Preliminary Remarks

Next to agriculture, forestry is the most important sector of the economy that provides raw materials for the bioeconomy. As the bioeconomy continues to expand, we must ask whether wood as a raw material can be made usable for other purposes and whether it is possible to sustainably expand the quantity and quality of this raw material for current and future uses. It is necessary here to consider technological innovations, competitiveness aspects and conflicts of use with respect to other demands which are placed on forests.

Innovative use of wood

In Germany, wood has previously been put to mainly traditional uses, i.e. in the sawmill and timber industry, in the wood-based materials and pulp industry, and also as fuel. Until now the material use of wood and its components as a chemical and technical raw material has played a secondary role. Classic products based on solid wood, wood-based materials and paper will continue to be a significant contribution by the timber sector to the bioeconomy as they are essential for many areas of life. It can also be assumed, however, that the areas in which wood is used in future will diversify and that new high-quality products made from wood and wood components will become increasingly important. As a result, there will be a shift in the current sector boundaries between the various areas of the timber industry and other sectors of industry, such as the chemical industry. Due to very different material properties, there is only a limited possibility of wood being a direct functional replacement for steel and concrete. Nevertheless, a combination of materials could well gain further importance. It is to be anticipated that materials with functionalized fibers or paper composite systems will be used for specific applications in lightweight construction...
and vehicle construction. New high-tech products, such as nanocelluloses, biobased aerogels or wood-based components for 3D printing, are not yet visible in the market but in the long term could result in high-priced products with huge innovative potential.

There are two major lines of development for innovative biorefinery processes: One route is the digestion of wood with subsequent enzymatic hydrolysis to obtain fermentation feedstocks and lignin. Thermochemical processes which provide fuel or basic chemicals as a result of pyrolysis or gasification are another option for using wood and straw in biorefineries. But neither of these development lines is market-viable as yet. In some cases, the processes are still in the pilot phase, in others they are not yet competitive given the price of oil. An important approach for the future must be to intensify the links between the various options for use so as to further improve the efficiency and cost-competitiveness of using wood. This also includes increased utilization of waste streams or process bypass streams.

At present, around a third of the timber felled in Germany is burned. If sawmill by-products, wood waste and scrap wood are also taken into account, the proportion used for energy production increases to around half the wood production in Germany. So far the material use of wood in Germany has therefore remained well below its potential.

Ways of increasing timber production

For centuries, forestry and the timber industry have been a good example of a sustainable and competitive bioeconomy. Expansion of the bioeconomy, however, would run the risk of becoming a zero-sum game if it took place at the cost of existing areas of use. An increasing use of wood in Germany’s bioeconomy therefore also requires expansion of the timber resource base. There are various ways of approaching this.

Enlargement of the forest area

Since the beginning of the 1990s, moderate expansion of the forest area has taken place in Germany at the rate of approximately 10,000 ha per year. This expansion, however, has come to a stop. Enlargement of the forest area can lead to a conflict of aims between fuel and food if agricultural land that was previously used for food production is reforested. There would be less escalation of conflict, however, if some of the more than 2 million ha of agricultural land which are currently used for bioenergy production (based mainly on maize or rape) were to be reforested. Here, utilization as short rotation coppices (SRC, up to 20 years rotation time without legal conversion to forest area) could be considered. It should be pointed out, however, that fundamental reservations about such a change in land use are expressed by both farmers (long commitment of land) and the population (changes to the landscape, long-term nature of land).

Lowering the utilization age

On average, forests in Germany are getting older and their trees thicker; timber stocks are increasing. To some extent, this involves significant economic risks, such as increasing
numbers of damaging events, devaluation of the timber quality or lower prices for large dimensions. Reducing the timber stocks would make it possible to counteract these risks and increase timber production. Naturally, this measure is only effective in the short term, that is until stocks have been returned to a lower level. Conflicts with nature conservation objectives can be reduced by specifically building up stocks of old and dead wood in selected deciduous forests with a high level of importance for biodiversity.

Change in the composition of tree species

As a result of the debates about so-called forest dieback and near to nature forest management, large areas of existing conifer stands have been converted into deciduous stands over the last 30 years. The effect of this is that 80% of secured forest regeneration now consists of deciduous trees. Conifers are considerably more productive on average and, due to the properties of their wood, they are also better suited to many different areas of use. It is therefore possible to sustainably increase future timber production by steering the composition of tree species towards productive mixed forests with a larger proportion of softwoods. The softwood tree species of interest include established, introduced tree species, such as the Douglas fir and Grand fir, which display excellent growth and good resistance to climate extremes in Germany. They can easily be mixed with native tree species such as beech. In many places, this is possible without coming into conflict with nature conservation objectives.

Use of reproductive material

Long-term field trials show that using selected reproductive material from recognized existing forests with high productivity and timber quality can lead to an increase in yield of between 10% and 60%. The carefully controlled use of tested and quality-assured seed as a result of forest plant cultivation can significantly increase timber production. Against the backdrop of climate change with its consequences (drought stress, fungal and insect infestations), it is also very important to use forest reproductive material that is better suited and will contribute to minimizing worries about loss of production.

Necessary plant protection

Pests repeatedly attack different tree species in Germany in the form of mass infestations with differing degrees of sometimes devastating intensity. Climate change and the

Forest and Timber worldwide

- At just under 4 billion ha, forests still cover about 30% of the earth’s land surface worldwide.
- The area covered by forest is decreasing continuously, on average by 3.3 million ha a year between 2010 and 2015. The existing area of indigenous forest has decreased by 8.8 million ha a year. To some extent this loss has been balanced by natural reforestation amounting to around 3 million ha per year. In addition, the area of planted forests has increased by 2.5 million ha a year.
- Worldwide, felling of firewood and wood for material use are roughly equal at 1.8 billion m³ each. In developing countries, felling of firewood dominates at around 70%.
- Wood and wood-based products are also traded worldwide in a volume of approximately 1.8 billion m³ raw timber equivalent. Paper and pulp account for the largest share at 450 million m³ (r) trading volume, followed by mechanical and chemical pulp at 400 million m³ (r). The high global trading volume amounting to the total timber production shows that biobased transformation processes in Germany and Europe can influence the global trade flows of biomass.
- Further anticipated expansion of planted forests in the tropics and their productivity gains due to cultivation, fertilization or silvicultural measures raise expectations of increasing market production from these countries.
- Worldwide, the spatial separation of forest functions (segregation) is frequently the dominant strategy for dealing with different demands: Depending on how priorities are set, forests are then used first and foremost for the production of wood or they serve predominantly ecological goals, e.g. protection of biodiversity; erosion control. In many developing countries, forests also play an important role as a source of raw materials and food for the rural population. These include fuel wood on the one hand, grazing pasture in the forest or the use of twigs and branches as cattle feed on the other hand. This use of forests is found mainly in subsistence farming.
increasing spread of introduced or immigrant pests due to globalized trade flows mean that such damage is likely to increase. It is possible in principle to counteract this using silvicultural, biological, mechanical and technical not to mention chemical measures. If alternatives are not available, chemical control measures must be considered as a last resort as part of integrated programs to protect forests where there existence is threatened. The use of chemical control measures must be weighed against the potential disadvantages for biotic communities in forests.

**Ecosystem services and goal conflicts**

Forests frequently fulfill several functions simultaneously. These ecosystem services include above all timber production, the role of forests for recreation or as a cultural resource, their contribution to soil protection and erosion control, water regulation and contributions to climate protection (CO₂ sink) and nature conservation (habitat function).

The many different roles assigned to forests give rise to conflicting goals which could be further exacerbated by a growing bioeconomy with a higher anticipated demand for wood. Essentially, it comes down to a conflict between forest protection and forest management. As part of the biodiversity debate, there was a call for unmanaged forests which should be left to develop naturally until 2020. They are included in the National Biodiversity Strategy (NBS) as a 5% target for forest coverage. At the same time, 2% of the land area should also be developed as wilderness areas. The following basic principles apply to requirements exceeding this: The fewer the interventions in the forest, the more old and dead wood structures form. These structures are home to many rare species. However, there are different estimates about the necessary threshold values for the quantities of old and dead wood required for large-scale conservation and development of these species. The evidence base is still small. In particular, it should be improved for biotope tree and dead wood concepts where only individual trees or tree groups would be spared in managed forests.

In unmanaged forests, in addition to carbon sequestration in the living trees, the CO₂ balance of the dead wood and the build-up of humus on the forest floor also contribute positively to climate protection. However, in a comparison between the CO₂ balances of different forest management concepts for Germany, it has been shown that, in the medium term, the substitution effects resulting from replacing non-renewable resources, such as concrete, oil and steel, with wood, are greater than the sequestration effects which result from increasing the timber available to store CO₂ in forests. If timber is removed from forests and processed into products, the CO₂ emissions are lower overall than if the timber remained in the forests and products based on concrete, oil and steel were to be used instead. From a climate protection point of view, utilizing forests sustainably is therefore beneficial compared to „non-utilization“.

With advancing climate change, it is only possible to maintain the productivity of forests if they are adapted to the changed conditions for growth and survival. It is therefore...
important to consider extending the cultivation of introduced tree species and, after careful consideration, also to consider plant species that were not previously native. It may also become necessary to develop new forestry concepts which are better suited to dealing with the increasing regional scarcity of water.

Policy Recommendations

Maintaining and increasing the raw material base

Productive, sustainable forestry is essential for Germany’s route to a bioeconomy. If higher priority is to be given to pursuing this aim, then more attention will have to be paid to climate adaption and productivity when choosing the tree species for rejuvenation. The use of quality-assured reproductive material and the inclusion of a greater mixture of productive, location-specific softwood should be encouraged. The funding of forest plant cultivation is an important task for the future. The pertinent legal regulations, forestry programs and funding guidelines must be adapted accordingly. Research should be intensified into effective, and at the same time environmentally compatible, handling of the gradation of pests and into measures preventing the introduction and spread of new invasive pests.

The appropriate legal regulations at European and national level[18, 19, 20] should give even greater consideration than before to protecting forests in the future. Measures for moderate expansion of the areas used for timber production (timber forest, short rotation coppices) would also have to be examined. Plantings for timber production can be carried out particularly where they fit synergistically into land use systems, e.g. when creating habitat systems, on rewetted areas or as erosion control strips. Harvesting methods which do not unduly damage the soil and the remaining stock should be developed for timber extraction; new challenges will emerge here due to the lack of longer periods of frost during the winter.

With chemical plant protection, which is considered to be the last resort in preventing total loss, the range of active ingredients available is insufficient, particularly in the case of insecticides. Cooperation should therefore be expanded between the federal authorities involved in licensing plant protection products, the applicants for plant protection products and the competent regional authorities in the area of forest conservation. It is also important to further explore the complex interrelationships between natural (e.g. insect infestations) and anthropogenic (effects of plant protection products) disturbances. It is necessary to agree methodical development and regular monitoring efforts for early detection of mass infestations of potentially dangerous harmful organisms in cooperation between the Federal Government and the individual states. Exemptions to the use of aircraft for efficiently applying plant protection products must be retained.

To secure the role of forests in the bioeconomy, it is necessary to solve the existing goal conflicts between nature conservation, which restricts the use of forest wood, and resource protection, which is aimed at using it sustainably. For this, it is necessary to develop social models for using natural resources that are adapted to their location. This requires policy initiatives. Science should play a supportive role in this by drafting utilization scenarios for the most important locations, estimating their consequences (among other things based on recognized sustainability criteria) and consolidating them into assessment proposals for society as a whole. Based on this, science should examine which policy options, determined through political discourse, can best achieve the utilization routes favored by society.

Use and control of international trade

Raw timber and wood-based products can also be imported to cover increasing demand. Due to the huge global significance of forests for climate protection and biodiversity protection, it is necessary to pay particular attention to the sustainability of forest management in the regions of origin.

Sustainability certificates essentially deserve support because they can provide both end users as well as trading and processing companies with clarity regarding the origin of wood and the local conditions under which it is produced. In view of unresolved issues regarding the quality of certification systems currently in existence, it is recommended that research into optimizing checking systems should be intensified. In addition, policy should seek to harmonize the national inspection systems for the timber trade so that they grow together into a seamless international network which effectively prevents illegal logging and trading worldwide. This should involve investment in both the comprehensive analysis of satellite data[21] and also DNA sequencing to determine the origin of timber.
There are large areas around the world where forests have been degraded or have even disappeared completely. It is possible to create the potential for using wood in the future by rehabilitating these forests and carrying out reforestation. Such measures are particularly worthy of funding because they can be used at the same time to achieve various other objectives connected with nature conservation, climate protection and development cooperation. Consequently, the Federal Government should give higher political priority to this approach. It is important here not simply to stop at funding selected individual projects but rather, with the help of research funding, to work towards an internationally agreed, workable body of legislation for using wood sustainably in the bioeconomy. It is important to involve the local population in the measures implemented, particularly those for reafforestation if we are to achieve the long-term success required when establishing new forests.

**Improved and more efficient use of wood**

Improved use of wood can be achieved in two ways: firstly, by using wood for longer and if necessary re-using it several times (recycling, cascaded utilization), and secondly by using it more efficiently. More efficient use of the material enables the creation of more products per unit of raw material. Further development of the bioeconomy therefore includes not only expansion of the resource base but also the most efficient possible use of these resources.

Research and development should result in improvements to material efficiency in the traditional areas of use, e.g. the construction sector. Research and development, however, are equally necessary to integrate the use of wood as a chemical raw material in biochemical, chemical and thermochemical processes. On the way from idea to industrial implementation, the funding of research and development must focus increasingly on the specific conversion and use segments offering both market opportunities and material efficiency in terms of a major contribution to the bioeconomy. As yet, however, there is virtually no information available on this. The aim would be to create this information base by financing longer term large-scale projects at the interface between economy and technology in order to steer the funding of research and development into the most promising conversion and use segments. The development and use of cutting edge wood preservation processes is also important if wood is to be used for longer periods. However, there is still a need for more research if we are to ensure recyclability and re-usability in terms of cascaded utilization.

In the past, increased use of wood in the construction industry has often failed because of State Building Regulations. The revision of these regulations is proceeding albeit very slowly. The Federal Government, together with the federal states, should press ahead more quickly with adapting the building regulations to the latest scientific findings and technical standards so as to facilitate the use of wood in construction.
Bioenergy policy and wood

Wood currently makes a major contribution to the generation of energy from renewable sources. Its share of the final energy supply from renewable energies is approximately 40%.[2]

Wood is used mainly for heat generation; private domestic fuel clearly dominates here. The impact of funding on the demand for fuel wood, e.g., via the Renewable Energy Source Act [EEG], is comparatively low.

Since the use of wood for energy takes an important raw material out of the bioeconomy, we should refrain from funding its use for energy more strongly. From a macroeconomic perspective, funding would only be justifiable if using wood were to provide renewable energy at the lowest economic cost (taking into account all the positive and negative external effects that are associated with the various energy sources). With the given performance indicators for wind power and solar energy, however, this is not to be expected in individual plants, at least not in the field of electricity generation. Co-firing in coal-fired power plants is encouraged in some countries to reduce greenhouse gas emissions cost-effectively. However, this is not recommended for Germany.

Moreover, priority for the material use of wood does not in any way mean having to forego its use for energy; if, in the course of cascaded utilization, it is possible to combine preliminary material utilization and subsequent energy-based utilization or if by-products and waste products from wood processing are ultimately utilized for energy, then basically a double dividend is achieved.

Funding of research capacities and young scientists

It is vital for a sustainable bioeconomy to provide sufficient capacities at university level for research and teaching. Temporary research and teaching networks made up of representatives from parent disciplines (e.g., ecology, biology, economics) can be very valuable supplements; they cannot, however, replace the forestry expertise which is required as a foundation. Sustainable forestry requires an understanding of the system. This is only achievable at a higher scientific level if an adequate number of professorships with long-term prospects are dedicated to interdisciplinary research in the subject area of woods/forests/timber.

With the current state of the German research landscape, these basic requirements are not necessarily readily available. On the contrary, there is a relatively high risk that the image-raising activities of universities will prove a greater threat to the comparatively small forestry or wood science faculties and institutes than to the large faculties such as biology, law or economics. The state governments and the Federal Government, as well as the university managements, should also be requested to exert a controlling influence. To ensure and improve performance, they should develop transnational research and teaching concepts providing for close cooperation with state and federal research institutes.

Greater importance should also be attached to the forestry and timber sector in research funding. Here, it is necessary to develop longer term research strategies and to implement them with the necessary stamina and tenacity. This should be done interdepartmentally so as to consider the various demands on the forestry and timber sector in integrated concepts while at the same time bridging the gap between basic and applied research.
Endnotes


