Forest-based Sector
Technology Platform

# Annex to the Strategic Research and Innovation Agenda

## *Research and Innovation Areas*





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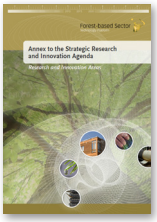


## Strategic Research & Innovation Agenda 2020 - Annex
Strategic Themes and Research & Innovation Areas

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**Figure A1. The research and innovation areas of the SRA are grouped under four Strategic Themes**

# Strategic Themes and key research and innovation areas

Achieving the overall vision and the vision targets as described in the renewed *FTP Vision 2030,* will require significant investment in research and innovation. The vision sets out four Strategic Themes which have been recognised by the sector and which have led to the identification of 19 specific research and innovation areas (RIAs) for the period 2013-2020. In Figure A1, the RIAs are grouped under the four Strategic Themes.

The first Strategic Theme, 'The forest-based sector in a biobased society', covers three RIAs and encompasses cross-cutting driving forces. It represents external drivers and processes that affect most of the other 16 research and innovation areas.

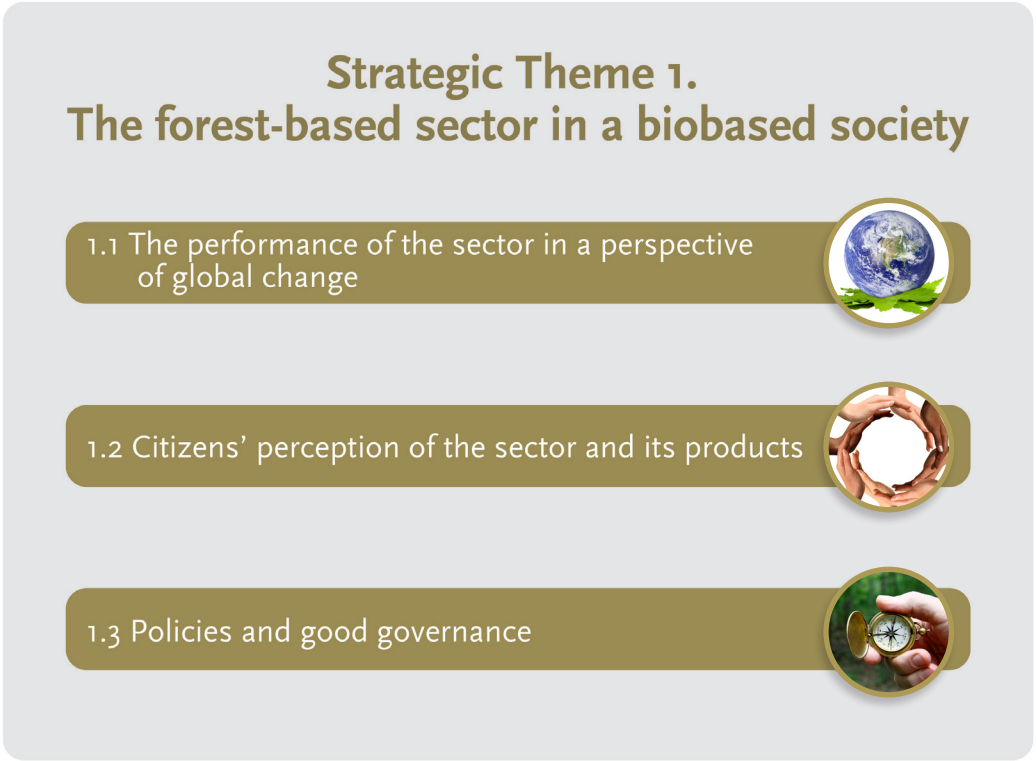
The Strategic Research and Innovation Agenda (SRA) recognises the need for the forest-based sector to continuously monitor and influence trans-national and global developments in its areas of interest, such as climate change (effects, adaptation and mitigation), global markets and changing consumer behaviour due to the implementation of new technologies, changing citizens' perception of the sector and the development of policies and legislation.

These fundamental drivers and processes need to be included in the work performed within the respective research and innovation areas under the other three Strategic Themes: *Responsible management of forest resources, Creating industrial leadership* and *Fulfilling consumer needs*. FTP will promote and inspire research on these overarching, cross-cutting issues, which are of the highest importance to the sector.

# Strategic Theme 1: The forest-based sector in a biobased society

Unleashing the potential of the forest-based sector to take the lead in Europe's endeavour to develop a biobased society will create new jobs and improve the livelihood for millions of citizens across Europe. The forest-based sector plays a pivotal role in society's combat against climate change as much as it needs to adapt to it. The sector's actual contribution, however, is dependent on policymakers as well as on European citizens, and how they perceive, accept and promote forest-based products and the activities carried out to produce these products. The performance of the sector in a perspective of global change, citizens' perception and the effects of policies and good governance of the sector are the three research and innovation areas under this Strategic Theme.

**Vision Targets for 2030: This Strategic Theme relates to all 10 Vision Targets described in the FTP Vision document.**



# 1.1 The performance of the sector in a perspective of global change

## Rationale

Raw materials, water, air, biodiversity and terrestrial ecosystems are all under pressure. The growing impacts of climate change, increasing demand for raw materials and energy, and environmental problems, such as land degradation and surface sealing, water shortages and floods, chemical pollution, and biodiversity loss, indicate that the planet is approaching the limits of sustainability. All these challenges directly affect forests, forest land and the provision of forest products, rural employment and common welfare. At the same time forests and the forest-based sector are mitigators of many of these negative trends, providing safe, economically-feasible, environmentally-sound and socially-acceptable solutions along their entire value chains. **Forest-based biomass can be transformed to substitute most products made with fossil carbon.** It is often forgotten that substitution of non-renewable or energy intensive materials by forest-based products is a particularly efficient way to drastically reduce fossil-based carbon emissions and **will demonstrate leadership in the development of a biobased economy.**

## State of the art 2012

Forests together with the atmosphere and the oceans are the three major carbon sinks. Trees that are growing, forest plants and soils the world over absorb about one third of man-made $CO_2$ emissions. The substitution of non-renewables and other critical raw materials by forest-based products is already taking place. The forest's ability to adapt to climate change and to contribute to its mitigation as well as its role in providing rural jobs, livelihoods and new biobased products is already recognised. However, addressing the sector's overall performance in times of societal change calls for co-ordinated research and innovation efforts across many disciplines and (sub-) sectors.

## Expected achievements by 2020

Based on quantitative data **the forest-based sector has proven to be one of the major mitigators of excessive $CO_2$ concentrations in the atmosphere.** Comprehensive monitoring systems and assessment tools are in place to prove the positive performance of the sector's long and complex value chains in the context of global change. By 2020 the overall economic and common welfare contributions of the forest-based sector to European society can be evaluated and compared to other sectors (see also RIA 1.3). Ecosystem services provided by different types of forests are documented and appreciated by society. The means to value these services have improved (see RIA 2.2). The forest-based industries have developed new products and service concepts, which are produced with zero net-carbon emissions; they are able to replace a large number of products based on fossil and non-renewable resources. These new wood- and fibre-based products are competitive and greatly appreciated by consumers.

## Required research and innovation activities

A. Assess and develop scenarios for the availability and valorisation of forest-based raw materials in Europe in the global context under changing economic, social and climatic conditions.

B. Develop assessment tools and monitoring systems for international production and trade flows including storage and $CO_2$ sequestration in forest-based raw materials and wood-based products.

C. Provide an overall economic valuation method for all products, employment, and ecological and common welfare services of the forest-based sector compared to other sectors at national and European level.

D. Create more added value from less resource consumption – decoupling economic growth from resource consumption.

E. Explore new space technologies to generate forest-related data, including high resolution space data, LIDAR-, IR- and radar data and to present those data layers together with relevant trade and climate change data.

F. Build up forest-related data infrastructures on existing pan-European and national monitoring networks in order to extract maximum benefit from earlier investments and already-compiled data series and knowledge. European efforts should be linked with the Global Forest Information Service (GFIS) initiated by the International Union of Forest Research Organizations (IUFRO) and the United Nations.

G. Assess the climate change mitigation effects of competing usages of forest biomass including comparative analysis with similarly-applied agricultural products, competing land uses and policy-regulated versus free market developments.

H. Understand and monitor the role of forest ecosystems and ecosystem management, including soils, for the global carbon cycle.

I. Assess challenges and further develop opportunities for specific European trans-boundary forest ecosystems in times of global change.

J. Assess and monitor global developments in total forest cover and ecosystem services, raw material supplies and their potential to mitigate climate change.

# 1.2 Citizens' perceptions of the sector and its products

## Rationale

Society places a deep emotional value on forests and, quite justifiably, pays close attention to the sector that depends on harvesting this re-growing resource for the supply of raw materials. The European forest-based sector needs to explain and clarify the rationale behind modern forest management and convince the public that forest raw material extraction is carried out responsibly and sustainably. Market, socio-economic and social analyses enable the sector to better understand and predict citizens' and society's demands and perceptions of itself and its products. Conflicting demands on different links of the value chains and potential misperceptions of different services, industries and products need to be addressed with concepts and approaches which consider individual branches and the overall performance of the sector, as well as influences from outside the sector.

## State of the art 2012

Most forests in Europe are certified under globally-accepted certification schemes such as FSC and PEFC, addressing concerns of sustainable forest management, forest degradation and loss of biodiversity. Nevertheless, studies show that a perceived conflict of interest between sustainable forest management and nature conservation persists among European citizens, often leading to a negative perception of the performance of the forest-based sector, even in comparison with truly unsustainable sectors. Measures to improve sustainability are not fully appreciated and the sector is considered neither very 'green', nor fundamental for job creation and the prosperity of rural regions. These perceptions impact on policymaking, consumer behaviour and recruitment.

## Expected achievements by 2020

Public perception of the sector will be improved by applying social sciences to forest-based sector governance issues, for example, through the innovative communication of research results to different target audiences. **Improving the public understanding of what the sector is striving to achieve and enhancing stakeholder engagement** will be a critical success factor to achieving the FTP Vision 2030.

## Required research and innovation activities

A. Raise public awareness of the role of forest biomass and forest-based products in climate change mitigation.

B. Strengthen citizens' knowledge of the role of forest-based industries in a biobased society.

C. Monitor emotional and fact-based societal perceptions of forest management practices, reused and recycled wood-based products, bio- and nanotechnology and its derived products.

D. Improve decision-making processes and knowledge transfer systems by taking into account both scientific knowledge and citizens' perceptions (including civil society, customers, forest managers and policymakers).

E. Monitor and predict shifting societal demands including scenarios for future priorities in raw material use, forest management and ecosystem conservation.

F. Predict future demands through quantitative and qualitative behavioural economics.

# 1.3 Policies and good governance

## Rationale

Policy frameworks influence stakeholder decisions concerning the forest-based sector. At the same time good forest-sector governance can greatly contribute to the success of European policy objectives. Meanwhile, policy decisions targeting other sectors often have unexpected effects on the forest-based sector and its capacity to contribute to societal objectives. A better overview and understanding of European and national policies and laws directly or indirectly affecting various links of the sector, as well as prices and consumer behaviour, will help individual forest-based value chains and the overall sector to align their strategies.

## State of the art 2012

Good governance of the sector is taking place within the interdependent triangle of state (laws and policies), markets (supply and demand, prices – see RIA 1.1), and society (as collective interest groups and individuals - see RIA 1.2). The policy framework affecting the forest-based sector is highly complex, resulting from diverse and changing societal perceptions and demands. It includes national and European directives, actions and targets such as LULUCF[1], Natura 2000, the Strategic Energy Technologies (SET) Plan, National Renewable Energy Targets, watershed management, recycling and waste directives, and building regulations, to name but a few. Several policies have partly conflicting or even competing objectives; some are supportive, some detrimental to the development of the forest-based sector. National standards and regulations, often designed for non-wood materials and products, are sometimes not up to date with current technologies especially in the woodworking sector. The degree of effectiveness and congruency varies across Europe. Adequate approaches to increased sustainable raw material supply from small-scale private forest owners remains a challenge.

## Expected achievements by 2020

Stakeholders of the forest-based sector, especially **decision makers, have a better understanding of the sector's setting in the complex international policy environment.** The sector is able to furnish evidence of potential negative effects of certain policies. In 2020 the sector is able to develop cross-cutting and congruent strategies to advise policymakers within and outside the sector, to inform decision-making processes with a short- and long-term perspective. Policymakers, on the other hand, have a better and more complete understanding of the forest-based sector and its contribution to European and national policy objectives

## Required research and innovation activities

A. Develop effective assessment and communication tools to inform political decision-makers about evaluation of forest ecosystem services compared to other land uses (See also RIA 2.2).

B. Analyse and monitor changes in forest ownership and their implications for forest management, new opportunities and markets.

C. Develop incentives for small-scale private forest owners to actively manage forests for wood production and other new services.

D. Improve understanding of trade-offs between policies supporting primary wood-based energy production and those supporting the material use of wood in the woodworking and construction industries, pulp and paper industry, biochemical and biomaterial industry.

[1] **Land use, land-use change and forestry** (LULUCF) is defined by the United Nations Climate Change Secretariat as "A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities".

E. Devise a more cost-effective EU and national policy framework for climate change mitigation by propagating the means of sustainable forest management, increased use of wood as well as wood-based products for systematic cascading.

F. Develop impact assessment tools for policies affecting the forest-based sector, especially those addressing changes in land use, energy production and energy saving. Also, with regard to recycling and cascading use of biomass.

G. Assess and communicate the prerequisites and means to increased building with wood and living with wood all over Europe.

H. Assess and address the direct and indirect effects of policy approaches, political incentives, development of sector relevant standards and regulations, market developments (see RIA 1.1), and changing societal perceptions and demands (see RIA 1.2) on the forest-based sector.

# Strategic Theme 2: Responsible management of forest resources

## Vision Targets for 2030

1. A resilient and diverse European forest is sustainably managed by a variety of owners and owner cooperatives who, assisted by new multi-purpose management systems, provide all the functions of the forest including raw material production, biodiversity and recreational opportunities.

2. In many regions specific forest growth is increasing and management is optimised for additional harvesting possibilities. In other regions, especially in the Mediterranean area, where the impact of climate change is predicted to be severe, creating resilient, stress-tolerant forest is particularly important. In some landscapes the main aim is nature conservation and providing ecosystem services. Bearing in mind the full range of demand and production constraints, harvesting possibilities in Europe have increased by 30%, enabling forest owners to manage their forests more efficiently and sustainably.

3. A cascade use of wood-based materials is established throughout the entire value chain. Recovery, reuse and recycling of forest-based products account for 70% of all recyclable material. When recycling opportunities have been exhausted, the remaining material is used for energy production.

# 2.1 Multi-purpose management of forests

## Rationale

European forestry has focused traditionally on sustainable wood production albeit with major differences from region to region. However, this single-use focus does not embrace the rich offering of goods and services forests can provide, such as nature conservation, watershed management, recreation, soil preservation, raw material production and carbon sequestration. For many owners the forest is not their main source of income and attention is shifting from wood production to more integrated forest management or nature conservation. These forest owners need innovative guidance approaches that can meet the new demands and at the same time make use of the landowners' forest-related skills. This research area of multi-purpose use and management forms a bridge between forest ecology and the provision of forest products and services.

## State of the art 2012

Forest management models up to the turn of the last century were traditionally directed to wood production in even-aged and mono-species stands. How forests should be managed to satisfy multiple demands in an optimal way is poorly understood. Spatial integration or the segregation of forest functions is heavily debated. New management systems that can deal with multiple objectives and assist forest managers in providing environmental services and growing new qualities and types of raw materials are lacking. Also, the interaction and communication between forest owners and society on the subject of multiple demands need to be strengthened. The impact of governance and regulations related to multi-purpose forestry is also little understood (see RIA 1.3).

## Expected achievements by 2020

By 2020 **better understanding of technological, biological and value-based aspects of how enhanced planning and improved forest management will support multi-functionality,** will have been achieved. The impacts of forest management on the ecosystem are much better understood. By then improved and optimal separation and integration of functions will take place, from local to national and at European level. Many of the multiple functions (next to wood as a source of income) are an integral part of new and concrete management regimes. Forest management systems simultaneously optimise the provision of several goods and services, taking into account the trade-offs between different management strategies.

## Required research and innovation activities

A. Research into the trade-offs between multiple technical, biological and value-based functions both on small and large spatial scales, to form the basis for socially and environmentally optimal new management regimes.

B. Research into regionally and locally specific forest management regimes that are able to cope with climate change and at the same time fulfil local and global needs.

C. Develop new modes of stakeholder-based adaptive management to fulfil all functions of the forest, optimally separated or integrated at various scales and under different regional conditions.

D. Try out new business models to activate small forest owners to improve their long-term social and economic sustainability.

E. Research the raw material requirements of the production of wood products, as well as new forest-based products, specialised products and the provision of a variety of non-wood products and ecosystem services.

F. Quantify the total value of forests and their functions.

G. Develop regulatory instruments to compensate for non-marketed goods and services.

H. Improved understanding and interaction between forest managers and society, industry and NGOs (local stakeholders as well as broader interest groups) and research governance modes, adaptive planning and supporting instruments.

I. Multidisciplinary research within the scope of an integrated landscape concept.




## 2.2 Forest ecology and ecosystem services

### Rationale

Understanding the ecological functioning of diverse European forests is a basic requirement, not only for a healthy and resilient forest, but also for a sustainable industry based on this resource. This ecological basis, in terms of composition, structure and function is changing, however, due to human influences and environmental changes. Diverse forests provide society with a multitude of ecosystem services and multiple wood and non-wood products. Forests capture 10% of the EU's $CO_2$ emissions, host biodiversity at species and gene level, ensure water conservation (see also RIA 3.3), enable habitation in mountainous areas by mitigating natural hazards, offer recreational opportunities and provide employment in rural areas. Through these services European forests provide great socio-economic value. The challenge is to find the right balance in space and time for providing these benefits.

### State of the art 2012

Ecosystem functioning and its many services is a basis for all other RIAs. Current research capacity provides a reasonable insight into forest dynamics, growth and management models at the member state level but there is a lack of coordinated research at EU level on new and innovative pathways. Intensifying international research and information exchange would enhance the understanding of climate change, biodiversity and service provision. Also, the understanding of the degree to which humans influence the system remains weak, as well as

the indirect effects of natural disturbances such as storms, droughts and fire. A better understanding is needed to create a variety of management systems - for everything from strict reserves and semi-natural forests to intensively-managed plantations - using improved silvicultural practice based on advances in functional ecology and genetics. Ecosystem services are difficult to evaluate. In addition, we lack a full understanding of the socio-economic and governance aspects surrounding the provision of goods and services.

## Expected achievements by 2020

By 2020 **fundamental understanding of ecological processes, interactions and resilience to climate change has improved**, of different components of the ecosystems and at different scales of space and time. **New modes of payments for ecosystem services have been developed** and are partially in place by 2020. Research has concentrated on quantifying the services, their value and on mechanisms of payments for these services. To address the wide variety of services, new models of governance are developed, integrating ecology with economics and social sciences.

## Required research and innovation activities

A. Improve understanding of the complex system dynamics of forests in relation to human society and global change, considering non-linearity of processes, threshold phenomena, feedback and feed forward loops, resulting in alternative stable states; derive improved concepts of resilience to disturbances and adaptive capacity.

B. Create a new and better-linked research and information infrastructure including integration of space data, monitoring networks and a harmonised database infrastructure.

C. Improve the understanding of biodiversity development (both intraspecific genetic diversity and species diversity, including aboveground and belowground food webs) in managed forests, and the role of biodiversity for the production and variety of raw materials, prevention of pests and diseases, water quality and water-related services, soil protection, carbon sequestration and other eco-system services.

D. Investigate and monitor the heritage value of high biodiversity forests in Europe, including key relics in biodiversity hotspots, ancient woodlands and virgin forests.

E. Develop criteria and indicator tools to quantify ecosystem services, identify their trade-offs, estimate the value of socio-economic benefits and assess the social and human impacts of rural, urban and peri-urban forests.

F. Improve insight into the value of environmental services to society in an integrated land use setting and analyse efficiency of various financial incentive systems and instruments for enhanced provision of these, including payment for ecosystem services (PES) and PES-like schemes.

# 2.3 Enhanced biomass production

## Rationale

The forest-based sector contributes to the mitigation of increasing concentrations of $CO_2$ in the atmosphere by, among other things, storing carbon in sustainably-managed forests and increasing forest biomass production. The intelligent and efficient production and use of biomass are core activities of the European forest-based sector.

## State of the art 2012

From a biomass and $CO_2$ perspective Europe's forests are managed sustainably. Biomass increment has exceeded biomass extraction for many years, resulting in a net storage of $CO_2$ in European forests. Biomass production is increasing steadily mainly due to modern forestry practices, including the selection of suitable tree species and improved planting materials. In some areas fertilisation is practised. Planted forests represent today around 7% of the world's forest area and contribute 36% of the annual requirements in roundwood. The results of traditional tree breeding are commonly implemented. Emerging biotechnologies are at the edge of application, for example, in mass propagation of planting material. The use of genetically-modified trees is so far prohibited outside of a pure research context.

## Expected achievements by 2020

We have new, flexible and adaptive systems for achieving sustainable forest production for higher yields, improved wood quality and stress tolerance in changing environmental conditions.

Europe leads the world in quantitative and biological sciences related to tree breeding. We have a better understanding of benefits and risks related to economic performance, social acceptance and environmental effects associated with the use of genetically-improved trees, as well as how wood and fibre properties in growing trees can be modified to better meet the requirements of end products. **Fast growing, currently low-value tree species are being harvested and grown for special wood properties and compounds for high-value wood-based products.**

We have developed strategies for sustainable forest plantations and tree farming which is a prerequisite for the optimal use of genetically-improved trees for increased growth, quality and changing environmental conditions. This has resulted in a large increase in productivity and reduced losses due to improved resistance and tolerance to biotic and abiotic stresses (e.g. climate change and nutrient constraints) in selected traits. **We know how to introduce managed forests in order to guarantee biodiversity and multi-functionality at landscape level.**

We aim to establish forest production on marginal or depleted sites as well as on land that today is not used for production.

## Required research and innovation activities

A. Improve monitoring, empirical modelling and space technology tools for assessing forest growth and biomass production trends on different spatial and temporal scales.

B. Improve existing and develop new techniques for silviculture and efficient forest management systems to reduce vulnerability to climate change including changing fire and storm patterns.

C. Develop decision support tools to help forest managers optimise growth, resource efficiency and water productivity in changing environmental conditions.

D. Develop new tree breeding strategies that include quantitative and molecular genetic tools aiming at sustainable and high yield of biomass, improved wood quality and resistance to stress.

E. Develop tailor-made biomass production systems for specific uses.

F. Study molecular, biochemical and physiological processes, determining wood and fibre properties and matrix architecture, as well as pest and disease resistance, water efficiency and nutrient biology.

G. Develop new, innovative technologies for mass propagation of seedlings.

H. Develop new tools to carry out performance and risk analysis for novel varieties or genotypes including exogenous genetic resources introduced in regions different from their origin.

I. Assess the economic, social and environmental benefits and risks associated with the use of genetically-improved trees.

J. Translate scientific information into a risk-management framework for resource managers.

K. Improve sustainable short-term rotation management schemes for woody biomass production.

## 2.4 Secured wood supply, forest operations and logistics

### Rationale

To maintain and strengthen the competitiveness of the European forest-based sector it is crucial to secure efficient, sustainable and high quality raw-material supply.

The provision of raw materials and the further development of efficient and environmentally-friendly forest operations, transport systems and management models for biomass supply chains are core activities of the forest-based sector.

### State of the art 2012

The EU's growing stock is increasing. In 2010 the annual increment of Europe's forests was 768 million $m^3$, while the annual harvest was 484 million $m^3$, equivalent to 63 % of the increment. Though variation is large, in no EU country does the harvest exceed increment. Still, the supply of biomass is far from secure. Reasons for this vary and include the divergent interests and stakes between industries and forest owners, probably due to a large variation in ownership categories and structure, as well as market mechanisms and the efficiency in forest operations, which differ substantially between regions.

New techniques now permit the measurement of a number of key wood quality parameters already in the forest. So far these methods have been sparsely implemented.

### Expected achievements by 2020

In 2020 a new generation of resource inventory systems and flexible planning tools, enabling **precise information on quantity and quality on local, regional and global scales**, has evolved. New forest management and wood **supply systems have improved the integration along value chains from forest to end-product**, shortening lead times, increasing capital turnover, improving profitability of forest ownership and reducing environmental impacts. New, **partly autonomous harvesting systems increase productivity** in harvesting operations and improve the working environment for operators.

The consequences of changing ownership structures for wood supply are better understood and this knowledge is used to advise on policy, reducing the negative impacts of these changes.

## Required research and innovation activities

A. Develop new inventory techniques for determining quantity, quality, dimensions and specific properties of forest resources.

B. Assess the future availability of woody biomass for different uses.

C. Develop flexible planning and decision support tools for obtaining sustainable wood supply from multipurpose forest landscapes.

D. Provide new and cost-efficient techniques to allow for chain of custody assessment.

E. Develop intelligent forest operation systems and new solutions for human–machine–terrain interactions.

F. Develop new (or adapt existing) ICT solutions for new, smart and integrated transport and logistics systems from local and regional to global scale.

G. Develop decision support systems for optimised supply chain management, including cascade use of wood, fibres and biomass, linked to forest planning tools for multifunctional forest management.

H. Assess market mechanisms, organisational systems and organisational behaviour to improve supply chain management systems.

I. Develop innovative processing concepts to be carried out during transport.

# 2.5 Cascade use, reuse and recycling systems


## Rationale

Wood and wood-based products have the potential to be re-used repeatedly as raw material. Waste from harvesting operations and wood processing is regularly used as high-value raw material for other types of processing. Low-value treetops and branches, stumps and roots, crude tall oil and other first and second generation biorefinery products contain chemically-attractive components which can be exploited in a variety of ways; woodchips and off-cuts from sawmills and furniture manufacturers constitute valuable input to wood-based panel manufacturing and pulp mills. All these materials are classified as pre-consumer wood.

Post-consumer wood, i.e. a wood product that has gone through at least one lifecycle, can be used for the production of new value-added products. There are different categories of post-consumer wood; recycling of each of them requires different methods.

It has been demonstrated that the multiple recycling of paper-based products and preferential material versus the energetic use of recovered flows generate more added value and create more jobs. Therefore recycling of paper and board products has formed an indispensable part of the manufacturing chain. Finally, the manufacturing of value-added biofuels (solid biofuels, biogas, etc.) and direct energy products will give extra value to wood waste in the final stage of its lifecycle, extracting the maximum potential from the lignocellulosic material.

By using the full potential of wood within cascading chains and recycling the added value generated, the number of jobs maintained or created is significantly higher than in transforming primary wood directly into bioenergy.

## State of the art 2012

The primary and secondary wood processing industries (sawmills, panel board industries, furniture sector) and pulp and paper industries have a long tradition of using residues as a secondary raw material or as bioenergy source for their industrial processes. No raw material is wasted. Wood-based panels, in particular particleboard, are manufactured to a large extent from recycled wood, while products such as packaging can be produced from 100% recovered wood.

The paper industry attained a recycling rate of 70.4% in 2011. Thus paper for recycling is the important raw material for paper making. This has been achieved through progress in paper collection and sorting, and in recycling and deinking technology despite more elaborate paper products (prints, stickies, more complex functional packaging). Reuse and recycling of post-consumer wood materials is more complex and requires different practices.

## Expected achievements by 2020

Stakeholders (forest owners, forest operators, forest-based industries, politicians, the general public and consumers) are aware of **the importance of cascade use and recycling for the sustainability of forests** and the entire sector. Forest-based industries have developed and are following **quality guidelines advocating a cascade use of wood** along the following lines of priority: (1) production of wood-based products, (2) re-use of products, (3) recycling into other wood-based products, (4) use as bioenergy source. Well-developed paper collection systems and progress in sorting technology deliver a controlled quality of paper for recycling for the different paper grades. Fibres from recovered paper and board are fractionated in order to obtain **fibre fractions to be utilised according to their potential within or outside the paper value chain,** e.g. for bioplastics and biocomposites production or as a base for cellulose biofuels production. Recycling rates are increased for the production of graphic and tissue grades. The pulp and paper sector has integrated cascade use of mineral resources (fillers and pigments) in a cross-sectoral approach.

## Required research and innovation activities

**Along whole value chain:**

A. Generate a better knowledge of useful or harmful chemical compounds in different tree parts and wood biomass fractions for cascading purposes (bioenergy, biorefinery and wood products).

B. Develop further improvement for the collection of residues from harvesting and processing (paper, construction materials, waste wood, forest residues, pruning residues from agriculture, etc.) with priority for separate collection and quality assortment classifications.

C. Develop and implement new socioeconomic and policy formulas for fostering stakeholder and societal awareness of the importance of cascade use.

D. Develop value-added applications of extracted wood polymers, nanofibrils, lignin, xylan, pulp fibres and paper, for example, for carbon fibres or ultra-lightweight composites in the fields of construction, interior design and packaging.

**Wood products:**

E. Improve the re-usability and recyclability of wood composites and construction material.

F. Develop systems for wooden buildings allowing for easy dismantling and remounting.

G. Develop environmentally-friendly additives and impregnating agents for wood products.

H. Develop solutions for the utilisations of used wood from construction operations (scaffolds, concrete casting moulds) as a biorefinery raw material.

**Paper and biorefinery products:**

I. Establish criteria for eco-design of graphic and packaging paper products for an optimised recyclability and a material cascading towards zero waste.

J. Develop innovative sorting systems using new sensors for detection and robotics technologies for paper, wood waste and forest residues to separate according to different types of fibres, inks and fillers, contaminants and soil residues and resulting in higher sorting accuracy and velocity.

K. Develop new process technologies like separation, fractionation or extraction with improved selectivity for various components in recycling stock which enables a utilisation in value-added applications inside and outside the production chain.

L. Research the treatment and pre-treatment of recycling stock, including enzymatic processes, for pulp and paper for recycling and other wood-based products.

M. Create radical innovations for the removal of inks from paper by easy-to-remove new inks and adopted printing technologies as well as by breakthroughs in deinking technology.

N. Boost and reactivate properties of recycled fibres (e.g. functionalisation) to enhance pulp and paper properties using new additives (e.g. nanofibrillated cellulose) and technologies.

# Strategic Theme 3: Creating industrial leadership

## Vision Targets for 2030

4. Activities to foster resource efficiency have resulted in a significant reduction in specific energy consumption, specific raw material input and specific water use in the forest-based industries.

5. The forest-based sector is taking advantage of its long experience in biorefining to help the process achieve its full potential.

6. New business concepts based on forest ecosystem services have been developed on 30% of the land by forest owner cooperatives, in collaboration with sectors including agriculture, water and tourism.

7. Thanks to new and innovative production technologies, reduced overall energy consumption, increased recycling of wood and paper products, and reuse and refining of side-streams, the sector will continue to be the leading provider of green energy and the biggest producer of green electricity and biofuels in Europe, with a production capacity of 10 Mtoe per annum (equivalent to 50 Mm3 of forest and mill residues) in 2030.

# 3.1 Resource efficiency in manufacturing

## Rationale

A growing world population and people´s legitimate claims for better living standards in less developed countries are putting increasing pressure on natural resources. The sustainable solution to meeting these needs with available resources is to significantly increase resource efficiency in the area of raw materials and energy. The European Union´s 2020 Strategy contains a flagship initiative for a resource-efficient Europe. The forest-based sector is going to be a key contributor to this strategy and the 'low carbon green economy'. It possesses a wealth of knowledge and experience on the enhanced use of renewable raw materials and dedicated recycling systems, leading to optimised biomass utilisation and creating the most added value from the raw material.

## State of the art 2012

The forest-based industries have a proven track record in increased resource efficiency. The increased use of residues from raw material processing (e.g. bark, chips, sawdust) to make wood panels or pulp, and the reduction in specific water and energy consumption in paper production, have significantly increased resource efficiency since 1990. Energy-intensive pulp and paper production is thus characterised by highly-efficient production facilities with high capital costs. Nevertheless further progress is essential, to reduce the specific material input in products, for example by reducing the grammage of papers and weight in wood construction, while maintaining or improving functionality.

## Expected achievements by 2020

New manufacturing technologies will significantly help achieve the targets set in the EU's strategy for a low carbon economy. More flexible production units, to respond to future consumer needs and with a highly skilled workforce, will make an important contribution to higher production efficiency. Improved and more sophisticated product design will optimise material use and reduce energy demand, enhance reusability and facilitate recycling. **The positive impact will result in lighter tailor-made products, lower demand for raw materials and additives, increased by-product valorisation and an overall reduction in waste.**

## Required research and innovation activities

A. Develop non-destructive wood property measurement techniques and systems that allow for traceability of individual wood objects, for optimised resource utilisation.

B. Apply new product design approaches, models and simulation tools and the necessary new production technologies for more functionality from less material and energy input, e.g. lightweight wood construction or reduced paper grammage.

C. Demonstrate and integrate new papermaking technology (e.g. stratification) that allows increased use of recycled fibre at lower grammage .

D. Develop product design approaches for the reusability of packaging or easy-to-dismantle building components and precise material characterisation to facilitate optimal sorting and recycling.

E. Develop production technologies with significantly optimised energy efficiency and energy management in defibration of wood, drying of sawn timber, production of panels, paper and board or in transportation.

F. Develop enhanced separation and fractionation technologies for material components to enable their optimal use in layered or composite structures.

G. Devise functional surface treatments such as layered curtain coating, including nanofibrillated cellulose, chemical grafting (chromatogeny) and surface activation (plasma) to enable bulk material reduction, enhance durability or extend life.

H. Use information and communications technology (ICT) to meet highest process efficiency, improving material flow, resource efficiency, process stability, machine productivity, etc.

I. Design new decision support systems for the optimal utilisation of recovered material of used wood and paper products.

# 3.2 Renewable energy solutions

## Rationale

Energy from renewable sources meets approximately 13% of primary energy demand in the EU, with biomass playing the greatest role (over 60%, compared to hydropower at 30%). Wood-based biomass dominates biomass resources. In order to meet the EU's 2020 energy targets, significant amounts of (woody) biomass have to be effectively converted to green electricity, transport fuels and bioenergy carriers.

## State of the art 2012

The forest-based industry is a large producer and consumer of bioenergy in Europe. The industry has invested heavily in highly-efficient biobased energy production. **More than 50% of the total energy needs in the pulp and paper industry are covered by energy produced from biobased raw materials in their own production processes.** The industry is also well located within a network of installed assets that can be used to generate power, heat and fuels for the future.

## Expected achievements by 2020

The forest-based industries has increased the production of bioenergy by further enhancing the use of side-streams such as black liquor, bark, sawdust, stumps and other forest residues as well as recycled materials with no further reuse potential.

The second and third generation of biofuel concepts have proven their feasibility in pilot or demonstration plants. New flagship and commercial scale units are operating.

The forest-based industries have increased their knowledge in close cooperation with the agro-technology and biochemical industries, forest owners and farmer cooperatives. In addition to supplying combined heat and power (CHP) plants, fuels based on new technology are being produced for transport.

## Required research and innovation activities

A. Quantify the green energy potential of present production sites including their biomass supply potential.

B. Engineer new technologies to increase energy production and reduce energy consumption.

C. Develop process concept studies of total production sites – energy and energy products available for society.

D. Demonstrate new large-scale combined heat and power (CHP) installations, higher efficiency and power-to-heat ratio in multi-fuel fired power plants.

E. Develop a production platform for various drop-in fuels for road, aviation and marine transport.

F. Adopt a cascading biomass-based added value approach, maximising value of by-products to fast-growing green energy markets (see RIA 1.3 and 2.5).

# 3.3 Sustainable water stewardship

## Rationale

Water availability varies dramatically, both in Europe and worldwide. Some regions suffer from severe water deficit, affecting forest growth and forest stewardship. At the same time, in most cases **forests are a prerequisite for the sustainable supply of water used in a great variety of processes in forest-based industries.**

Water supply is an ecosystem service provided by forests and in this context industrial water use is directly and indirectly dependent on a well-functioning forest ecosystem. Likewise pulp and paper mills depend on a sustainable water supply, even though they are gradually reducing the intake of water by closing the water loops.

The principal role of forests in the hydrological cycle is well known. However, the importance of individual hydrological processes (e.g. infiltration, evapotranspiration and run-off) differs depending on climate and soil conditions, as well as on vegetation (e.g. tree species mixture). Such differences need more attention to enable forest management to adapt to regional conditions.

## State of the art 2012

Internal water treatment techniques have been developed for the cleaning of process water. **Membrane and evaporation techniques have been successfully tested on an industrial scale**. Due to the relatively-high volumes of water used, treatment tends to be very expensive. In addition it increases energy consumption in the production process. Water cost alone, however, is not sufficient to justify the investment cost in water technologies. Other elements also need to be considered, such as regional scarcity of water.

## Expected achievements by 2020

Improved and adapted hydrological models able to assess the effect of forests on rainfall patterns and water availability in relation to geographical variations, vegetation or tree species mixtures, management interventions and climate change, allow for accurate predictions of the quality and quantity of available water resources. Regional problems with water supply have resulted in new quantitative models able to assess the economic value of secured water supply. Revenues are created from recovered dissolved and colloidal compounds and from recovered heat from process water. The enhanced performance of effluent treatment plants with improved control of microbiological processes mitigating slime, odour and corrosion reduces environmental impact. A value-added utilisation of sludge for green energy generation or nutrients for agriculture is established. Cascade re-use of wastewater between different value chains is recognised as safe and sustainable.

## Required research and innovation activities

### Rural water systems

A. Study the effects of various forest management practices on water use and lifecycle perspective in a context of climate change, ecosystems and biodiversity.

B. Eco-climatological research on the effects of forests on rainfall patterns on a continental scale.

C. Hydrological and hydro-chemical modelling focussing on combined effects of climate change, tree species choice and mixtures as well as management regimes in different geographical settings.

D. Research on quantification of the economic value of the ecosystem service, 'sustainable water supply'.

### Industrial water systems

E. Improve separation and cleaning technologies (using physical chemistry and/or industrial biotechnology) for a further closure of water cycles and to reduce the amount of effluent.

F. Develop innovative technologies for the value-added use of separated and extracted components from wastewater treatment.

G. Invent new concepts for the re-use of treated water, for example, industrial symbiosis.

H. Engineer new concepts for heat recovery from water cycles and their value-added utilisation.

I. Integrate new technologies in existing process water systems in order to further improve optimal water use.

J. Ensure or enhance the microbiological stability of industrial water systems.

## 3.4 Biorefinery concepts

### Rationale

Reducing our dependence on non-renewable resources for energy, but also consumer products, is a central objective of the EU. Building alternative value chains based on biomass is one of the solutions. In such value chains existing biorefinery units (e.g. pulp and sawmills) play an essential role as they can supply the downstream value chain actors with renewable, non-food raw material. On the other hand, the markets for certain traditional end products of forest-based value chains are declining, especially in Europe and North America. Meanwhile, the role of recycled paper as a raw material for paper and board is growing compared to the use of virgin fibre. These developments generate an internal push to develop the existing European wood-handling mills. Novel biorefinery concepts will thus be crucial also from this internal perspective.

### State of the art 2012

Hundreds of large, highly-integrated pulp mills are in operation globally. The leading concepts are built around Kraft, sulphite and a few other processes. The mills operate on both hard- and softwoods. Fast-growing wood species, especially eucalyptus, have been gaining ground. Annual plants, too, are used as raw material, for instance straw, which is popular in China. With regard to products, the main products of a Kraft mill are pulp and bioenergy, with some chemicals formed and isolated as by-products. Sulphite mills, on the other hand, produce a range of products (see RIA 4.3). Recently, new concepts to integrate the production of transport biofuels in existing mills have reached industrial pilot scale. The number of sawmills is even greater. In addition to their main product (sawn wood), sawmills also produce raw material for pulp mills, as well as heat and power, and energy carriers such as pellets.

## Expected achievements by 2020

**The new biorefinery concepts will strengthen the competitiveness of the forest-based industries in their current markets, as well as lay the ground for new value chains to emerge.** To ensure efficiency and to make a significant impact on the anticipated targets, many of the industrial developments by 2020 will be linked to existing mills. Integrated production of biofuels and other products at the mills is thus a likely development. Similar developments will also take place at mill wastewater treatment plants, where biogas and chemicals will be produced. Lignins from both current mills and emerging bioethanol plants will be a source of bulk and

fine chemicals. New greenfield biorefineries will use flash pyrolysis, gasification and/or new wood fractionation methods. The range of raw materials processed by future biorefineries operated by the forest-based industries will be broadened to include agro-materials and various recycled materials ('urban biorefinery').

## Required research & innovation activities

A. Develop biomass supply chains, including supply chains for new biomass types (strong link to the 'responsible management of forest resources' Strategic Theme).

B. Demonstrate improved pulping processes (see RIA 3.1).

C. Develop concepts for turning the wastewater treatment plant into an energy-producing entity.

D. Develop separation technologies applicable in the forest-based industries and more specifically, demonstrate concepts for the separation of valuable components from pulping spent liquors.

E. Develop new biorefinery concepts using the sawmill as the starting point.

F. Extend the use of bark, harvesting residues and other side-streams to make woodworking and other products.

G. Develop concepts for turning recycled, solid wood products into fibre and other high-value products.

H. Develop combinations of mechanical, thermal, chemical and/or biochemical technologies for biomass deconstruction or fractionation and processing, laying the ground for new biorefineries producing novel materials for further upgrading.

I. Demonstrate novel concepts based on gasification, producing as an intermediate product, clean synthetic gas ('syngas').

J. Demonstrate novel concepts based on flash pyrolysis, producing as a first or intermediate product pyrolysis oil ('bio-oil').

K. Demonstrate concepts converting recycled/waste fibres into fermentable sugar solutions.

# 3.5 New business models and service concepts

## Rationale

Innovative business models help to create new jobs and are a basis for a competitive and green European industry. The forest-based sector offers a broad range of businesses from the area of ecosystem services towards traditional consumer goods and bioenergy generation. Businesses aimed at broadening feedstock resources and the development of new $CO_2$-neutral products and services, which substitute fossil-based products, increase the sector's contribution to tackling the effects of climate change.

## State of the art 2012

Monetary evaluation of externalities is largely non-existent in the forest-based sector at present. Business operations are traditionally business-to-business and research typically plays a minor – if any – role in the business of large operators. Expansion and improvement of raw material resources and logistics, multi-product and service concepts are emerging along the forestry-wood chain. The shift from traditional businesses towards cross-sector models results in novel products and services.

## Expected achievements by 2020

Successful cooperation models make it possible to offer 'soft' forest values, i.e. the social and environmental benefits of forests, to the 'consumer market'. **New concepts for economic evaluation of ecosystem services and externalities will be developed** and are starting to be implemented. Joint ventures and company clusters are formed around existing mills validating side-streams, by-products and new raw materials. In some cases **a total conversion or repurposing of mills will take place.** New services will be offered to customers of traditional and new products. Harmonised data exchange along the supply chain and between stakeholders will increase sector performance. **Business models will be based on consumer and end-user perceptions.** Interactive communication will play an important role in (e-) commerce.

## Required research and innovation activities

A. Develop new concepts for economic evaluation of ecosystem services, externalities and marketing as well as advanced business models incorporating potential climate change impact in management decisions.

B. Develop foresight methodologies to predict market changes and consumer behaviour and create business models that target evolving consumer needs and behaviours.

C. Develop strategies for marketing dwellings and houses and after-sales services taking into account consumers' expectations and preferences for building with wood.

D. Develop new business tools and interfaces to interact with consumers of final products and the do-it-yourself home improvement segment.

E. Develop 'emotional' computer applications for shopping experiences and IT integration on cognitive influences and rational decision-making processes. Create virtual environments for controlled simulation of the effectiveness of shopping experience.

F. Conduct standardisation and pre-normative research in ICT applied to the forest-based sector for improving information exchange, business-to-business models and consumer perception and interaction.

G. Research new business models between local communities of forest owners, forest operators and industries for the creation of new value chains.

H. Create business models based on opening up the raw material pool and conversion of traditional mills to new markets.

# Strategic Theme 4: Fulfilling consumer needs

## Vision Targets for 2030

8. Wood-based construction in Europe has tripled its market share, from the 2010 level, reaching a turnover of € 200 billion, 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 housing structures and functional furniture.

9. The pulp and paper industry is well on its way to reaching the targets set out in the CEPI 2050 Roadmap. Novel and smart packaging solutions, integrated printed and digital products and innovative hygiene goods, for increased efficiency, value and safety have evolved.

10. Added value from new markets for non-wood forest goods (mushrooms, berries, clean water) and services (recreation, tourism, climate change mitigation) has increased ten-fold.

# 4.1 Building with wood

## Rationale

Construction wood products derived from forest biomass are fully acknowledged as being a renewable resource ideal for building sustainable homes, whereas non-renewable construction materials will become scarce and more expensive in the coming decades. Given that wood and wood products act as a carbon sink and reduce $CO_2$ in the atmosphere, the use of structural wood material in place of concrete or other more emission-intensive construction materials is one of the most efficient ways of cutting $CO_2$ emissions and meeting ambitious international climate targets.

As more and more buildings in Europe come to the end of their first lifecycle or no longer meet energy efficiency requirements or social demands, they will be renovated or redesigned with strong regard for ecological considerations such as embodied energy and sustainable materials.

## State of the art 2012

Wood construction methods have developed strongly in Europe over the last 20 years. From being confined primarily to small-scale buildings in the 20th century, wood-based construction systems have now been technically proven for buildings of 8-10 storeys high, while 20-storey projects are being planned. These wood construction systems can be prefabricated in a factory and transported in ready-made assemblies to the building site, unlike other building systems. This has the potential to revolutionise the construction industry.

Nevertheless, the current market share of wood construction material for multi-storey buildings is very low. Reasons for this low market impact vary and include legislative barriers and public perception of the properties of wood as a construction material.

Building regulations in many European countries still restrict the use of wood structures more than is technically justifiable. Furthermore, there are no economic incentives for choosing materials and construction systems that result in lower $CO_2$ emissions in the production phase of a building and there are very few positive credentials for this in present environmental building classification systems.

## Expected achievements by 2020

**Green sustainable building and green renovation practices will be fully established in Europe.** Green building refers to a structure and process that is environmentally responsible and resource efficient throughout a building's lifecycle: from site selection to design, construction, operation, maintenance, renovation and demolition. **Green building practice will expand and complement the classic building design concerns of economy, utility, durability and comfort.** Building regulations will have functionally-based requirements for product performance (fire safety, acoustics) and will not discriminate against the use of wood in multi-storey constructions. **Wood-based construction methods will generally be perceived and credited as low carbon footprint constructions.**

## Required research and innovation activities

A. Identify barriers to sustainable and environmentally-friendly construction and develop further urban building solutions.

B. Harmonise building standards in Europe.

C. Integrate information and production technologies in design and building information models for new generation wooden houses.

D. Develop cost-effective integrated prefabricated timber building systems including hybrid and composite materials.

E. Investigate human wellbeing, operational safety, structural quality and energy efficiency in wooden buildings.

F. Develop design concepts taking into account changing building services during the building's lifetime.

G. Improve building physics, indoor air quality and the behaviour of wooden constructions, especially in low-energy houses.

H. Develop advanced non-destructive measurement systems for quality prediction and quality control in wood in construction and in wooden structures.

I. Develop advanced scientifically-justified lightweight wood and fibre-based products, engineered wood products and composite materials with superior performance, low emissions, produced with novel, high quality environmentally-friendly biobased adhesives.

J. Develop solutions with superior thermal and ventilation properties, positive health effects, resistance to moisture and microbial attacks in wood-based, fibre-based or ecologically-treated insulation materials and systems.

K. Develop advanced wooden structure joints to improve performance and broaden the applicability of wooden structures to substitute for carbon-intensive materials.

L. Improve outdoor performance of wood-based materials and develop new biobased protection treatments for wood-based products. Develop, document and offer training in methods for protecting wood through design solutions.

M. Develop construction systems and biobased treatments to enhance the long-term durability of high performance wood-based products.

N. Given the functional requirements imposed on the respective products, develop methods to match the lifespan of wood to that of other construction materials (holistic approach, risk of failure, lifecycle costs, lifecycle planning, strength and sustainability analysis).

## 4.2 Indoor environment and functional furniture

### Rationale

Combining partly unique mechanical properties, excellent cost/performance properties, a great versatility and a sense of familiarity for users, wood products deliver added value to living environments from many points of view. The new generation of wood products for interior use meets strict demands for a healthy and safe environment and satisfies a host of functional requirements. In addition, wooden living environments have a positive effect on human wellbeing. The tactile and aesthetic qualities of wood-based products, their ability to act as moisture buffers and their potential for latent heat buffering are increasingly acknowledged as important for the overall living environment.

### State of the art 2012

A wide range of new protection-giving designs, surface treatments and material modifications that enable the reliable use of wood in weather barriers, furnishings and furniture are available. There is a steady development towards an increased share of auxiliary components like adhesives and coatings produced from biobased raw materials.

Wood is increasingly regarded as an engineering material with added functional performance. Complex wood products for our homes are being produced in advanced industrial processes and offering considerably lower construction costs, greater energy efficiency and higher quality.

## Expected achievements by 2020

**A new generation of wood-based interior systems will be established in buildings.** Wood will be successfully integrated with other materials in various types of design solutions. New wood-based materials and methods for modifying wood will be established. **Wood will be considered an engineering material offering quality-proved methods to ensure durability and shape stability.** Novel value-added products based on recycled wood will have entered the market. Furthermore, new generation wood-based products and biobased material systems for outdoor use with minimum maintenance requirements will be in use. Almost maintenance-free barrier systems (paints, clear varnishes, etc.) and engineering models that allow far better predictions of performance in a variety of exposure and wear situations will be developed. **A new generation of intelligent furniture will adjust to the changing needs of an ageing population.**

## Required research and innovation activities

A. Develop technological designs for moisture-controlled use of wood and wood-based products in buildings' weather barriers in different climatic conditions. Use of sensors for monitoring and control (see RIA 4.1).

B. Clarify the role of wood and wood-based products in securing good indoor environments and contributing to perceived comfort.

C. Further develop the multi-material concepts and multi-functionality for wood and wood-based products in interior fittings, furniture and everyday products.

D. Develop indoor system solutions that promote flexibility regarding changes in use (ageing inhabitants, changing family structures, growing children) (see RIA 4.1).

E. Study factors that influence people's appreciation of the aesthetics of wood, especially in interior furnishings and identify barriers preventing greater use of this sustainable and environmentally-friendly product.

F. Develop environmentally-friendly multifunctional varnishes and lasuring coatings with micro-encapsulations (aromas, biocides, UV filter absorbents and fire retardants).

G. Develop intelligent furniture surfaces (integrated sensors and electrical conductivity) and use a 'learning from nature' approach towards state-of-the-art surface qualities, durability and mechanical properties of wood-based materials.

H. Develop new application systems for water-based and powder coatings.

I. Develop natural bioadhesives and other biopolymers to enhance bonding in furniture components (see RIA 4.1).

J. Continue to develop environmentally-friendly methods for modifying wood and improving the long-term properties of wood-polymer composites to increase their resistance to deterioration (see RIA 4.1).

K. Create new functional wood and composite products for home and urban furniture (see RIA 4.1).

L. Combine superior material properties of wood with high-level design and a segmented marketing approach (see RIA 3.5).

M. Develop biobased lightweight 3D furniture components.


# 4.3 New biobased products

## Rationale

Today, pulp and sawn wood are the primary products of the forest-based industries. These are further refined into a spectrum of products, ranging from commodity to consumer products (see state of the art below). The emerging biobased economy, however, demands more alternatives to current fossil-based products. This opens up significant opportunities for the forest-based sector, as **wood has the potential to be much further exploited than it is at present.**

## State of the art 2012

A multitude of products are produced today from wood. Key products of the woodworking industry include wood panels, house-building materials and furniture, while the pulp and paper industry has four main product groups: paper, board, tissue and cellulose derivatives. Paper and board are used for communication and packaging, whilst tissue includes hygiene products such as toilet paper and nappies. Cellulose derivatives are used in films of regenerated cellulose (cellophane or sausage casings), to make clothing (viscose fibre) and adhesives, varnishes, explosives (nitrocellulose) and rheology modifiers, e.g. in food applications. The pulp and paper industry, especially mills that apply sulphite pulping, produce several by-products: lignosulphonates, ethanol, acetic acid and xylose (for xylitol). Other products of today's forest-based industries include turpentine, tall oil products, materials with a composite structure (e.g. wood fibre-plastic composites) and even bioactive substances.

The role of energy-related products is also increasing. In addition to producing heat and power, the forest-based industries also produce wood pellets and bio-oil (by flash pyrolysis).

## Expected achievements by 2020

Several new, wood-derived products are expected to be commercialised by 2020. Advanced biocomposites used, for instance, for vehicle interiors, as well as new building materials have been introduced. **Bioplastics, derived either from native wood polymers or re-built from wood-based monomers like 'syngas', will bring novel bio-solutions to the packaging sector,** for example. Regenerated cellulose fibres have been used for decades to make textiles and nonwoven materials; the coming years will most likely see further advances in this segment (i.e. new processes, novel regenerated fibres, broadened application areas). **As the demand for biobased products grows, new wood-based performance polymers (glues, resins, paints, etc.) and techno-chemicals (solvents, detergents, water chemicals etc.) will reach the marketplace.** There will also be developments in wood-based cosmetic constituents, functional foods, nutraceuticals, pharmaceuticals, and even materials used in medical tissue engineering. **The portfolio of energy-related products made from wood will also grow.** New energy carriers (e.g. pellets, biogas, synthetic natural gas and bio-oils) especially for heating purposes, as well as various biobased hydrocarbons for transport fuel applications, are likely to be commercialised by 2020. Wood-based alcohols, by novel routes, will also be available.

## Required research & innovation activities

A. Develop new products from wood fibre (nano/microfibrillated cellulose (MFC), nanocrystalline cellulose (NCC), fibre/polymer blends, novel (solvent-free) derivatives, some even with improved thermoplastic properties, etc.).

B. Invent new textile fibre qualities based on cellulose for replacement of cotton fibres in textiles.

C. Develop new products from lignin (e.g. chemicals, in composites and as carbon fibre) and hydroxy acids (chemicals and polymers).

D. Develop hemicellulose-based products, in which the hemicellulose is utilised especially as an oligomer or as a polymer (e.g. chemicals, films).

E. Develop products based on wood extractives, including chemicals but also products based on the bioactivity of the forest-based components (used for protection of woodworking products, as food ingredient or even as pharmaceuticals).

F. Develop more advanced products from traditional fractions, such as tall oil and turpentine.

G. Develop weatherproof panels, fibre-based insulation materials and wood-polymer composites suitable for exterior use.

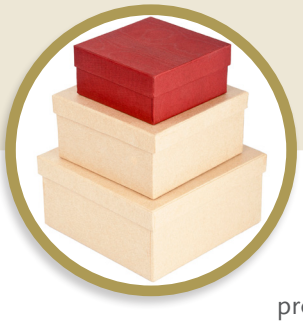
H. Improve existing, long-lasting adhesive systems for flake boards, medium density fibreboard (MDF), oriented strand board (OSB) and plywood boards as well as for glulam by using ingredients which are not based on fossil resources and are free of emissions (e.g. adhesive systems based on renewable resources).

I. Study new materials generated by novel wood fractionation technologies (see RIA 3.4).

J. Upgrade syngas and bio-oil into transportation fuels and further into chemicals and polymers (see RIA 3.4).

K. Develop new industrial value chains starting from sugar solutions, based on fermentation or other means to upgrade the sugars (see RIA 3.4).

L. Adapt biomimetic design approaches and, in general, the integration of recycling-oriented product design criteria into the development processes of new biobased products.



# 4.4 Intelligent packaging solutions

## Rationale

Packaging serves to carry and protect a product during transportation and storage. Information about the contents, origin, date of manufacture, delivery address as well as other relevant data can be gathered from the packaging. Durability and protection are key quality parameters whilst environmental conditions such as relative humidity and temperature also affect performance. New consumer demands on packaging include more product information, improved safety and prolonged shelf life.

## State of the art 2012

Wood and fibre-based packaging materials provide protection for a wide range of products ranging from food and liquid to consumer goods and transportation pallets; both recycled and virgin fibres are used. Packaging materials and components based on new generation biobased polymers are at pilot phase or even on the market. Extensive use of renewable materials improves the sustainability of distribution systems.

## Expected achievements by 2020

Technologies have been developed that significantly reduce raw material consumption and improve the competitiveness of forest-based packaging materials. **Fibre-based packaging solutions have been developed that have improved moisture resistance and barrier properties. New sensor systems give information about the origin, shelf life and safety of the product**. Integrated information systems provide information about the product or connect the client to the manufacturer's website for further instructions. The same information system can also connect to a consumer's domestic system (for instance, internet-connected fridges) and manage storage and purchases based on best-before dates.

## Required research and innovation activities

A. Enhance the material efficiency of packaging with, for example, new lightweight construction approaches.

B. Improve the performance of packages and wood- or fibre-based packaging materials, not limited to mechanical properties but including, for example, resistance to moisture and microbial contamination, in particular prevention of microbial activity in food packages with the help of shielding gases or active substances.

C. Integrate sensor and information systems in packaging materials – printing applications using functional inks and tags carrying anti-counterfeiting information.

D. Develop tools to safeguard the reliability and usefulness of embedded information systems in different packaging chains and to monitor the history and performance of different packaging solutions.

E. Enhance surface properties, for example, for self-cleaning or automatic surface correction and release of active substances using capsulated materials.

F. Develop and establish design criteria to ensure the full recyclability of packaging materials, in particular barrier layers and embedded electronics.

G. Develop concepts and upscaling to production scale for the manufacture of 100% biobased packaging.

# 4.5 Hygienic, diagnostic and healthcare products

## Rationale

Demographic changes such as population growth in developing countries and an ageing population in the West, combined with increasing standards of living and urbanisation trends, will foster a greater demand for products linked to human wellbeing, health and hygiene. **Consumers are demanding enhanced product properties, guaranteed product safety, environmental compatibility and new functionalities** such as intelligent features or in-built services (e.g. diagnostics or monitoring). New products have to contribute to enhancing healthcare services and reducing their costs whether for laboratories, hospitals or mobile services.

## State of the art 2012

The use of paper towels offers a cost-effective basis for improved hand hygiene. The performance of tissue products has been improved considerably in terms of their water-binding capacity. Soiled towels, nappies and incontinence aids are collected and disposed of sustainably and safely in order to protect public health. However, moisture barriers made of non-degradable plastics reduce the overall biodegradability of the products. Consumers are shifting from recycled fibre-based products to virgin fibre products.

## Expected achievements by 2020

New hygiene and healthcare products with improved softness, strength and antibacterial properties have been developed. A production concept for nappies and pads with high water absorption and repellent layers has been developed. Functionalised cellulose fibres will be used to create nappies and incontinence aids with special filter properties. Bioactive functions are integrated with tissue products for diagnostic and drug delivery purposes.

## Required research and innovation activities

A. Develop methods to improve softness and strength of tissue products.

B. Enhance the microbial safety of different fibre raw materials.

C. Develop production concepts of layered tissue products with multi-layer properties.

D. Develop concepts to monitor dryness of hygiene products like nappies and to acquire diagnostic data via embedded intelligence and communicating functions in tissue products.

E. Develop and establish design criteria to enable recyclability of relevant product categories and methods for the safe disposal of non-recyclable materials.

F. Develop advanced and edible paper-based substrates for pharmaceuticals with controlled release properties, smart intake control functions and consumer personalisation.

G. Explore the applicability of wood- and fibre-based material in medical applications.

# 4.6 Integration of new solutions in printed products

## Rationale

The consumption of traditional printed media, in particular newspapers, has decreased continuously in North America and Europe and the profitability of the printing and graphic paper industry is under threat. The rapid evolution of electronic media for information and communication purposes, in particular smart phones and tablet computers, has displaced printed media from its pre-eminent role. The challenge is to develop new business concepts and new generations of value-added paper-based printed products that use wood fibres, wood-fibre sheets and printed electronics in the fabrication of e-paper products. Future printed media may serve as a port to the internet offering advantages to consumers and publishers, as well as the possibility to develop value-adding services. Smart phones, tablets and other kinds of computers with web cameras can be used for scanning codes, text or images to connect printed with electronic media. Presumably, papermaking processes need to be modified in terms of sheet properties and, in particular, surface properties.

## State of the art 2012

Electronics can be printed on various substrates such as plastic, paper or board. Printed electronics are used where large surfaces, flexible substrates, simple fabrication and low cost are preferred, such as flexible and conformable displays (posters, large area displays) and smart labels or packaging.

A large variety of promising electronic printed product concepts are under development. Possible future products include power generation devices, electronic wallpapers, flexible OLED TV, flexible lighting elements, electronic product codes, product identification systems, electronic multimedia, intelligent sensors (temperature, pressure, oxygen, chemical), embedded systems, flexible batteries integrated into packaging systems, complex smart packages and sensors and fuel cells integrated into textiles.

## Expected achievements by 2020

Based on a deeper understanding of consumer perception and needs, new business and marketing concepts have been developed to fulfil the information requirements with printed products and combine printed and electronic media. New substrate properties allow high-precision printing of electronics on fibre-based structures at competitive prices. Printing and packaging technologies will converge further. **Smart electronic functions printed on packaging include applications for monitoring and indicating product safety or freshness, to protect branding and support logistics.**

## Examples of activities and research approaches

A. Investigate consumer perception and trends in the use and the acceptance of features based on combined electronic and printed media.

B. Develop high-precision paper substrates and surfaces that enable the printing of electronics and safeguard their functionality and durability.

C. Develop technologies for high-precision and cost-efficient printing of electronics or electric or magnetic features on fibrous structures or wood-based surfaces.

D. Develop smart and intelligent features for applications based on printed electronics or printed biosensors, e.g. in packaging.

E. Develop design concepts for ensuring recyclability of hybrid products and technologies for the separation and reuse of used material components.

F. Develop business concepts that exploit the advertising possibilities of the integration of printed and electronic media, and use shopping features to print media products by direct connection to internet shopping sites.

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