**Document for consultation (without RIAs):**

**FTP SRA 2030 - 2nd FTP Stakeholder Consultation**

**How to contribute and what we want to know**

(We allow for both track changes and comments on the text)

Input on the Challenges:

Can you add supporting data, ideas and arguments to any of the Challenges?

Can you help us to explain better, improve the wording?

Do you have any suggestions for Research & Innovation Activities (RIAs)?

Which Challenges do you find most important/the best/the worst?

Do you consider any of the Challenges redundant, in order to reach the Vision Target?

Would you propose additional Challenges? If so why?

Suggesting RIAs – what to think about and some examples of “good” RIAs

Be short: One, max two, sentences and as clear as possible. Remember to describe an actual activity

Examples of good RIA texts:

* Generate a better knowledge of useful or harmful chemical compounds in different tree parts and biomass fractions
* Develop innovative processing concepts to be carried out during transport
* Develop environmentally friendly additives and impregnating agents to replace creosote in durable wood products
* Develop decision support tools to help forest managers optimize growth, resource efficiency and water productivity in changing environmental conditions.

Table of Contents

[1. Sustainable forest management, biodiversity and resilience to climate change 4](#_Toc6573222)

[A: Capitalizing on the interdependencies between forest management and functional diversity 4](#_Toc6573223)

[B: Strengthening forest ecosystem resilience and fostering Climate Smart Forestry 4](#_Toc6573224)

[C: Enhancing the vital role of forests in regional and continental water supply 4](#_Toc6573225)

[D: Mitigating wildfire risks in forested landscapes 5](#_Toc6573226)

[E: Improving the partnership with citizens 5](#_Toc6573227)

[**2. Increased, sustainable wood production and mobilization** 6](#_Toc6573228)

[A: Improving forest propagation material to increase productivity and resilience 6](#_Toc6573229)

[B: Utilizing the digital revolution for precision forestry 6](#_Toc6573230)

[C: Empowering small-scale forest owners 6](#_Toc6573231)

[D: Harnessing novel technologies and automation in forest operations 7](#_Toc6573232)

[E: Analyzing forest-based product markets and material flows 7](#_Toc6573233)

[**3. More added value from non-wood ecosystem services** 8](#_Toc6573234)

[A: Improving business opportunities for non-wood forest products 8](#_Toc6573235)

[B: Enhancing value creation with other ecosystem services 8](#_Toc6573236)

[C: Providing forest-based benefits for urban and peri-urban societies 8](#_Toc6573237)

[D: Capitalizing on the benefits of forest expansion as a consequence of land-use change 9](#_Toc6573238)

[E: Targeting forest governance to foster forest-based benefits for society 9](#_Toc6573239)

[**4. Towards a zero-waste, circular society** 10](#_Toc6573240)

[A. Optimizing material recovery through efficient detection, collection, sorting and separation 10](#_Toc6573241)

[B. Adapting reuse and recycling technologies to various types of complex and durable products 10](#_Toc6573242)

[C. Product designing for circularity - methods for cost assessment and optimization of recycling 11](#_Toc6573243)

[D. Boosting the circularity of forest-fibre commodities 11](#_Toc6573244)

[**5. Efficient use of natural resources** 12](#_Toc6573245)

[A. Reducing energy consumption in biorefineries, including paper mills 12](#_Toc6573246)

[B. Optimizing the use of wood raw materials 12](#_Toc6573247)

[C. Improving raw material efficiency and product valorization in sawmills and wood manufacturing processes 12](#_Toc6573248)

[D. Improving water balance and use of process water treatment 13](#_Toc6573249)

[**6. Diversification of production technologies and logistics** 14](#_Toc6573250)

[A. Developing industrial symbiosis 14](#_Toc6573251)

[B. Adopting additive manufacturing technologies and new production methods 14](#_Toc6573252)

[C. Extracting and producing natural compounds for different uses 14](#_Toc6573253)

[D. Improving traceability and chain-of-custody (c-o-c), throughout the value-chain 14](#_Toc6573254)

[E. Integrating autonomous and/or electrified working (e.g. harvesting) and transportation systems 15](#_Toc6573255)

[**7. Purposeful, safe jobs and links between rural and urban regions** 16](#_Toc6573256)

[A. Creative jobs growing the forest-based sector 16](#_Toc6573257)

[B. Creating job opportunities through economic incentives for management of small- forest ownerships 16](#_Toc6573258)

[C. Developing new market places and jobs in response to changing consumer trends 16](#_Toc6573259)

[D. Adapting job offers in an era of artificial intelligence (AI) 17](#_Toc6573260)

[**8. Renewable building materials for healthier living** 18](#_Toc6573261)

[A: Innovation in and optimization of building systems including modular and pre-fabricated systems 18](#_Toc6573262)

[B: Improving wood-based products for construction, including engineered wood and composites 18](#_Toc6573263)

[C. Harmonization and standardization research and more intelligent, digital design tools 18](#_Toc6573264)

[D: The experience of living with wood and researching its health benefits 19](#_Toc6573265)

[**9. New fibre-based products and 80 per cent lower CO2 emissions** 20](#_Toc6573266)

[A.Providing sustainable, fibre-based, high-value end-consumer products 20](#_Toc6573267)

[B. Developing more sustainable and competitive processes for paper-making and other biobased products of today and tomorrow 20](#_Toc6573268)

[C. Developing building blocks for biobased materials and chemicals in the circular society 20](#_Toc6573269)

[D. Adding value through digitalization and functionalization 21](#_Toc6573270)

[**10. Renewable energy for society** 22](#_Toc6573271)

[A. Developing advanced biofuels and chemicals and more efficient production technologies 22](#_Toc6573272)

[B. Enhancing bioenergy production through the valorization of forest residues 22](#_Toc6573273)

[C. Establishing integrated and holistic energy systems (including energy storage) 23](#_Toc6573274)

[D. Providing a fact-based approach for balancing energy production, environmental concerns and other needs of the bioeconomy 23](#_Toc6573275)

# 1. Sustainable forest management, biodiversity and resilience to climate change

The importance of sustainable and multifunctional forest management is widely acknowledged, due to its benefits for society. Resilient and diverse European forests, managed through different types of ownership, provide a wide array of forest ecosystem services including raw material production, climate change mitigation, biodiversity conservation and protection of water-related ecosystems.

Challenges

## A: Capitalizing on the interdependencies between forest management and functional diversity

Effects of management interventions on forest stand development depend on the relationship between biodiversity and ecosystem functions. This affects the capacity of forests to provide services to society, including biomass production, their resilience and, if needed, restoration potential. Research is needed on the cause-effect relationship between genetic and tree species diversity, structures at landscape and stand level, soil diversity, on the one hand, and silviculture and harvesting regimes on the other hand, on functional traits in forest ecosystems. Relevant traits have to be identified that enable better selection of species combinations that maximize ecosystem functions. The consequences for biomass production and carbon sequestration, biodiversity conservation and the provision of other ecosystem services have to be analysed with reference to all sustainability criteria, also considering climate change impact.

## B: Strengthening forest ecosystem resilience and fostering Climate Smart Forestry

The concept of Climate Smart Forestry combines reducing greenhouse gas emissions with adapting forest resilience and a sustainable increase in forest productivity and income. Considering local and regional circumstances, forest management has to maximize climate change mitigation and adaptation impacts, while mitigating abiotic and biotic risks. Research is needed on the utilization of vigorous genetic regeneration material and silviculture regimes to foster growth under changing climate conditions. Combined hazard impacts and risk interactions and the efficiency of prevention measures need more insights to enable new strategies for risk management to increase resilience and support the design of insurance schemes. Analysis of trade-offs between mitigation and adaptation measures is required to guide regionally tailored forest management strategies.

## C: Enhancing the vital role of forests in regional and continental water supply

Forests play a vital, but underappreciated role in ensuring water supply in sufficient quantity and high quality, and in mitigating water-related hazards. Increasing demand for fresh water, consequences of land use for regional and continental water balances, and climate change, impact on this role. Research is needed to assess the effects of forest composition and structure on rainfall patterns, water availability (quantity and quality) and flood prevention in relation to natural variations, forest management and climate change. This includes analysis of the sensitivity to local and regional climate, hydrological and cultural conditions. This will improve the integration of forest-driven water and energy cycles into regional, national and continental decision-making on climate change adaptation and mitigation, land use and water management.

## D: Mitigating wildfire risks in forested landscapes

Land abandonment, urban sprawling and changing climate conditions result in the growing risk of wildfire occurrence, severe consequences of greater intensity and severity on nature, the carbon sink and affected socio-economic systems. The resilience of forested landscapes needs to be strengthened by integrated fire management approaches with stronger prevention and preparedness efforts. Research is needed on the influence of climate change and socio-economic trends on the vulnerability of forested landscapes regarding wildfires, and on new approaches to improve their fire resistance and resilience, also addressing the wildland-urban interface. More insights are needed in fire prevention, behaviour, detection and post-fire recovery. This includes better fire risk assessment models, methods for detection of initial fire stages, decision support tools for integrated long-term fuel management, and the restoration of burned areas.

##

## E: Improving the partnership with citizens

The perception of the value of forests, their management and economic significance differs remarkably between certain sections of society and the forest-based sector. Societal promotion and public appreciation of actively managed forests for multiple benefits for citizens, including the use of wood for a wide variety of products and energy, have to be improved. Research is needed on the design of new ways of interaction with citizens to better understand their values and demands, build trust, and increase their awareness of the contribution of the forest-based sector in building a sustainable and climate-neutral society. This includes understanding citizens’ values and priorities across the EU and Europe, including a broader database on public perceptions of forests, new modes of interaction such as living labs and co-creation approaches, and novel methods such as citizen science and new media to connect the sector with the public, in particular with young citizens.

# **2. Increased, sustainable wood production and mobilization**

Forest growth is increasing, leading to increased CO2 sequestration. Management practices are being further optimized for even higher productivity and stand quality. The creation of climate change-resilient and stress-tolerant forests is particularly important.
Research, innovation and careful, long-term forest management have increased harvesting possibilities ﻿in Europe by 30 per cent, between now and 2040.

Challenges

## A: Improving forest propagation material to increase productivity and resilience

Changing growing conditions and new demands from more diversified forest-based products call for improved understanding of the genetics of trees. This refers to growth dynamics affected by climate change, susceptibility to interlinked disturbances including native and exotic pests, but also biomass characteristics relevant for the production efficiency, quality and value of traditional and novel wood products. Research is needed on new methods and strategies for tree breeding and propagation material provision, cultivating plants, establishing new forests, and effective regeneration. This has to include the design of protection measures for endangered genetic resources of high interest for climate change adaptation, and the design of measures for assisted migration. The consequences on the provision of high-quality seeds and plants of native and introduced species that grow better under future climate conditions, are more resistant to pest and diseases, and provide more suited wood qualities have to be analysed.

## B: Utilizing the digital revolution for precision forestry

New measurement technologies, remote sensing, land-based smart sensors, detailed production data from machinery, mobile devices, industrial scanning records and standardized interfaces, offer new avenues to establish Big Data hubs, enabling new levels of precision forestry using comparable and comprehensive data. The application of advanced prediction models, including artificial intelligence (AI) and Internet of Things (IoT), for the characterization, visualization, harvesting plans, retrospective traceability for the sustainable mobilization of wood material, and for forest monitoring has to be analysed. Better insights are needed on the consequences for improved decision-making processes in forest management and optimized wood logistics, the design of new business models, and strengthened forest protection. For this, participatory approaches have to be tested that include forest owners, forest contractors and logistics operators, industry, society and end users.

## C: Empowering small-scale forest owners

An increasing diversity of private individuals and organizations owns a majority of EU forests, often in small-sized holdings. Ownership rights, management objectives and behaviour, and organizational support differ, posing challenges on meeting the future demand for forest biomass and other ecosystem services. Collaboration between forest owners and targeted assistance by owner associations and advisory services in providing knowledge, planning tools and operational support have to be improved. Research is needed on the drivers for decision-making, on the design of effective supporting instruments and incentives for active forest management and improved cooperation. Innovative approaches for better cooperation between forest owners, forest entrepreneurs and the wood processing industry are required. This should strengthen their participation in the circular bioeconomy, in particular, but not limited to wood mobilization.

## D: Harnessing novel technologies and automation in forest operations

Novel technologies and automation such as machine learning and robotics offer great potential for improving the productivity of forest operations (planting, tendering, thinning, harvesting, logging), but also for providing social (attractiveness of rural jobs, gender balance in forest employment), safety and environmental benefits. Research is needed to customize progress in automation for applications under complex and extremely variable forest environments and for improved decision-making support for operators. The potential of semi-autonomous and autonomous functioning, and teleoperated machinery to foster forest operations working in greater harmony with the forest environment and with effective integration of human supervision, has to be analysed.

## E: Analyzing forest-based product markets and material flows

Forest-based industries are undergoing major structural changes with shifting portfolios of traditional and new bioproducts based on tree biomass. Manufacture is becoming more spatially separated, with companies placing processing plants at different geographic locations along the value chains. Increasing diversity and complexity of interdependent value chains for forest products implies challenges for developing and monitoring markets. This makes conditions for investments less predictable. Research is needed on the impact on the future demand for different product categories, the various interdependencies between existing and emerging markets, and on the consequences for markets in different regions. This includes the analyses of wood flows from the forests to the various finished products.

# **3. More added value from non-wood ecosystem services**

In 2040, we have successful new business models based on forest ecosystem services. They are often based on cross-sectoral cooperation with sectors such as food, water and tourism. The added value from new markets for non-wood forest goods (mushrooms, berries, clean water) and services (recreation, tourism, climate change mitigation) has increased tenfold.

Challenges

## A: Improving business opportunities for non-wood forest products

Non-wood products from forests for food and non-food uses, like cork, are part of the circular bioeconomy, offering economic benefits and employment opportunities. Their role in income generation for forest owners and in diversifying their business activities, but also in contributing to regional economies, has to be strengthened. Research is needed to improve the sustainable supply of non-wood forest products in quantity and quality by adapted integrative forest management approaches. New business cases and cooperation models have to be generated to provide these products in an economically viable way to the markets. New avenues for processing such materials to create higher added value end products have to be developed. This includes cross-sectoral collaboration to facilitate effective processing and branding, as well as the creation of standards and labels.

## B: Enhancing value creation with other ecosystem services

Beside woody biomass and non-wood products, other services from forest ecosystems also benefit society and contribute to inclusive regional growth. To meet the growing demand in quantity and quality, new avenues for a more market-oriented provision of such services are required. Research is needed to improve integrative forest management approaches that enable the provision of such services (e.g. recreation, health, well-being, carbon sequestration) with the right balance in providing other products and services under changing climate conditions and environmental constraints. Concepts have to be developed for the economic evaluation of these ecosystem services and for the design of effective business cases to provide them in an economically viable way. This includes cross-sectoral cooperation (e.g. tourism, wellness-health sector) and the involvement of beneficiaries of these services.

## C: Providing forest-based benefits for urban and peri-urban societies

Trees, woodlands and forests in and near densely populated areas contribute nature-based solutions for urban resilience and climate smart cities. Agglomerations will need more benefits from the services provided by forests around them, for improved local/regional climate, recreational and leisure activities to generate health benefits. Research is needed to meet the growing demand on forests close to cities, urban trees and forests planted near buildings to reduce their energy consumption for cooling and heating, to provide amenity values from green infrastructure, and to improve urban air quality as well as the health and well-being of urban citizens. This requires better knowledge of citizens’ perceptions and behavioural economics, to adapt forest and tree management to urban needs. This includes consideration of urban planning and the use of participatory co-creation processes. Risks related to city extensions have to be addressed (wildfires, new pathogens).

## D: Capitalizing on the benefits of forest expansion as a consequence of land-use change

Europe is undergoing significant forest expansion due to the abandonment of rural areas, driven by economic and demographic changes. Recently established forests provide key ecosystem services, such as establishing new habitats supporting biodiversity conservation, and increasing carbon stocks supporting climate change mitigation. They can also contribute to biomass production, encouraging a growing circular bioeconomy in the region. Research is needed to forecast the drivers and tendencies in forest expansion in the EU, and its impacts on the regional socio-economic systems, including related risks. The resilience of such newly established forests on sites with a different land-use legacy (soil characteristics shaped by former agricultural practices) has to be analysed in comparison with long-established forests. This includes the increased use of agro-forestry systems.

## E: Targeting forest governance to foster forest-based benefits for society

The EU will face a significant new era of forest-related policy-making after 2020 with the need to support agreed global policy targets, by global changes in markets and political power balances, by different new EU policies, a new orientation of the FOREST EUROPE process, and possibly a new legally binding agreement on forests in Europe. Transdisciplinary research is needed for new, science-informed European co-governance mechanisms that provide stronger strategic guidance and coordination among different policy domains. This includes intra- and cross-sectoral policy and future outlook studies, implementation and impact research, and a better understanding of synergies and trade-offs in a complex policy environment. These insights should enable the forest-based sector to strongly contribute to the transformation towards a sustainable and climate-neutral society.

# **4. Towards a zero-waste, circular society**

By 2040 material collection rates of forest-based products have increased to 90 per cent and their reuse and recycling account for 70 per cent of all recyclable material. This circular economy stores carbon and substitutes more energy-intensive materials.

Challenges

## A. Optimizing material recovery through efficient detection, collection, sorting and separation

Recycling is an option to obtain materials from processed goods and a means to enhance resource efficiency that, in turn, relieves the pressure on extracting and harvesting resources from nature, while preventing the need to dispose of materials in the environment. However, complete recycling of bio- and wood-based products, parts and components, with a view to recovering pure raw materials with their original performance and value, is environmentally, economically and technically neither achievable nor feasible. Often, today, the original functionalities and value of the material cannot be recovered in the recycling process when the concentration of the material is low, different materials are being mixed, or the material is susceptible to degradation. Research needed is to focus on essential innovative solutions to improve the value and the market opportunities for recycled materials.

## B. Adapting reuse and recycling technologies to various types of complex and durable products

In product design and development, the recent trend for more complex products demands excellent separation technologies and intensive efforts to also recover low volumes from high added-value consumer goods. On the other hand, losses will be predominant if recyclability is not involved in all process steps of paper materials including design options. The shortening of both technology and product life-cycles and the introduction of disruptive technologies, makes it difficult for the recycling industry to keep pace. In addition, there is a need to determine an appropriate flow of secondary raw materials and to develop strategies to make, for instance, paper fibres more resistant to degradation during the recycling loop, or wood waste less toxic when burned at the end of life. There is also a research need for how to incorporate eco-design in bio- and wood-based products, to achieve a prolonged service life for bio- and wood-based buildings and products.

## C. Product designing for circularity - methods for cost assessment and optimization of recycling

Currently, assessments of the best product recycling solutions must consider economic, environmental, health and safety, social and functionality constraints. New materials with a higher percentage of recycled components would reduce the cost of separation, disassembly and manufacturing, e.g. particle board made 100% with recycled materials. The extent of the technological, environmental and socio-economic advantages or disadvantages of recovering materials from increasingly complex products must be carefully assessed. New urban mill concepts are necessarily targeting a 100 % recycling rate for all components and consistency of input materials. In particular, combined and multiple utilization paths have to be implemented for wood, wood-composites, fibres, fillers, plastic materials, metals, print pigments and organic residues to the same extent. New recycling technologies and new innovative design of existing materials are needed to meet all the requirements for use of recycled materials for food contact products. An advanced-level cascade use of biobased raw materials, especially wood, is also needed.

## D. Boosting the circularity of forest-fibre commodities

The circular economy requires better sorting, collection and recycling of wood and fibre. Since more than half of the fibre mix in papermaking in Europe is recycled fibre, it is critically important to ensure a qualitative stream of sufficient and cost-effective quantities of recycled fibre. Beyond traditional uses of recycled fibre in paper and board making, new valorization options i.e. upcycling, should be explored, that prolong the life of fibre and expand its possible uses. Alongside virgin fibre-based biorefineries, Europe should be taking the lead in piloting, demonstration and deploying recycled fibre-based biorefineries.

# **5. Efficient use of natural resources**

Activities to foster resource efficiency have resulted in signiﬁcant improvements in energy efficiency, speciﬁc raw material input and speciﬁc water use in the forest-based industries. This contributes to the provision of high-added value products with a drastically reduced environmental footprint.

Challenges

## A. Reducing energy consumption in biorefineries, including paper mills

The forest industry is already characterized by highly efficient production facilities. However, breakthrough innovations in fibre industry technologies, pulping, water use and re-use, energy use and recovery and process controls are still required, in order to maintain competitiveness and fulfil the expected new ambitious energy-efficiency targets. The largest reduction of energy needed in the process is accomplished by reducing the amount of process water used. This water needs to be heated to the process temperature, and later on extracted or evaporated to form the final product. Significant research and innovation efforts should be invested in process designs and technologies that reduce the amount of water needed for this process.

## B. Optimizing the use of wood raw materials

The efficient utilization of raw materials is needed for the development of effective, market- and knowledge-driven and successfully-cooperating production systems that can give Europe a leading position in the bioeconomy. Industry 4.0, i.e. the extensive use of IT, such as IoT, gives a remarkable opportunity to support the industry, allowing for faster development. Together with big data analytics it will support the industry in aspects such as management control of production in forest industry processes, e.g. wood-based board manufacture or pulp and paper manufacturing. Diverse factors (e.g. climate, fertility rates, growth competition, maintenance, genetics, structural variations and age) provide substantial variations in the characteristics of different European forest raw materials, between and within sites, but also within the stem wood of individual trees. Improved technologies and methods need to be developed to detect wood characteristics as early as possible within the supply chain.

## C. Improving raw material efficiency and product valorization in sawmills and wood manufacturing processes

Sawmills need to improve process efficiency, raw material efficiency and storage turnaround. New knowledge on the interplay between process and wood material is needed to develop the control and scheduling of wood drying. New wood decomposition technologies and customer order-controlled production is required to further increase productivity and stock turnover. Technology and business development are needed to transform side streams, e.g. sawdust, to create higher added value products and carbon binding in products with a longer life-cycle. The carpentry and furniture industries need greater automation and greater use of wood material with defined properties to replace fossil-based materials and find new end users. Digitalization and 3D measurement technologies can further increase the already high added value offered by carpentry and furniture.

## D. Improving water balance and use of process water treatment

Water is an essential resource for use in the production processes of natural fibre-based products, e.g. fiberizing. Besides reducing the amount of water to reduce energy requirements, as described in challenge 5A, the purity and quality of the process water is an essential aspect of maximizing the resource efficient use of water. It is of the utmost importance that new separation processes and biotechnologies are researched and developed. Precise and efficient separation and extraction of chemicals and particles (both solid impurities and valuable bio-molecules) from the process water, without endangering the process stability, needs research and innovation.

# **6. Diversification of production technologies and logistics**

With new technologies, such as AI, and improvements in automation and digitalization, traceability is fully implemented throughout the value-chain. Diversification of technologies also helps to make small-size production units economically feasible. They might be stand-alone or part of a regional industry ecosystem.

Challenges

## A. Developing industrial symbiosis

The further development of collaboration between companies of various sizes, whilst gaining benefit from each other - true industrial symbiosis - is vital for creating a sustainable circular ecosystem. At best, it boosts European raw material security and underpins EU-based businesses. It is important to enhance and secure primary raw materials for the entire forestry-based sector and the use of recycled paper and board materials as a major packaging material, fulfilling the safety demands of logistics and consumers.

## B. Adopting additive manufacturing technologies and new production methods

New methods making use of ICT/AI exist for efficient raw material steering and information feedback between market, industry and forest, as do new business and logistics systems affecting the entire forest industrial system. Digitalization of the various value chains plays a key role in the integration of this new knowledge. In addition to this, we need to demonstrate and integrate new wood processing technologies (e.g. 3D CT scanning, laser cutting) to optimize the breakdown of logs and laser-cutting solutions (wood and wood-based materials) based on the highest resale value of final products.

## C. Extracting and producing natural compounds for different uses

The biorefinery concept provides numerous possibilities for the creation of pigments, new materials for additive manufacturing and bio-adhesives. The “bio” concept opens up new market niches and gives new possibilities for research and innovation.

*(Editor’s comment: research need is missing here!)*

## D. Improving traceability and chain-of-custody (c-o-c), throughout the value-chain

The demand for traceability of raw materials and products is global and increasing in importance for multiple reasons. Sustainable, pest-free, traceable wood raw material is a competitive factor for Europe’s forest-based industries. However, traceability needs to be extended to recycled raw materials as well. This requires the creation of multilateral, international cooperation through dedicated networks and logistical platforms which operate and maintain the viability of source, collection, recovery, recycling and transport of waste and materials.

## E. Integrating autonomous and/or electrified working (e.g. harvesting) and transportation systems

Full integration of economically and environmentally efficient, smart harvesting, measuring, processing, sorting and logistics technology and systems, with evolving industrial processing technologies and systems will enable the valorization of forest-based biomass in sustainable and continuously optimized products and value chains. New autonomous harvesting systems can increase productivity and the precision of operations. Semi- and full-automation in terrain transport systems can improve efficiency and reduce environmental impact.

# **7. Purposeful, safe jobs and links between rural and urban regions**

In 2040, the forest-based sector is an attractive employer, known for providing meaningful and safe jobs in rural as well as in urban regions. It is well known for developing the skills of its workers and managers and has significantly increased the number of employees involved in different aspects of research, development and innovation activities.

Challenges

## A. Creative jobs growing the forest-based sector

Tasks related to research, creative design and communication become increasingly important as the forest-based sector enters into new markets and shorter production series become more economically advantageous. Fashion designers and new groups of engineers/researchers are needed when the forest-based sector develops new cross-sector partnerships. New creative jobs can also be offered in the area of biobased construction solutions, if the sector manages to increase awareness about biobased building systems, as well as developing state-of-the-art training and educational methods for architects, property developers and local authorities. Design tools will ideally be easy to use and intuitive.

## B. Creating job opportunities through economic incentives for management of small- forest ownerships

Today, many smaller forest holdings have little economic incentive to manage their forest efficiently, if at all. This is particularly common in regions with very fragmented forest ownership or where forestry-related services and industries are few. New innovative business concepts are needed to increase the economic benefits of actively managed smaller forest holdings and create new jobs for forestry entrepreneurs and in downstream industries.

(This Challenge is closely related to Challenges in Vision Target 2)

## C. Developing new market places and jobs in response to changing consumer trends

Market and consumer trends have emerged that will likely accelerate and have significant impact on society in 2030/2040. New jobs can be created if the sector researches the socio-technological changes and is sufficiently innovative developing new business models. The **social economy** and **collaborative consumption** (such as AirBnB and Uber) are offering new market places, as are **Internet retailers** (such as Amazon and Alibaba). Increasing use of packaging and transportation services and a decrease in classified ads and print media, means recession for malls and physical stores. Sustainable consumption patterns and consumer awareness will most likely benefit the forest-based value-chain, particularly in the areas of construction, textiles and materials such as wood and cork composites, substituting petroleum-based plastics.

## D. Adapting job offers in an era of artificial intelligence (AI)

The use of AI and digital automatization will create new opportunities for humankind and do many wonderful things. However, society has so far underestimated the speed at which employment opportunities are lost to automatization and digital solutions. Particularly in the transport and service sectors with predictable physical tasks (packaging, sorting, quality control), many jobs will be replaced by digital services and autonomous machines. This will lead to significant professional displacement. The forest-based sector should be prepared for this mega-trend and be at the forefront offering constantly evolving work tasks that create higher added value. For instance, when trucks drive autonomously, truck managers could, with the right vocational training, perform work during transport, related to new innovative, agile, on-the-go processing concepts.

**8. Renewable building materials for healthier living**

Wood, the most commonly used renewable construction material in the world, has a bright future. In 2040, biobased construction in Europe has tripled its market share from the 2015 level, whilst the overall added value of the woodworking industries has doubled. Increased value will come from new products and services, as well as more widespread use of energy-saving, modular and flexible housing structures and functional furniture.

Challenges

## A: Innovation in and optimization of building systems including modular and pre-fabricated systems

There are several parameters by which wood-based building systems including modular and prefabricated systems are superior to non-renewable construction systems. Due to the huge variety of wood-based products and the many ways they can be assembled, dimensioning wooden construction systems are far more complex than the systems for non-renewable materials. Therefore, wood-based building systems need to be better harmonized for improving their uptake by the construction sector in different countries. Lean manufacturing processes that are more resource efficient and that compare better than today on complex attributes, such as acoustic performance, need be developed. Timber construction is flexible and dynamic but systems are often company specific, which creates a very complex market for customers, designers and architects. There is a clear need for European cooperation in the development of new building systems.

## B: Improving wood-based products for construction, including engineered wood and composites

Solid timber, engineered wood (e.g. cross-laminated timber) and **performance-targeted biobased composites** are manufactured to make wood-based products for construction that far out-perform non-wood materials when it comes to carbon-neutrality and many physical properties, such as weight and insulation capacity. These products are the building blocks used in various wood-based building systems.

Key performance criteria such as durability, structural integrity and fire performance need to be better understood and much more price-competitive production methods should be developed. Research and innovation can also bring about the utilization of so far underutilized hardwood species.

## C. Harmonization and standardization research and more intelligent, digital design tools

Innovative, engineered products offer excellent performance adapted to current and future sustainable building requirements, but they are relatively immature compared to concrete and steel-based systems, and they can encounter “teething problems”. Standardization research can help to improve the knowledge about and uptake of important new design tools. Durability, fire safety, acoustics, dynamics and carbon footprint counting are variables that can be handled. Advanced building information modelling (BIM) including LCA and product property catalogues need significant development. Technologies such as artificial intelligence, augmented reality or virtual reality (VR) can be used in a multitude of ways that will benefit production, marketing and virtual inspections of buildings, and should be the target for further research and development.

## D: The experience of living with wood and researching its health benefits

Above and beyond the well-documented climate change mitigating effects of wood-based construction, a focus on the benefits to human health and well-being from spending time in buildings made from wood-based construction materials, is required. Current state-of-the-art, based largely on anecdotal information will have to be significantly upgraded with larger more in-depth studies. Interdisciplinary approaches, including both social and natural sciences, will ascertain the positive influence on the human body and mind. This will have a strong influence on future design criteria for materials, products and building systems alike. Health benefits and positive cognitive responses can ultimately become one of the design criteria to be modelled in advance.

# **9. New fibre-based products and 80 per cent lower CO2 emissions**

The forest-fibre and paper industry is well on its way to reaching the targets – set out in the CEPI 2050 Roadmap – to cut its carbon emissions by 80 per cent, while creating 50 per cent more added value. While established product segments, mainly paper, packaging and hygiene, have evolved and remain the main source of income, almost half of the new added value is expected to come from other new biobased products such as textiles and green chemicals.

Challenges

## A.Providing sustainable, fibre-based, high-value end-consumer products

**Biobased packaging solutions** can provide growing global markets with smart, secure and biodegradable solutions for business and consumer markets. Customer demands on sustainability can be met by a reduced carbon footprint, reduced need for raw materials, more efficient transportation, content protection and reduced food waste. **New hygiene and health care products** can reduce the carbon footprint and assist in medical treatments. Biobased disposable products in health care can replace large amounts of fossil-based products globally. Fibre-based products with in-built solutions can be integrated into diagnostic work, and can be used for controlled drug dispensing. **Sustainable textile production** from cellulose can replace fossil- and cotton-based textiles, as global textile demand is expected to triple by 2050. New sustainable production processes are needed for cellulose quality with high customer acceptance.

## B. Developing more sustainable and competitive processes for paper-making and other biobased products of today and tomorrow

Existing paper-making processes and products have been optimized over the years to reach the current levels of efficiency and profitability, but the processes are complex. Therefore, giant leaps are not to be expected, but incremental improvements demand development of new fundamental knowledge about the dynamics from a system perspective. Research needs include the processes of the paper mill, and to some extent the pulp mill, with a focus on simplification and efficiency, cellulose-water interaction, as well as new mechanical properties on micro and macro levels.

## C. Developing building blocks for biobased materials and chemicals in the circular society

**Green chemicals** can provide biobased functional chemicals and additives that are compatible with future biobased materials. This is needed to provide specific unique properties and other added value, or for direct use in cleaning, surface treatment and adhesives. **Wood-based polymers** can replace fossil-based plastics in packaging, construction and building materials thanks to a range of new material-forming methods, with which materials with high geometric complexity can be created. **Biobased composites and fibres** can provide composite materials where the constituents create combined functions related to fire, moisture, stability and wear, while still supporting recycling at the end of the product’s lifetime. Research activities include new separation and purification methods, catalysts, macro-molecular chemistry and nanotechnologies. New innovative production methods need to be tested and developed.

## D. Adding value through digitalization and functionalization

Functionalization on a molecular, fibre and structural level can provide biobased materials and products with physical, chemical and electronic properties that meets customer demand in high-end markets. Providing functionalities instead of bulk products is a way of offering high-value solutions for European markets, instead of selling bulk in cost-competitive developing countries. Research is needed to provide features like tracking, anti-tampering, anti-counterfeiting, connectivity and microbial resistance. Obtaining the capacity to engineer products and materials with specific biodegradability properties is also a key area of the functionalization challenge. Consumer values, digitalization and all aspects of sustainability need to be focused on, whilst maintaining a multidisciplinary and holistic view of the value chain.

# **10. Renewable energy for society**

Thanks to new and innovative production technologies, reduced overall energy consumption, increased recycling, reuse and reﬁning of side-streams, the sector will continue to be the biggest producer of green electricity and biofuels in Europe, with a capacity in 2040 to provide the equivalent of 100 million barrels of crude oil (produced from about 65 million m3 of forest and mill residues).

**Challenges**

## A. Developing advanced biofuels and chemicals and more efficient production technologies

Side-streams from the forest-based industries such as sawdust, bark, tall oil and lignin can be used for the production of valuable chemicals or composite materials. However, due to economic reasons, the first step is often to make fuel or to use the biomass for heat and energy. Biofuels can be used in aeroplanes, cars or as a solid energy carrier. On a larger scale, there are facilities for the extraction of biodiesel from tall oil, for example, or as ethanol or methanol. Projects for the development of other biobased energy solutions are ongoing. Lignin, which represents about one third of wood is still underutilized and significant research and innovation efforts are needed to develop pathways by which lignin can be utilized as chemicals or biofuels.

## B. Enhancing bioenergy production through the valorization of forest residues

Pre-commercial cleaning and thinning operations are often expensive for the forest owner. Consequently, many European forests grows too densely, giving poorer harvests, and increasing the fire risk, in particular in southern Europe. Lowering the cost of these forest operations and increasing the value of the biomass could change the financial equation and also make it economical to use by-streams, such as roundwood damaged by bark beetles, storm breaks or rot, or small-sized logs and branches from the forest. It is therefore important to incentivize improved forest management while increasing the amount of biomass available for bioenergy production. This may require new, more efficient forestry machines and better transport solutions, but also improvements in the efficiency of local energy production and innovative infrastructure investments, such as placing wind farms on forest land.

**(This Challenge is closely related to Challenges in Vision Target 2)**

## C. Establishing integrated and holistic energy systems (including energy storage)

Creating smarter and more integrated energy systems will require research and innovation and significant infrastructure investments, from demonstration to commercial scale. New innovative business models and business partnerships such as pulp mills integrated with biochemical industries or combined heat and power (CHP) plants, need to be further developed.

Different strategies for storing energy (as energy, biomass or electricity) should be studied intensively to render the sector an integral part of a future European smart energy grid. This includes research and innovation on low TRL levels in the use of biomaterials for energy applications, for example, wood-based batteries and solar panels.

## D. Providing a fact-based approach for balancing energy production, environmental concerns and other needs of the bioeconomy

Achieving public acceptance for the sustainable production of bioenergy and biofuels from side-streams, forest residues and organic waste is crucial for the forest-based sector. The sector has to be able to provide relevant data and research to support transparent and fact-based decision making on all levels. The bioeconomy requires, as well as offering, several alternatives to current fossil-based products. The establishment of new, competitive, energy- and material-efficient biobased value chains for energy and fuel is therefore essential for the development of a successful European bioeconomy. New research is also needed to be able to change CO2 from emissions into raw material for new products. This would have a remarkable effect on the reduction of emissions and on climate mitigation. The development and acceptance of new products is often a risk when it comes to technology, prices, markets and policies.