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RESEARCH NEEDS AND RESEARCH TRUST AREAS IN BIOECONOMY

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ABSTRACT

The bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy via innovative and efficient technologies provided by Industrial Bio technology. This paper deals with research needs and research trust areas in bioeconomy. In this connection, it outlines the research needs in agriculture, research thrust areas in agriculture, research needs in sustainable agricultural production, and research thrust areas in sustainable agricultural production, sustainable agriculture promotion measures, research needs in production of healthy and safe foods and research thrust areas in healthy and safe food. This paper makes a special note on application of renewable resources in industrial production, research needs in renewable energy, research issues and research areas in renewable energy, research needs in biomass energy and inters disciplinarily research needs in bioeconomy. This paper concludes with some interesting findings along with policy suggestions.

KEY WORDS: *Agriculture, safe food, renewable energy, biomass, research areas, research needs*

INTRODUCTION

The bioeconomy term has been proposed as a path towards the sustainable management of resources and economic growth. The term bioeconomy entered the global discussion in the recent decade and has now become a widely used definition. The term originates from the Seventh Framework Program of the European Commission and the Organization for Economic Co-operation and Development in 2009. However, the term has been used in various forms and definitions and been mentioned in relation with food security, sustainable production and energy needs for a growing population.

The objectives of bioeconomy are diverse, they include: The reduction of climate change impact, reduced use of non-renewable raw materials, increased added value from biomaterials concomitant with reduced energy consumption, recovery of nutrients and energy from waste and by-products as additional end-products, and to optimize the value and contribution of ecosystem services to the economy.

The biological resources that can be identified are those which are currently being utilised and those that can be considered for utilisation. Utilised resources have an economic value represented by their contribution to the economy while unused resources do not have a current value, but a potential value that should be revealed. In addition to the identified resources, there is a category of undiscovered resources, hypothetical and even unconceived resources.

The Bio-economy models of development emphasises the evidence-based technology approach, focusing on biotechnology applications in primary production, health, and industry. The development of the economy of the world is to a large extent driven by technological progress and knowledge. With increasing knowledge, the view of the world changes and technological progress enables the industry, scientists, politicians and the general public to take on the challenges of the world in new and improved ways. Challenges dealing with population increase and natural resource scarcity have been prominent for the last 20 to 40 years. In order for the human population to survive, food security must be ensured. It is also preferable that the future human population´s living conditions should not be worse than they are now.

RESEARCH NEEDS IN AGRICULTURE

To ensure nutrition for 9.5 billion people in 2050 with changed consumer demands food production must be increased significantly and the availability of foodstuffs improved for vulnerable population groups. The arable land needed for production is limited, and in many areas is above all qualitively and quantitatively affected by soil degradation. In the long term, agriculture will also be affected to a significant extent by the effects of climate change, and will have to cope

with soil deterioration, water shortages and floods, and the spread of plant pests. As regards raw materials, rising prices with increased volatility is anticipated. Determined engagement is critical above all in agricultural research and in the biosciences – to tackle the challenge of global food security. This commitment must be strengthened both at a national and international level. Given the number of years that typically elapse from the start of a research project to the transfer of the results into agricultural practice, this is a pressing issue.

To increase agricultural production in accordance with regional requirements, research must be applied on different levels. Plant breeding is above all focused on the expansion of the productive potential of crops, on stabilising yields through improved resistance to pathogens, and on enhanced tolerance. Among others, this takes the form of tolerance to heat, drought, cold, and salinity, as well as suitability for sustainable forms of farming. This requires that the causes and effects of abiotic and biotic stress factors including investigations into plant diseases and the corresponding plant reaction mechanisms – must be better understood in order to make them usable for plant breeding and cultivation. In addition, it will be necessary to preserve locally adapted forms whilst also broadening the range of cultivated plants, also taking into account plants and cultivation conditions that are of high relevance for developing countries.

RESEARCH THRUST AREAS IN AGRICULTURE

•Highly significant is research into the breeding of agricultural crops, among others using modern methods of plant biotechnology. Thereby, basic research projects and the transfer of knowledge into breeding practice should be supported.

• Research promotion activities focused specifically on the requirements and problems of India will be driven forward. Here, approaches for regionally- and locally-adapted land management must be researched, or new approaches developed, among other things including the participation of farmers and scientists in the respective locations.

• Suitable phenotyping technologies based on scientific concepts for the investigation of environmental influences on plant traits must be put into place.

• Modern approaches plant cultivation and agricultural technology are needed to achieve sustainable gains in efficiency and productivity. Likewise, post-harvest losses can be reduced through new technical and logistical solutions.

• New, efficient, animal-friendly and consumer-accepted procedures must be developed for the breeding of healthy, adaptable and high-performance animals. Here, feed efficiency, stress tolerance heat, etc., as well as reduced greenhouse gas- and air pollutant emissions, must also be taken into consideration.

• There is a need for research in the development of regionally adapted climate prediction models, as well as investigations into the interaction between the climate and biosphere.

• Investigations into agricultural biodiversity in agricultural organisms and close wild relatives to uncover potentially important characteristics, including the relationship between phenotypic trait expression and its genetic basis, must be strengthened.

RESEARCH NEEDS IN SUSTAINABLE AGRICULTURAL PRODUCTION

Natural resources are the means of production for the bioeconomy, and thus their sustainable management is in the highest interest. The required increase in agricultural production must be achieved by means of efficient and resource-friendly management. The implementation of this must correspond to the challenges posed by climate change, environmental and climate protection, raw material supplies, water availability, and biodiversity protection. This also demands research efforts that take into account all the factors of agricultural production systems for terrestrial as well as aquatic biomass production according to specific location requirements, and allowing for aspects of sustainability.

RESEARCH THRUST AREAS IN SUSTAINABLE AGRICULTURAL PRODUCTION

The production factors 'land' and 'water' occupy a special position because they are not increasable, and because regional distribution is predetermined. Important nutrients such as phosphorus and potassium are only limitedly available in the concentrated deposits in use today. Deterioration or shortage of these production factors in regional and National scales must be confronted with environmentally sound protection, utilization and reclamation concepts. This requires research into an improved understanding of the complex agricultural production system, and for concrete solutions for nutrient recycling or for nutrient optimisation.

Alongside improved farming practices, plants optimised for sustainability are of particular importance in the production of plant-based biomass. Plant protection is nevertheless an integral component of agricultural production, and of protection of stocks. Above all, integrated plant protection methods should be further developed in order to mitigate related unavoidable risks to humans, animals, and the natural environment. Included here, alongside biological and technical plant protection measures, is the technical further development of plant protection equipment and advanced procedures for the economisation of plant protection products. For example, precision farming, sensor-based controls, robotics, as well as prevention of introduction and spread of harmful organisms. All of these aspects are gaining in significance in the context of climate change and expanding international trade.

Because genetic engineering is being increasingly applied around the world, a responsible handling of genetically modified plants is crucial to ensure sustainable agricultural production. To these ends, biological safety research is indispensable. This must be able to keep pace with the dynamic development of genetic engineering. Furthermore, the social and economic disciplines can make an important contribution to questions of sustainability. The coexistence of agricultural production systems is likewise an area to be investigated, in order to bring into line the legitimate interests of society and farmers, conducting either traditional agriculture or the cultivation of genetically modified plants.

In the context of the bioeconomy, it is crucial to retain ecosystem services. The concept of sustainable land management integrates biodiversity conservation with soil and water protection. Sustainable land management covers a variety of issues on the interaction between production

systems and ecosystem services. These include correlations between land use/ecosystem services/climate change, analyses of source and sink functions of systems used in agriculture as regards greenhouse gases, as well as investigations into the socio-economic framework conditions. To relate this to knowledge- and implementation-oriented research requires, in addition to a high degree of interdisciplinarity, also transdisciplinarity through the incorporation of decision-makers and relevant stakeholders. There is often a tension between the use of biological resources and the conservation of biological diversity. Solutions to this will require considerable research work, among other things including the determination of an optimal level of biodiversity in agricultural production systems, the quantification of biological diversity with regard to ecosystem services, and the development of procedures for future-oriented biodiversity management.

An integrated approach will also be pursued in agricultural and forestry research, which increasingly places climate and environmental issues in the foreground in the context of management/husbandry and value creation. This can contribute, to the development of energy efficient, soil friendly and low-carbon agricultural production- and processing systems, and to advancing the sustainable use of pesticides and fertilisers. Research into organic farming should be further developed in this context.

With regard to the spectrum of cultivated plants, there is also a need for research that combines diversity and performance. Here, essentially two directions of development can be brought forward:

1. All properties that influence plant growth and yield formation.

2. The quality properties of the product. This is because properties that are present from the beginning facilitate all subsequent processing steps, and improve efficiency.

Further research is required for the production of agricultural animals and in aquaculture. Necessary for climate-, nature-, environment-, resource-conserving, animal-friendly as well as efficient production, are innovative concepts for animal breeding, -husbandry and nutrition among other things with a targeted reduction in emissions as well as analyses and scientifically-founded improvement strategies for animal welfare. Furthermore, the development of animal-friendly and low emission housing and transport systems contributes to environmental- and animal welfare protection, as well as industrial safety. The entry of veterinary drug residues into the environment should also be given consideration.

Agricultural-technical innovations will have to be driven forward to be able to realise these sustainable concepts. This is also to enable reductions in emissions of greenhouse gases and environmental pollution along all the stages of agricultural production, and to improve resource- and energy efficiency. The economic and social implications of agricultural production will likewise be investigated and action strategies de-rived, e.g. analyses of competing uses, as well as the development of control systems for more efficient societal use of scarce land area.

SUSTAINABLE AGRICULTURE PROMOTION MEASURES

- Internationally oriented concepts for the protection of climate, nature, soil, water, air and important nutrients must be researched.
- The integration of agricultural crops with novel characteristics and cultivation techniques can be further improved.
- Integrated pest management techniques should be optimised or newly developed in the light of scientific knowledge.
- Biological safety research and co-existence research should be continued.
- Methods for the quantification of biological diversity with regard to related ecosystem services, and towards the development of future oriented biodiversity management on a national and international level, are required.
- Inter and transdisciplinary research for sustainable land management should be expanded.
- Research into organic and environmentally friendly farming must be further developed also due to relevance for developing countries
- Research and innovation into breeding, feeding, housing, and into the health of livestock including bees and fish supports the sustainability objectives of the bioeconomy.
- Innovations in agricultural technology along the entire agricultural value chain should be advanced.
- Investigations are required into the optimisation of the sustainability effects of agricultural production systems, and the efficient use of resources on national and international scales.
- Social, economic, policy and planning research to strengthen institutions in rural areas should be supported.

RESEARCH NEEDS IN PRODUCTION OF HEALTHY AND SAFE FOODS

Consumers expect healthy, high-quality, safe and at the same time inexpensive foods. Demographic change and changing lifestyles and circumstances are altering dietary behaviour. A healthy diet presupposes a corresponding availability of food that meets individual requirements.

Prevention and positive influence over dietrelated diseases, including among others obesity, diabetes, allergies, heart and circulatory diseases, as well as the positive influence of aging processes through diet, represent important social and scientific challenges. Research topics on the effectiveness of foodstuffs and their components in the human body will be under takenThe nutritional value and processing quality of vegetable and animal starting products can already be optimised in agricultural production. Furthermore, the effects of production- and environmental conditions on food quality should be clarified. The health effects, quality, and safety of foodstuffs can be optimised according to specific need profiles, in terms of the development of suitable products for allergy sufferer. This is thanks to innovative concepts and methods that can specifically enrich or add positively acting substances, to agricultural products, or reduce/eliminate negatively acting substances, such as allergens.

Ecologically produced foods contain almost no residues of chemical-synthetic fertilisers and pesticides. Research approaches for the prevention or reduction of residues of chemical-synthetic fertilisers and pesticides also in normal agricultural production should be expanded. In particular in the field of food processing, gentle approaches, with further reductions in the use of additives and processing auxiliaries, should generally be further developed. This can also reduce allergenic potential.

Healthy foodstuffs of animal origin are possible only with healthy animals. Many factors such as the increasing

production of animal foodstuffs, global trade, and also climate change have an influence on animal diseases spreading more frequently and quickly. Besides the effects on animal health and the economic damage to agriculture, specific animal diseases are also associated with a risk of transmission to humans.

There is therefore a high need for research into the clarification of the causes of epizootic and animal diseases, as well as for measures for their prevention and control. Epidemiological studies are of high importance in order to engage with and comprehend disease occurrences more quickly – in terms of both time and spread as well as for improved prediction capabilities, thus aiding control and prevention. Furthermore, application-oriented research work for quick, sensitive and specific diagnostics, as well as developments for innovative vaccines and veterinary drugs, must be driven forward. In parallel, strategies should be developed to minimise the use of veterinary drugs, and for their careful management. Nevertheless, the future sustainable production of animal foodstuffs will come hand in hand with other animal health challenges. New concepts for animal hygiene measure, and for increasing resistance to infection through modern breeding methods, represent further research objectives.

Another important issue is the verification of the safety and quality of foodstuffs of animal and plant origin. Required here are innovations for analytics, monitoring and above all prevention measures, including quality- and risk management systems. New technologies and methods, for example from nano and biotechnology, and the development of IT based traceability systems, can improve hygienic quality and safety, as well as safe life of foodstuffs. Innovation potential is also seen in process improvements that make optimal use of substance flows including bioprocess technology for the handling and processing of foodstuffs.

Here, innovative solutions are required not only to improve conventional preservation methods influencing freshness, naturalness, and nutritional value, but above all to improve the sustainability and efficiency of production processes. Moreover, the growing demand for convenience products, and increasing away-from-home consumption, require efficient and flexible distribution channels and generally optimised processes along the value creation chain called food supply chain management. There is hence a need for research that is both of a technical as well as organisational nature. This will lead to innovations, for example in the packaging industry, in the transportation and logistics industries, in trade, and in food-related service sectors. Moreover, it is important to continuously observe need profiles and consumer behaviour in accompanying studies, and for these results to be used to align research questions. Alongside benefits to consumers, innovative products, processes, and services provide opportunities for the food industry in dynamically expanding markets. For this reason, the predominantly medium-sized companies that conduct own research activities only to a limited extent should enter into co operations with the scientific community as early as possible and to a greater extent.

RESEARCH THRUST AREAS IN HEALTHY AND SAFE FOOD

- The development of health-promoting foods is called for
- To improve food security, the inter-relationships between environmental conditions and production techniques in animals and plants should be further clarified and optimised.
- Gentle and conserving methods for organic and conventional food processing are in need of further development.
- Animal health research should be supported alongside the development of appropriate measures for prevention, control and treatment, among other things through studies into causes, spread and disease processes.
- For food safety, there is a need for high-performance analytics, and monitoring- and prevention measures, including quality and risk management systems.
- The development of sustainable and quality-retaining food technologies is required.
- Technical and organisational innovations for the optimisation of processes along the food production chain should be supported. Of particular importance is the development of effective and efficient certification systems for social and ecological standards.

APPLICATION OF RENEWABLE RESOURCES IN INDUSTRIAL PRODUCTION

Biobased products, which combine biotechnical, chemical, thermal, or mechanical methods in their manufacturing process, not only help protect nature, the environment, and the climate, but also enable greater independence from fossil raw materials. Furthermore, they make a significant contribution to the structural change from a petroleum-based to a biobased industry with related opportunities for growth and employment. Industrial biotechnology, also known as white biotechnology, is an important driving force in this transition. This field of activity is given high priority in the federal Government.

RESEARCH NEEDS IN RENEWABLE ENERGY

In the changeover from industrial, petroleum-based raw material supplies, renewable materials, as a result of their wide variety of ingredients, provide numerous opportunities for innovative applications in medicine, industry, agriculture, and for the environment. Furthermore, biomass can also already be modified for subsequent processing in the development processthrough plant selection, cultivation methods, or breeding using modern methods of biotechnology. Because of the inherent ingredients, their rapid growth, as well as the high degree of efficiency for the plant world, algae are garnering increasing interest as a source of raw materials. Likewise, wood represents a large biomass reservoir for traditional application in the construction, paper and pulp industries, as well as for sustainable husbandry as a renewable source of raw materials.

In the future, the various biomass raw materials can be further processed into high-quality products, among other things through cascading and coupling. In analogy to petrochemical refineries, the term biorefinery is used when all the components of various plants and waste, as well as residual materials, are used to as great an extent as possible (zero waste) for example, in the production of food and feed products, chemicals, fuels, electricity, and heat. There are

many research topics to be worked through towards the concept of biorefineries, for example on the decomposition, processing, and conversion of biomass, in particular of wood and on product purification. All of these must be incorporated in a project plan (road-map) for biorefinery development.

For the application of biomass as industrial raw material, previously unused microorganisms and molecularly optimised production systems open up as-yet untapped opportunities with regard to substrate spectrum, product variety, and production efficiency. Greatly promising here is the combination of concepts and methods from the biological sciences in terms of genome research, biocatalysis, systems and synthetic biology with chemical process technology. The expansion of these competencies provides opportunities both for start-ups and for the expansion of technology leadership in the light of global competition. For wider diffusion in traditional industry sectors, it will be vital to be able to identify high-quality bio-based platform molecules that can be modularly combined and integrated into product trees.

Competitive bio-based, industrial raw material products are a substitute not only for conventional petroleum-based products. They frequently also represent true product innovation with highly specific customer benefits, in terms of biodegradable plastics, and enable significant improvements in production efficiency. With its high growth and employment potential for the bioeconomy location are gaining in economic importance. These include, among others, basic and fine chemicals, pharmaceutical products, food additives, detergents and cleaning agents, bio-based plastics, textile products, and cosmetics.

RESEARCH ISSUES AND RESEARCH AREAS IN RENEWABLE ENERGY

•Plant raw materials, in particular those not used as animal/ human nutrition, can already be optimised in development, through plant selection, cultivation and breeding.

•The use of biomass from different sources in zero-waste biorefineries will require intensive process developments, as well as investigations into industrial feasibility, which must be incorporated into a project plan (roadmap).

•The technical and economic aspects of the integration of biobased platform molecules in industrial product trees should be investigated

•The next generation of biotechnological processes for new useful and pharmaceutical substances must be driven forward in the context of a strategy process.

•Research with the objective of identifying new bioactive substances as basic chemicals and as end- or precursors products, for pharmaceuticals, food additives, detergents and cleaning agents, textiles, cosmetics, is necessary.

•The scientific assessment of the technological, economic, environmental and social aspects of the various fields of application of bio-based products and processes requires further development.

Effective and efficient conversion processes for biomass through thermochemical, chemical catalysis and biocatalytical require interdisciplinary development along the process chain. This will require the establishment of strategic alliances between research facilities, manufacturers, and user companies, as well as with associated institutions.

The contribution made by energetic- and material utilisation of renewable raw materials in efforts to reduce CO2 must be investigated and evaluated.

DEVELOPING BIOMASS-BASED ENERGY CARRIERS

Energy from biomass will continue to gain in importance as a component of the overall energy mix. In the framework of regional health provision concepts, this cans contribute to local creation of value, and to the creation of jobs in agriculture, forestry, and industry. Extensive technical research work and studies into sustainability as well as scientific monitoring of demonstration projects and market introductions will be essential if bioenergy is to become internationally competitive. the challenge also lies in establishing modes of production and utilisation that climate-, nature-, and environment-friendly. Systems should be de-signed to be efficient, sustainable, and economical along the entire process chain.

RESEARCH NEEDS IN BIOMASS ENERGY

Biomass can find application in a wide variety of areas including material use, as a source of energy. In the area of energy, in the future biomass can make an increasingly significant contribution to balancing fluctuating renewable energies for needs-based electricity supplies. Here, research into the optimisation of power heat coupling and the production of biomethane from the gasification of biomass will also play a role. Next generation biofuels with improved economic efficiency and environmental compatibility can be of significance in certain mobility segments. The need for research in the area of bioenergy takes in the entire process and value creation chain – from breeding, to cultivation and harvesting, up to the processing of raw materials and conversion processes.

The objective of research efforts must be to reach the economic efficiency of processes, and to improve and increase resource efficiency and environmental compatibility. The priority of this work should be to sustainably optimise yields and the use of resources, as well as to increase net energy yields. This means that, in the future, the highest possible yields will be achieved with a minimum net use of resources per unit area. Included here, among other things, are research aspects towards increasing process efficiency, achieved, for example, with the assistance of the development of new strains of anaerobic bacteria, and enzymatic products from biogas production. These could contribute, among other things, to robust and productive plants that are optimised for conversion processes. Likewise, the potential of algae should be further researched. CO2 reductions should be considered with regard to climate protection goals and ecological aspects in the course of process optimisation.

Furthermore, studies should also be carried out into whether and how food production will change though increasing competition for land use. In addition to reducing storage and processing losses, among other things via improved agricultural logistics systems, system studies are required to estimate monetary and resource costs for different plant sizes and conversion technologies. Here, appropriate technical and technological process issues will have to be solved, as well as entirely new processes developed so that these can be enduringly established on the market. Included among these are bio catalytic processes, alongside methods for combustion, pyrolysis and gasification, among others of organic residues and waste materials. In addition, studies should be carried out into synergies between biotechnological and chemical-physical processes. Sustainability effects

throughout the entire process chain also require investigation. Overall, the solid, liquid and gaseous sources of bioenergy will have to be optimally secured for fuel, heat, and electricity production in the energy policy triangle between environmental compatibility, economic efficiency, and supply security. The growing global demand for bioenergy will increase the need for related process technologies. Here, international research collaborations form the basis of export opportunities, and support the climate protection efforts of other countries. Opportunities for value creation and employment potential in rural areas through domestic production of bioenergy should be investigated, and action strategies derived.

RESEARCH THRUST AREAS IN BIOMASS

•Intensive research is needed towards improvements in the breeding, cultivation, harvesting and processing of plant biomass including algae, above all those not used in animal/ human nutrition.

•Efficient conversion processes for biomass, including the identification, analysis and development of systems for the coupling of these procedures, should be strengthened as field of research.

• The entire process chain, including cultivation, processing, and process and manufacturing technologies must be optimised with regard to efficiency and sustainability criteria.

•Research is necessary towards the establishment of sustainability standards and certification systems, as well as concepts for the parallel development of markets for food and feeds, and for biomass for energy and material use.

•Research to demonstrate the technical and economic feasibility of bioenergy plants must be driven forward. • Efforts must be made to optimise energetic use of agricultural and forestry residues and waste mate-rials.

•Innovative concepts must be devised for the efficient and environmentally compatible supply of renewable raw materials for different plant sizes and conversion procedures.

• Technologies suited to storage, and to approaches for compensation of fluctuations in bioenergy power feeds, as well as to the optimisation of applied heat-power cogeneration concepts, should be further developed.

•The development of market-viable processes for increasing resource efficiency, and for further reduc-ing negative environmental effects and greenhouse gas emissions, should be strengthened.

•Improved technological and organisational biogas concepts are essential. The scientific and process-engineering basis for the effective political guidance of this sector must be further developed.

INTERDISCIPLINARY RESEARCH NEEDS IN BIOECONOMY

A basic understanding of biological systems and their individual components can give rise to a range of innovations for food, energy, and industrial processes and products. These are characterised be the advanced technologies from a variety of natural and technical sciences that are employed in their development.

The creation of a knowledge-based bioeconomy requires the integration of the life sciences with agricultural, natural, environmental and climate sciences, as well as with further key technologies such as computer science and mathematics, nanotechnology and materials sciences, microsystems engineering, process engineering, and plant engineering systems research and research in the economic and social sciences must be adequately funded to be able to tackle issues of sustainability, including economic and social dimensions. The integration of all of these competencies also enriches the individual disciplines. Promoting collaborations in projects means that existing structures can be networked and utilised efficiently across disciplines and institutional boundaries. This should be accompanied by the professionalisation of the business of these structures for scientific management.

Platform technologies play an important role in the bioeconomy, for example in the study of biological systems and processes using molecular biological and biochemical methods. This includes technical processes such as fully automated high-throughput analysis and precision analysis equipment, imaging processes, databases, or bioreactors. These platform technologies can also lay the groundwork for commercial applications, and provide the basis for new business models.

In addition, the corresponding setting of priorities in training and professional development is essential to convey the necessary skills and knowledge. The knowledge-based bioeconomy requires that understanding of complex interrelationships is attained and implemented at all levels of training and education. Here, knowledge of socio-economic issues is of major significance.

INTERDISCIPLINARY RESEARCH REQUIREMENT

Adequate socio-economic and systemic accompanying research is required for the creation of a sustainable bio-based economy, discipline- and institution-spanning cooperation, for example through joint projects and the expansion of research centres, should be supported. Alongside, structures for scientific management must be professionalized, the development of platform technologies can be promoted through the integration of project- and institutional funding, interdisciplinary priority areas that include multidisciplinary qualifications for young talent assist in the training of skilled workers for the bioeconomy and the expansion of funding for young scientists provides advantages in the competition for talent.

SPEEDING UP TRANSFER INTO PRACTICE

Through promotion policy, the scientific community will be offered incentives for the early development of commercialisation perspectives. Assessment systems for science will award both publication activity and application-oriented research.

To validate new scientific knowledge, and to assist transfer into business, the promotion of cooperative projects between science and industry must be expanded. Likewise, industrial researchers can transfer their development and process know-how to the scientific community. Consideration should be given to new forms of cooperation between industry and science, and to unusual alliances between partners from very different areas.

Small and medium-sized enterprises in industry and agriculture are the innovation drivers of the bioeconomy. It is essential that the technological capabilities are strengthened, and that cooperation with science and corporate clients is successful. The bioeconomy research strategy thus strives towards the highest possible participation in the form of

collaborative projects between science and industry, as well as cooperations between many companies. This company cooperation in research and development can increasingly be seen in bioeconomy relevant sectors. They often provide the basis for promising business models aimed at highly specialised services and products for clients in industry and agriculture.

RESEARCH ISSUES

Technology transfer activities and also other forms of commercialisation of scientific results through improved conditions for business start-ups must be supported. Scope for young scientists in research funding should be enlarged. Exchanges of personnel and cooperation between science and industry should be intensified. The involvement of SMEs in research projects and the promotion of cooperations with science should be strengthened and business cooperations among innovative SMEs in research and development should be driven forward.

CONCLUSION

It could be seen clearly from the above discussion that the promotion of bio economy is very essential in the context of unsustainable means of production of goods and services. The sustainable development can be achieved through bio economy. Hence there is a need to promote bio economy by the way of identifying the research needs and research areas. It could be noted that the identification of research needs and requirements depends on government investment on research and development in bio economy. In order to improve the research in bio economy, the government should allocate more funds for research in bio economy and publishing its results. The research performance in bio economy depends on creation of required infrastructure facilities and technical assistance on the part of the government agencies. Further the government should encourage the innovative research projects by the way of providing research grants and research assistance.

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