society as a whole. The Federal Government has various organisational bodies for this purpose.

- ***Funding-support to a pilot and demonstration project on bioenergy use of long-term grassland:*** The Federal Ministry of Food and Agriculture is giving funding-support to a pilot and demonstration project on the use of long-term grassland that is not ploughed up, to provide biomass as an energy source. Above all, this affects areas no longer needed for grassland use in the classic sense, such as extensively-farmed grassland in lower mountain ranges.

- ***Research studies to estimate the consequences of various paths of development:*** Within the framework of research assignments, estimates should be made of the consequences of various paths of development of future land-use, to ascertain how advantageous they are for the overall economy. Value chains in food production and in material use and energy-source use are to undergo a comparative assessment in terms of how much they benefit the overall economy.

G3 The use of renewable resources must be more strongly concentrated on the most efficient paths of use

Strategic approach

The material use of renewable raw materials competes not solely with food and feed production but also with the production of heating, electricity and biofuels, because in part these make use of the same biomass.

Policy-makers influence the competitiveness of paths of use through a series of funding-support measures and regulatory framework conditions. Taking into account the Federal Government's goals, the production of biofuel and biogas are particularly favoured in relation to other paths of use. To assess the merits of the various paths of use, a uniform yardstick of assessment is needed.

The various paths of use of renewable resources differ in terms of environmental, economic and social criteria. A particularly important criterion in terms of efficiency is the CO_2 avoidance costs: for farmed biomass it is the energy yield per hectare. Further criteria are the funding-support requirement and the effects in terms of value-added and employment. These aspects have been examined in numerous studies[41]. In view of the multitude of possible paths of use, there are limits to any general observations that can be made. Nevertheless the following conclusions can be drawn: among the paths of use as an energy source and in relation to the stated criteria, biomass has much merit as a source of heating (subject to compliance with valid emission norms), as does combined heat-and-power use of residual materials and by-products. Paths of use based on energy crops perform less favourably than those based on residual materials and by-products.

The indications are that the CO_2 avoidance costs of material use are not to be evaluated less favourably than those of many paths of use involving biofuel production. Funding-support for material use is essentially through funding-support to research and development. Related to the same amount of biomass, material use can frequently result in a higher degree of value-added. Against this background, and consistent with a sustainable and efficiency-oriented expansion of renewable raw materials, the strengthening of material use is evaluated as being a priority. Likewise, priority is given to use as a source of heating and to the CHP use of by-products and residual materials. Where possible and purposeful, the aim here must be a cascading and coupled use. Under certain circumstances, intelligent interlinking of value chains or process chains respectively can lead both to the defusing of possible competition between industrial-material and energy-source paths of use respectively, and also to the tapping of innovation potential.

Measures

- ***Review and adaptation of funding-support measures for bioenergy:*** Future reviews and adaptations of funding-support measures relating to bioenergy must also include the repercussions on material use (Amendment of the Renewable Energy Sources Act (EEG), the Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz), rulings on biofuel).

- ***Expanding funding-support to research into use as a source of materials:*** The Federal Government's funding-support programmes with regard to research and development are to be expanded in favour of material use.

Areas of Action C and D also describe measures aimed at boosting material use which also support this strategic goal.

41 Federal Ministry of Food and Agriculture, 2004/2007: Market Study “Renewable Raw Materials”

H *International context*

H1 Balance out food production and provision of renewable raw materials for energy and industry

Strategic approach

In view of the global growth in demand for food, and the simultaneously growing international demand for raw materials, a coherent policy for a sustainable bioeconomy must find a balance, internationally as well as nationally, between the competing claims on agricultural areas for food-security needs and for biomass used for energy and in industry. At the same time it must be borne in mind that the globally-growing demand for animal products raises the pressure on the use of agricultural areas and forests. The land requirement for one unit of a farmed animal product is usually higher than for one unit of plant-based product. In developing countries and emerging economies also, there is a need to sustainably raise productivity in agriculture and to incorporate this into an integrated development of the rural areas.

Knowledge transfer, technology transfer and the build-up of necessary capacities can boost sustainable production among *agricultural and forestry producers in developing countries and emerging economies*. Combined with appropriate planning for land use, and efficiency enhancements in the value chains, this contributes to reduced competition between uses of land, and also competition with food production; at the same time it has the potential for strengthening local rural economic areas. Consistent implementation of the Right to Adequate Food[42], to which the Federal Government is committing its efforts globally, is the focal point in this. In particular, the food situation should be improved for those affected the most by hunger and malnutrition. In this regard it is important that bioeconomic activities and investments correspond to high environmental standards and standards of social responsibility, as well as the international agreements relevant to this. In this context, particular care must be taken to abide by land-use and water-use rights and also to safeguard biodiversity and maintain the services that the ecosystem provides. The relevant framework for action with regard to conservation and sustainable use of biodiversity is the Convention on Biological Diversity (CBD) and its Protocols (the Cartagena Protocol and the Nagoya Protocol). A sector-specific solution was created for agriculture, with the International Treaty on Plant Genetic Resources for Food and Agriculture[43].

For biofuel production in developing countries, the following basic principles should be observed, so that the development-policy potential of investments in sustainable agricultural projects can be used: priority

42 "Right to Food": The Right to Food is anchored in the Universal Declaration of Human Rights and in the international treaty on economic, social and cultural rights. The United Nations' Committee on Economic, Social and Cultural Rights defines the Right to Food as follows: "The right to adequate food is realized when every man, woman and child, alone or in community with others, has physical and economic access at all times to adequate food or means for its procurement".

43 International Treaty on Plant Genetic Resources for Food and Agriculture, www.planttreaty.org

of human rights, particularly the right to food and water; a positive climate balance and also the conservation of biodiversity and of other services rendered by ecosystems; the observance of minimum standards of social responsibility; the inclusion of the local population; the respecting of land rights and water rights, including informal ones; appropriate adding of value in situ.

Measures

- ***Project to defuse competition between uses in developing countries:*** Jointly with the FAO, the Federal Ministry of Food and Agriculture will provide funding support to a project aimed at defusing competition between food-security and bioenergy uses in a developing country. The project is to provide a systematic approach regarding how bioenergy production can be structured in a way that is socially and environmentally responsible, within the framework of a sustainable land-use policy.

- ***Support to rural development and to food security:*** In the Federal Ministry for Economic Cooperation and Development's Ten-Point Programme on rural development and food security, various areas are explicitly named which form the focus of the activities in 2012–2013: anchoring of food security in development cooperation; the fight against land degradation; enabling private-sector initiatives to flourish and building up value chains in rural areas; fair and secure access to land, as well as the reduction of post-harvest losses. Around € 700 m. annually are invested in rural development, agriculture and food security. In 14 partner countries working together with German development activities, these topics are an agreed point of emphasis; in a further 15 countries, significant programmes are being implemented in this regard. Beyond this, the Federal Ministry of Food and Agriculture is also active in this subject area, in the context of its own bilateral cooperation projects and multilateral projects, e.g. with the FAO.

- ***Improving processes for sustainable agricultural and forestry production:*** Expansion of joint efforts to improve sustainable agricultural and forestry processes in third countries, particularly taking into account both the avoidance of changes in land use which are harmful to the environment, and also efficiency with regard to attainment of climate-protection goals.

- ***Bilateral trustee fund with the FAO for combating hunger and malnutrition:*** Within the scope of its cooperation with the FAO, the Federal Ministry of Food and Agriculture is giving support to the FAO through a *bilateral trustee fund*, amounting to € 8.3 m. annually, for projects to overcome hunger and malnutrition, e.g. by producing and disseminating instruments for examining the consequences that expanding the cultivation of bioenergy crops has on food security; this is in addition to instruments for developing sustainable strategies for the use of bioenergy's potential in emerging economies and developing countries.

- ***Formation of German-African research networks:*** The Federal Ministry of Education and Research's funding-support initiative "*Global Food Security – GlobE*", forms participative German-African research networks focused on food systems and systemic research approaches. Relevant topics include the areas of agricultural production/food/health, use of resources/soil/water/material-flows and recycling processes, reduction of losses along the whole value chain, structures of farmers' operations and gender-specific structures, regionally-adapted research solutions, and in addition plants/plant cultivation, biomass/bioenergy and animals in the system.

- Giving support to partner countries of German development-cooperation in implementing the Convention on Biological Diversity: In the context of its international obligations with regard to maintaining biodiversity, since 2008 Germany has almost trebled the support that it provides to developing countries and emerging economies in this area of activity, via the Federal Ministry for Economic Cooperation and Development and the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety. Points of emphasis in the funding-support are primarily the protection of biological diversity, sustainable use of that diversity, e.g. via adapted models of production and consumption, as well as fostering just participation in the benefits bestowed by nature. From 2013 the Federal Government is making available € 500 m. annually for the conservation of forests and other ecosystems.

H2 Securing market access to renewable raw materials within the framework of international trade

Strategic approach

Bilateral trade agreements or trade agreements within the framework of the WTO also determine conditions for trade with bioeconomy goods and act as a basic prerequisite for an internationally competitive German bioeconomy. For Germany, access to renewable raw materials on international markets is becoming ever more important, in view of the growing demand, for both energy and industry needs. At the same time, there is a need to take into account the possible effects of German exports and imports of bioeconomy products on food security and sustainability in production, especially in less developed countries.

Measures

- ***Improvement of market access:*** In the WTO[44] negotiations, the Federal Government is committing itself to the improvement of market access by means of reducing customs duties, reducing internal support (to domestic suppliers) and also reducing export subsidies. It pursues the abolition of restrictions on exports. Multilateral trade rules should be supplemented by bilateral trading agreements in conformity with WTO rules.

- ***Simplified import:*** Apart from making market access easier for bioethanol and biodiesel, efforts are being pursued to make it easier to import ethyl alcohol for material use. This would necessitate a reduction in tariff duties.

44 WTO: United Nations World Trade Organisation

H3 Establishing and further developing internationally-recognised sustainability standards in agriculture and forestry

Strategic approach

In view of the increase in international trade in food, raw materials and energy sources, and the international obligations to maintain and to foster the natural basis for life in the developing countries and emerging economies, the biobased products must be produced and used sustainably according to international rules. In this regard, internationally-recognised market-based sustainability standards in the agriculture, forestry and fisheries business, consistent with international trading rules, are an important instrument for guaranteeing adherence to environment and social-responsibility requirements and standards. In particular, these should also include the consequences of direct or indirect changes to land-use. In developing countries, secure rights of access to land and other productive resources, and also sustainable management of those resources, are crucial to the survival of people in rural areas. They are a key factor in the implementation of the human Right to Food and should be taken into account in sustainability standards. However, in individual cases, use of sustainability standards can also entail disadvantages for developing countries. In order to minimise these disadvantages and to strengthen the advantages of sustainability standards, the Federal Government gives support to the developing countries in their efforts to adhere to these rules, within the framework of their bilateral collaboration. Beyond this, it is a key issue of the Federal Government to dismantle non-tariff obstacles to trade. Within the EU, distortions to competition among the substitutes must be avoided.

Measures

- ***Expanding the sustainability certification for biomass:*** The Federal Government commits itself to extending the EU sustainability criteria used for solid and liquid biofuels, including existing voluntary certification systems, so as to encompass solid and gaseous bioenergy sources and also, on a voluntary basis, feed and food. The Federal Government supports wide-ranging application of credible certification, as an instrument of proof for wood products for material use and energy-source use, from legal and sustainable forestry businesses in international trade.

- ***Support of voluntary partnership agreements and implementation of Regulation No 995/2010 of the European Parliament and of the Council on timber and timber products:*** The Federal Government supports the EU and non-European wood-producer countries, so that as many states as possible conclude and implement voluntary partnership agreements with the EU, within the framework of the EU's FLEGT Council Regulation[45] from 2005 for ensuring the legality of wood imports. According to Regulation No 995/2010 of the European Parliament and of the Council on timber and timber products, only legally-produced wood can be brought onto the EU market. The Federal Government supports checks on implementation that are as uniform as possible throughout the EU, and the application of supporting instruments for the wood trade, such as fingerprint procedures, and a Europe-wide information platform for market participants.

- ***Support for the voluntary guidelines of the UN Committee on World Food Security:*** The Federal Government commits itself to global adherence to the "*Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*"; this is with regard to the planning of land use and also the structuring of investments involving transfers of property and usage rights to land, fisheries and forests, and it also supports the FAO in the implementation of these guidelines. The guidelines are relevant for companies and other stakeholders investing in the production of renewable resources in countries with weak governmental leadership and/or sourcing products from such countries respectively.

45 FLEGT = Forest Law Enforcement Governance and Trade; Council Regulation (EC) No 2173/2005.

H4 Expansion of international research and technology cooperations

Strategic approach

In many technology areas of the bioeconomy, Germany ranks among the leading countries. Exports emerging from this create value-added and employment in Germany. At the same time, providing such technologies can help developing countries and emerging economies to produce or use biomass more efficiently. In order to make the most of these advantages, technology cooperation with important partners must be expanded globally and partners in developing countries must be rendered able to use the advantages.

A programme forming a basis for worldwide cooperations in research is the Federal Government's strategy for internationalising science and research, establishing four primary goals: "*Strengthening research cooperation with the world's best*", "*Tapping international areas of potential for innovation*", "*Sustainably strengthening the collaboration with developing countries in education, research and development*" and "*Taking on responsibility internationally and mastering global challenges*".

Measures

- ***Building-up biomass partnerships:*** The building-up of biomass partnerships with countries that have raw-material surpluses, with the focus placed both on the potential for use of hitherto unused by-products of food production (shells, fibres, other remnants from harvests, etc.), and also on establishing sustainability criteria and formulating efficiency strategies.

- ***Giving support to the Global Bioenergy Partnership (GBEP):*** The GBEP is an international initiative with the goal of spreading the sustainable use of biomass, founded in 2006 at the initiative of the G8. In terms of content, a point of emphasis is the sustainable use of biomass in developing

countries. An essential goal that Germany has is to strengthen and advance the initiative through active collaboration (Federal Ministry of Food and Agriculture; Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety). A particular area of interest at present is the forming of competences and the application of the GBEP sustainability criteria for bioenergy in the individual member states. There are currently 23 states and 13 international organisations that are partners (members) of the GBEP, including many industrialised countries, as well as emerging-economy countries and developing countries; a further 22 states have observer status.

- ***Knowledge transfer and technology transfer and also demonstration projects for sustainable agriculture and forestry:*** In the context of bilateral and multilateral projects, the Federal Ministry of Food and Agriculture fosters knowledge transfer and technology transfer with regard to modern land-management that is sparing on resources and that increases food production: (among other activities) this is done by demonstration projects for agriculture and forestry, by sending specialist personnel, or by advising the respective government. The Federal Ministry of Food and Agriculture intends to expand its commitment in emerging economies and developing countries.

- ***Giving support to development-oriented agriculture research:*** For decades, via the Federal Ministry for Economic Cooperation and Development, the Federal Government has been supporting development-oriented agricultural research; this is done in a global research partnership with the Consultative Group for International Agricultural Research (CGIAR), via international agricultural research centres, national agricultural research institutions, and also German agricultural and climate research centres. As part of a global research agenda, solutions are found jointly that improve life sustainably for people in the north and the south.

- ***Policy-supporting research, knowledge management and policy consultation for world food:*** This new research concept entails strengthening and optimising the contribution made by the Ministry of Food, Agriculture and Consumer Protection and its business area for the improvement of world nutrition: this contribution is made through application-oriented research, information management and knowledge management, as well as through providing policy consultation, thus operating in a complementary capacity to the activities of the Federal Ministry for Economic Cooperation and Development and the Federal Ministry of Education and Research.

- ***Expanding research cooperation:*** The Federal Ministry of Education and Research is expanding research cooperation, particularly with internationally leading countries in areas of technology or production relevant to the bioeconomy, e.g. through use and processing of agricultural residual materials. Through "BioeconomyInternational", this includes fostering R&D projects in the context of international partnerships. Alongside technological issues and development goals, socioeconomic aspects and approaches at the systemic level are also of significance. In order to tap bioeconomic areas of potential at European level, transnational collaboration projects are fostered, e. g, within the framework of ERA-NET initiatives. These include the ERANet Industrial Biotechnology (ERANetIB2) for using new methods and concepts of industrial biotechnology in order to tap opportunities not yet fully exhausted, regarding industrial-material use of biomass. With partnerships that span national borders, between industrial and academic research, the goal is also to accomplish an improvement and acceleration of technology transfer. The ERANetEuroTransBioPro aims at integration and cooperation among research and development activities, within the framework of public funding-support for biotechnology-based SMEs, in order to raise their international competitiveness; the ERA-NET WoodWisdom-Net pursues the goal of building-up a lasting transnational collaboration in funding-support for research in the forestry and wood sector.

Glossary

Agricultural raw materials
Raw materials from agricultural production, used as feed or food and also as renewable resources.

Biobased products
"Biobased" is the term given to all products made partly or wholly from biomass, with the exception of food and feed. This includes, among other things, basis chemicals, fine chemicals, pharmaceuticals, cosmetics, biopolymers, pulp, paper or wood products.

Biobased business
Used as a synonym for the bioeconomy.

Biogenic raw materials/resources
Material of organic origin (anything of fossil origin excluded)

Biomass
Total mass of organic material which has been produced biochemically. A constituent part of biomass is agricultural and forestry plants and also aquatic organisms, including the residual materials and waste materials, such as biowaste from households, from farming animals, or from food and feed production (anything of fossil origin excluded).

Bioeconomy
Knowledge-based production and use of renewable resources to provide products, processes and services in all economic sectors, within the framework of an economic system which is viable for the future. According to this definition, the concept of the bioeconomy encompasses all economic sectors and their associated service areas, which produce, work and process, use or trade with renewable resources – such as plants, animals and microorganisms and products made from them.

Biorefinery
A biorefinery is characterised by an explicitly integrative, multi-functional overall concept that uses biomass as a diverse source of raw materials for the sustainable production of a spectrum of different intermediate products and finished products (chemicals, materials, bioenergy incl. biofuels), entailing as complete as possible a use of all raw-material components; where applicable, food or feed can emerge as a coupled product.

Biotechnology
The use of science and technology on living organisms and also on their constituent parts, products and models, with the aim of changing living and non-living materials for the production of knowledge, goods and services.

Renewable resources
Raw materials from agriculture and forestry, and also aquatic and microbiological raw materials of non-fossil origin, including biogenic residual materials and waste materials.

Renewable raw materials
Products made by agricultural and forestry work, in addition to aquatic products not used as food or feed. Such products can be used as a source of materials and/or as an energy source.

Notes

Imprint

Publisher
Federal Ministry of Food and Agriculture (BMEL)
Division 531 – Strategy and Coordination of the Directorate-General
"Biobased business, sustainable agriculture and forestry"
Wilhelmstraße 54
D-10117 Berlin | Germany

Current as of
March 2014

Text
BMEL

Design
design.idee, büro_für_gestaltung, Erfurt

Picture credits
BMEL/walksreen; Bildschön; Thomas Lother; Stefan Körber + Frank Schöttke + Sven Hoppe + ernstboese + Dan Race + picsfive + Aleksei Potov + Alexander Raths + fransen + Elenathewise + micro_photo + travelguide + Edelweiss + contrastwerkstatt + Smileus + twixx + Ralf Gosch + netsuthep + Floydine + psdesign1 + ZIHE + michaeljung + maxoidos + jorisvo + Fotimmz + beeboys + Wolfgang Jargstorff + creativenature.nl + blvdone (alle) Fotolia.com; puchan/istockphoto.com; FNR; BPA Baumann/all4foto; Thünen Institut; Leuna, cbp Fraunhofer; FAO/Giulio Napolitano; Ilja Hendel/Thünen-Institut; Fuse/gettyimages; Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB); Hendel/BMEL

Printed by
MKL Druck GmbH & Co. KG
This brochure is made of 100% recycled paper and was printed using linseed-oil paint.

Ordering information
You can order this and other publications free of charge:
Internet: www.bmel.de/Publikationen
www.aus-natur-gemacht.de
E-Mail: publikationen@bundesregierung.de
Fax: 01805-77 80 94
(Fixed price: 14 ct/min., prices from mobile networks may deviate from this)
Tel.: 01805-77 80 90
(Fixed price: 14 ct/min., prices from mobile networks may deviate from this)
Orders in writing: Publikationsversand der Bundesregierung (Federal Government's office for dispatch of publications)
Post box 48 10 09 | D-18132 Rostock

Further information is available in the Internet at www.bmel.de