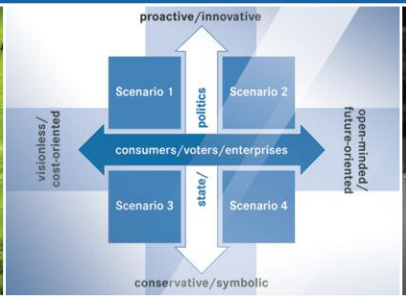

Possible Futures towards a Wood-Based Bioeconomy: A Scenario Analysis for Germany

Research for the environment

HELMHOLTZ
CENTRE FOR
ENVIRONMENTAL
RESEARCH – UFZ

BioEconomy Cluster

Information on the
Leading Edge Cluster
Bioeconomy

HELMHOLTZ
CENTRE FOR
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RESEARCH – UFZ

Information on the
working group
"Law and Governance"

Preface

The past few years have seen a significant increase in awareness that creating sustainable economic activity will require more in the future than a decarbonisation of energy supply. Around the world, governments are now pursuing comprehensive "bioeconomy" strategies. This also entails a transition towards sustainable industrial production, which requires the establishment of a sustainable circular economy. The bio-based economy is thus expected to play an increasingly important role worldwide. However, for our business practices and lifestyles, this will require a complex change of path, which is already presenting major challenges in the energy sector, not least with regard to ensuring the sustainability of those developments.

Within the BioEconomy Excellence Cluster funded by the German Federal Ministry for Education and Research (BMBF) partners from science and industry (the timber and forestry sectors, the chemical industry, the plastics industry and the plant construction sector) in Central Germany are working together on the material and energy-related use of non-food biomass, especially wood. The accompanying scientific research of the Excellence Cluster includes the development of policy and economic environment analyses. Using the scenario analysis method - originally developed for the business sector but now widely employed - alternative future development paths can be described which, among other things, allow businesses and policy makers to make strategic decisions under conditions of uncertainty.

In this brochure, the Working Group on Law and Governance of the Bioeconomy presents the results of its scenario analysis "Possible futures for the wood-based bioeconomy: A scenario analysis for Germany". Drawing on expert opinion, it illustrates potential future developments in the wood-based bioeconomy in Germany, and key influencing factors. As such, it makes an important contribution to strategy development not only for the BioEconomy Excellence Cluster itself but also for future bioeconomy policy.

Univ.-Prof. Dr. Erik Gawel

Univ.-Prof. Dr. Wolfgang Köck

UFZ, location in Leipzig

Content

Step 1: Define the Key Factors

- Identify the factors that influence the development of the bioeconomy
- Determine the key factors: the most significant influencing factors according to experts from the BioEconomy Excellence Cluster
- Define how the key factors might manifest

Step 2: Develop the Scenarios

- Define the various attitudes of policy makers, entrepreneurs, voters and consumers to the bioeconomy
- Derive four scenarios
- Creation of storylines in which key factors and scenarios are linked

Step 3: Derive Recommendations

- Discussion of the implications of the alternative scenarios of the bioeconomy for policy makers, entrepreneurs, voters and consumers
- Derivation of policy recommendations
- Recommendations for the further development of the Bioeconomy Excellence Cluster

Aim and Methods of the Scenario Analysis

The **aim** of this scenario analysis is to illustrate various plausible futures for Germany's wood-based bioeconomy up to the year 2050. Taking these outlined futures into consideration, businesses can develop strategic action plans. The analysis also allows us to derive recommendations for policy makers. Finally, it contributes to the scientific debate on how the bioeconomy and its framework conditions could be shaped in the future.

The scenario analysis presented here is based on **three** consecutive **steps**:

In the first step, **key factors** that are critical to the development of the bioeconomy and their possible feature characteristics were determined. This was done by identifying the factors that could possibly influence the future development of the wood-based bioeconomy in Germany. The findings were presented to experts from the BioEconomy Excellence Cluster (scientists, industry representatives and members of the cluster management board) who were asked to name the five most important influencing factors from their point of view. During a workshop, the key factors' role in the bioeconomy system was further discussed among the experts, and projections of extreme and opposed developments of each factor were defined.

In the second step of the analysis the various attitudes of policy makers, entrepreneurs, consumers and voters with regard to the bioeconomy were identified (ranging from "very open" to "very sceptical") and four alternative **scenarios** were derived. Building on this, the different projections of the key factors were used to develop corresponding **storylines** for the four scenarios.

The third step involved deriving **recommendations** for the future shaping of Germany's wood-based bioeconomy in general and the Excellence Cluster in particular.


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Ressourceneffizienz in der Bioökonomie – Defizite und Herausforderungen am Beispiel der Verwertung von Reststoffen durch hydrothermale Karbonisierung
BioEconomy Cluster
Beiträge zur Bioökonomie
1 Recht und Politik
KURZANALYSE ZUR REACH-VERORDNUNG IM RAHMEN DES SPITZENCLUSTERS BIOECONOMY
AbfallR
Zeitschrift für das Recht der Abfallwirtschaft
UFZ Discussion Papers
Department of Environmental and Planning Law
Department of Economics
22/2014
Die Öffentliche Verwaltung
DÖV
Zeitschrift für öffentliches Recht und Verwaltungswissenschaft
WASSER UND ABFALL
BODEN · ALTLASTEN · UMWELTSCHUTZ
BWK die Umweltingenieure
GJAE German Journal of Agricultural Economics
The Political Economy of Fostering a Wood-based Bioeconomy in Germany
Die politische Ökonomie der Förderung einer holzbasierten Bioökonomie in Deutschland

Scenario Analysis and Governance Research

The scenario analysis is incorporated into the various studies conducted by the **Working Group on Law and Governance** of the Bioeconomy as part of the **accompanying scientific research** of the BioEconomy Excellence Cluster.

These studies relate on the one hand to **analyses of the legal framework** for the bioeconomy (Köck 2014; Ludwig et al. 2014a, 2014b; Ludwig et al. 2015a, 2015b; 2015c; 2015d; Gawel et al. 2015) and on the other hand to **resource economics analyses**, especially on governance and transformation of the bioeconomy, and to the instruments of bioeconomy policy in the area of wood-based biomass (Pannicke et al. 2015a, 2015b; Gawel et al. 2016). The economic analysis of bioenergy policy also plays a significant role in the publications of the group (Purkus et al. 2015; Purkus 2016).

In addition to publishing in scientific journals at both national (e.g. the German-language journals Wasser und Abfall and Abfallrecht) and international level (e.g. Biomass and Bioenergy, the German Journal of Agricultural Economics as well as Sustainability) the working group is also directly involved in **knowledge transfer activities for the Bio Economy Excellence Cluster**. This is done, for instance, by presenting fact sheets and short analyses on topics such as the REACH regulation (Köck 2014), hydrothermal carbonisation (HTC) (Ludwig/Gawel/Pannicke 2015a; Gawel/Ludwig/Pannicke 2015) as well as on the overall legislative framework for the forest-based bioeconomy in Germany (Ludwig/Tronicke/Köck 2014b).


BioEconomy Cluster

Fact Sheets zur Bioökonomie

1 Recht und Politik

„RECHTSRAHMEN DER FORSTBASIERTEN BIOÖKONOMIE IN MITTELDEUTSCHLAND" – BESTANDSAUFNAHME

Status Quo and Trends: The Wood-based Bioeconomy in Germany

In Germany, the **contribution of the bioeconomy sector** - that is, all sectors involved in the production and processing of renewable resources - **to the overall value added** has increased slightly in the last few years. The bio-based economy includes the agriculture and horticulture sectors, the forestry and wood industry, the fishing industry, the bioenergy sector, the tobacco processing industry, the textiles and clothing industry, leather manufacturing, the manufacturing of chemical products and rubber and plastic products, and ultimately also bio-based services. In 2007, its share in the German economy already accounted for 12.5 % of the working population (4.96 million workers) and 7.6 % of the gross value added (160 billion €) (Efken et al. 2012).

In the wood sector, the energy-related and material **use of wood** has doubled over the last two decades, amounting to 135.4 million cubic meters in 2012 (Mantau 2012, S. 15). A high portion of the demand for wood can be attributed to energy-related uses (Figure 2). The share of energy-uses exceeded the material use for the first time in 2010 (Figure 3).

The **material use** of wood for **innovative applications**, for example in the chemical industry, is however rather small, accounting for only 2.2 % of Germany's total wood consumption (FNR 2014a, p. 58). The innovative use of renewable resources is most advanced in the automotive industry where a total of 30,400 tonnes of wood and a further 50,600 tonnes of other natural and wood fibres were used in 2012 (FNR 2014b, p. 12).

In general, the material use of wood remains dominated by **traditional sectors** such as the sawmill industry, the timber industry, and the paper and pulp industry (Figure 1).

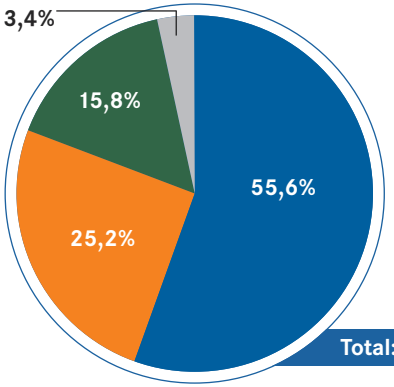

Fig. 1: Wood Use: Material-related use in Germany in 2010

- Sawmill industry
- Wood materials
- Wood pulp and cellulose
- Other material uses

Source: Mantau 2012

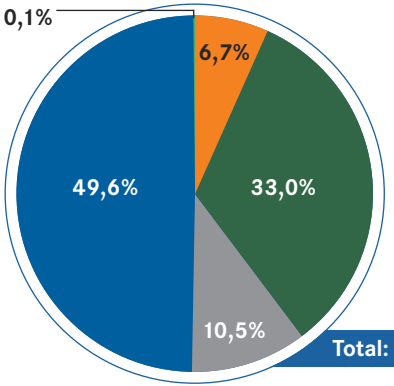

Fig. 2: Wood Use: Energy-related use in Germany in 2010

- Manufacturers of energy products
- Energy-related use > 1 MW
- Energy-related use < 1 MW
- Domestic fuel
- Other energy-related uses

Source: Mantau 2012

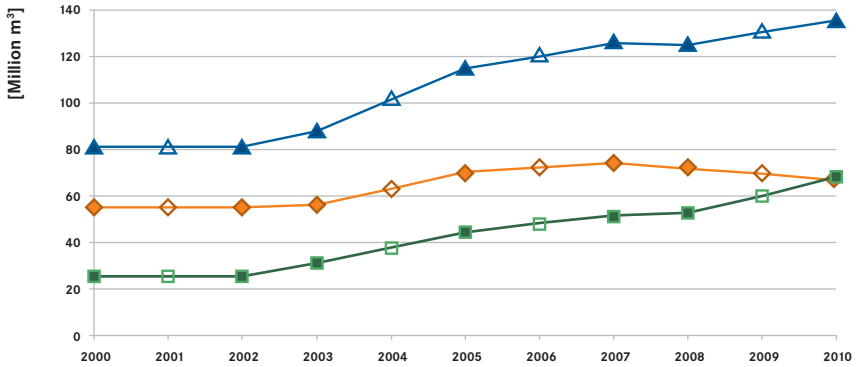

Fig. 3: Wood Use in Germany from 2000 to 2010

- Total wood use
- Total material use
- Total energy-related use

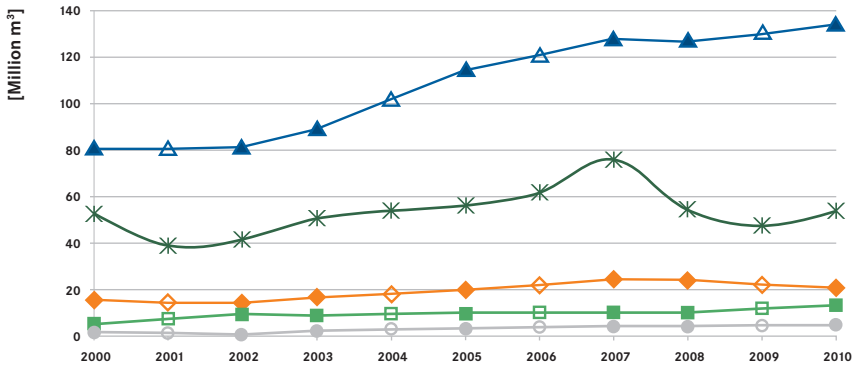

Fig. 4: Wood Supply in Germany from 2000 to 2010 (imports not incl.)

- Total fellings from forests in Germany
- Total wood supply
- Wood residues from production
- Waste wood
- Material from landscape conservation

Sources: BMVEL 2005, p. 3; BMEL 2014b, p. 4; Mantau 2004, p. 20; 2009, p. 28; 2012, p. 15; Speth 2013, p. 33; missing values (in white) were estimated

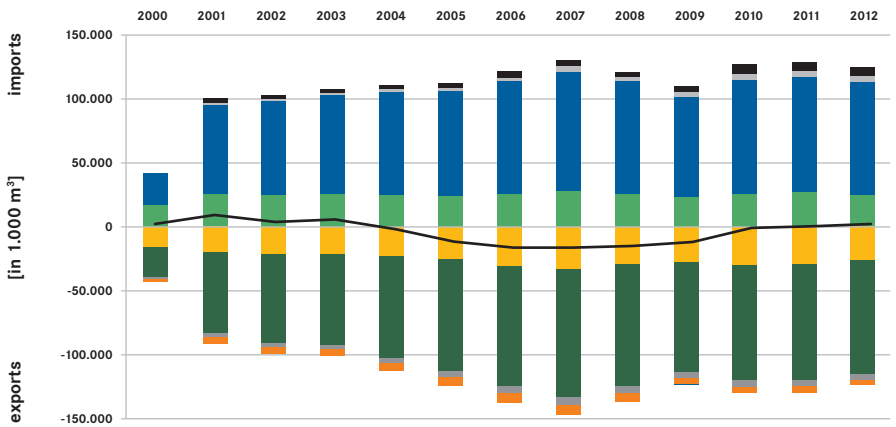

Fig. 5: Imports and Exports of Wood and Wood Products in Germany from 2000 to 2012 in 1,000 m³

- Raw wood - imports
- Wood residue - imports
- Semi-finished goods - imports
- Finished products – imports
- Raw wood - exports
- Wood residue - exports
- Semi-finished goods - exports
- Finished products – exports
- Net trade balance

Sources: Dieter 2002, p. 11; 2003, p. 13; 2005, p. 20; 2006, p. 12; 2007, p. 14; Seintsch 2010, p. 15; 2011, p. 14; Seintsch/Weimar 2013, p. 15; Weimar 2014, p. 15

Approximately two thirds of the wood used in Germany comes from **German forests**. Roughly one quarter of the wood used in Germany are residual materials from production such as sawmill by-products and industrial wood residues as well as waste wood. Other **domestic sources of raw wood materials** include **landscape conservation measures** and **short-rotation coppices** (for a representative example of selected sources of raw wood materials see Figure 4).

The international trade in wood has also increased (Figure 5). Due to the presently low mobilisation of potential wood reserves such as wood from private forests and waste wood, the increasing demand for wood in Germany is primarily met by **imports**. In the period 2000-2012, the volume of trade in wood and wood products almost tripled. Nonetheless, Germany is currently a slight **net importer of wood and wood products** because there was also a similar increase in export quantities in the same period (Figure 5).

Status Quo and Trends: Wood-based Bioeconomy Policy in Germany

The Federal Government of Germany is committed to the bioeconomy as a strategic option and this commitment is anchored in several of its more recent **programmes and strategies** (Table 1).

Nevertheless, an independent field of a bioeconomy policy has not evolved so far (Pannicke et al. 2015b) – nor is there a clearly outlined Law of Bioeconomy (Ludwig et al. 2015d). For the individual bioeconomy sectors and also for the different value creation stages (raw materials, processing, products, recycling), this means that the respective sectoral laws and regulations still apply. This situation hinders consistent development – see, for example, Ludwig et al. 2015a on hydrothermal carbonisation (HTC).

Table 1: Programmes and strategies of the German Federal Government related to the bioeconomy

Programmes and strategies	Content
National Policy Strategy on Bioeconomy (BMEL 2014a)	Main strategies concerning the material recovery of biogene resources, including wood
National Research Strategy BioEconomy 2030 (BNBF 2010a)	
Action Plan of the German Federal Government on Material Usage of Renewable Raw Materials (BMELV 2009)	
National Biomass Action Plan for Germany (BMU/BELV 2010)	
Perspectives for Germany. Our strategy for sustainable development (Bundesregierung 2002)	Overarching guidelines for a sustainable development
National Programme for Sustainable Consumption (BMUB 2016)	
Ideas. Innovation. Prosperity. High-Tech-Strategy 2020 for Germany (BMBF 2010b)	Important strategies regarding Research and Development
6th Energy Research Programme of the Federal Government (BMWi 2011)	
Strategy of the Federal Government for the Internationalisation of Science and Research (BMBF 2008)	
National Strategy on Biological Diversity (BMUB 2007)	Important strategies regarding health and nature protection
Health Research Framework Programme of the Federal Government (BMBF 2010c)	
Forestry Strategy 2020 (BMELV 2011)	Strategies regarding wood and forests in general
Increased wood use (BMELV 2004)	
Joint instruction on the procurement of wood products (Bundesregierung 2010)	

Wood-related bioeconomy policy rests on three pillars (Figure 6):

- Direct policies supporting the bioeconomy resource base,
- Direct policies promoting bio-based processes and products, as well as
- Indirect policies which have a restrictive effect on the competing use of fossil resources and fossil based processes and products.

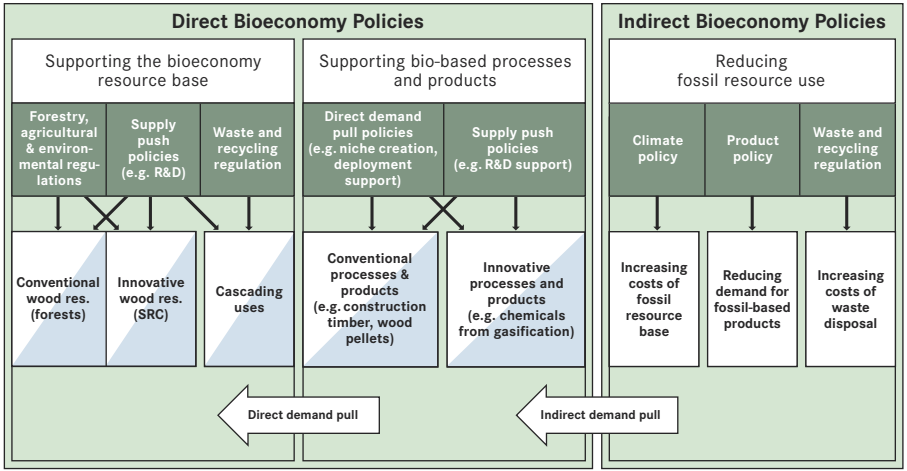

Figure 6: Three pillars of wood-related bioeconomy policies (blue colored: explicitly sustainability oriented policies) Source: Pannicke et al. 2015b, p. 226

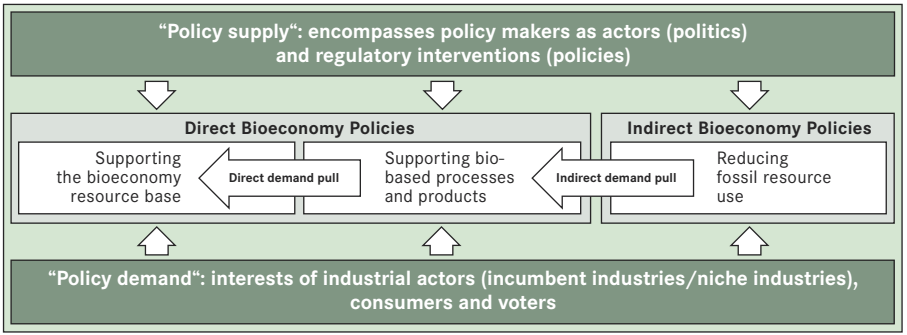

Figure 7: The "market" for bioeconomy policies Source: Pannicke et al. 2015b, p. 232

However, policymakers will only offer appropriate policies if they are rewarded by **voters and interest groups** in their role as "policy demanders" (Figure 7).

Elements of the Scenario Analysis

Actors

Key influencing factors

Policy recommendations

Influencing factors

Scenarios

Storylines

STEP 1: DEFINITION OF RELEVANT INFLUENCING FACTORS

Selection of Relevant Influencing Factors

The scenario analysis begins with the selection of factors which might influence the wood-based bioeconomy in Germany and the subsequent identification of so-called "key influencing factors" based on expert opinion.

First, factors that might influence the development of the wood-based bioeconomy were identified based on a careful analysis of existing scenarios relating to bioeconomy, forestry and land-use.

In this first step, a total of 22 factors which could potentially influence the further development of the wood-based bioeconomy in Germany were identified (Table 2).

Table 2: 22 Generally Relevant Influence Factors

Category	Generally Relevant Influence Factors
Society/ Consumers	1A) Public influence
	1B) Environmental awarness
	1C) Risk and innovation attitude
	1D) Willingness to pay for bio-based products
	1E) Voting behavior (supporting sustainable politics)
Economy/ Producers	2A) Globalisation and global economic development (oil price/exports)
	2B) Domestic economic development
	2C) Supply and demand for wood
	2D) Willingness to invest in innovations
	2E) Focus on short term or long term-oriented profit
	2F) Site conditions (e.g., establishment of businesses, infrastructure)
Politics	3A) Energy- and climate policies
	3B) Technology, innovation and research policies
	3C) Forest, environment and nature conservation policies
	3D) Support of the circular economy
	3E) Support of local value chains
	3F) Direction of economic, competition, tax, industry and agiricultural policies
	3G) regional planning and development (e.g., role of federal states and regional associations)
Technology	4A) Innovations along the value chain of wood (including products)
	4B) Innovations for the exploitation of fossil resources (non-conventional)
Environment	5A) Climate change
	5B) Biomass availability/forest structure


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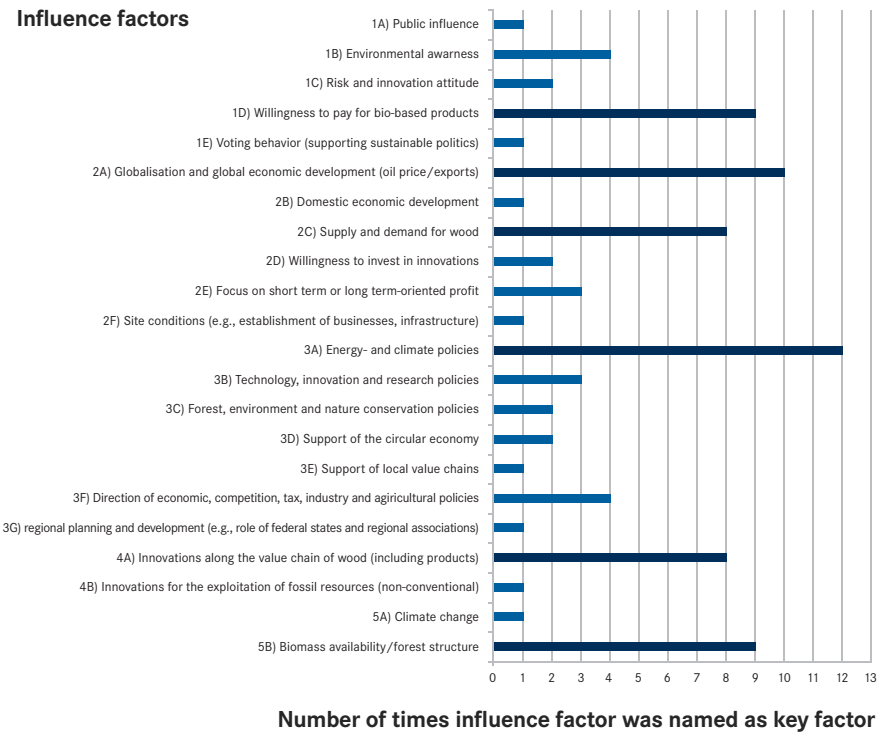
Deriving Six Key Influencing Factors

In all, 18 experts from the BioEconomy Excellence Cluster (including scientists from various disciplines, business representatives, cluster management board) were then asked to evaluate the five most relevant influencing factors from their point of view. Figure 8 shows that a total of six influencing factors – the so-called "key influencing factors" – were by far the most frequently mentioned:

- Consumers' willingness to pay for bio-based products,
- globalisation and global economic development,
- timber supply and demand,
- energy and climate policy,
- innovations along the value chain for wood including wood products and
- biomass availability/forest structure.

Figure 8: Relevance of potential influence factors (as estimated by experts)



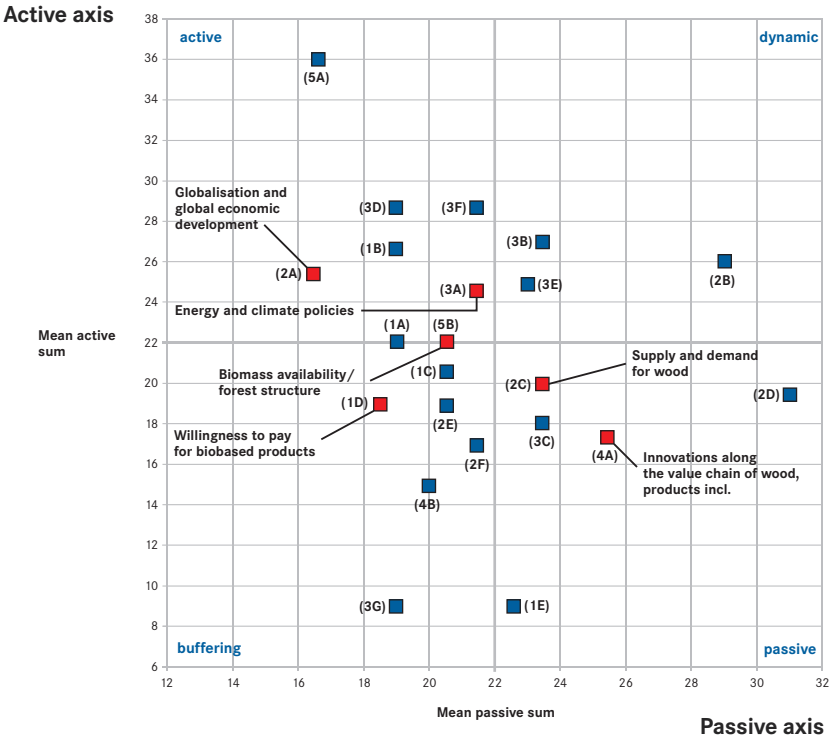


Figure 9: Interrelation of influence factors presented in a system grid

Clustering and Classification of Key Influencing Factors

The experts participating in the survey were also asked to appraise how those influencing factors might affect each other. Based on how they interact, the factors were then classified into “active/dynamic” and “passive/buffering” factors (Figure 9).

The influencing factors which in Figure 9 were assigned to the **“active”** quadrant on the top left have a major impact on other factors, but are only weakly affected by those other factors themselves. One example is globalisation, which of course cannot be steered by the other factors but which itself influences many of the factors listed – wood supply and demand, for instance.

Dynamic influencing factors (top right quadrant) also have a major impact on other factors, but they are also subject to strong external influences. None of the six key factors falls into this category.

Passive influencing factors (bottom right quadrant) do not display active characteristics, but they are strongly influenced by other factors. Due to this feature they are suitable indicators of overall development, for example, innovation along the wood value chain.

Buffering factors (bottom left) on the whole exhibit hardly any interdependencies with other influencing factors. Nevertheless, they can be relevant for the development of the bioeconomy as is, for example, the willingness to pay for bio-based products. However, the influencing factors in the other quadrants are of greater importance for the system as a whole.

Projections of Six Key Influencing Factors

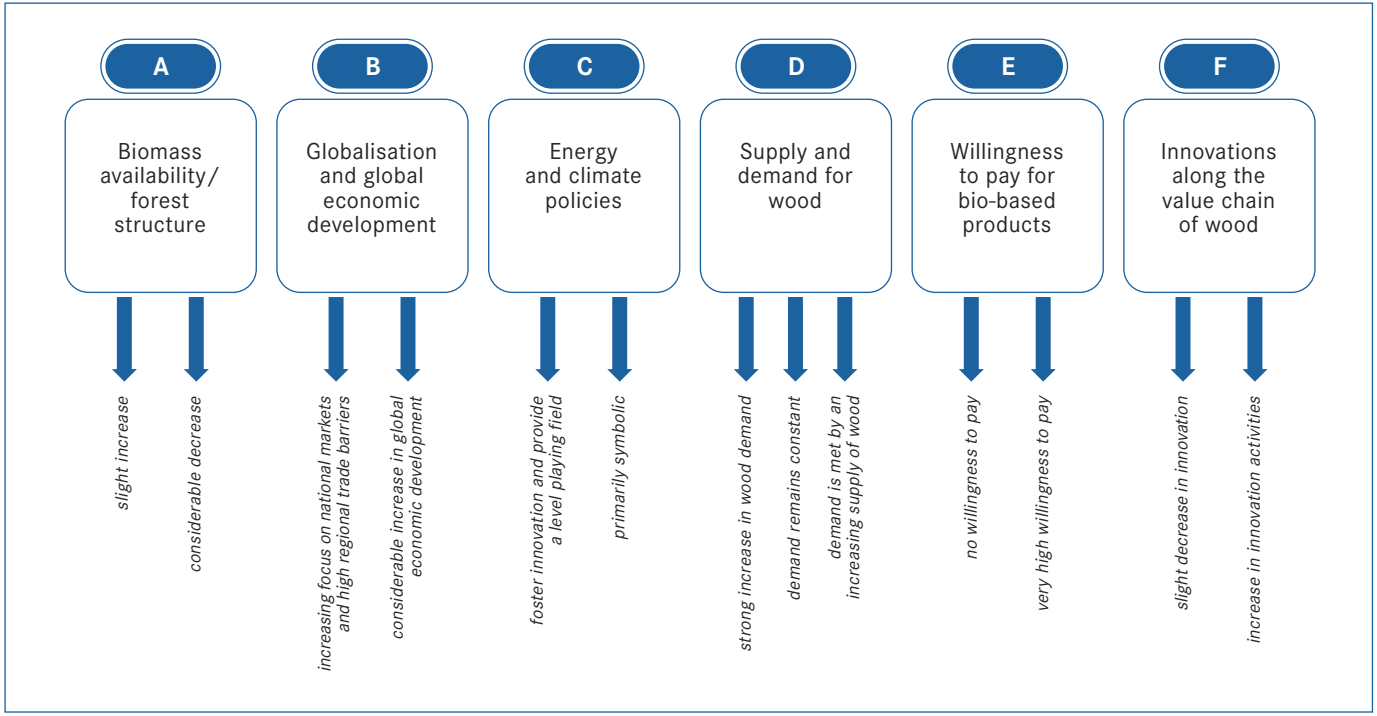


Figure 10: Overview of six key influencing factors and their projections

Overview of the Six Key Influencing Factors

In the following, those six key influencing factors, which the experts ranked by far the most frequently among the relevant determinants of the wood-based bioeconomy, will be characterised in brief. At the same time, the respective attributes of these key factors will be defined (e.g. “strong” or “weak”); these are needed later to create the storylines for the individual scenarios (for an overview, see Figure 10).

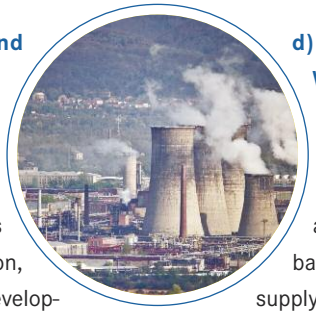
a) Biomass Availability and Forest Structure

How the bioeconomy will develop depends, among other things, on how much biomass is available in the first place. Decisions and strategies pertaining to future land use are highly relevant to this development, especially in the wood sector. Site conditions, forest structures and substrate diversity also play a role. Depending on technological advances as well as the legal and economic incentives, the use of waste products could also account for a significant share of the raw material base. The scenario assumptions about the future availability of biomass vary from “high” to “low” availability or productivity of the forest structure. A strong increase in the availability of high-quality biomass is considered unrealistic, because trees are slow-growing and the forest structure can only change gradually.

b) Globalisation and Global Economic Development

The development of national bioeconomies strongly depends on global economic trends such as long-term increases in the price of fossil resoures, global availability of biomass, the development of global trade routes as well as international regulations. All of the scenarios assume that – at least in the long term – oil prices will rise (again). Different assumptions were based on projections that the importance of national markets could increase due to high trade barriers or that global trade will increase and be accompanied by extensive dismantling of trade barriers.

c) Impulses from Energy and Climate Policy



International, European and national climate and energy policies affect the competitive position of fossil raw materials and fossil energy consumption, thus indirectly affecting the development of the wood-based bioeconomy. The overall potential for sustainable biomass production and the demand for energy from biomass is also impacted by climate protection and climate adaptation measures. For the development of the storylines, it is assumed that effective energy and climate policy promotes innovation and makes renewable energies competitive. By contrast, one scenario describes a future in which energy and climate policies remain largely symbolic and fail to set effective incentives for a true path transition.

d) Supply and Demand for Wood

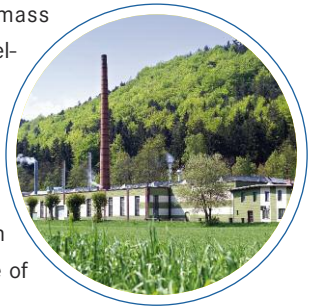
Just how quickly the wood-based bioeconomy can expand depends on the demand and supply for wood and wood-based products. The balance of supply and demand also determines the price of wood biomass. Because wood is mainly traded on global markets, foreign supply can strongly influence the price of domestic biomass and drive it out of the market. In addition, the demand for biomass in other sectors, for example, for the production of bioenergy, has effects on the market equilibrium. Given the importance of wood in the energy sector, none of the scenarios assume a significant decline in demand. The alternative scenarios assume either constant demand (due to the efficient use of biomass), increasing demand with a simultaneous increase in supply (accompanied by public concern over sustainability) or strongly rising demand which cannot be fully met (due to strict import regulations).

e) Willingness to Pay for Bio-based Products

Consumers' willingness to pay for bio-based products as well as their consumption habits affect demand and therewith also the profitability of investments along the value chain of wood. The acceptance of consumers as well as policy makers, who influence consumption patterns through political measures, is therefore crucial to the future development of new technologies and products (Peck et al. 2009). The scenario analysis covers a broad spectrum of future developments for this factor: The assumptions range from "practically no willingness to pay for bio-based products" to "very high willingness to pay". However, interaction between this factor and other influencing factors is comparatively weak. This indicates that willingness to pay for bio-based products is difficult to control by political measures.

f) Innovation along the Wood Value Chain

The future of the bioeconomy also depends on process- or product-related technological and institutional innovation, because innovation can lead to cost reductions. As another consequence of technological innovation, demand for biomass might fall if processes are developed which require less biomass input and/or involve the use of waste. The outward forms of the scenarios range from a slight decline in innovation activity in the case of weaknesses in the innovation system to an increase in innovation activity through which knowledge transfer and learning effects are generated. Such an increase in innovation activity would probably be accompanied by incentives from climate and energy policy, high willingness to pay for bio-based products and favourable biomass availability.




Szenario 1
Szenario 2

STEP 2: DEVELOPMENT OF SCENARIOS

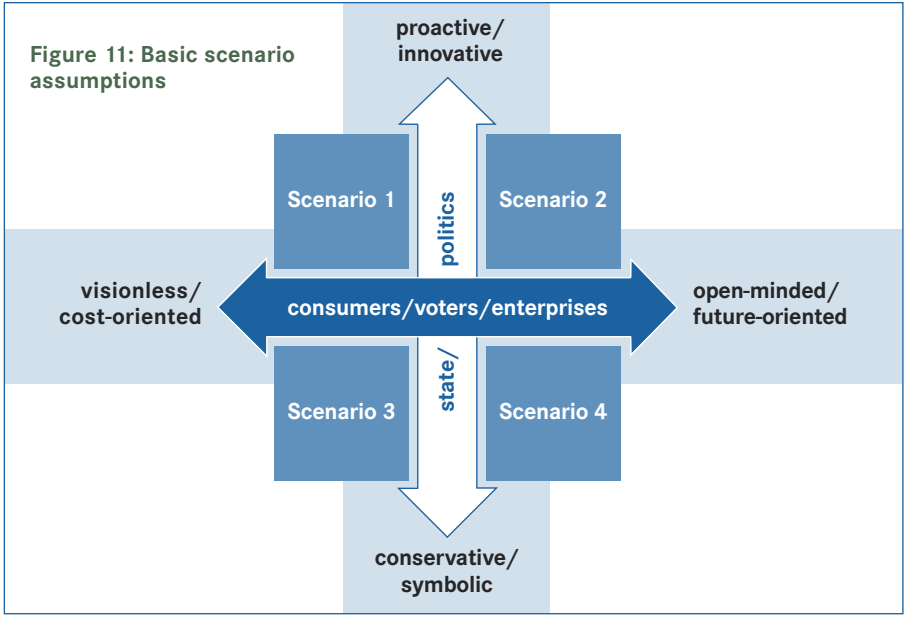
Deriving the Four Scenarios on the Future of the Bioeconomy

Based on the findings from the survey of experts, each of the four groups of actors – the state, voters, consumers and representatives of industry – plays a central role in the development of the wood-based bioeconomy.

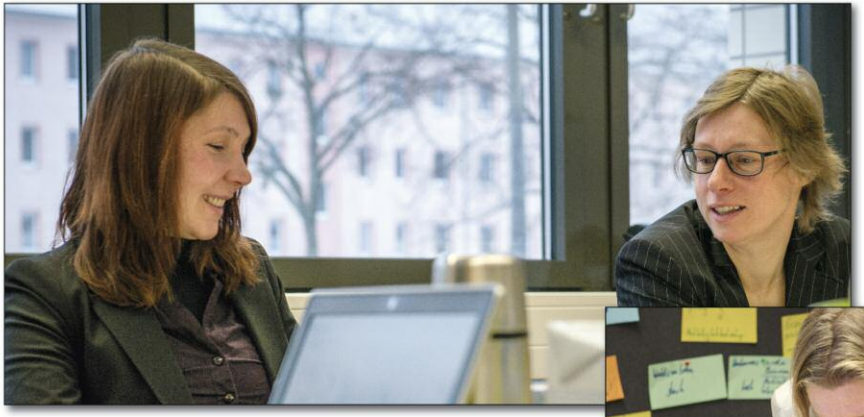
To simplify the analysis, these groups of actors are assigned to two categories, **the public and the private sector**.

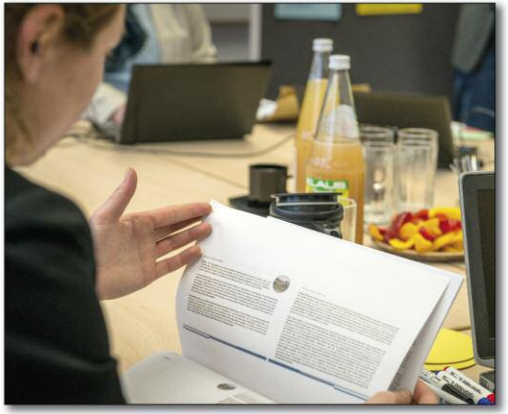
To develop the scenarios, the various conflicting assumptions about the possible behaviour of these groups of actors were then made, each of which epitomise either a favourable or a sceptical attitude (Figure 11).

Figure 11: Basic scenario assumptions



The possible combinations result in a total of exactly four alternative scenarios for the development of the bioeconomy (Figure 12).





Overview of the four scenarios

Scenario 1: Government as Driver

- A state which is oriented towards sustainability and promotes the bioeconomy is confronted with cost-oriented industry representatives, conservative consumers and critical voters.

Scenario 2: Trend Towards Sustainability

- A proactive, creative state is faced with open-minded consumers and producers.

Scenario 3: Keep going

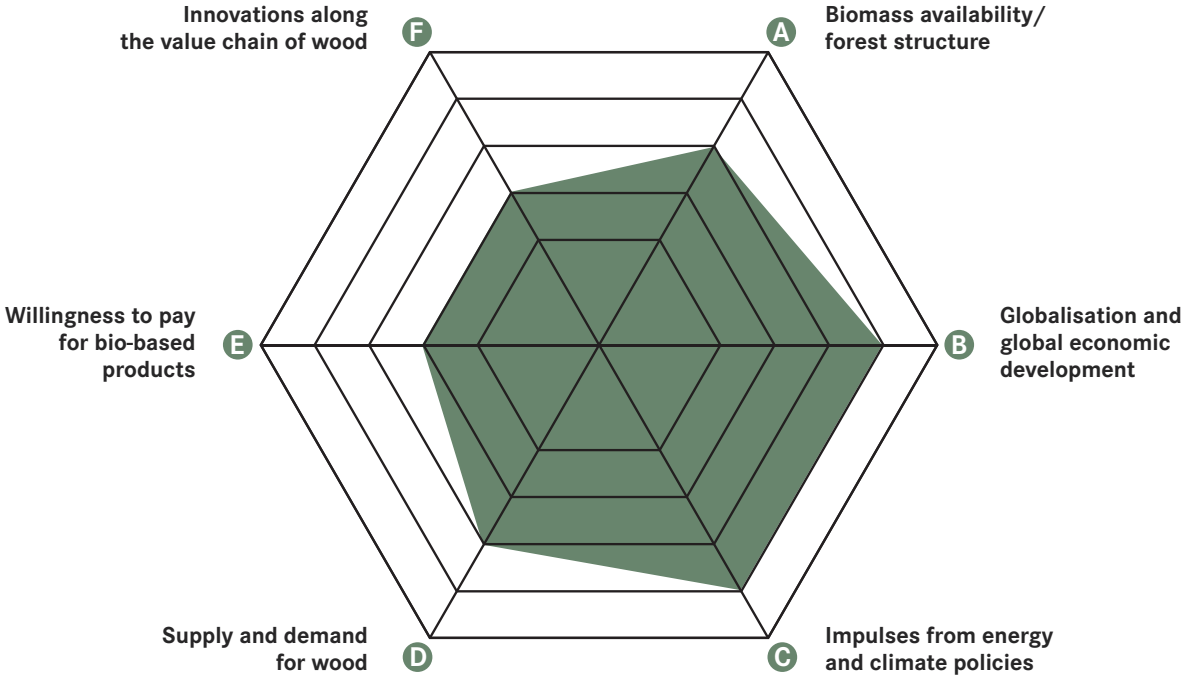
- State and society trust in traditional values and established structures; no one dares to make changes, rather they carry the short-term burden of proof for improvements.

Scenario 4: State as Obstacle

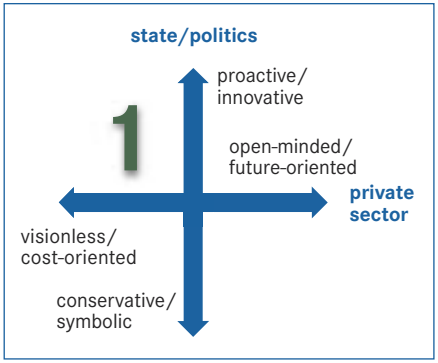
- In spite of impulses from an engaged society and businesses that are willing to innovate, a politically inactive, conservative state acts cautiously and attempts to maintain established structures.

Figure 12: Overview of the four scenarios

Figure 13: Scenario 1 (“Government as Driver”): Projection of six key influencing factors



The Storylines of the Four Scenarios



Scenario 1: Government as Driver

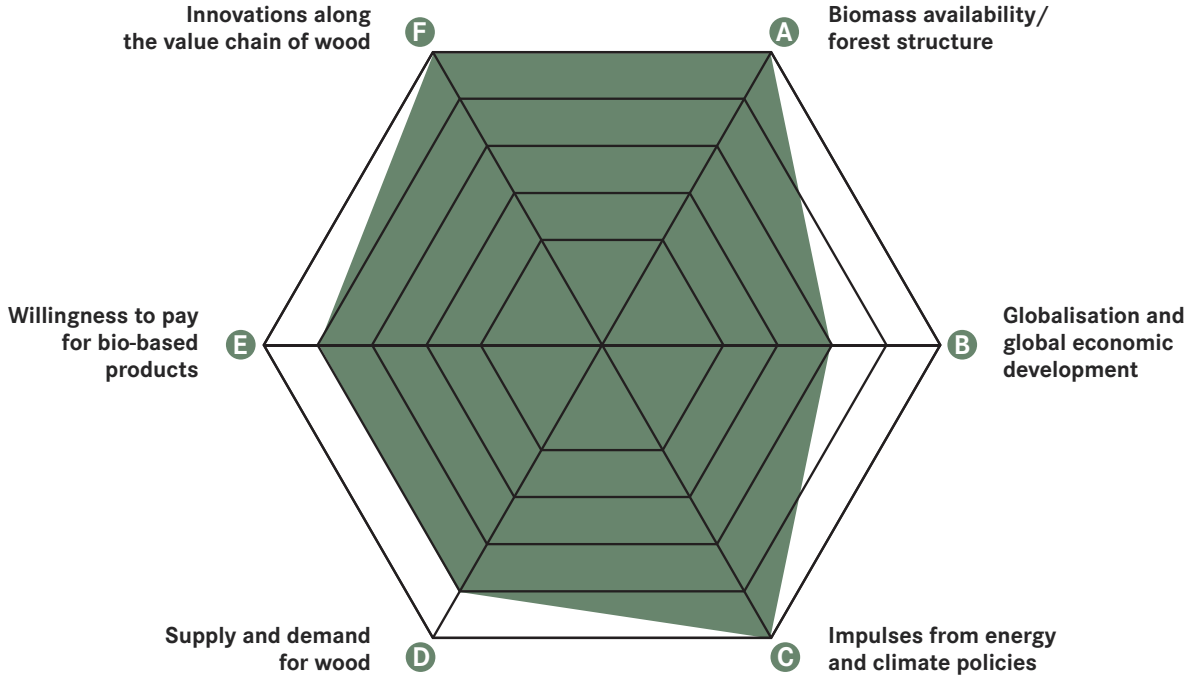
In the first scenario, the state plays a proactive role. It sees itself as a pioneer of sustainability and promotes innovative approaches which, however, raise various concerns among the public (e.g. in relation to competition for biomass use).

Consumers are price-conscious and cautious about buying bio-based products, their willingness to pay is low. In the business sector, too, the ambitious targets set by the government for the future development of renewable energies and climate protection are viewed critically. The companies are cost-conscious and risk-averse; they tend to aim for short-term benefits and only respond to political signals when the profitability of their investments is guaranteed. Although the state offers start-up funding, companies avoid making investments because they view the development of the supply of raw materials as well as long-term state support as uncertain. As a result, the rate of investment is low.

The moderately increasing demand for wood-based resources is met mainly by imports because most of the domestic wood reserves have already been tapped. Little use is made of potential sources of raw wood such as private forests or secondary raw materials (e.g. waste, cascade uses). Only a small number of innovative environments, which are motivated by government involvement in innovation, contribute to a moderate increase in the supply of wood-based raw materials. These stimulate only moderate forest restructuring towards a more diverse forest structure, which is characterised by innovative combinations of various indigenous tree species of different ages and is open to novel forest management methods.

This creates potential for a more diverse substrate supply for the wood-based bioeconomy.

Figure 14: Scenario 2 (“Trend Towards Sustainability”): Projection of six key influencing factors

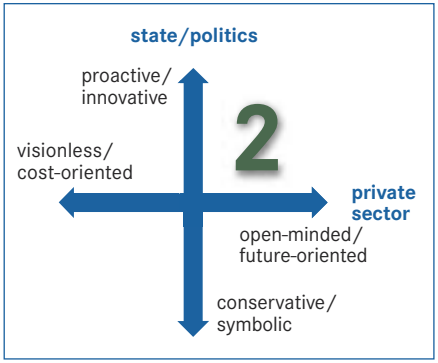


Scenario 2: Trend Towards Sustainability

In the second scenario, the government's ambitious targets for renewable energies and climate protection are strongly supported by the public and by businesses, even when they give rise to higher energy and production costs. Open-minded consumers and producers think about the long term and view the trend towards greater sustainability as an opportunity. In return for their high willingness to pay, consumers and voters demand transparency, the right to have a say, and quality control/assurance. Businesses profit from this trend and advocate cascade use, but demand adequate public support. In this scenario, innovation success is very high, also because investments in research and development are aimed at establishing technological standards.

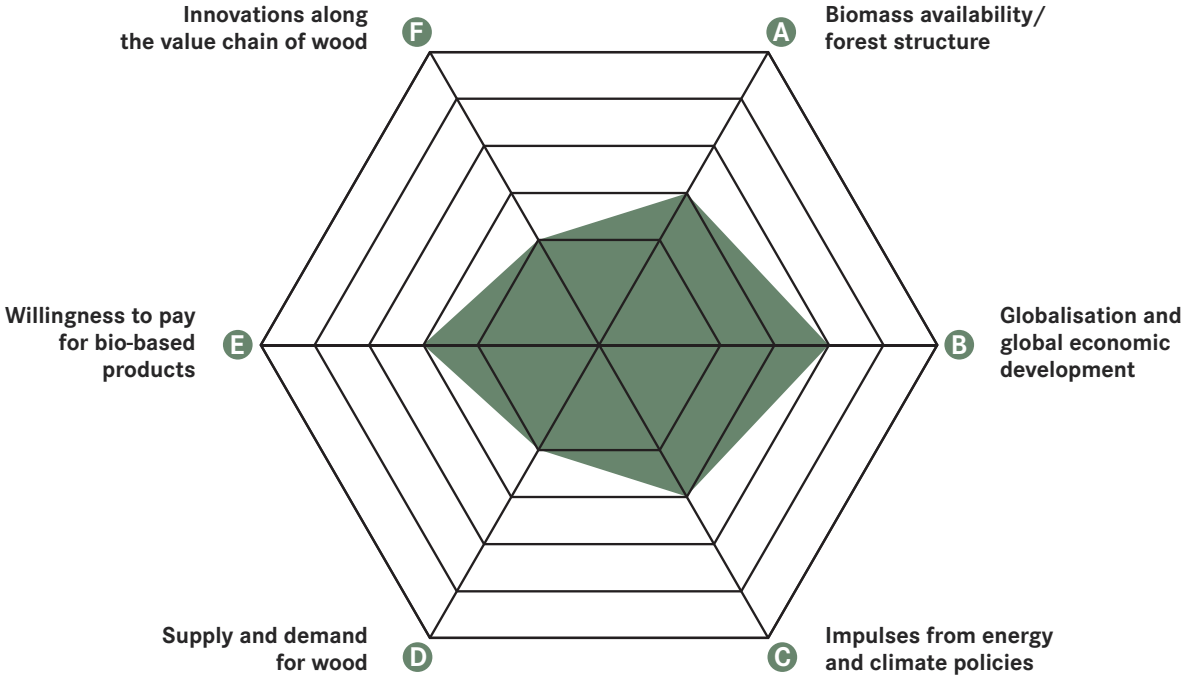
The state reinforces the transition to a bioeconomy by also striving to achieve economic sustainability: The high demand for wood-based raw materials encourages the state to implement policy instruments which reinforce the demand and supply of innovative technologies and products. This leads to positive feedback loops on the electoral market and in bioeconomy interest groups; this, however, gives rise to an increasing number of measures being implemented prematurely.

Innovative methods of forest restructuring which include the use of non-indigenous tree species are supported by society. A diverse forest structure and widespread cascade use lead to high substrate diversity. Innovative concepts involving the use of private forests also meet the high demand for wood. Nevertheless, the options for increasing the supply of wood-based raw materials for material use remain limited. Scarcity is exacerbated by the demand for wood – including wood from short rotation coppices on agricultural land – for energy-related uses. A growing share of the raw material demand is met by imports.



The low sustainability standards in relation to conditions of production in exporting countries make this situation possible.

Figure 15: Scenario 3 (“Keep going”): Projection of six key influencing factors



Scenario 3: Keep Going

Voters and producers are fully aware of the long-term challenges of sustainability, but they acutely shy away from fundamental reforms and also accept the steadily rising prices for fossil raw materials. Technical and institutional path dependencies in favour of established fossil structures retain the upper hand and therefore a carbon lock-in seems almost impossible to overcome.

A fundamental path transition towards decarbonisation and closing material cycles is, however, unlikely. Businesses continue to use and profit from existing fossil-based paths and few lock-out-relevant innovations are created. Cautious state support for research and development and a generally low level of interest in new sustainability-oriented technologies, processes and products also contribute to this situation.

Climate and energy policy targets do not go beyond rather vague international agreements and, in addition, are often not achieved. More ambitious targets or strategic approaches aimed at promoting material sustainability and energy efficiency remain largely symbolic. Thus, wood demand and wood supply do not receive any signals.

At the same time, changes in the areas of forest structure, silviculture and forest management are only marginal. Biomass from alternative sources, for example from private forests, landscape conservation or secondary raw materials from cascade use, remains largely unused because the overall demand for wood and alternative raw materials is low and cost disadvantages from the lack of internalisation policies remain. This situation gives rise to rather low substrate diversity.

External effects of the energy sector are not sufficiently reflected in prices, so that a strong substitution of fossil-based products and a sustainable structural transformation does not take place. All in all, in this scenario, the bioeconomy remains a niche sector.

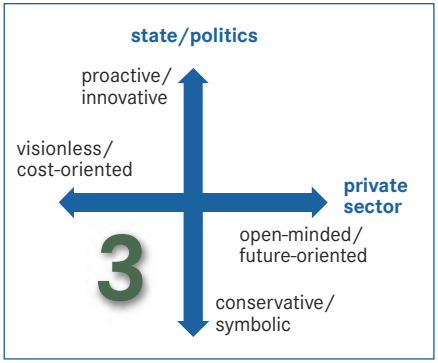
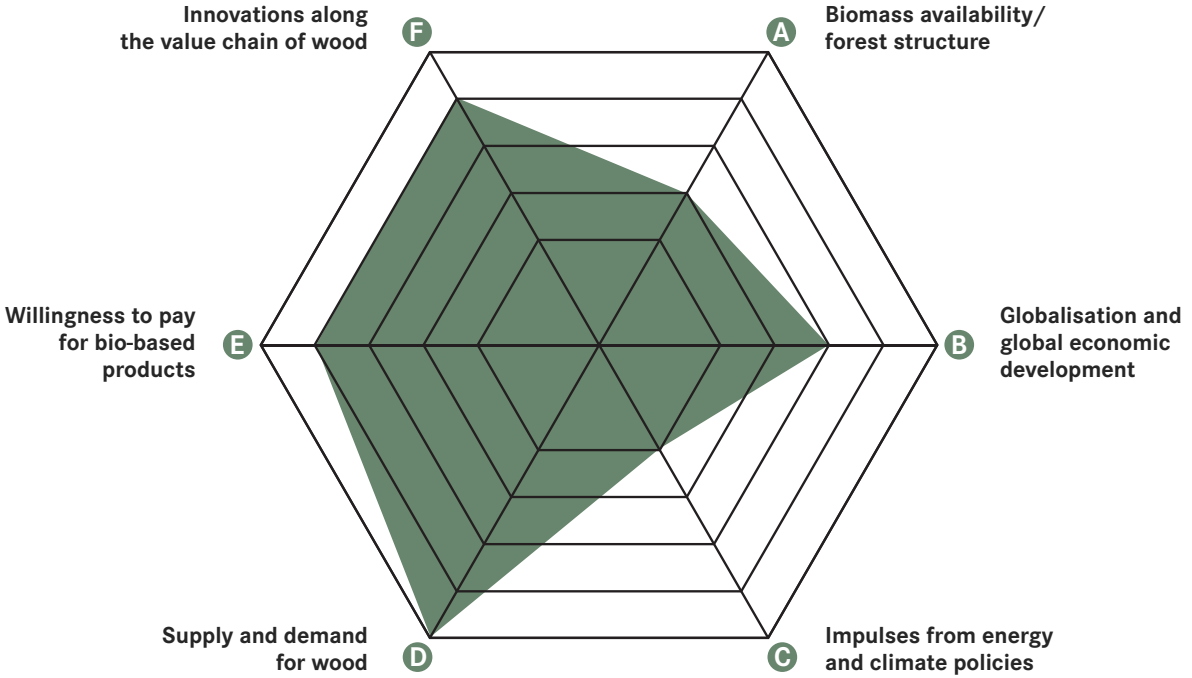


Figure 16: Scenario 4 (“State as Obstacle”): Projection of six key influencing factors



Scenario 4: State as Obstacle

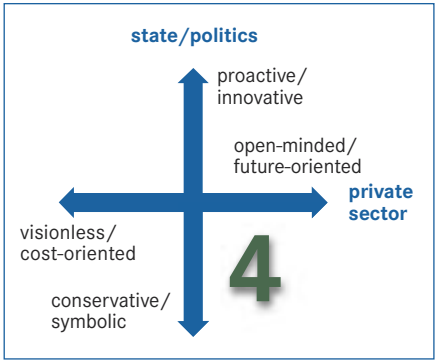
Open-minded consumers with a high willingness to pay, in combination with higher prices for fossil products, generate a noticeable increase in the demand for wood-based products. Private initiatives refer to the advantages of voluntary carbon markets, but the reach of such initiatives remains limited due to a lack of political support.

Producers act with the long term in mind and see the trend towards sustainability as an opportunity. Large businesses strive to promote innovation by making their own investments. In contrast, small and medium-sized businesses are dependent on state support, which doesn't exist. Nevertheless, small businesses manage to some extent to build up networks, thus creating synergies and learning effects.

A high level of willingness to innovate displayed by businesses is confronted with a cautious state, which responds only hesitantly to demands for support for sustainability innovation. In other sustainability policy action fields, the state remains rooted in traditional structures and shys away from the political and short-term economic costs of transforming the system. Instead, the demand for sustainability reforms is met with symbolic measures which are mainly initiated after high-profile events. But these measures are only implemented partially or not at all and, fail to bring about any sustainable structural transformation.

With regard to climate protection, options such as natural gas, carbon capture and storage in combination with cost-efficient renewable energy technologies play an important role. However, a profound transformation of the energy system does not take place.

Consequently, the throughput economy based on fossil raw materials persists. Experiments,



for example with new tree species, lead to a slight increase in substrate diversity. Due to the lack of demand, the import quota is quite low.

Overview of Projections of the Four Scenarios

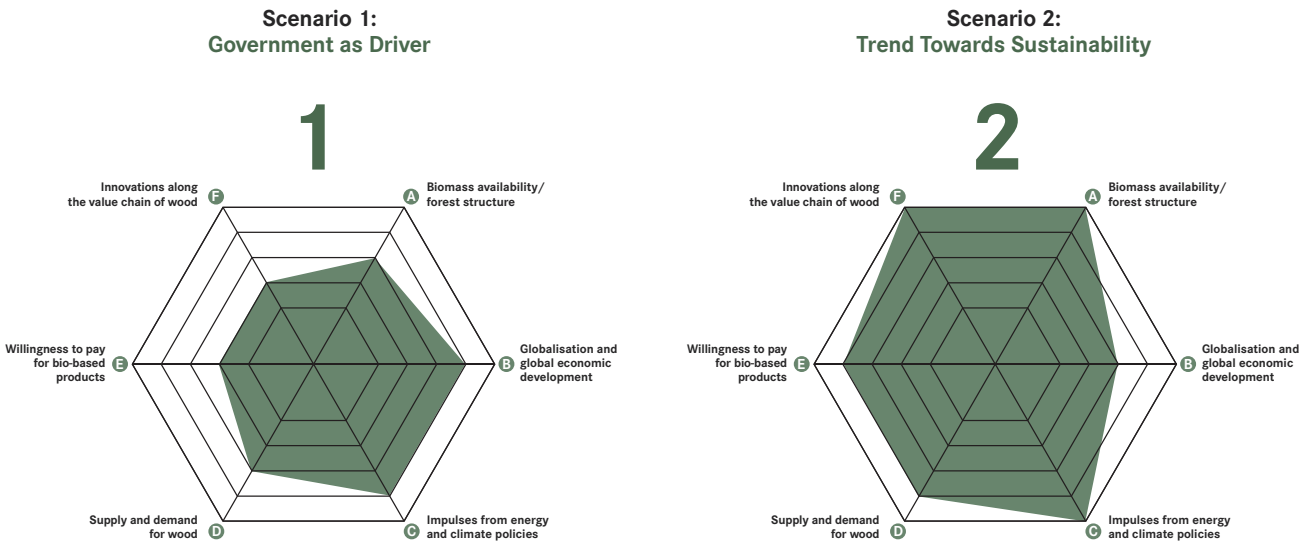
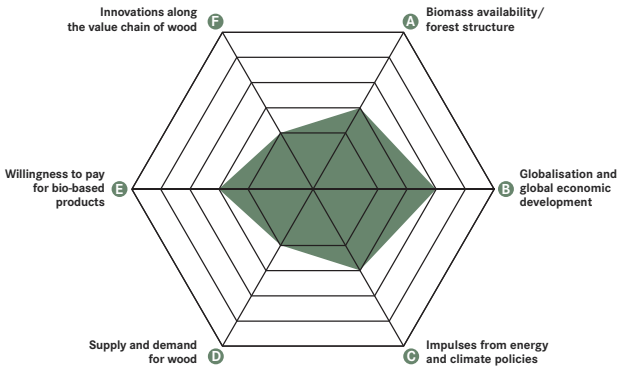


Figure 17: Overview of projections of the four scenarios

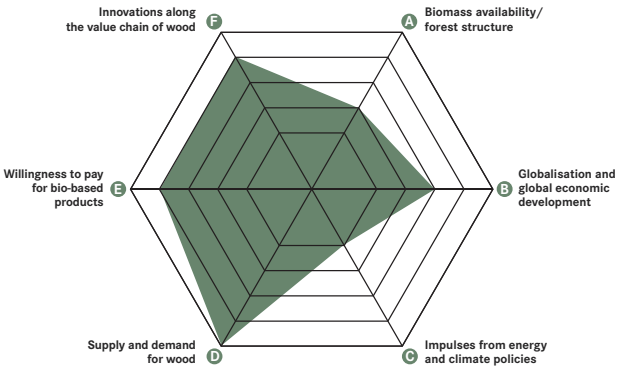
Scenario 3:
Keep Going

3



Scenario 4:
State as Obstacle

4



» Bioeconomy has to be more than just conducting business with bio-based raw materials. As a normative concept of sustainable economic development preferably conducted in closed material cycles, it also offers, in addition to a vision, a projection for numerous social, political and economic objectives and demands.

Against this background, the scenario analysis shows that making the transition towards a bioeconomy is associated with numerous unavoidable conflicts of interest and frictions, and the sustainability of such a development requires its own political safeguarding. «

Univ.-Prof. Dr. Erik Gawel

STEP 3: DEDUCTION
OF RECOMMENDATIONS

Implications of the Scenarios for Policy Makers, Businesses, Consumers and Voters

What conclusions can be drawn from the scenario analysis? Clearly, in all of the scenarios, various **uncertainties** have an important impact on the future development of the bioeconomy (cf. Purkus et al. 2015). This is not surprising, given the scope of the transformation of our entire economic system and lifestyle that is needed. These uncertainties include factors such as climate change, the economic framework conditions such as globalisation and global market prices, the discovery and utilisation of **new sources of fossil resources**, future biomass availability, process- and product-based innovation potential, but also the effects of international conflicts.

Many of these uncertainties can only be controlled to a very limited extent **by policy**.

Businesses, however, make their investment decisions on the basis of the structure and extent of such uncertainties. Vandermeulen et al. (2012) show that businesses need long-term, stable political framework conditions. Unstable political framework conditions or erratic policy signals represent an additional risk. **Consumers** are often less well informed about the risks and uncertainties of the different methods of resource utilisation; this directly influences their acceptance of new products. Therefore, the generation, availability and distribution of information on bio-based economic activity are key to increasing acceptance of and the demand for wood-based products.

Policy-making, however reaches its creative limits wherever consumers and producers do not accept incentives or are not, if necessary, willing to pay higher prices. Conversely, bioeconomy policy must ensure that the added social value of the bioeconomy (e.g. its contribution to decarbonisation) is adequately reflected in market prices.

» The legal framework for doing business is a relevant factor in the creation of market opportunities in the bioeconomy. The more consistent a legal system is in its requirements for climate protection and a circular economy and the more sensitive it is to the specific characteristics of bioeconomy products, the better the bioeconomy can demonstrate its advantages on the market.

To achieve a sustainable bioeconomy it is essential to maintain and safeguard the raw material base in one's own economic area and to strike a balance between ecological protection and economic utilisation interests.

In addition, it is important to ensure that sustainability requirements apply also to (raw material) imports e.g. through effective certification systems. Here, too, the law is extremely important as an instrument of control. «

Univ.-Prof. Dr. Wolfgang Köck

Implications of the Scenarios for Policy Makers, Businesses, Consumers and Voters

Ultimately, the impulses required to achieve a **comprehensive path transition** – in a similar way to the energy transition – can only be sent by an **active bioeconomy policy under the responsibility of the state**. However, these impulses will only be forthcoming if they are also expected to garner enough support on "political markets".

Coalitions of companies and social groups who support a sustainable bioeconomy politically can play an important role here by balancing the political weight of actors who have invested in fossil-based paths (Lehmann et al. 2012; Dewatripont / Roland 1995) and therefore tend to be interested in maintaining the status quo.

Three dimensions should be taken into account when shaping bioeconomy policy. First, in view of the growing demand for biomass, it is necessary to examine to what extent existing policies on forestry, agriculture, the environment and trade need to be adapted in order to ensure sustainability. In addition, waste policy needs to be adapted in order to set incentives for sustainable circular economy concepts. Second, research and development, knowledge sharing and niche creation (e.g. through public procurement provisions or the introduction of sustainability labels) should be promoted in order to push forward the development and distribution of innovative bio-based products and processes. Third, there is a need for policy measures which drive up the costs of competing, fossil-based alternatives directly, thus indirectly promoting the spread of bio-based options.

In view of the ubiquitous implications of uncertainty it can, moreover, be concluded that a **gradual introduction of well-defined, strategic policy measures** aimed at improving the position of the bioeconomy appears more promising than the premature implementation of numerous new instruments to give a strong push to the bioeconomy. Instead, the **governance of the bioeconomy as a "learning system"** should gradually but reliably set impulses for a sustainable transition path. However, this also assumes that the contours of "bioeconomy policy", as a genuine field of policy, and "bioeconomy law", as a discrete field of law, will need to be more strongly defined in the future in order to be able to send non-conflicting signals from the state sector.

Conclusions

It is possible to conclude from the scenario analysis presented here that the wood-based bioeconomy certainly has the potential to make a substantial contribution to the transition from a fossil-based economy to a sustainable bio-based circular economy, providing certain conditions are met:

- The **state** creates stable, long-term framework conditions for the development of the wood-based bioeconomy. These comprise the direct promotion of innovative applications and technologies as well as steadily increasing costs for the fossil-based competitors. For this, coordination with global economic developments is just as essential as ensuring long-term political approval of the transformation towards sustainability.
- A **learning bioeconomy policy** is pursued which considers the uncertainties associated with a higher demand for biomass for energy-related and material uses, and attaches great importance to the sustainability assurance of bio-based economic activity (i.e. no support “at all costs”).
- **Consumers** recognise added social value in sustainable bio-based products, articulate a higher willingness to pay for those products, and are open to innovation. A consistent sustainability-oriented pricing policy, but also communication and information on the part of policy makers and businesses operating in the bioeconomy, can contribute to this situation.
- **Businesses** look for long-term development opportunities, focus on innovation and quality, and form political alliances which confront the supporters of maintaining “fossil development paths” in the political sphere, too (not just on markets).
- A clearly outlined, genuine field of **bioeconomy policy** and a consistently pronounced, corresponding field of **bioeconomy law** is forming.

The scenario analysis provides specific recommendations, not least also for the **Bio Economy Excellence Cluster**, for contributing to the successful development of a wood-based bioeconomy in Germany:

- A strict **focus on added economic values** which, as a "sustainability service", "supply" something to society and do not "demand" anything from it:

  - identification of and specialisation in sustainable and competitive innovation,
  - utilisation of recycling potential and alternative raw materials,
  - investments in research for the targeted use of waste products,
  - strict adherence to and own research on sustainability standards (sustainability assurance),
  - integration of value added chains, in particular linking of material and energy uses, for instance through the cascade principle,
  - consistent and active communication of risks and consumer benefits.

- **Proactive Linking of Technology and Society**

  - The significance of the economic, legal and political influencing factors in these scenarios underscores the need to actively integrate the accompanying legal, economic and political research.
  - Creation of transparency in relation to the origin and processing of products.
  - Social visibility as actors, willingness to participate in dialogue, and political communication as strategic fields of action.

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Possible Futures towards a Wood-Based Bioeconomy: A Scenario Analysis for Germany

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Abstract: Driven by the growing awareness of the finite nature of fossil raw materials and the need for sustainable pathways of industrial production, the bio-based economy is expected to expand worldwide. Policy strategies such as the European Union Bioeconomy Strategy and national bioeconomy strategies foster this process. Besides the advantages promised by a transition towards a sustainable bioeconomy, these processes have to cope with significant uncertainties as many influencing factors play a role, such as climate change, technological and economic development, sustainability risks, dynamic consumption patterns and policy and governance issues. Based on a literature review and an expert survey, we identify influence factors for the future development of a wood-based bioeconomy in Germany. Four scenarios are generated based on different assumptions about the development of relevant influence factors. We discuss what developments in politics, industry and society have a central impact on shaping alternative futures. As such, the paper provides a knowledge base and orientation for decision makers and practitioners, and contributes to the scientific discussion on how the bioeconomy could develop. We conclude that the wood-based bioeconomy has a certain potential to develop further, if adequate political framework conditions are implemented and meet voter support, if consumers exhibit an enhanced willingness to pay for bio-based products, and if among companies, a chance-oriented advocacy coalition of bioeconomy supporters dominates over proponents of fossil pathways.

Keywords: scenario development; bioeconomy; Germany; uncertainty; renewable resources; wood

1. Introduction: The Wood-Based Bioeconomy—Aims, Perspectives and Uncertainties

Driven by the growing awareness of the finite nature of fossil raw materials and their climate change impacts as well as the need for more sustainable methods of industrial production and consumption patterns, the bio-based economy is expected to expand in the future. The bioeconomy sector is seen as a warrantor for a green economy: “[. . .] the use of biomass offers solutions to many of the problems of the fossil-input-based economy: it ensures both energy diversity and security and is environmentally friendly, owing to carbon sequestration and the resulting climate change mitigation” [1] (p. 454). As a result, expanding the bioeconomy has been identified as a strategic aim by the EU [2] and member states, such as Germany [3,4]. Also internationally, the transition to a bioeconomy garners political support [5].

Imprint

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Further information

Information on the accompanying research group of the Leading Edge Cluster BioEconomy is available at (German only): **www.ufz.de/biooekonomie/governance**

Information on the Leading Edge Cluster BioEconomy is available at: **http://en.bioeconomy.de**

Information on the Department of Economics is available at: **www.ufz.de/economics**

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