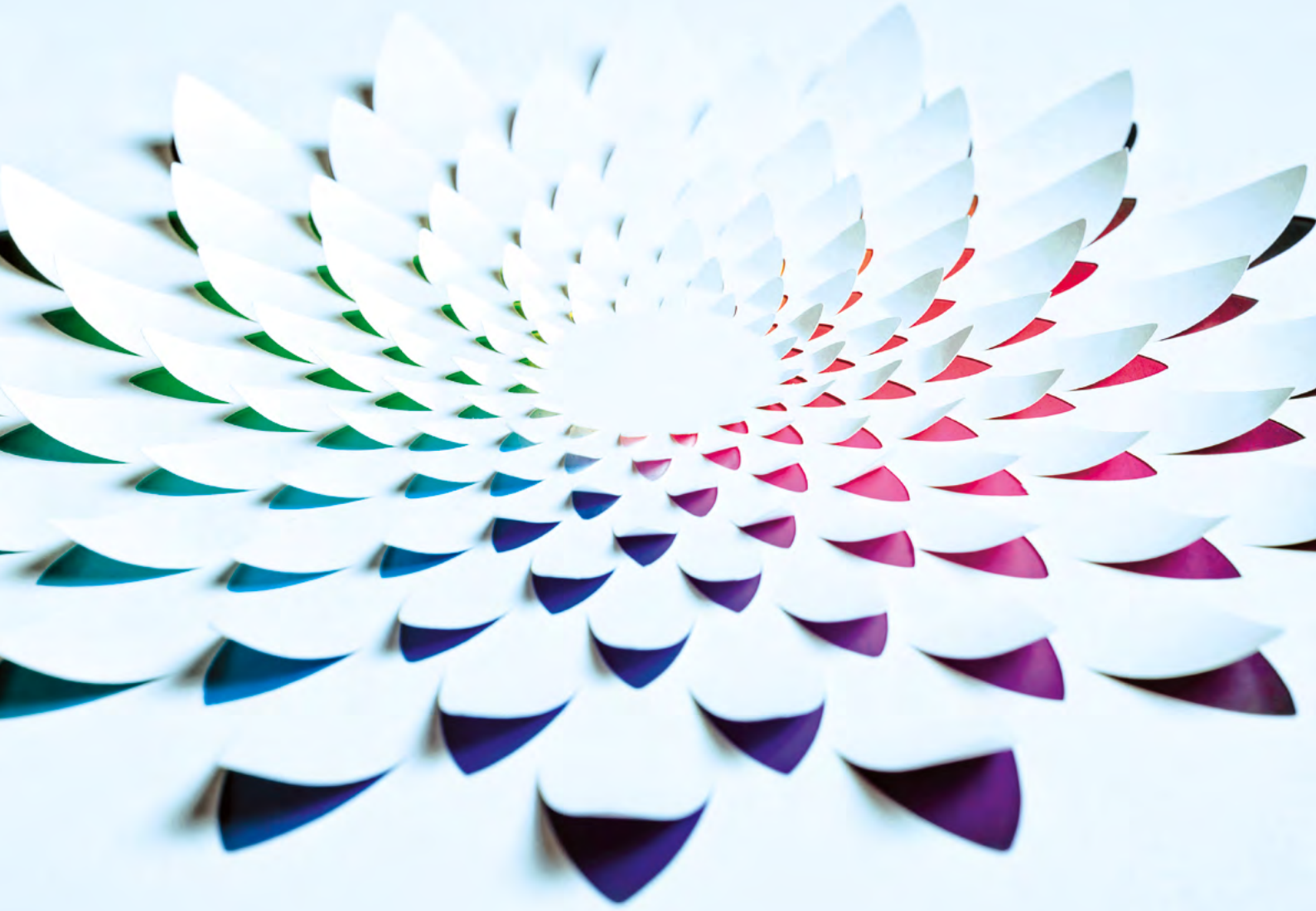
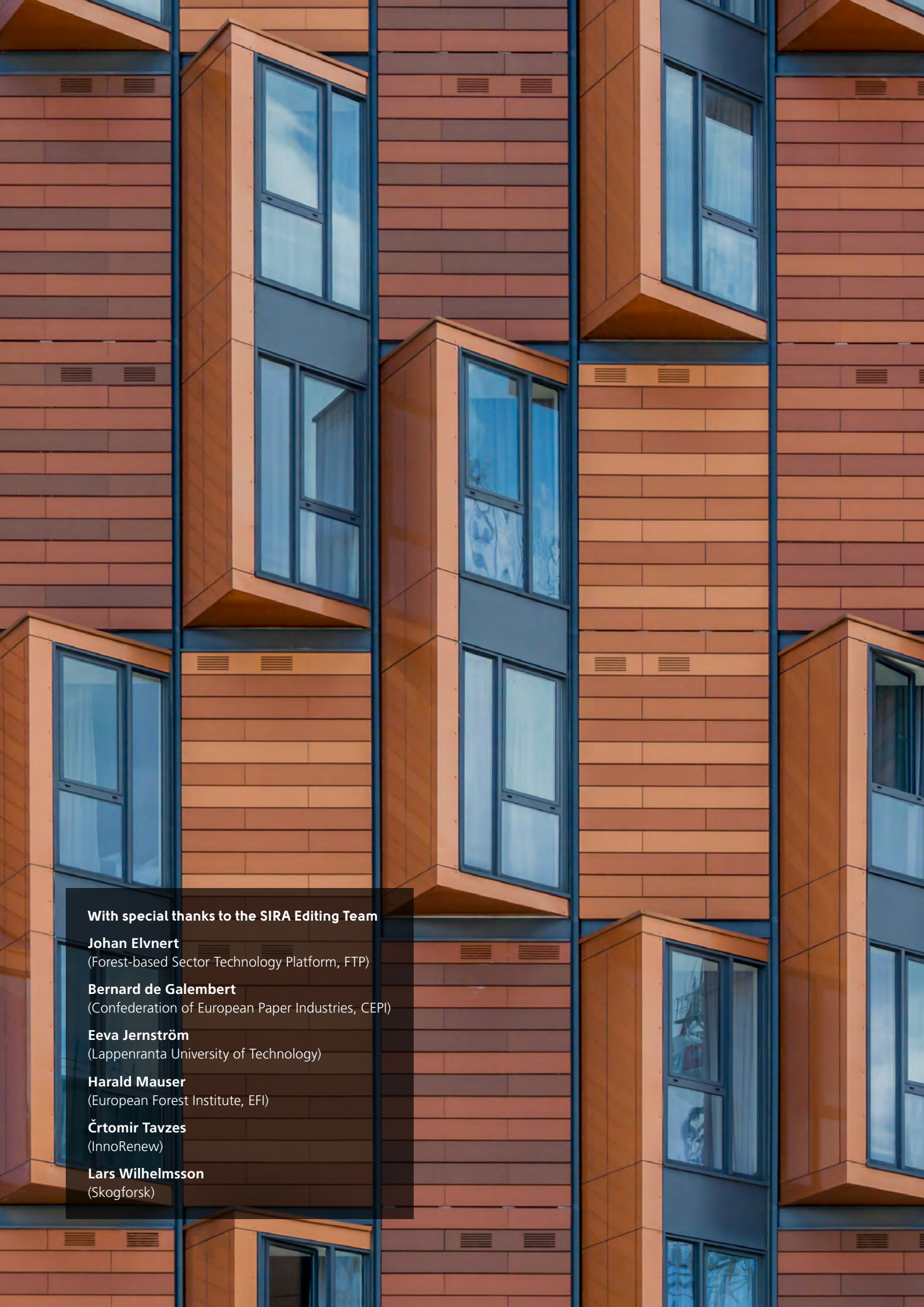
STRATEGIC RESEARCH AND INNOVATION

AGENDA 2030

OF THE EUROPEAN FOREST-BASED SECTOR



Forest-based Sector
Technology Platform



With special thanks to the SIRA Editing Team

Johan Elvnert
(Forest-based Sector Technology Platform, FTP)

Bernard de Galembert
(Confederation of European Paper Industries, CEPI)

Eeva Jernström
(Lappenranta University of Technology)

Harald Mauser
(European Forest Institute, EFI)

Črtomir Tavzes
(InnoRenew)

Lars Wilhelmsson
(Skogforsk)

preface

The Forest-based Sector Technology Platform (FTP) was set up in 2005 to define a vision for the future of the sector and identify priority areas for innovation and research. It was established as an industry-led initiative encouraged by the European Commission to define research objectives and roadmaps for delivering agreed goals. In 2005, FTP produced its first Vision document and in 2006 its first Strategic Research Agenda.

To remain relevant and ambitious as well as to reflect the objectives of Horizon Europe, the EU's research and innovation funding programme for 2021-2027, the FTP Vision 2040 and the Strategic Research and Innovation Agenda (SIRA 2030) have now been launched. Together, the Vision 2040 and the SIRA 2030 present our long-term common goals and the far-reaching technical, business and societal innovations that must be undertaken to meet major challenges facing European society.

The forest-based sector is a well-integrated value chain with three main sub-sectors: forestry, the woodworking industries and the pulp and paper industries. It represents 8% of manufacturing added value in the EU and creates close to 4 million jobs. In addition to raw materials, forests also provide a wide range of vital ecosystem services. They play an essential role in climate change mitigation, protecting human living space, safeguarding biodiversity, providing fresh water, non-wood forest products and recreational environments. No other industrial sector offers a similar range of products and services to society as a whole.

Extensive work by representatives of industry, forest owners, researchers and public bodies across Europe has gone into the SIRA 2030. Industry and researchers will find the SIRA to be an important point of reference for further actions but it is also intended to help policymakers and funding providers at both the EU and national levels play their part in achieving the forest-based sector's vision to serve our society.

FTP organization

National Support Groups (NSGs) are an important element of FTP's organizational structure. The NSGs serve as coordinators for business and national research bodies, authorities and funding agencies. They have a key role in securing regional support for the platform. The NSGs and core stakeholders participate in regular meetings of the FTP Advisory Committee in Brussels, where the FTP headquarters are located. The FTP Board is the highest decision-making body. At present, the Board is comprised of representatives from industry, the chair of the Advisory Committee, the European State Forest Association (EUSTAFOR), the Confederation of European Paper Industries (CEPI), the Confederation of European Forest Owners (CEPF), and the European Confederation of Woodworking Industries (CEI-Bois).

The forest-based sector is a well-integrated value chain with three main sub-sectors: forestry, the woodworking industries and the pulp and paper industries.

contents

a timely vision for a **European Green Deal**

"Becoming the world's first climate-neutral continent is the greatest challenge and opportunity of our times. It involves taking decisive action now. We will need to invest in innovation and research, redesign our economy and update our industrial policy."

Ursula von der Leyen, President-elect of the European Commission

The FTP Vision 2040 has been agreed and approved across the European forest-based sector. Our sector speaks with one voice when it comes to research and innovation.

The heart of the vision can be explained as follows: Forest volumes continue to increase across the EU. Sustainable forest management ensures the resilience and vitality of ecosystems and is the foundation for a growing circular bioeconomy.

- The forest-based sector is the leading actor in, and enabler of, a circular bioeconomy.
- Consumer needs and the smart and sustainable use of forest resources are the cornerstones of the sector.
- The sector is bustling with entrepreneurial activity that creates employment and enriches both rural and urban regions.

We, as a sector, prosper from satisfying people's desire to live in greater harmony with nature and reduce their environmental footprint. Smart services and products designed for reuse, recycling and recovery, contribute to people's good health and general feeling of well-being.

We urge European decision makers to consider the importance of this agenda, and the forest-based sector, in reaching the objectives of a new European Green Deal as well as the UN Sustainable Development Goals.

A dynamic forest-based sector is ready to take the lead in ensuring a climate-neutral and prosperous Europe by accomplishing these ten Vision Targets:

1 **Sustainable forest management, biodiversity and resilience to climate change**

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

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

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

5 **Efficient use of natural resources**

6 **Diversification of production technologies and logistics**

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

8 **Renewable building materials for healthier living**

9 **New fibre-based products and 80 per cent lower CO_2 emissions**

10 **Renewable energy for society**

introducing the strategic research **and innovation agenda** (SIRA 2030)

The FTP SIRA 2030 focuses on achieving the Vision 2040. In order to do so, it identifies for each of the 10 Vision Targets, the challenges that require significant efforts in research and innovation. All in all, close to 50 challenges have been identified. For each challenge, we also identify some important examples of research and innovation activities.

The forest-based sector continuously monitors and influences transnational and global developments in areas such as climate change, digitalization, changing consumer behaviour and new policies and legislation. These developments have been taken into account when identifying the most urgent challenges, and of the research and innovation activities that need to be undertaken to address them.

Achieving the 10 Vision Targets of the FTP Vision 2040 requires far-reaching technical, business and societal innovations. The SIRA only takes us to 2030, as we believe that at least a decade will be needed for new solutions to be generally adopted in time to reach our goal for 2040. As such, the SIRA will play an important role in reaching EU climate and energy policy objectives and the discussion on more ambitious emission reduction targets for 2030.

It is FTP's mission to turn the vision of the forest-based sector into reality.

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

The extent to which forest management interventions impact on stand development depends on the relationship between biodiversity and ecosystem functions. This relationship affects forest stands' capacity to provide services like biomass production, as well as their resilience and restoration potential. In terms of functional traits in forest ecosystems, research is needed on the cause-effect relationship between two spheres: on the one hand, genetic and tree species diversity, structures at landscape and stand level, and soil diversity; and on the other hand, silvicultural and harvesting regimes. Relevant traits and thresholds should be identified to allow better selection of genetic material and species combinations, with the goal of maximizing sustainable ecosystem functions. All sustainability aspects, as well as the impact of climate change, need to be taken into account when analysing the consequences for biomass production, carbon sequestration, biodiversity conservation and the provision of other ecosystem services.

Examples of research and innovation activities

- Study the relationship between biodiversity characteristics and dynamics, and forest ecosystem functions to identify relevant traits
- Improve forest management approaches to better harness functional diversity
- Identify functional traits in forest ecosystems that improve the long-term sequestration of soil organic carbon

B Strengthening forest ecosystem resilience and fostering Climate Smart Forestry

The concept of Climate Smart Forestry combines the reduction of greenhouse gas emissions with the strengthening of forest resilience and a sustainable increase in forest productivity and income. To accomplish this, forest management needs to be adapted to local and regional circumstances, and the mitigation of abiotic and biotic risks, including the impact of ungulates, needs to be improved. Research is needed on using vigorous regeneration material, altered growth dynamics, species shift and silvicultural regimes to foster growth under changing climate conditions. Further insights into hazard interaction analysis, the role of forest structures and the efficiency of prevention measures are required to develop new strategies for risk management that increase resilience and support the design of insurance schemes. Analysing trade-offs between mitigation and adaptation measures should guide regionally tailored forest management strategies and post-disturbance regeneration.

The importance of sustainable and multifunctional forest management is widely acknowledged, due to its benefits for society

Examples of research and innovation activities[1]

- Analyse interrelated forest risks and develop integrated decision support tools
- Analyse trade-offs between mitigation and adaptation measures in forest management
- Develop early-warning systems that harness the digital revolution to identify and map forest pests and diseases, including invasive species

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

Forests play a vital but underappreciated role in ensuring sufficient water supply and quality, and in mitigating water-related hazards. This role is impacted by many factors, including increasing demand for fresh water, the influence of different land uses on regional and continental water balances, and climate change. Forest-driven green water, blue water and energy cycles need to be better integrated into regional, national and continental decision-making, especially on topics related to climate change adaptation and mitigation, land use and water management. Research is also needed to assess how forest composition and structure affect rainfall patterns, water availability (quantity and quality) and extreme water-related weather events (both floods and droughts) in relation to natural variations, forest management and climate change. This includes analysing sensitivity to local and regional climate, hydrological and cultural conditions, with a specific emphasis on interaction with farming practices.

Examples of research and innovation activities

- Research the effects of forests on rainfall patterns on a regional and continental scale
- Develop hydrological and hydro-chemical modelling that focuses on the combined effects of climate change and forest management regimes on water supply and quality in different geographical settings
- Further explore the role of forests in flood prevention, in relation to natural variations and to forest management practices

D Mitigating wildfire risks in forested landscapes

Land abandonment, unmanaged forests, urban sprawl and changing climate conditions all contribute to the growing risk of wildfires occurring, spreading and burning with greater intensity. This has severe consequences on nature, the carbon sink and the affected socio-economic systems. The resilience of forested landscapes needs to be strengthened through integrated wildfire management approaches, with a stronger focus on prevention and preparedness. Research is needed on the influence of climate change and socio-economic trends on the vulnerability of forested landscapes, and on new approaches to improving their fire resistance and resilience. As part of this, risks in the wildland-urban interface should also be addressed. More insights into fire prevention, behaviour, detection and post-fire recovery should be sought, including better fire risk assessment models, decision support tools for integrated long-term fuel management,

1 The FTP website www.forestplatform.org provides a comprehensive list of research and innovation activities on this and other topics. See also The European Forest Institute's publication "Living with bark beetles: impacts, outlook and management options".

restoration of burned areas, and the design of fire-smart landscapes and infrastructures.

Examples of research and innovation activities[2]

- Improve prediction capacity and real-time risk analysis for large and severe fires
- Identify thresholds of change and tipping points in ecosystem regeneration, taking into account climate trends and past land-use/management history
- Improve fire resilience within the scope of an integrated landscape concept, including the establishment of agroforestry systems

E Improving the partnership with citizens

There are remarkable differences in how certain segments of society and the forest-based sector perceive the value of forests, their management and economic significance. Societal perception and public appreciation of the ways in which actively managed forests provide multiple benefits for citizens, including the use of wood for a wide variety of products and energy, have to be improved. Research is needed to design new ways of interacting with citizens, local communities and stakeholders in other sectors, and to better understand their demands. New approaches to building trust and increasing awareness of how the forest-based sector contributes to a sustainable and climate-neutral society are also needed. Efforts to better understand the values and priorities of citizens across the EU and Europe could include setting up a database on public perceptions of forests, and establishing new ways to interact with the public (e.g. living labs, co-creation approaches). Combined with crowd science and social media activities, these efforts could strengthen the partnership between the sector and the public, in particular with young citizens.

Examples of research and innovation activities

- Develop tools to monitor and project shifting societal demands, including scenarios for future priorities in the use of forests
- Apply semiotic analysis to communication activities to better reflect citizens' values
- Use novel approaches, including new digital media, to personally involve citizens in the dialogue on forests

2 The FTP website www.forestplatform.org provides a comprehensive list of research and innovation activities on this and other topics. See also the European Commission's publication "Forest fires – Sparking firesmart policies in the EU" which provides a comprehensive list of research and innovation areas relevant to this challenge.

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

Forest growth is increasing, leading to increased CO_2 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 seeds, seedlings and plants to increase productivity and resilience

Changing growing conditions and new demands from more diversified forest-based products call for an improved understanding of tree genetics. This includes understanding in detail the role genetic factors have on the tree's growth dynamics, resilience to climate change, susceptibility to native and invasive pests and diseases; also, how the genotype controls biomass characteristics important for the quality and value of wood products. Research is needed on new methods and strategies for tree breeding, propagation material provision, plant cultivation, establishment of new forests and regeneration of existing forests. This includes designing measures to protect endangered high-interest genetic resources so they can adapt to climate change, as well as measures for assisted migration. Analysis will also be needed on the consequences of providing high-quality seeds and plants of native and introduced species that have not only better growth possibilities under future climate conditions, but also higher resistance to pests and diseases, and more suitable wood qualities.

Examples of research and innovation activities

- Study genetics and biochemical/physiological processes that determine wood and fibre properties as well as pest and disease resistance, water use and nutrition efficiency
- Analyse non-native tree species in terms of their potential impact on, and use in, EU forests
- Develop sustainable strategies for assisted migration, including assessment of the impact on the receiving ecosystems and on forest genetic resources

B Using 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 bring opportunities for the collection of detailed and dynamic information. This wealth of comprehensive data will enable new levels of precision forestry. Ways in which advanced prediction models can be applied, including the use of artificial intelligence (AI) and Internet of Things (IoT) data, need to be explored and developed. These predictive models can be used for characterization, visualization, harvest planning and retrospective traceability of mobilized wood material, as well as for forest monitoring. Research is also needed to design applications for improved decision-making processes in forest management and optimized wood logistics, to develop new business models and for strengthening forest protection. To bring this about, participatory approaches that include forest owners, forest contractors and logistics operators, industry, technology providers, society and end users need to be tested.

Examples of research and innovation activities

- Develop planning and monitoring tools for multi-purpose forest landscapes
- Optimize supply-chain management including for harvesting, transport and pre-processing, linked to forest planning tools
- Develop traceability systems covering the entire value chain from raw materials to wood-based products

The creation of climate change-resilient and stress-tolerant forests is particularly important

C Empowering small-scale forest owners[3]

An unprecedented diversity of private individuals and organizations owns the majority of EU forests, often in small-sized holdings. This results in differing ownership rights, management objectives and behaviour, and organizational support, which in turn poses challenges on meeting future demand for forest biomass and other ecosystem services. Collaboration between forest owners, use of traditional/local knowledge, and targeted assistance with planning tools, operational support and knowledge by owner associations and advisory services will be needed. Research is also needed on the drivers for decision-making, the design of effective supporting instruments and incentives for active forest management, and improved co-operation. Innovative approaches for better co-operation between all participants of the value chain are required, such as IT solutions that can meet the needs of such a diverse target group. Diversification through short-rotation stands, agroforestry and using wood sources outside of forests also need to be analysed.

Examples of research and innovation activities

- Analyse changes in forest ownership and attitudes to forest management, including interest in engaging in new opportunities and markets
- Research tools and approaches to encourage behavioural changes amongst forest owners and managers
- Design digital tools to foster co-operation and knowledge transfer
- Evaluate the role of forests in mitigating desertification in Europe

3 Challenge VT2-C overlaps in scope and activities with Challenge VT7-B

D Harnessing novel technologies and automation in forest operations[4]

Novel technologies and automation, such as machine learning and robotics, not only offer huge potential to improve the productivity of forest operations (planting, tendering, thinning, harvesting, logging), but also to provide social (attractiveness of rural jobs, gender balance in forest employment), safety and environmental benefits. Used to its full potential, automation can create new job opportunities in rural areas. Research is needed to adapt advances in automation for use in complex and extremely variable forest environments, and to improve decision-making support for operators. The potential of semi-autonomous, fully autonomous, and remotely-operated machinery to enable forest operations to work in greater harmony with the forest environment, while at the same time integrating human supervision, needs to be analysed.

Examples of research and innovation activities

- Develop combined human-robot forest harvesting systems
- Improve the automation of harvesting systems, including remote-controlled machinery, drones and measurement technologies that can provide an integrated data flow to the industry
- Improve automation for forest nursery operations and the tending to of young forest stands

E Analysing and foresighting markets and material flows of forest-based products

The forest-based industries are undergoing major structural changes, with shifting portfolios of traditional and new bioproducts based on forest biomass. The increasing diversity and complexity of interdependent value chains for forest products and services bring challenges for developing and monitoring markets. This makes investment conditions more challenging to assess. Research is needed on the future demand for different product and service categories, the various interdependencies between existing and emerging markets (e.g. carbon offsetting), and on the consequences for markets in different regions. This includes analysing regional potential to provide biomass and other services (quantity and quality), logistics of wood flows from forests to the various finished products, and better information for forest owners on market requirements so they can optimize forest management and harvesting.

Examples of research and innovation activities

- Assess future availability of, and demand for, forest-based raw materials in the EU, within the global context of changing economic, social and climatic conditions
- Assess market mechanisms, governance systems and organizational behaviour to improve supply-chain management systems
- Improve foresight methodologies to predict market changes and consumer behaviour

4 Challenge VT2-D overlaps in scope and activities with Challenge VT6-E

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, such as cork, are part of the circular bioeconomy, and offer both economic benefits and employment opportunities. Their role in adding to forest owners' income could be strengthened significantly while simultaneously making a diversifying contribution to regional economies. Research is needed on adapted integrative forest management approaches that can improve the sustainable supply of non-wood forest products both in terms of quantity and quality. In addition, new business cases and co-operation models should be developed to successfully bring these products to market in an economically viable way. New avenues for processing these materials to create higher added value end products should also be explored. This includes cross-sectoral collaboration to ensure effective processing and branding, as well as the creation of standards, labels, marketplaces and platforms.

Examples of research and innovation activities

- Establish new value chains and business models that involve forest owners and other sectors to create value added products and expand markets
- Adapt forest management to improve the productivity and quality of mushrooms and plants for food, as well as for pharmaceutical uses
- Develop standards for non-wood forest products

B Enhancing value creation with other ecosystem services

Besides woody biomass and non-wood products, other forest ecosystem services also benefit society, and can contribute to inclusive regional growth. To meet the growing demand of services, new approaches should be developed to deliver these in a more market-oriented way. Research is needed to improve integrative forest management approaches that can support the provision of these services (e.g. recreation, health, well-being, carbon sequestration, clean air) and, at the same time, provide biomass and other products. Such balanced approaches should be as unperturbed as possible by changing climate conditions. Concepts, including the upscaling phase, need to be developed to evaluate the economic value and interest of these ecosystem services. Effective business cases then need to be developed, demonstrating how services can be provided in an economically viable way. This is likely to require cross-sectoral co-operation (e.g. tourism, health & wellness sectors) and the involvement of those who would use the services.

Examples of research and innovation activities

- Establish new value chains and business models based on co-operation between forest owners and users of ecosystem services
- Develop an economic valuation method for non-wood forest ecosystem services at national and European levels that includes the effects on employment
- Analyse the efficiency of various financial incentive systems and instruments for enhanced provision of other ecosystem services, including payment for ecosystem services (PES) and PES-like schemes

The added value from new markets for non-wood forest goods and services has increased tenfold

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

Trees, woodland and forests in, and near, densely populated areas offer nature-based solutions for urban resilience and climate-smart cities. Urban agglomerations will need to fully extract the benefits offered by the forests around them, e.g. for improving the local/regional climate, providing recreational and leisure activities, and generating health benefits. Research is needed to meet the growing demands placed on forests close to cities, urban trees and forests planted near to buildings. These demands include: reducing buildings' energy consumption for cooling and heating; community benefits from parks, greenways, open spaces and other natural landscape elements; improving the air quality, health and well-being of urban citizens; and providing local biomass. This requires better knowledge and understanding of citizens' perceptions and behavioural economics, in order to adapt forest and tree management to urban needs. To do this, concerned urban planning and participatory co-creation processes should be used.

Examples of research and innovation activities

- Research the impact of urban trees and forests on the health and well-being of urban citizens under new climate conditions
- Analyse economic and social interdependencies between urban and forested rural regions and the influence of geographical distance
- Assess risks of city extensions for forests (e.g. wildfires, new pathogens)

D Identifying the benefits of forest expansion as a consequence of land-use change

Europe is seeing 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, which helps conserve biodiversity, and increasing carbon stocks, which helps mitigate climate change. 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, as well as its impacts on the regional socio-economic systems and water regime. Related risks and the resilience of such newly established forests on sites with a different land-use legacy (soil characteristics shaped by former agricultural practices), have to be analysed in comparison with long-established forests. This includes the increased use of agroforestry systems.

Examples of research and innovation activities

- Investigate the consequences of forest transition on biodiversity, resilience (e.g. forest fires, soil erosion) and bioeconomy development in different European regions
- Develop regional strategies for enhanced provision of ecosystem services by expanding forests, focusing on social benefits (e.g. recreational and ecotourism opportunities, spiritual sites)
- Assess the potential in the EU for rewilding forested landscapes in regions with land abandonment

E Innovation in forest governance to promote forest-based benefits for society

The EU will face a new era of forest-related governance after 2020, due to a combination of factors. These include the need to support agreed global policy targets, global changes in markets and political power balances, new EU policies, a new orientation of the FOREST EUROPE process, and possibly a new legally binding agreement on forests in Europe. Research is needed on new European co-governance arrangements, providing stronger strategic guidance, coordination and coherence among different policy domains in terms of forests. This includes intra- and cross-sectoral policy and outlook studies to develop a better understanding of synergies and trade-offs in a complex policy environment. It also includes policy implementation and impact research to study how these goals and targets are implemented in the national and local contexts. The respective socio-political strategies need to be defined, and an improved science-policy interface is needed so that innovative governance initiatives can be successfully implemented.

Examples of research and innovation activities

- Perform comparative analysis of forest governance regimes and practices in the EU Member States
- Develop impact assessment tools for policies that affect the forest-based sector to better capture its complexity and trade-offs
- Design new European forest co-governance arrangements that include better cross-sectoral integration

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 collection, sorting and separation

Recycling recovers raw materials from products that have reached their end-of-life. It also improves resource efficiency by reducing the need for virgin fibre and by minimizing waste. However, complete recycling of biobased products for raw materials that offer the same original performance and value is not achievable. The original functionality and value of materials cannot be recovered in the recycling process when the concentration is low, when different materials are mixed, or when the materials are susceptible to damage or degradation. Large-scale collection and sorting systems need to be developed and widely adopted by the general public in order to recuperate more fractions and materials for recycling.

Examples of research and innovation activities

- Develop solutions to improve value and market opportunities for recycled materials
- Develop processes to maintain the functionality and original characteristics of recycled materials
- Develop efficient large-scale systems for the collection and sorting of goods for recycling

B Adapting reuse and recycling technologies to complex products

Current trends for more complex products means that excellent separation and extraction technologies are needed to recover low volumes of high added value raw materials from consumer goods. To minimize the loss of raw materials, recyclability needs to be taken into account at all steps in the process of creating wood and fibre-based products, including design. The high rate of technological development, shorter product life cycles, and the introduction of disruptive technologies make it difficult for recycling actors to keep pace.

Examples of research and innovation activities

- Develop eco-design principles to increase product lifespan and make recycling easier
- Identify material flows that can recover all parts of recycled products
- Remove or replace harmful substances in bio- and wood-based products

By 2040 material collection rates of forest-based products have increased to 90 per cent

C Defining methods for cost assessment and optimization of recycling

Standardized methods for assessing product recycling solutions need to consider economic, environmental, health and safety, social and functionality constraints. While new materials that have a higher percentage of recycled components could reduce the cost of separation, disassembly and manufacturing, the advantages or disadvantages of recovering materials need to be carefully assessed. New mill concepts, including urban mills, are targeting a 100% recycling rate for all components and materials. In particular, combined and multiple utilization paths need to be implemented for wood, wood-composites, fibres, fillers, plastic materials, printing pigments and organic residues, etc.

Examples of research and innovation activities

- Develop standardized methods for the assessment of product recycling solutions
- Develop recycling processes relevant for all fractions and balances at mill level
- Develop design principles for using recycled materials in food contact products

D Boosting the circularity of forest fibres and wood products

The circular economy requires better collection, sorting and recycling of wood and fibres. Since more than half the fibre mix used in papermaking in Europe is recycled fibre, it is critically important to ensure a continued supply of quality recycled fibres in quantities that are both sufficient and cost-effective.

Examples of research and innovation activities

- Identify new uses for recycled fibre in paper- and boardmaking
- Develop upcycling processes that prolong the lifespan of fibres and open up new application areas
- Take the lead in piloting, demonstrating and deploying biorefineries for recycled fibres

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 pulp and paper mills

Despite having highly efficient production facilities, forest industries need to reduce energy consumption in order to stay competitive and fulfil new ambitious energy-efficiency targets. Breakthrough innovations are needed in fibre industry technologies, pulping, water use and re-use, and process control. The greatest potential for energy reduction is in reducing the amount of process water used, since process water is first heated to the process temperature and later extracted or evaporated to form the final product.

Examples of research and innovation activities

- Develop production processes that reduce the amount of process water needed
- Develop pulping processes and control strategies that reduce energy consumption
- Develop technologies for efficient heat transfer between different processes

B Optimizing the use of raw materials by exact control of natural variations

The qualitative characteristics of wood vary greatly between and within different stand locations, but also within the stem wood of individual trees. This is due to differences in climate, fertility rates, growth competition, maintenance, genetics, structural variations, age and other factors. These variations need to be fully exploited to ensure efficient utilization of the forest raw material, and so that effective, market- and knowledge-driven production systems can be developed. Increased use of IT, such as digital twins, IoT, big data analytics and AI, can support the industry in this much-needed development.

Examples of research and innovation activities

- Develop methods to determine forest raw materials characteristics as early as possible within the supply chain
- Develop processes that exploit and make good use of natural variations in wood quality
- Develop IT-based methods that exploit raw material variations in ways that meet market demands

Activities to foster resource efficiency have resulted in significant improvements in energy efficiency

C Improving raw material efficiency and production value in wood-based manufacturing

Sawmills need to improve process efficiency, raw material efficiency and storage turnaround. To develop more advanced wood drying techniques, in terms of control and scheduling, a better understanding of the interplay between process settings and variations in the wood material is needed, for instance when refining the control and scheduling of wood drying. New wood decomposition technologies and customer order-controlled production are also required to further increase productivity and stock turnover. New technology and business models should be developed to use side-streams, e.g. sawdust, to create higher added value products and maximize carbon binding in products with a longer life cycle. The carpentry and furniture industries also need to develop a higher degree of automation and by implementing new technologies to manage natural variations in wood material quality, they can replace fossil-based materials and appeal to a new customer base. Digitalization and 3D measurement technologies can further increase the already high added value offered by carpentry and furniture.

Examples of research and innovation activities

- Develop efficient wood decomposition and wood drying strategies
- Develop technology and business models to valorize side-streams from wood manufacturing
- Develop automation and digitalization methods for the carpentry and furniture industries

D Improving water balance and process water treatment

Water is an essential resource in the production of fibre-based products, and an efficient extraction of the particles, fibres and chemicals that are dissolved and circulated by the process water is a key factor in achieving a stable and efficient production process. The purity and quality of process water are key as only clean water should leave the processes. This requires increased stability in closed-loop systems and process water recirculation, as well as energy-efficient and high-yielding separation and extraction. Achieving a high yield extraction, even at very low concentrations is important not only for the water treatment itself, but also for the re-use and valorization of chemicals and biomolecules.

Examples of research and innovation activities

- Develop precise and efficient separation processes to extract chemicals and particles
- Develop methods that ensure process stability in new process water treatments
- Develop methods to extract valuable biomolecules from process water

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

Mutually beneficial collaboration between companies in different industry sectors and at different steps of the value chain, where the waste or by-products of one company becomes the raw material for another, needs to be further developed. This kind of true industrial symbiosis is vital for a sustainable circular economy and to increase the security of raw material supplies in Europe. The process of forging together distinctly different production systems, as efficiently as possible, will mean reconsidering some of the most traditional and long-standing production process technologies. Many breakthroughs will undoubtedly be made in exploring new, economically feasible designs for production modules that are smaller in size, less capital intensive and more agile. Meanwhile, increasingly interdependent and connected cross-sectoral systems will require a digital infrastructure and intelligent solutions that are resilient to cyberattacks and other disturbances.

Examples of research and innovation activities

- Identify and support process technologies and logistical solutions that can be integrated in a symbiotic way to create a circular economy
- Identify regional opportunities to share primary materials, recycled materials, and side-streams between different industry sectors in a secure and economically feasible way
- Develop processes to share heat, process water and chemicals between different businesses, at production site level

B Creating new biorefinery concepts for the circular and biobased economy

New biorefinery concepts are crucial for increased competitiveness and are the cornerstone for several novel value chains with new profitable products, services and business models. New biorefinery sites need to process a broader range of raw materials, including recycled materials. They also need to develop on-site co-operation with energy and chemical companies, as well as with users of new materials and composites.

Examples of research and innovation activities

- Develop separation process technologies for organic compounds
- Develop new processes that efficiently circulate energy and chemicals on extended production sites
- Develop new methods for fibre biorefineries, such as fibre fractionation and fibrillation to nano- and microscale

Diversification of technologies also helps to make small-size production units economically feasible

C Adopting additive manufacturing technologies and new production methods

New methods need to be adopted to optimize the use of raw materials and to use information feedback between market, industry and forest. This calls for new digital business and logistics systems that cover the entire forest-based value chain, as well as associated value chains, retailers and customers. Additive manufacturing technologies using plastics, metals and composites are developing rapidly and are now the predominant production method in some product niches. The forest-based sector should take the lead in developing this technology for the use of cellulose (including nanocellulose), wood-based polymers and composites as raw materials for products ranging from medical prosthetics to aeroplane components.

Examples of research and innovation activities

- Demonstrate and integrate wood preprocessing technologies such as 3D CT scanning
- Develop additive manufacturing using biobased materials and eco-design
- Develop digital business and logistics systems that support market information feedback

D Extracting and producing natural compounds with high added value

Extracting natural compounds creates new market opportunities ready to be exploited. The biorefinery concept needs to address the numerous possibilities for the creation of pigments, new materials for additive manufacturing, bioadhesives and biobased functional additives. New production methods for nanomaterials such as graphene and carbon nanotubes need to be developed.

Examples of research and innovation activities

- Develop efficient methods to extract valuable molecules (including food ingredients and nutraceuticals) from biomass in different suspensions
- Develop methods to extract supra-molecular and high-molecular structures without energy-consuming material decomposition
- Develop a range of biobased raw materials for additive manufacturing
- Develop new production methods for composite materials based on graphene and carbon nanotubes

E Improving traceability and chain-of-custody throughout the value chain

The demand for traceability of raw materials and products is increasing worldwide. Using sustainable, pest-free, traceable wood gives Europe's forest-based industries a competitive advantage. However, new, innovative technologies offer significant room for continued improvements. The concept of traceability also needs to include recycled raw materials. This requires multilateral, international co-operation and logistics that operate and maintain the traceability of source, collection, recovery, recycling, and transport of waste and materials.

Examples of research and innovation activities

- Develop a holistic system, including standards, for the traceability of virgin and recycled raw materials
- Develop standards for traceability in recycling processes, transport and end-of-life waste that can be accepted at regional level as well as in international co-operation
- Investigate how to use and adapt tracking technologies such as RFID, DNA marking and blockchain technologies to secure the chain-of-custody

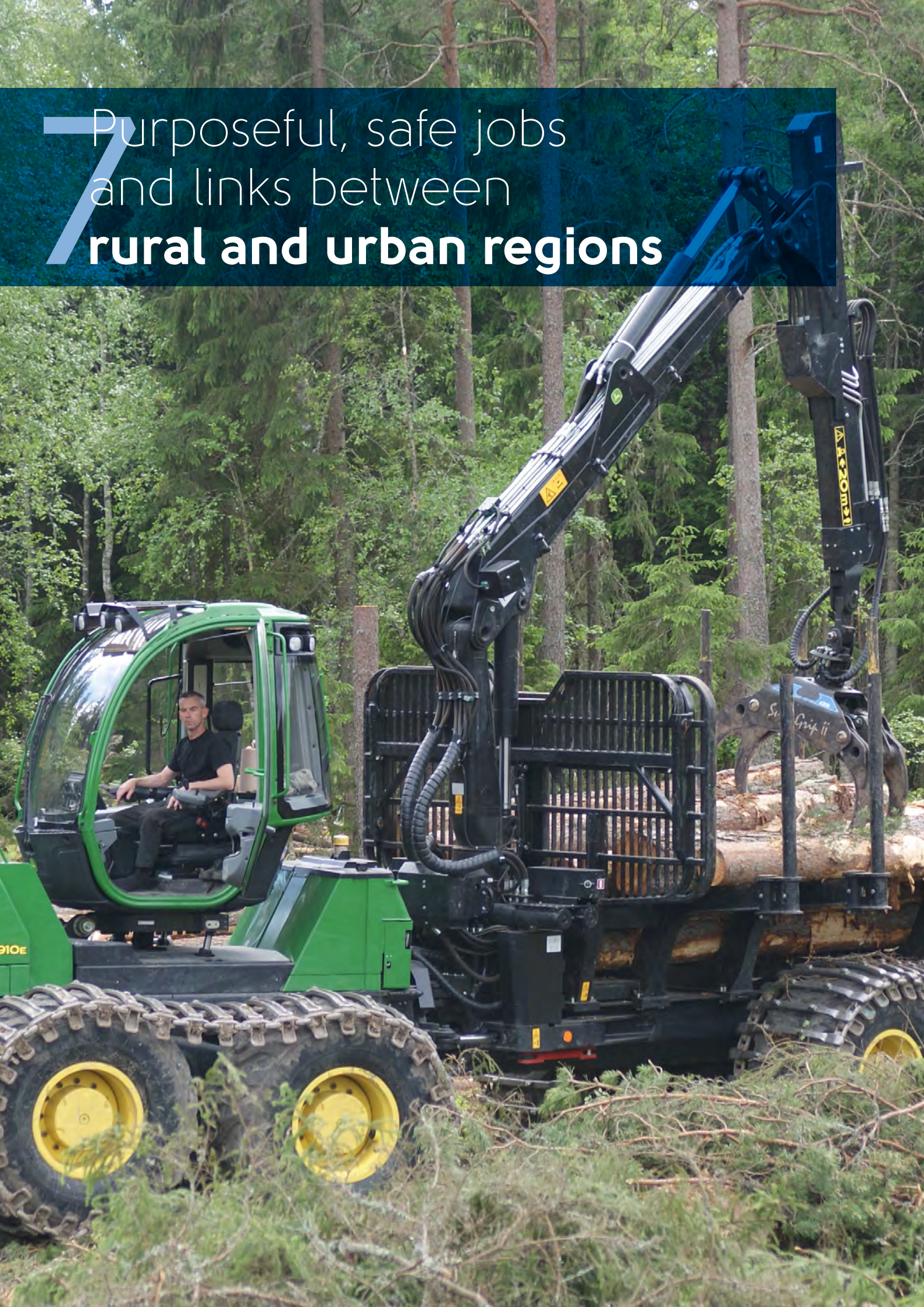
F Integrating autonomous and/or electrified harvesting and transportation systems

The marginal cost of transport and logistics from the forest to the end market is a prohibitive factor in supplying many sustainable forest-based solutions. Being an early adopter of digital technologies and autonomous transportation solutions could significantly reduce transport-related emissions and costs whilst significantly increasing speed and flexibility. The objective is a completely seamless integration throughout the value chain, from sourcing of raw materials (including harvesting), to measuring, processing, sorting and logistics.

Examples of research and innovation activities

- Develop autonomous and/or electrified harvesting systems that increase precision and productivity
- Develop semi- and fully-autonomous transport systems to improve efficiency and reduce environmental impact
- Develop methods for the assessment of total logistics efficiency to reduce emissions

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 Growing the forest-based sector through creative jobs

Activities related to research, creative design and communication are becoming increasingly important as the forest-based sector enters new markets, and shorter production cycles become more common. Fashion designers, engineers, and researchers with experience from other sectors and disciplines will be needed when the forest-based sector develops new cross-sectoral partnerships. New jobs will also be created in the area of biobased construction solutions if the sector can increase awareness about biobased building systems, and develop state-of-the-art training and educational programmes for architects, property developers and local authorities. Digital design tools should ideally be easy to use and intuitive.

Examples of research and innovation activities

- Organize design competitions to attract talent and identify new market opportunities
- Identify business models for co-operation between companies and independent individuals with creative talent
- Develop models for co-operation between architects, property developers and local authorities on biobased building systems

B Creating job opportunities along the value chain through proactive management of small forest ownerships[5]

New innovative business concepts are needed to make active management of smaller forest holdings more economically interesting, and thereby create new jobs for forestry entrepreneurs and in industries downstream.

Examples of research and innovation activities

- Develop digital tools to support small-forest owners in forest management and co-operation
- Develop tools for visualizing the balance between forest production and other ecosystem services
- Develop tools for visualizing the long-term effect of different forest management strategies

The forest-based sector is an attractive employer, known for providing meaningful and safe jobs

5 Challenge VT7-B overlaps in scope and activities with Challenges under Vision Target 2

C Developing new marketplaces and jobs in response to changing consumer trends

New emerging market and consumer trends are likely to accelerate and have significant impact on society in 2030-2040. New jobs can be created if the sector adapts to the socio-technological changes and is innovative enough when developing new business models. The trends towards the 'social economy' and 'collaborative consumption' offer new marketplaces, as do internet retailers. Increased use of packaging and transportation services, and a decrease in classified advertisements and print media, means a steep drop in business for shopping centres and physical stores.

Sustainable consumption patterns and consumer awareness will most likely benefit the forest-based value chain.

Examples of research and innovation activities

- Investigate market changes emerging from altered consumer behaviour in the digital era
- Develop business models that meet the needs of digital citizens
- Develop business models that support sustainable consumption patterns and consumer awareness

D Adapting job offers in an era of Artificial Intelligence (AI)

The use of AI and digital automatization has the potential to create radically new opportunities for humankind. However, society has so far underestimated the speed at which job opportunities will be lost to automatization and digital solutions. The transport and service sectors will be particularly impacted, as many jobs involving repetitive physical tasks (e.g. packaging, sorting and quality control) will be replaced by digital services and autonomous machines. This will lead to many people losing or leaving jobs because their positions are no longer necessary or because of insufficient work. The forest-based sector should be at the forefront of this mega-trend, offering continually evolving work that creates work satisfaction and higher added value.

Examples of research and innovation activities

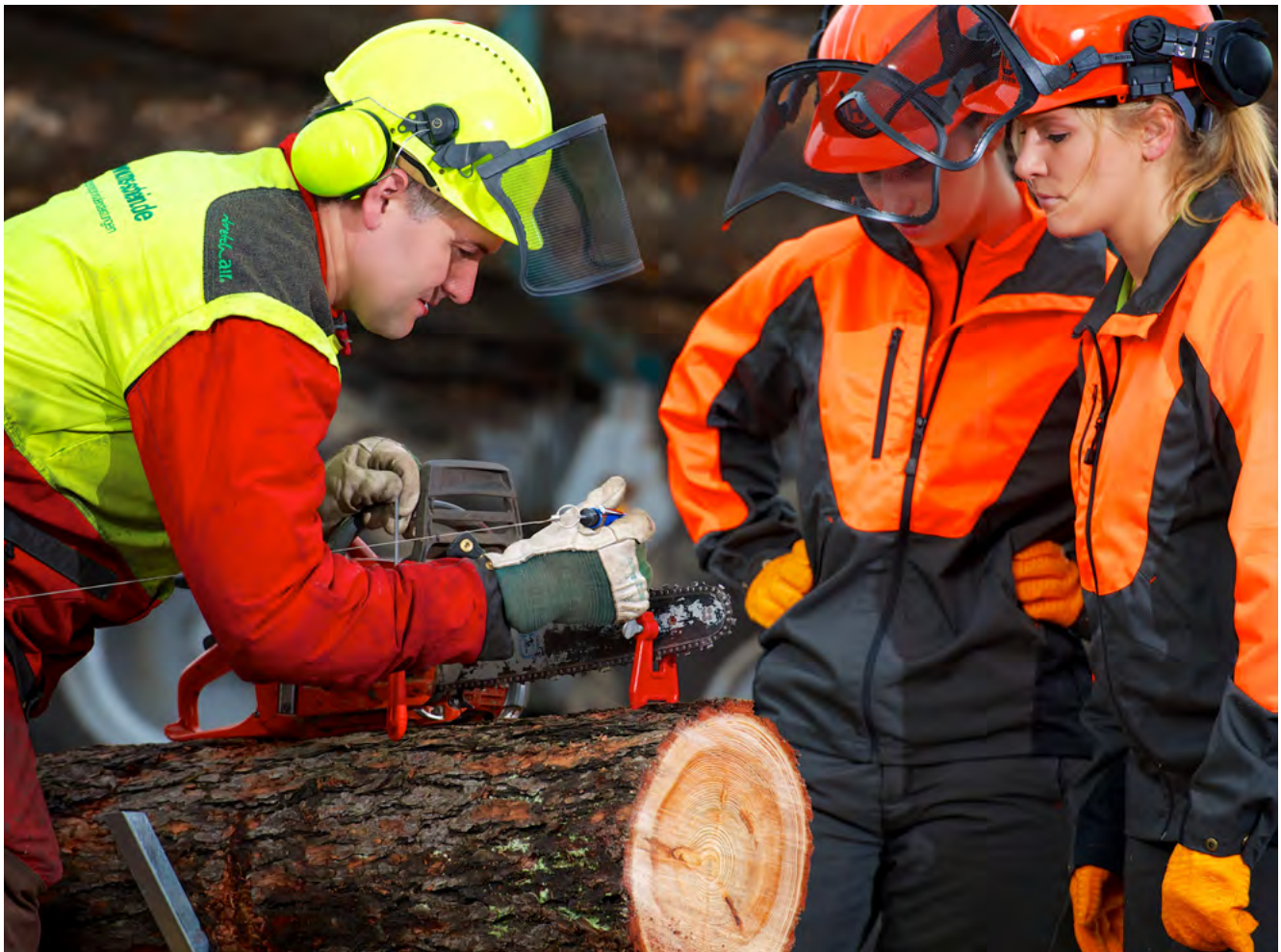
- Identify job sectors that will likely be replaced by digital services and autonomous machines
- Investigate matching opportunities between jobs lost and new competencies needed
- Develop models for co-operation with digital businesses and service providers to secure market positions

E Improving operator safety and ergonomics

Although new technologies and general concern for workers' safety and well-being have successfully reduced the frequency of accidents and injuries in the European forest-based sector, many jobs still come with significant occupational risks. The processes for identifying the causes of accidents, establishing the need for preventive measures, and providing feedback for those involved in prevention services are constant, and these require the involvement of workers themselves, industry representatives, government agencies and insurance companies.

Examples of research and innovation activities

- Develop safer machinery and personal protective equipment through novel design
- Further automate and digitalize hazardous work tasks
- Develop new, innovative ergonomic solutions



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 Developing new building systems, including modular and prefabricated systems

Wood-based building systems that use modular and prefabricated elements offer superior performance on many parameters when compared to non-renewable construction systems. However, due to the natural variations in wood quality and the multiple ways in which wood-based components can be assembled, dimensioning of wooden construction systems is far more complex than those using non-renewable materials. Therefore, wood-based building systems need to be further improved and better harmonized so that construction sectors in different countries increasingly opt to use them. Dedicated research and development is needed in lean manufacturing processes that are more resource efficient, and in building systems that compare better on complex attributes, such as indoor climate or acoustic performance. Building with wood is flexible and dynamic, but systems are often company specific, creating a very complex market for customers, designers and architects. There is a clear need for European co-operation in developing new sustainable building systems.

Examples of research and innovation activities

- Adopt additive technologies, including 3D printing, robotization, autonomous drone assembly and logistics solutions to drastically decrease construction costs
- Improve the functionality and interoperability (design, construction and operation) of complex prefabricated construction assembly systems, including their disassembly and reuse
- Create and maintain a harmonized, Europe-wide, collaborative, artificial intelligence-supported open design and innovation platform that also looks at optimizing construction for local climate, local wood species, etc.

B Improving wood-based products, including engineered wood and composites

Products manufactured from solid wood, engineered wood (e.g. cross-laminated timber) or biobased composites, far outperform non-wood materials in terms of carbon-neutrality and in many physical properties, such as low weight and high insulating capabilities. These products are used in various wood-based building systems, but also in furniture, boats and cars, as well as in many infrastructure solutions that need to be both highly durable and affordable, e.g. railway sleepers. Although the demands vary significantly depending on the use, common key performance criteria are durability, structural integrity and fire performance. These need to be better understood, and at the same time, more competitive production methods need to be developed. Research and innovation can also expand opportunities for using hardwood species that are currently underused.

Wood, the most commonly used renewable construction material in the world, has a bright future

Examples of research and innovation activities

- Enhance the performance of wood-based materials and products in terms of building engineering physics, behaviour, safety, durability, circularity, and for optimized building operations and services
- Expand the environmental benefits of building with wood by developing new environmentally friendly adhesives, impregnations, coatings and other treatments that use non-toxic and renewable solutions
- Improve long-term durability and outdoor performance of wood-based products by developing new and sustainable protective treatments and design solutions
- Research new, integrated smart functions such as photovoltaic and heat-conversion properties, and biosensors that provide provenance and traceability until end-of-life

C Harmonization, standardization and more intelligent digital design tools

Innovative, engineered wood products and building systems offer excellent performance for sustainable building requirements. However, they are still much less established and mature than concrete and steel-based systems, and therefore have difficulty penetrating the market. Still, in many regional markets, wood construction is growing and diversifying, being used for renovation, retrofitting and even in new high-rise buildings. Standardization research is needed for many important product categories and to include complete and appropriate information on wood products in digital design tools. The characterization of durability, fire safety, acoustics, dynamics and carbon footprint accounting needs to be further developed. Building Information Modelling (BIM), including Life Cycle Assessment (LCA) and product property catalogues, need significant development. Digital technologies

Photo credit: Ros Kavanagh

such as computational design, the use of robotics in prefabrication, 3D printing and augmented or virtual reality (AR/VR) should be developed and exploited. These can bring significant benefits for the production, marketing, maintenance and virtual inspections of buildings, leading to broader market uptake and overall growth of the sector.

Examples of research and innovation activities

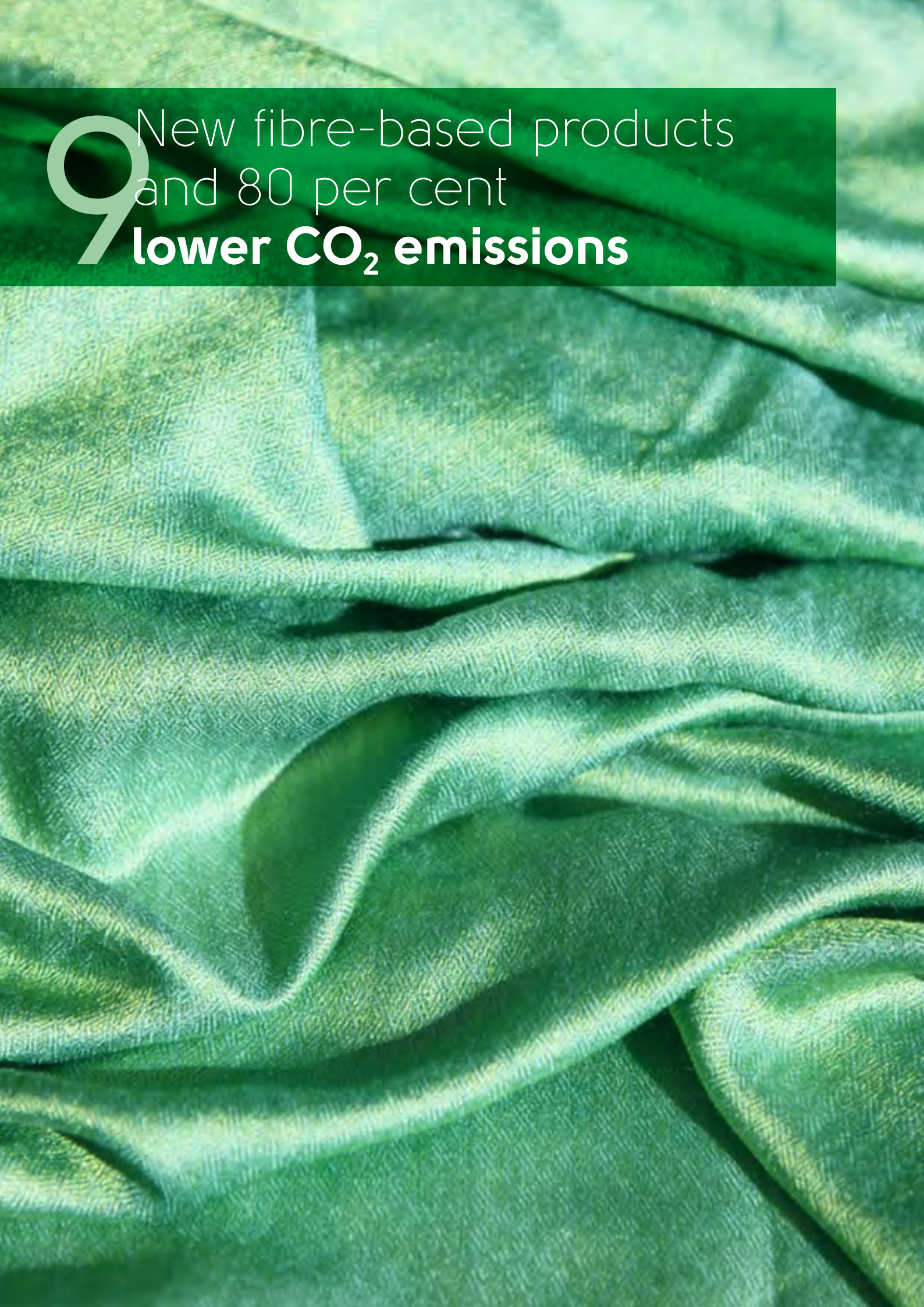
- Collect test and research data to advance the harmonization and standardization of materials, products and systems for wood construction in all relevant and emerging market segments
- Assemble product information and develop product property catalogues for Building Information Modelling (BIM) and Life Cycle Assessment (LCA)
- Develop design tools to handle new innovations, from prefabrication using 3D printing, to the use of augmented and virtual reality for marketing, maintenance and virtual building inspections
- Investigate the factors that influence public perception and national and regional policy frameworks, as well as, for example, how zoning authorities regulate the use of wood in construction, with a special emphasis on visible wood in urban construction

D Exploring the experience of living with wood and its health benefits

As well as the positive effects of wood-based construction in mitigating climate change, the health and well-being benefits of living and working in buildings and interiors made of wood and biobased materials need to be better understood and exploited. Systematic research and larger in-depth studies are required. Interdisciplinary approaches that combine social and natural sciences, are needed to ascertain the benefits on the human body and mind. This can pave the way for new and better design concepts and for criteria for materials, products and systems that can be used in buildings, furniture and interior design. If health benefits and positive cognitive responses can be modelled in advance, they can ultimately become an essential part of building system design and monitoring through smart technology.

Examples of research and innovation activities

- Undertake human-centred, interdisciplinary studies with the ultimate objective of making predictive modelling of cognitive responses to wood an essential part of building system design and monitoring
- Perform in-depth studies that connect ambient comfort, human health and well-being from living with wood, to chemical markers, such as the presence of volatile organic compounds (VOC) and physiological and psychological markers (including group dynamics, for example)
- Explore social, societal, cultural (including cultural heritage), ethnographic and anthropological aspects of wooden construction worldwide, including its influence on public health and well-being and the transfer of these findings into policy recommendations



9 New fibre-based products and 80 per cent **lower CO_2 emissions**

The pulp, paper and forest fibre 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 consumer products

Biobased packaging solutions need to provide growing global markets with smart, secure and biodegradable solutions for both B2B and consumer markets, while at the same time, reducing their carbon footprint. To meet customer demand for increased sustainability, industries need to respond with reduced use of raw materials, more efficient transportation, content protection and reduced food waste. New hygiene and healthcare products, with a reduced carbon footprint should be used in medical care. Biobased disposable healthcare products need to greatly replace fossil-based products globally. Fibre-based products with built-in digital solutions should be integrated into diagnostic work and be used for controlled drug dispensing. Sustainable wood-based textiles need to replace fossil- and cotton-based textiles, as global textile demand is expected to triple by 2050. For this, new sustainable production processes need to be developed to ensure comfortable, high-quality fibres that satisfy customers' expectations.

Examples of research and innovation activities

- Develop freely formable, biodegradable fibre-based substitutes to replace fossil-based packaging
- Develop smart functions (e.g. information, anti-tampering, anti-counterfeiting, traceability) that can be applied to fibre-based packaging solutions
- Develop lightweight fibre-based packaging materials that have improved performance (e.g. moisture resistance and stiffness)
- Study the medical safety of wood components when used in medical and healthcare applications
- Develop advanced functionalization of cellulose for use in medical applications
- Develop specific cellulose treatments for textile fibres to reduce environmental impact

B Developing more sustainable and competitive processes for papermaking and other biobased products

Existing papermaking processes and products have been optimized over the years to reach current levels of efficiency and profitability. However, the processes remain complex. Therefore, rather than seeing giant leaps in progress, gradual improvements are more likely. For this to happen, a new, fundamental understanding of system dynamics needs to be developed. Research needs to include the paper mill processes, and to some extent pulp mill processes. The focus should be on simplification and efficiency, cellulose-water interaction, as well as on new mechanical properties at micro and macro levels.

Examples of research and innovation activities

- Develop zero-carbon emission technologies for the papermaking process
- Study options for low- to zero-carbon energy carriers in forest fibre-processing installations
- Develop sensors and models to improve the energy efficiency of forest fibre-production processes

The pulp, paper and forest fibre industry is well on its way to reaching the targets to cut its carbon emissions by 80 per cent

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

Green chemistry needs to provide biobased functional chemicals and additives that are compatible with future biobased materials. These are needed for their unique properties and other added value, as well as for direct use in cleaning, surface treatment and adhesives. Wood-based polymers need to replace fossil-based plastics in packaging, construction and building materials. New material-forming methods are needed, to be able to create materials that have a high geometric complexity. The constituents of biobased composites and fibres need to offer combined functions related to fire and moisture resistance, stability and wear, while still being able to be recycled at the end of the product's lifetime.

Examples of research and innovation activities

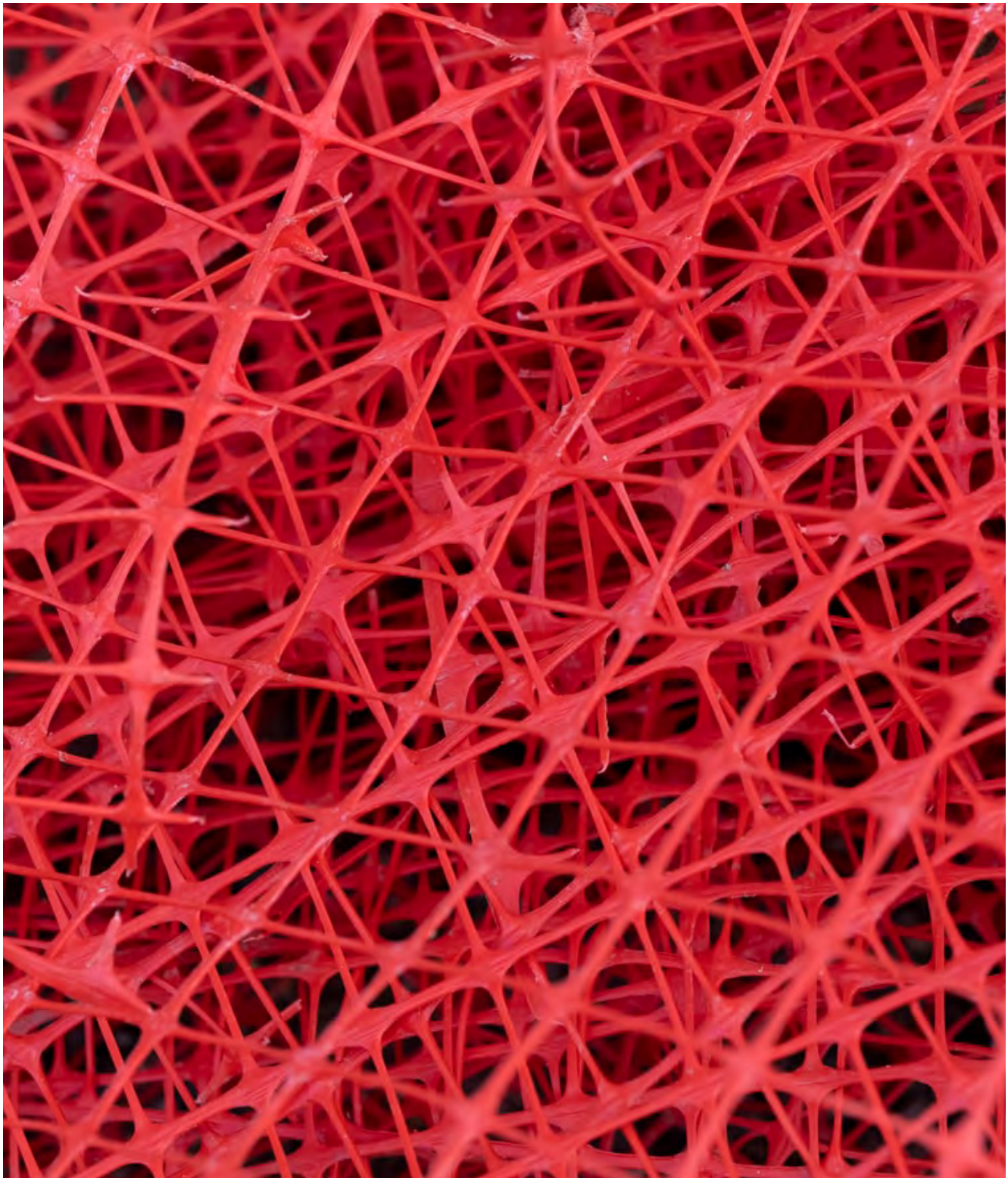
- Develop separation and purification methods, catalysts and macro-molecular chemistry
- Develop new recycling technologies for biobased composites
- Develop new products and applications from lignin, hemicellulose and cellulose

D Adding value through digitalization and functionalization

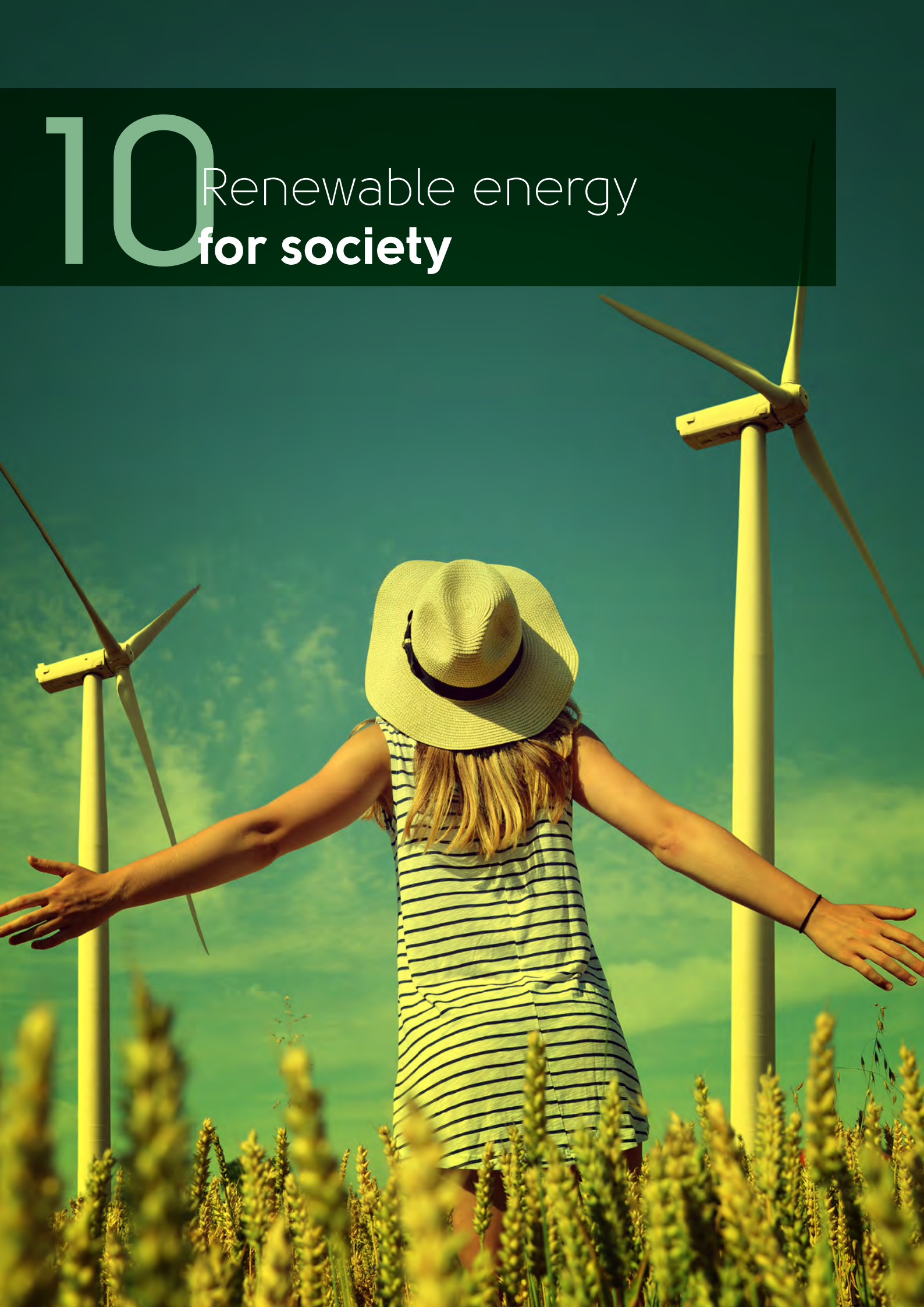
Functionalization at molecular, fibre and structural level needs to give biobased materials and products the physical, chemical and electronic properties that meet customers' demands in high-end markets. Providing this kind of functionality, instead of providing bulk products, is a way of offering high-value solutions to global markets. Features like tracking, anti-tampering, anti-counterfeiting, connectivity, microbial resistance and biodegradability need to be developed.

Examples of research and innovation activities

- Develop methods to safely embed functionalized components in cellulose-based substrates
- Develop solutions for just-in-time delivery of customized products that meet market demands
- Develop tools for big data analytics that can lead to improved functionalization



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 m^3 of forest and mill residues).

Challenges

A Developing new, efficient production systems for advanced, clean biofuels and chemicals

By-products from forest-based industries, such as sawdust, bark, tall oil and lignin, can be used efficiently in the production of valuable chemicals and composite materials. By far the largest markets for such products are still the markets for fuel and energy products. Commercial-scale facilities for the extraction of biodiesel from tall oil, for example, as well as several other projects for the development of other biobased energy solutions are ongoing. Biofuels can be used in aeroplanes, cars or as a solid energy carrier. Wood is made up of about one third lignin, a resource that is still underutilized. Significant research and innovation efforts are needed to develop ways in which lignin can be used in the production of chemicals or biofuels. Research is also needed to develop clean and effective methods for side-stream gasification and liquefaction so that production can be fossil free.

Examples of research and innovation activities

- Develop new production platforms for various drop-in fuels for road, aviation and marine transport
- Develop new products from lignin and advance the area of lignin chemistry and processing

B Enhancing the valorization of forest residues[6]

The availability and mobilization of sustainable biomass is key to reinforcing the competitiveness of forest-based industries and to determining how large a contribution bioenergy can make to the 2040 energy mix. Today, however, pre-commercial cleaning and thinning operations are costly for forest managers. As a result, many European forests are growing too densely, giving poorer harvests, and increasing the fire risk, particularly in southern Europe. Lowering the cost of these forest operations and increasing the value of the biomass could change the financial equation, making it economical to use residues from cleaning and thinning operations. This may require new and cheaper collection and transport solutions, which would improve the efficiency of local energy production and innovative infrastructure investments. New strategies are also needed to maximize the mobilization of low-quality sawmill residues and biomass harvested due to natural disasters, such as roundwood damaged by bark beetles, storm breaks or rot.

The sector will continue to be the biggest producer of green electricity and biofuels in Europe

6 Challenge VT10-B is closely related to Challenge VT2-C

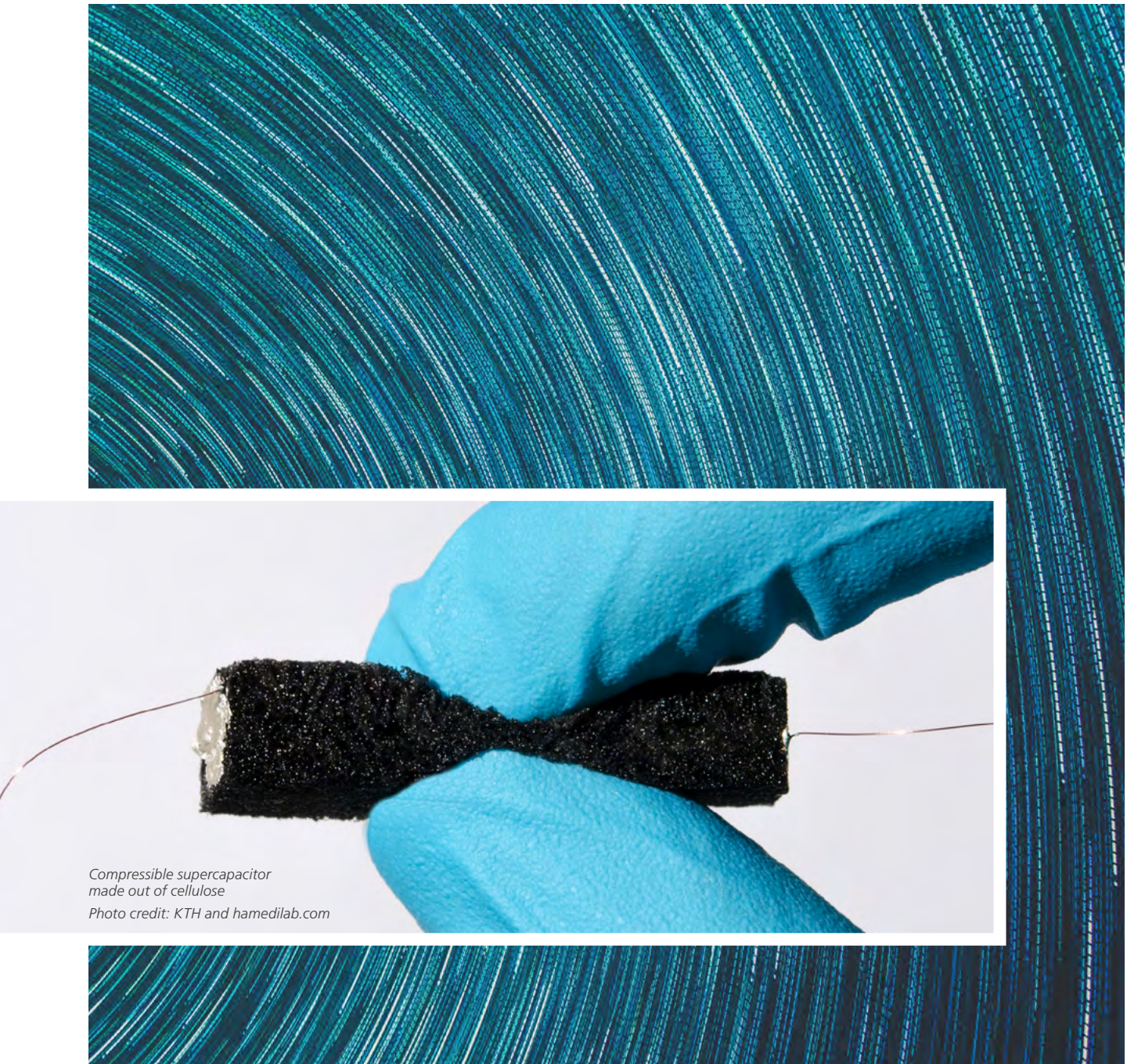
C Establishing integrated and holistic energy systems (including energy storage and managing demand fluctuations)

Creating smarter and more integrated energy systems will require research and innovation and significant infrastructure investments, from demonstration to commercial scale. With an increase of renewable energy sources, managing the balance on the power grid becomes a challenge. New innovative business models and business partnerships need to be further developed, such as pulp mills integrated with biochemical industries or combined heat and power (CHP) plants.

To ensure the forest-based sector becomes an integral part of a future European smart-energy grid, research is needed to identify different strategies for energy storage (as energy, biomass or electricity). This includes research and innovation on low Technology Readiness Levels (TRL) in the use of biomaterials for energy applications, for example, wood-based batteries and solar panels. Research is also needed to develop methods to increase the exergy of fluid streams and thereby improve waste heat utilization.

Examples of research and innovation activities

- Develop new wood-based batteries and energy carriers
- Develop new innovative business models and partnerships for future European smart-energy grids
- Exploit the potential of pulp mills to produce energy to balance the energy grid



Compressible supercapacitor made out of cellulose

Photo credit: KTH and hamedilab.com

D Supporting fact-based decision-making on bioenergy-related issues

Gaining 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. To advance this, the sector must be able to provide relevant data and information to support transparent and fact-based decision-making at all levels. New, competitive, energy- and material-efficient biobased value chains will therefore need to be established for the development of a successful European bioeconomy.

New research is also needed to be able to use biogenic CO_2 as a raw material for new products. This would have a remarkable effect on reducing emissions and on climate mitigation, as carbon capture and utilization (CCU) can reduce the need for fossil-based raw materials. However, the development and acceptance of new products is often a risk when it comes to technology, prices, markets and policies.

Examples of research and innovation activities

- Disseminate scientific facts to strengthen citizens' knowledge of the role of the forest-based economy in a biobased society
- Monitor and predict shifting societal demands for renewable energy, renewable materials and ecosystem conservation
- Improve the understanding of trade-offs between policies supporting primary wood-based energy production and those supporting the material use of wood

implementing **the SIRA**

The role of FTP and its National Support Groups (NSGs) is to bring together industry representatives, forest owners, researchers and public authorities in ways that will contribute to the FTP Vision 2040 goals. This will be achieved through co-operative research, development and innovation projects. Although industry, researchers, forest owners and forest managers will be primarily responsible for the work required, focus and strong support from European policymakers and both EU and Member State funding providers will also be vital to achieving the goals. This is a win-win collaboration that benefits both the forest-based sector and society as a whole.

Strengthening the European dimension

Transnational co-operation removes barriers and creates a 'common market' for research and innovation. In creating a European Research Area (ERA) in the forest-based sector, different national and regional priorities need to be aligned, as well as concepts related to the whole forest-based value chain. This kind of strong European collaboration expands international networks and increases opportunities for wider international co-operation.

The FTP's National Support Groups have a pivotal role to play in reinforcing the European dimension while at the same time, strengthening national and regional agendas by implementing their National Research Agendas.

Developing cross-sectoral collaboration

Thanks to the growing political determination to tackle the Sustainable Development Goals outlined by the United Nations in 2015, the forest-based sector has the scope to look at radically different ways to use forests and their renewable raw materials. There are no monopoly rights on these resources and other sectors have already recognized the strategic potential of forests as a resource base.

Cross-sectoral collaboration is a real opportunity for the forest-based sector to gain knowledge and create mutual benefits, for example, by integrating production concepts that use all components of the biomass to create added value via a wide range of renewable products. Expanding this co-operation to include the agricultural and waste sectors, and the

use of agro-industrial side-streams, contributes to an even more flexible and stable biomass supply chain. This ongoing integration process continues to gather critical mass through knowledge exchange and joint investments. FTP's role is to help create a new biobased industrial landscape for global markets using local and regional resources.

Improving communication with European citizens

Society places a deep emotional value on forests, and the European forest-based sector has founded its operations on a sustainable and socially acceptable paradigm. However, studies show that public perception of the sector in Europe is often based on ignorance and misinformation. For example, important measures that have been taken to improve sustainability are not widely understood, and the sector is not considered favourably in terms of job creation or career opportunities. The impact of this image problem extends to policymaking, consumer behaviour and recruitment. Improving public understanding of what the sector is striving for will be a critical success factor to achieve the FTP Vision 2040 goals.

FTP's bottom-up approach and network of National Support Groups encourages and facilitates communication with and within the forest-based sector community in general and with policymakers in particular. Further efforts should be made to ensure easy access to new innovative concepts and research results.

Measures to promote global innovation

Having the commitment and support of large companies is essential for establishing the conditions needed to encourage innovation in the European forest-based sector. While adequate protection for inventions and intellectual property is crucial, a key element of innovation is access to information and knowledge. Open innovation clusters and transnational networks, such as FTP, help to close the gap between businesses, research and resources. And companies that make use of them are able to bring knowledge-based products to the market faster.

While the management culture and stance of large companies is important, a network of examples of 'innovation leaders' should also be created to motivate others. The focus of innovation efforts therefore has to be on people and their ideas, rather than on technology.

Supporting innovation in SMEs

Small and Medium-sized Enterprises (SMEs) that already have good innovation management practices in place need further encouragement and support to invest in research and innovation. They should be able to draw on the full innovative potential of the international market and should be encouraged to create new business opportunities in Europe and beyond. Some SMEs need support and encouragement to invest more in research and innovation.

Participating in EU research and innovation is firmly in the best interests of SMEs. Amongst other benefits, it:

- strengthens their research, innovation and technology capabilities;
- increases their capacity to generate, absorb and use new knowledge;
- encourages and accelerates the commercialization of new developments;
- boosts innovation in products, services and business models;
- promotes business activities in larger markets; and
- helps SMEs develop more international knowledge networks.

Cross-border collaborations are also an important element in the innovation strategy of SMEs. These collaborations can help overcome some of the size-related constraints many SMEs face, such as access to technological and scientific competences. Partnering events and co-operation within the National Support Groups framework are valuable ways to foster collaboration and support SMEs that are committed to innovation.

Monitoring progress towards the vision

Implementing this SIRA will generate a continuously changing portfolio of programmes and projects in the field of research and innovation. To evaluate the performance of each individual project/programme, and secure further investment at different stages, an effective monitoring system needs to be established. For companies, as well as public funding bodies, assessing and communicating the value and uniqueness of an investment prospect is fundamental: "You can't manage what you can't measure". Within this context, it should be emphasized that in the forest-based sector, collaboration with competitors has traditionally been managed within a relatively open environment.

The European Technology Platform (ETP) for the Forest-based Sector is recognized by the European Commission

For further information please contact us on:
mail@forestplatform.org

or visit our website:
www.forestplatform.org

The Forest-based Sector ETP
European Forestry House
Rue du Luxembourg 66
B-1000 Brussels

Johan Elvnert, Managing Director

European Confederation of Woodworking Industries
CEI-Bois aisbl
Rue Montoyer 24, box 20
B-1000 Brussels

Confederation of European Paper Industries
CEPI aisbl
Avenue Louise 250, box 80
B-1050 Brussels

Confederation of European Forest Owners
CEPF asbl
Rue du Luxembourg 66
B-1000 Brussels

European State Forest Association
EUSTAFOR aisbl
Rue du Luxembourg 66
B-1000 Brussels

Design by **www.lyon.nu**

Forest-based Sector
Technology Platform

The Forest-based Sector Technology Platform (FTP)

The European Forestry House
Rue du Luxembourg 66
B-1000 Brussels

+32 (0) 2 239 23 03
mail@forestplatform.org

www.forestplatform.org

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