



## **Collaborative shaping of Research Agendas in WoodWisdom-net**

**Workshop for researchers and industrial leaders**

**New-value added products and production**

**Tuesday February 14, 2006 Helsinki**

**Solicited research issues**

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## **Sub-area 1.1 Wood-based biopolymers to composites**



### **1.1.1 HYCOWOOD**

**Positioning:** Applied

**Short Description:** Lack of adequate research and development has restrained the improvement of wood products and has, thereby, obstructed wood and wood composites from being more widely used for construction, furnishing, interior decoration and other purposes. Modern manufacturing technologies enable combining of wood and wood-based fibres with many different materials (such as plastic, steel, mortar, glass, ceramics etc.) and producing hybrid composites with unique properties. In this field of study, innovative hybrid composites from wood-based materials will be designed to achieve the following objectives: - to develop materials with porosity gradients and low density materials with adequate mechanical properties for building and transport industry - to develop maintenance free (UV-resistant, mildew/soil-free etc.) material surfaces - to improve fire and thermal resistance of building materials - to improve acoustic properties of buildings or to reduce noise level of highway networks and construction sites - to enhance decorative effects of building materials - to improve moisture behaviour of building materials and components. The approaches to produce these innovative composites will include a variety of techniques normally used to create multi-layer structures and multi-material blends. However, in the manufacturing procedures - such as in compounding, extrusion, pressing and glueing - parameter adjustments and pre-treatments of interfacing surfaces will be needed.

**Justification:** The study will result in following products and innovations • cladding materials with multi-layer structures for maintenance freeness • interior decoration films or wall boards with good fire resistance and/or acoustic properties for use at domestic or office applications (e.g. in home theatres, schools, hall like factories, swimming halls, lobby areas) • mobile elements with good sound absorbing properties e.g. sound absorbing surfaces integrated in furniture, for instances on the undersides of tables or chairs • noise reducing dividers for out and indoor use • materials absorbing impact sounds for flooring structures. The research area will be an "imago-lifting" activity for the timber and forest industry by resulting in highly value-added wood-based products. In addition, environmental aspects will be considered in the study by using waste wood in combination with other materials to make high performance composites. In the long run, maintenance intervals of building structures will be lengthened which reduces chemical consumption and overall costs. By producing clean (mould-free) and functional surfaces, welfare and safety in the society will be improved and health care costs decreased.

**European relevance and collaboration:** The topic on wood-based composites and nowadays also on the hybrid composites has raised interest throughout Europe. In some European and Nordic research institutes, extensive work on interfacial phenomena of different materials and on surface activation effects has been carried out, whereas in some institutes, focus has been on processes and on performance of composites. Combining the expertise areas of the different institutes lead more cost-effective research concept. The manufacturing and analytical facilities needed for the study are manifold and therefore, sharing the manufacturing and analytical activities will lead to more reliable and cost-

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effective results, as well. The potential research groups implementing the research would be the following: Finland Denmark Sweden Norway Germany VTT, Research Centre of Finland, Espoo, Dr. Anne-Christine Ritschkoff Danish Polymer Centre, Roskilde, Dr. David Plackett Dept. of Fiber & Polymer Technology Royal Institute of Technology (KTH), Stockholm, Dr. Lars A. Berglund Norwegian University of Science & Technology, Trondheim, Dr. Kristiina Oksman Institut für Werkstofftechnik, Kunststoff- und Recyclingtechnik Universität Kassel, Kassel, Dr. Omar Faruk Luleå University of Technology Luleå, Dr. Roberts Joffe Institut für Polymertechnologien e.V., Wismar, Dr. Hans Korte

### **1.1.2 Better understanding of role of fibre structure**

**Positioning:** Applied

**Short Description:** Wood fibres have great potential as reinforcement in composites. However, in order to exploit their potential and to make the competitive with other fibres more research is needed to understand how fibre separation techniques as well as degree of disruption of the cell wall structure affect physical and mechanical properties of composites. Compatibility with polymer resin systems (thermoplastics and thermosets) needs also to be addressed together with the possibility of developing bio-resins. The paper industry has tackled similar problems in relation to papermaking but the equivalent knowledge for wood-based composites is much less

**Justification:** The demand for sustainable, renewable and biodegradable materials is growing but they will not succeed unless they become competitive on economic as well as performance arguments. The research should provide a strong scientific link between the wood fibre as made by trees (fibre quality, control of properties), their extraction (fibre aggregates, individual fibres, cellulose microfibrils) and their re-constitution within composites. As a result, improving the performance of wood-based composites can make them more competitive with significant positive environmental impact

**European relevance and collaboration:** Wood is a European asset with a strong presence in high quality basic and applied research in many countries. Better integration of this knowledge would be enhanced by Europe-wide programmes. There is a very thriving community actively involved in COST Actions which could make a significant contribution. STFI in Sweden, BOKU in Vienna are among the research groups which can have a key role

### **1.1.3 Wood based composite material, with preserved fiber-organization**

**Positioning:** Applied

**Short Description:** Wood has as material very good properties in elasticity and strength combined with a relatively low density. This is partly due to that wood is organized in several hierarchic levels from molecular to macroscopic scale. Unfortunately it also suffers from problems with unevenity in the structure, which means that a large fraction of the biomass harvested from the forestry cannot be used in sawn timber products. Such material is to a large extent used for pulping, where the fibers are separated from each other by chemical or mechanical means. Except for production of papers and boards, pulps are used in composites. By the fiber separation in pulping, the organization on macroscopic level, i.e., the fiber orientation is lost. In this project, novel types of high performance composites based on wood fiber with preserved fiber orientation. Such materials will have excellent properties and can be used to replace plastics and even metals in many applications.

**Justification:** The use of non-renewable resources for production of materials of different kinds is not compatible with a long time resistant technical culture. Furthermore, the use of petroleum products for plastics is hazardous on the global climate, since it increases carbon dioxide to atmosphere, which leads to a green-house effect with increased temperature as a consequence. Thus there is a strategically interest to increase the use of renewable raw materials. Unfortunately, the qualities of materials made of renewable resources are not always as good as the corresponding non-renewable materials, as paper compared to plastic films. Therefore it is of large strategic interest to develop novel high performance materials based on wood.

**European relevance and collaboration:** The European union is a densely populated area with a diverse industry, including a large branch based on forest products. The development of high performance environmentally friendly materials based on the renewable raw material wood is therefore an all-European interest. The project is complex and many different research groups in different disciplines need to be involved. The project shall be coordinated by the department of Fiber and Polymer Technology at the Royal Institute of technology, Stockholm, Sweden.

### ***1.1.4 Rheological properties of woodfibre-reinforced composites using model interfaces prepared by chemical modification***

**Positioning:** Basic

**Short Description:** The utilisation of wood fibres in polymer-reinforced composites has considerably increased in the last few years. More and more products are now found in the market place, especially in United States (decking, window frames...). To develop this product and create new applications, more basic research is required, especially to understand mechanisms at the polymer/fibre interface. For instance, one critical barrier to obtain valuable agrofibres-reinforced composites is the lack of adhesion between the hydrophilic fibres and the hydrophobic polymer. In the current proposal, the chemical modification of lignocellulosic materials is envisaged in order to improve interfacial properties and to understand the mechanisms involved. The chemical modification of lignocellulosic fibres with model treatments will be carried out, to create model interfaces. These model interfaces will then be studied with regards to their rheological properties.

**Justification:** - Development of the fundamental knowledge about interfacial properties of woodfibre-reinforced composites - improvement of rheological properties of such composites - New applications for woodfibre-reinforced composites -development of bio-based materials.

**European relevance and collaboration:** - this research is important in Europe to concurrence American products and research, which is much more developed. - European groups that could be involved: University Bordeaux1 (France), CTBA (France), The biocomposites Centre (UK), University of Goettingen (Germany), VTT (Finland), University of Lorient (France)

### **1.1.5 Composite matrix from soluble cellulose ( Celmax)**

**Positioning:** Basic

**Short Description:** The biotechnology-based process (EU project FP6-505567-1 Biocelsol) for producing >98% alkaline soluble cellulose is utilized in thin composite manufacturing. Viscous cellulose solutions are blended with composite fibres (pulp and synthetic) and different shapes of plates are produced by acid coagulation method. The mechanical and durability properties of plates are studied and the manufacturing method is optimized.

**Justification:** The main innovation is related to products based on fibre-cellulose(polymer)-composites, where cellulose (II) is first time used as matrix polymer. New products in the area of composite plates for building, machine, and packaging industries offer competitive advantages for old and new companies.

**European relevance and collaboration:** Within the background project Biocelsol a network of excellence on bioprocessing soluble cellulose from various pulps has been built. The project is realized with the collaboration of Biocelsol solution group and research institutes/industries specialised on chip board technology.

### ***1.1.6 heat treated shavings for insulation material***

**Positioning:** Applied

**Short Description:** This research issue is about heat treated shavings for insulation material. It can be studied on a two disk measuring tool bfor insulation properties and by putting weight on for static resistance.

**Justification:** Heat treated shavings could enhance regular shavings in terms of insulation properties and static resistance. Therefore it makes the use of wood insulation material more competitive as compared to regular mineral insulation material. This is a step into eco friendly house building and therefore important for a healthy environment. A precondition for the broad use of (heat treated) shavings is the legal authorization by the Bundesamt für Bauwesen.

**European relevance and collaboration:** The hat treatment of shavings can advantageously be done via the french retification procedure. The testing site for our trials is in Germany. The Rétitech S.A.R L. company (F) specializes on heat teratment, the Technische Hochschule Kaiserslautern and the Forschungsanstalt für Waldökologie und Forstwirtschaft Rheinland-Pfalz (G) could play key roles in testing the heat treted material.

### **1.1.7 Mono-Component Cellulose Materials**

**Positioning:** Basic

**Short Description:** The project aims at developing multiphase mono-component nano-composite materials based on wood cellulose and modified wood cellulose. In a “All Cellulose Composite” by adjusting the cellulose structure by partial dissolution/mercerization so systems with variations in crystal lattice (cellulose I or II), degree of order (crystalline and more or less unordered) and size of load bearing components (crystallite or cellulose fibril dimensions) are obtained. In a “Derivatized Cellulose Composite” by controlled derivatization of cellulose fibril surfaces to obtain partially thermoplastic regions (matrix) reinforced by underivatized cellulose fibrils (fibril cores). The project will involve studies of cellulose substrate (ultra)structure to optimise reactivity and accessibility, followed by chemical and physical modification to obtain mono-component cellulose materials and evaluation of mechanical properties and biodegradability

**Justification:** Because of recyclability, nowadays there is a major trend to focus on simple, mono-component systems rather than on complex polymer blends. As an alternative to composite materials based on several chemically different components the development of single natural polymer mono-component composites based on cellulose fibrils (or crystallites) in a cellulose matrix might be a promising approach towards renewable, recyclable and environmentally friendly material systems.

**European relevance and collaboration:** A close and symbiotic relation between the European chemical industry and the forest products industry cluster in the development of material technology for the refinement of wood-based raw materials will be a substantial step to protect the global competitiveness of the European forest products sector. A competitive and sustainable European forest products industry, transformed from resource-based to knowledge-based product concepts, will help to secure employment and infrastructures, of which SMEs are important parts, particularly in rural areas. Research groups in fields of wood morphology/ultrastructure, cellulose chemistry/technology and material technology should play key roles in the implementation of this research.



### **1.1.8 Wood polymers in coatings**

**Positioning:** Applied

**Short Description:** The objective is to clarify whether wood based fibers and wood based biopolymers (e.g. lignin, cellulosa, tannins) could be used as effective and cost efficient binders in coating colors instead of currently used oil-based binders. The suitability of the wood based binders in coatings can be fairly well assessed already with laboratory coating trials and laboratory test printings. A interdisciplinary literature review is needed in order to clarify the polymer material sources available.

**Justification:** Substitution of oil-based binders with biopolymer ones support sustainable value chain in paper production. Also more better use of by-product streams (in paper making) enhances efficiency and decreases waste. Biodegradability of paper is also improved.

**European relevance and collaboration:** This kind of approach needs wide networking accross the wood to paper value chain. Knowledge from the coating process technology needs to be combined with understanding of the polymer properties and modification. Institutes, universities and small spin-off companies working on fibre modification or on effective use of raw materials should join in this research project.

### **1.1.9 Improving interfacial compatibility in biocomposites**

**Positioning:** Basic

**Short Description:** Nature has been an engineer far superior to man in the design and manufacturing of high performance biomaterials. Mimicking biological systems to synthesise organic polymers and to self-assemble molecules represents an exciting challenge for the future. By learning from nature we can improve biocompatibility and engineer material surfaces to have many different properties for increased functionality. The vision for this part of the proposal is to use the complex cell walls of wood fibres as a biomimetic model for advanced materials design by way of interdisciplinary research.

**Justification:** In composite materials, the interfacial stability and the mechanical properties depend on good association of the reinforcing unit with a polymer matrix. Since cellulose is hydrophilic it is poorly compatible with most hydrophobic matrices. Surface modification of cellulose is therefore a prerequisite for its effective use as a reinforcing component in high performance composite materials. However, the hydroxyl groups available for chemical modification of cellulose surfaces are also responsible for the mechanical properties of cellulose. Therefore, chemical modification often leads to loss of fibre strength. This has led to increased interest in enzymatic modification of cellulose surfaces by e.g. laccases and peroxidases to activate surface exposed lignin. To permit chemical modification of pure cellulose, the use of other natural polymers such as xyloglucan as chemo-enzymatically modified compatibilizer binding to cellulose surfaces has been recently demonstrated. By integrating top-level European expertise in the key areas of biomaterial science and technology, new types of materials that are both biodegradable but also have high performance can be developed.

**European relevance and collaboration:** Many very competent European groups have expertise in biotechnological modification of plant fibres e.g. at KTH, Stockholm, Sweden and at VTT, Espoo, Finland. Good biomaterial science is carried out e.g. by at the CNRS in Grenoble, France, and at KTH, Stockholm, Sweden.

### **1.1.10 New eco-efficient and durable wood polymer composites for outdoor applications**

**Positioning:** Applied

**Short Description:** One of the major issues of wood based composites is their high moisture sensitivity, and the great difference in hygro-thermal properties between the wood and polymer components. The over-all objectives of this research work is to develop a new knowledge-based generation of eco-efficient and durable wood polymer composites (WPCs) for the use in outdoor applications. Specific scientific objectives are to to achieve a better understanding of I) wood polymer interaction also involving the interference with water; and II) biological and weathering deterioration mechanisms of wood-polymer systems. The goal is to create breakthrough technologies for improved bonding between wood and polymers in the presence of moisture combined with improved resistance against microbiological decay and weathering. The conceptual idea is based on new eco-efficient wood modification technology which has the potential to create a water resistant wood-polymer bonding. Examples of potential wood modification routes are acetylation, furfurylation and heat treatment. State-of-the-art analytical methods need to be applied to deliver insight into the complex wood-polymer systems in the wood cellwall as well as wood-polymer interfaces. Extensive durability evaluation based on decay experiments in laboratory combined with out-door field test in ground and above ground should be performed as well.

**Justification:** Environmental concerns about traditional toxic biocides, such as creosote and chromated copper arsenate (CCA), to prevent biological deterioration of wood and wood composites have resulted in an urgent need for new eco-efficient, durable and sophisticated wood-based materials. An example is so-called wood polymer composites, or biocomposites, from renewable resources and recyclable plastics. Such materials are easily formed to building blocks by profile extrusion or to three dimensional shapes, e.g. furniture components, by injection moulding. Demands related to both material properties as well as economical and ecological issues have to be fulfilled, i.e. the materials have to be sustainable or eco-efficient. Wood based materials have an intrinsic potential to fulfil these criteras, i.e. being made from renewable resources available in vast quantities and if properly design e.g. a high strength-to-weight ratio. A development of more sophisticated wood-based materials and systems has the potential to create numerous innovative and knowledge based industries in Europe.

**European relevance and collaboration:** To be able to exploit the full potential of wood, advanced analytical methods need to be applied to engineer new wood-based materials, especially regarding the moisture sensitivity. In this case, multidisciplinary formations between applied wood technology research and more fundamental material science research is necessary. Collaboration between strong research groups at e.g. KTH BiMaC, SP Tråtek, VTT, Wood K-Plus, Kassel University could form a strong platform for a successful implementation of the research.

### **1.1.11 Wood powder as filler in barrier biomaterials for packaging**

**Positioning:** Applied

**Short Description:** The research aim to develop wood powder filled biomaterials and a production process that can be used by the conventional packaging industry for making packages with special barrier properties. There is a great potential for the packaging industry if wood powder are used in packaging biomaterials. The oil prices increases and so do the demands on environmental sustainability. Renewable, biodegradable, or biofragmentable, plastic materials can be developed by using wood powder fillers, occurring from by-products and virgin products of the forest industry. One of the purposes by this research is to develop and understand the mechanism behind a selected group of renewable and natural compatibilisers that enhance the interaction between the wood powder and the matrices. The methods and equipments that will be used are e.g. co-extruder, rotational die cutter and compression moulder, SEM, AFM, OM, FTIR, DMTA, etc. The studied aspects are, e.g. temperature profiles, shear impacts, surface adhesion, sealability, hot-tack, effects of compatibilisers/surfactants, printability, etc. Migration, permeabilities, and the mechanism that controls the barrier properties will be studied. Research will be performed on synergistic effects between the wood powder particles and the matrices, which improve the barrier properties. A source of competence that is requested is expertise on wood extractives.

**Justification:** Potential innovations and products are packaging plastics, based on 75-80 % of wood powders. This aim to replace more than 50% of the traditional plastic materials with wood powder. A limited amount of research has been performed in this area (except for non-renewable plastics), but with less appropriate matrix materials and without renewable compatibilizers. This project will contribute to European industries' knowledge about renewable wood based composites. The social effects will be increased environmental considerations, usage of renewable packages and highly increased use of wood in the traditional plastic industry. Increased usage of environmentally friendly packages, as will turn out of this project, will contribute to a decreased usage of traditional packaging plastics. This will in turn save the environment from pollution, decrease green house effects and plastic waste. The developed materials will be biodegradable or biodegradable, so the landfill problems will be strongly decreased. The aimed renewable composites will be developed and studied after the demands set by the industry, and fully competable with traditional plastics All composites will be possible to run in traditional process equipments and the final quality of the wood filled packaging materials will not be less than the traditional plastics that are used today.

**European relevance and collaboration:** Packaging waste is an international problem, and strongly regards all European countries. European packaging companies, forest industries and retailers are natural partners. By developing renewable wood based plastics, the competitiveness for European companies over e.g. American and Asian companies will strongly be improved. Competence, from several European forest companies, plastic producers and packaging retailers are found in e.g. Finland, Sweden,

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Spain, Germany, Poland, Netherlands and Denmark. Specific skills on wood powder is found at e.g. KCL (Finland) and STFI-Packforsk (Sweden). Biomaterial competence are found at e.g. TUT (Finland), Cobro (Poland) and IATA (Spain), ENSA-INRA (France), STFI-Packforsk, KTH, Karlstad University (Sweden), etc.

## **Sub-area 1.2 Eco-friendly chemicals and polymers**

### **1.2.1 Chemicals of Non Wood Forest Products - Innovation in the forest**

**Positioning:** Basic

**Short Description:** Organic compounds, obtained of Non Wood Forest Products, parts of the tree other than wood, are tested for their application possibilities and potential to launch the market. In the first phase the project focuses on the identification of NWFP – compounds and substances from selected tree types and their existing areas of applications considering technical, cosmetic and chemical - pharmaceutical utilizations. Phase two will analyze the best possibilities of converting ideas for utilizations/products into tangible product developments (product innovations) for chosen NWFP (4 or 5 substances). Furthermore a technological feasibility for the intended products will be given. Meanwhile market research will be carried out. This will identify the most suitable NWFP with the highest market potentials as well as show the market requirements for derived products. By doing so the potential value added and the market impact will be obtained allowing detailed estimations on the socio-economic implications of NWFP product developments. Derived from these three working packages possible steps to NWFP - product developments as well as steps to concrete market launches and to the production (up to pilot scale) of NWFP products will be facilitated. These outcomes should be implemented with the foresters and industrial partners in following projects.

**Justification:** - implementation of new and innovative applications of chemical compounds from Non Wood Forest Products (NWFP) for technical, cosmetic and chemical - pharmaceutical applications in industry - development of rural areas - transformation to a knowledge-based industry in a sustainable context - creating new employment and qualified jobs - raise the awareness of the forester for NWFP and their utilization potentials - created structure is intended to keep the bulk of value added within the circle of foresters - will open new opportunities to use materials of the wood in different parts of industry - ambitious highly innovative project with a potential for a real breakthrough in this specific research field - new technologically and economically feasible value chains for NWFP - product developments from NWFP - generate a platform of stakeholders from industry and silviculture

**European relevance and collaboration:** - important role in the generation of value added for the European forestry sector in order to strengthen sustainable incomes and create additional jobs in rural areas - Major competence needed: A multidisciplinary team consisting of : chemists, economists, foresters, representatives of industries (chemical, pharmaceutical, technical and cosmetic), technicians

## **1.2.2 New techniques for wood modification**

**Positioning:** Applied

**Short Description:** Wood is an aesthetic and renewable material which is available worldwide and can be used in a wide application range. Due to of its natural characteristics it shows some disadvantages compared to other materials, like metal, plastics or concrete. The resistance against biodegradation and the weathering performance of most wood species grown in our moderate climate is relatively low. Normally biocide preservatives are used to elongate the service life of wooden products. Alternatively, highly durable tropically wood species can be used for outdoor applications. The public discussion about the sustainability and management of rainforests as well as about toxic substances used for wood preservation requires the development of new treatments for our native wood species. The objective of wood modification is to improve specific disadvantages of wood, such as low dimensional stability, biological durability or resistance against UV-light, by changing its cellular and molecular structure. Various chemicals and treatment techniques offer significant potential for wood modification, but only a very few processes, like heat treatment or furfurylization, have reached the industrial scale. Further investigations will be necessary to make these promising processes available for wood working companies and to widen the application rang for our native wood species.

**Justification:** The competition of wood against alternative high-tech materials for all kinds of applications is intensified. Especially the high maintenance costs of wooden products in outdoor usage have negative influences on its image. Various thermal wood modification techniques have been investigated and scaled up in recent years, so that presently approximately 26 companies produce thermally treated wood in Europe. That indicates the big demand for durable and environmentally friendly wood. Although a lot of different types of non toxic and eco friendly chemicals showed very promising results on a laboratory scale, only Furfurylization has reached the industrial scale in 2000. In contrast to the thermal treatments, by using chemical wood modification, different mechanical properties, like surface hardness, compression strength and E-modulus can be improved as well. Other polymerizing resins, which have been used by the textile and paper industries for many years and which are available in a huge amount, have already proven their modifying potential. Different kinds of silicon compounds have shown potential for hydrophobating effects as well as for an increased durability against fungal attack. Moreover, different anhydrides are suitable for wood modification. These techniques are able to improve the characteristic properties of our native wood species without using toxic substances, so that their application range could be improved and the wood consumption could be stimulated.

**European relevance and collaboration:** The development of modification techniques on an industrial scale requires the collaboration of research institutes, wood working companies, the chemical industry and mechanical engineers. A lot of knowledge in all of these fields is necessary to establish new methods. All over Europe wood science institutes are already dealing with the modification of wood, for example in Great Britain



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(University of Wales Bangor in Gwynedd; Centre for Timber Technology and Construction, Building Research Establishment in Garston), Netherlands (SHR Timber Research in Wageningen), Germany (Institute of Wood Biology and Technology in Göttingen, Federal Research Centre for Forestry and Forest Products in Hamburg; IHD in Dresden); Belgium (Laboratory of Wood Technology in Ghent), France (Laboratoire de Chimie des Substances Végétales in Bordeaux), Norway (Norwegian Forest Research Institute in Ås), Latvia (Latvian State Institute of Wood Chemistry in Riga), Sweden (SP Swedish National Testing and Research Institute in Borås) and Austria (University of Natural Resources and Applied Life Sciences in Vienna).

### **1.2.3 Development of WPC for outdoor application in hazard class 4**

**Positioning:** Basic

**Short Description:** The aim of this research is to find environmentally friendly alternatives to the classical preservation techniques involving heavy metals used actually for hazard class 4. The approach envisaged concerns chemical modification of the wood polymeric backbone through impregnation of easily curable waterborne monomers able to penetrate in cell walls and to fill lumina. An important part of this project concerns the nature of the investigated monomers which should be if possible obtained from renewable materials.

**Justification:** Develop green chemistry in the field of wood preservation. Promote the use of wood allowing to stock Carbon

**European relevance and collaboration:** Several groups are working in the field of wood chemical modification and could be implied in such program

### ***1.2.4 Modified Biopolymers for wood preservation***

**Positioning:** Basic

**Short Description:** The modification of biopolymers is a eligible candidat to replace inorganics salts for the preservation of wood. The chemical modifications focus on the understanding about the antimicrobial and antifungi properties of chitosan and chitosan derivatives.

**Justification:** The main innovation is the selectivity of this kinds of chemical for bacterial, fungi and insects. The preconditions of these impacts dependent on a better understanding of the interactions between microorganisms and these new chemicals.

**European relevance and collaboration:**

### **1.2.5 New glues and coatings for wooden interior components for building and furniture**

**Positioning:** Applied

**Short Description:** For the next years, environment, health and safety will be always the main words for the production and the using of wooden components in the interior usage (doors, floorings, furniture, ...) For that the green chemistry must be developed to propose new glues, coatings or polymers materials. The research must be a collaboration with the raw materials, the glues and coatings producers, equipment suppliers and users. The Nanotechnologies may be included to obtain some performance. The REACH programme will modify the supply of raw materials. Coatings and glues must integrate this new data in the future. In the same time new products provided by the green chemistry will have to be assessed in terms of processes, performances and end of the life but also during their use by consumers (related to the Indoor Air Quality)

**Justification:** This research must give solutions to continue to produce in European Countries, for that solutions must be innovative, safe with regard to the European Regulations, competitive. The aim is to keep some industrial activity in European countries for the employment (for example for furniture coatings are very crucial to be innovative and reactive on the market).

**European relevance and collaboration:** This research must be a collaborative research between the market demand (furniture, flooring, interior build components, ..) the different supplies (products, chemistry, processes, ..) and R&D units and Universities. For some part of studies, Industrial Associations or end-users or consumers associations may be involved to integrate all parameters.

## **1.2.6 Health-care products from wood and bark components**

**Positioning:** Basic

**Short Description:** It is well known that extractives such as e.g. certain lignans and flavanoids may have medical, e.g. antiviral effects on human and animal cells. Similar types of effects have been reported for lignins. Numerous examples from the polysaccharide field are also well known. The search for such compounds has, however, not been done in a very systematic way and a cooperation between wood chemists and medical/pharmaceutical chemists seems highly justified. In that way, the isolation technique of individual components from wood or bark, their possible chemical or enzymatic modification and their structure – efficiency properties in medical applications could be elucidated and further developed. This research area requires a broad range of scientific and technical knowledge as well as work on a variety of selected tree species.

**Justification:** The development of non-toxic compounds of plant origin that can interact with biomolecules including proteins can have potential medicinal benefits. Such high value-added products from low value starting materials would contribute to the competitiveness of the European industry and provide opportunities of using former agricultural land for the production of new types of biomass. In selected rural areas in Europe, such a development may strongly increase job opportunities and thus the standard of living. Health-care products based on renewable resources and with an emphasis on biochemical conversion processes will also add to the sustainability of the society.

**European relevance and collaboration:** The forest-based sector in Europe is widespread, has a strong economic and social weight and a global technological leadership. The traditional production of solid wood, pulp and paper products is, however, challenged by similar production in other parts of the world enjoying much lower raw material and labour costs. At the same time, the manufacturing technology is available everywhere. The strongly growing competition will result in successively decreasing margins in traditional forestry products. A development of new areas of use for wood combining smaller scale of production with sophisticated new technology aiming at high value-added products therefore seems highly justified. Suitable academic and institute participants in such a development are available throughout Europe thus making this area very suitable for joint research efforts. The presence in Europe of world-leading companies within the pharmaceutical, the forestry and the enzyme supplier sectors should give a strong industrial backup.

### **1.2.7 Novel Adhesives from Derivatives of Vegetable Oil Components**

**Positioning:** Applied

**Short Description:** Other than surfactants and soaps, vegetable oils like palm oil being triglycerides of fatty acids, have a number of excellent properties, which could be utilized in producing valuable PU products. These PU products could be coatings and/or adhesive binders. The research should focus on the development of adhesive binders for the gluing of wood based panels (eg. MDF, OSB, Veneers, Malamine Paper). The first step is the screening of potential vegetable oils for their suitability as adhesive resins. The functionality must be checked and adapted to be well above 1.5 being suitable for polymerisation. To enhance the functionality crude vegetable oil must be refined and synthesized via reactions typically carried out in the oils and fats industry such as esterification, transesterification, epoxidation or alcoholysis. The characterisation of modified oil derivative such as determination of hydroxyl value (OHV), acid value (AV), iodine value (IV), viscosity and colour follows. In the next step desired polyester polyol resin will be synthesized and finally will be tested in commercial adhesive formulations used in the wood based industry in Europe. The provision of fundamental vegetable oil derivatives will involve close by Fraunhofer WKI well established collaboration with respective chemical companies in Europe.

**Justification:** Owing to the steady rise in crude oil price, polyols based on vegetable oils are increasingly becoming more viable alternatives to the petrochemical polyols. Now polyester polyols account to 25% of the market and this upward trend is expected to continue. In line with this development, Fraunhofer Wilhelm-Klauditz-Institut WKI in Germany has invented a new type of polyol derivative (polyester polyol resin) made from palm oil products, which is found suitable for applications in 2K PU adhesives. However, substantial R&D is needed to convert these findings to other vegetable oils being more pre-dominant with higher supply rates in Europe (eg. rapeseed, soya bean, sunflower oil). These developed vegetable oil based adhesives can be supplied roughly 25% cheaper on a long-term basis given that the price for crude oil will further rise in the next 5 to 10 years. Besides the vegetable oil based adhesives can be produced on an industrial scale process.

**European relevance and collaboration:** The wood industry enterprises in Europe are facing similar challenges such as reducing their overall production costs, improvement their eco-balance and to identify alternative more eco-friendly solutions to replace the conventional materials. Thus to foster the development of adhesives from natural resources, European research institutes and industrial R&D departments shall collaborate to develop suitable resins from different vegetable oil resources. Many European organisation and global industrial players already possess significant knowledge and experiences in this field. Here, public R&D centres in Austria (University Vienna), France (NCTRM, ISPA, Alencon), Germany (Fraunhofer WKI, Universität Freiburg), the U.K. (BC, Bangor) and Nordic Countries (Technical University of Denmark, Department of Chemical Technology, Lyngby, Denmark, Riso National Laboratory, Roskilde,

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Denmark, Lund University of Technology, Sweden) together with key industrial core groups (Cognis, Akzo Oleochemicals, BASF et al.) shall effectively cooperate to up-scale the existing current developments in this area.

### **1.2.8 Reduction of VOC from solid wood and timber materials**

**Positioning:** Applied

**Short Description:** Forest-fresh pine wood contains approximately 0.5 and 2 % mono-terpenes, above all a- und b-pinene, 3-Carene and carvones. The typical odour of fresh pine wood results from these compounds. Therefore all natural construction units from pine wood contain terpene emissions in combination with pine wood odour. Additionally from these fatty acid-rich woods smell-intensive aldehydes are set free within the hot drying process and pressing by thermo-oxidative reactions. However hardwood only contains small quantities of terpenes. Wood based material is manufactured from cut wooden particles (veneers, strands, splinters, fibers) under addition of an adhesive usually manufactured into board shape products. Oriented strand boards (OSB) made of laminar splinters ("strands") are in the meantime the third-most important wood based materials and predominantly applied in the building branch. Also wood based materials of this kind emit volatile organic compounds (VOC Volatile Organic Compounds) due to the presence of pine wood as raw material. New legal regulations or stipulations for building products complicate the competitiveness of ecological wood products compared with other, probably more less emitting products but altogether less ecological products (primary energy need, CO<sup>2</sup>-Emissionen). In order not to discriminate wood as building material, the technical and material bases for the wood working manufacture process to solid wood products or high-quality innovative oriented strand boards (OSB) obtaining low emission values shall be researched upon.

**Justification:** To fulfil the requirements of given limit values, the users, e.g. the building industry, will request the building suppliers to deliver products with appropriate characteristics. Under these aspects the manufacturers and processing plants of wood products (solid wood, wood based material) must be able to estimate both the emission potential as well as possible room air concentrations of VOC and their sensory effect. Thus consumers can better be protected and informed as well as problems (complaints, rework etc.) can be avoided in advance. For this purpose the knowledge of suitable process engineering processes and or a choice raw material (wood based materials) and/or a pre-treatment is necessary. Questions raised in connection with the emission evaluation of building products have to be explained in order to obtain the meaning of importance of the wood as building product. Besides the fundamental research analysis, a co-operation with the respective industries to develop the process engineering that can reduce the emission potential to erase any doubts about a health impairment shall be sought. With the results of different individual work packages a technology shall be generated to the manufacturers of wood products which enables them to reduce the emission potential of resin-rich wood species to a large extent and/or the production of low-emission OSB from hardwood. The acceptance of wood products as ecological building material will clearly increase subject to building products of natural resources, which are considered at the same time as low emission products.

**European relevance and collaboration:** In case that justified or unfounded doubts about the ecological compatibility of wood should arise through the building product evaluation



direct economic consequences would follow. Primarily the European building industry and particularly small and me-dium-sized enterprises of the sawing industry and carpentry would be affected. For many smaller sawmills a further, even smaller decrease in sales would bear economical risks. The loss of further jobs, usually in structure-weak regions, would be one result. Disadvantages to the ecological building material wood can result from regulations for the permission of building products as well as from new standards for the interior air hygiene law by the EC and the corresponding critical behaviour of many consumers. This is actual neither justified nor intended. The solution of the emission problem is a multi-national European task, because only by a close collaboration of most diverse national research establishments solutions in the total European interest can be compiled, which consequently do not lead to a competitive distortion. The problem resulting for building products from the building product evaluation, is also for the manufacturers of painting systems, floor coverings, adhesives and wall coverings of importance. Research partners could be BC (U.K.), HFA (Austria), Träteck (Sweden), VTT (Finland), CTBA (France) and others.

### **1.2.9 Development of innovative cellulose solution formulation technology (Cellatex)**

**Positioning:** Basic

**Short Description:** Alkaline soluble cellulose (II) manufactured by biotechnical method is basing on enzymatic activation of bleached pulp. The use of sodium hydroxide in dissolution and sulphuric acid in regeneration of cellulose (II) needs large amounts of water and produces electrolytes (Glauber's salt) into process water. The aim of this study is to research and develop stable cellulose water-based latexes by using cellulose with reduced molecular mass, high concentrations and latex surfactans.

**Justification:** The demand for using latex-binders for coating of paper and package materials is high. The main innovation of this project results in creating a natural cellulose(II)-polymer-based coating for paper and packaging products. These new types of latexes offer new business-opportunities for related paper and chemical industries. The use of cellulose in coating decreases the oil-dependency, water pollution and favours the utilisation of renewable raw materials.

**European relevance and collaboration:** There are basic groups in EU (Biocelsol) and Scandinavian (NewCell) projects formed by researchers and industrial partners for developing technology for activation, direct dissolution and derivatives of cellulose. These groups include TUT, VTT Biotechnology, Univ.Helsinki, Åbo Akademi, and KCL Finland, KTH Sweden, Univ. Potsdam Germany, Inst.Chemical Fibres, Poland.

### **1.2.10 Biodegradable substances in wood protection**

**Positioning:** Applied

**Short Description:** Controlling the moisture content is very effective way to protect timber. Natural oils are capable of preventing the water uptake by wood. Additionally, these unsaturated oils can oxidize when exposed to the air, which results in a more protective layer at the wood surface. However, the oil oxidation within the wood is slow, and oil tends to be exuded from the wood. The aim of this research is to enhance the durability of the wood with environmentally friendly, biodegradable substances such as natural oils. More specific, the methods to accelerate the oil oxidation within the wood will be studied.

**Justification:** Systems enhancing the durability of wood should be sustainable both in production and use. In addition to this, treated wood products should, at the end of their life, be suitable for energy production by combustion, composting or for use as a secondary fibre source by related industries, without presenting any problems of residual chemicals arising from the treatment. Using this method increases the durability of sapwood, and also makes the wood more homogenous. This wood protection method can produce water repellent, environmentally friendly, more functional, and above all safer wood products that can be burned after the end of its useful life.

**European relevance and collaboration:** The European directive place restrictions on the substances, that have been used in wood protection. Also Americans have been banned some of these. Many new substances and methods have been widely studied all over the Europe, but none of these have proved to be excellent compared to the others. Collaborative European research might produce the substitute for the old systems. Professor Holger Militz from University of Göttingen could have the key role in the implementation of this research.

### ***1.2.11 Nanotechnology applications in wet-end chemistry, paper laminates and coatings***

**Positioning:** Applied

**Short Description:** There are several emerging nanotechnology applications in papermaking. Two groups of substances are nanocellulose/microfibrillar cellulose and exfoliated clays. One aspect is their manufacture in large scale. Another aspect is their use in the above mentioned applications. Apart from patent literature/proprietary developments little is known about these fields of application.

**Justification:** A new generation of ecologically friendly (recyclable, less waste) barrier materials to replace PE-laminations on papers/board maybe developed. New high performance bionanocomposites may also emerge.

**European relevance and collaboration:** The complexity of the practical application of these additives onto paper/board is high. Many different approaches are possible and different competences are needed. This is a typically value added function late in the manufacturing chain. Greg WOOD, Pira International, UK; Tom LINDSTRÖM, Royal Institute of Technology and STFI-Packforsk, Sweden; Susana AUCEJO ROMERO, Itene, Spain; Christine CHIRAT, Ecole Française de Papeterie et des Industries Graphiques (EFPG); Lars Berglund, Royal Institute of Technology, Sweden; Lars Wågberg, Royal Institute of Technology, Sweden; and Sören Östlund, Royal Institute of Technology, Sweden

## **1.2.12 Cereal betaglucans as performance chemicals in cellulose composites**

**Positioning:** Basic

**Short Description:** This research aims at creating novel biodegradable composite materials, made from renewable resources in the form of a wood cellulose fibre or fibril reinforced biopolymer matrix. One difficulty that has prevented a more extended utilization of wood cellulose is the lack of good adhesion to most polymeric matrixes. The hydrophilic nature of cellulose surfaces adversely affects adhesion to a hydrophobic matrix, resulting in both poor strength properties and moisture resistance. In the project plant hemicelluloses and their derivatives will be evaluated as performance chemicals for compatibilization and increased adhesion to cellulose surfaces. The main target hemicelluloses will be cereal betaglucans (for example oat and barley), and as reference xyloglucans will be used. Betaglucans are built up by  $\beta$ -(1,3)-linked celotriosyl and celotetraosyl units, and of more cellulose-like structural sequences and should therefore be able to show strong interaction with cellulose surfaces. The project has the following objectives: § Characterization and selection of betaglucans based on European agro-industrial resources. § Chemoenzymatic synthesis of betaglucan derivatives. § Preparation of cellulose composites. § Demonstration on a pre-competitive level of composite performance.

**Justification:** There is an increasing demand for sustainable development and the replacement of heavy and non-renewable materials with new bio-based high performing materials. Hence, new products and materials are of great interest to the European forest products industry (pulp and paper, packaging and wood products). In the continuous strive to improve business; new products and the associated materials are of increased importance. Many of these materials consist of biofibres and are essentially biocomposite materials, on either micro- or macro scale.

**European relevance and collaboration:** In 2001, 15,100 tons of natural fibres were used for composites in the German and Austrian automotive industries. For the period 2001-2005, an annual growth of approx. 14 to 15% is expected. The current requirements of 5 to 10 kg natural fibres per vehicle – and the present production of 16 million vehicles in Western Europe – gives a market potential of 80,000 - 160,000 tons per annum for natural fibres in press moulding. To speedy expand the cellulose composite market collaborative European research in the fields carbohydrate chemistry, cellulose technology, biotechnology and material science is of outermost importance.

### **1.2.13 Tailor-made Polysaccharide Derivatives for New Biomaterials**

**Positioning:** Applied

**Short Description:** The material properties of cellulose derivatives are highly dependent on their molecular structure. Conventional production processes of cellulose derivatives give only a very limited control over the distribution pattern of the substituents on the cellulose backbone. A precise control of the substitution pattern of the cellulose derivative structure bears the potential of biomaterials with tailor-made properties. Not only cellulose derivatives but also derivatives of other polysaccharides like hemicelluloses are subject of scientific interest. Addressing the potential of new raw material sources, like wood hemicelluloses, an in-depth knowledge of the raw material structure is necessary. Central objective of the research is to achieve good control over the substitution pattern to control the material properties. Since chemical synthesis of regioselective substituted cellulose derivatives are rather complex, it shall be focused on the usage selective enzyme catalyzed processes. Enzymes offer the possibility to modify biopolymers in a highly selective way. Screening of existing enzyme libraries as well as engineering enzymes is promising. Additionally the relationship between structure and properties of the new biopolymer materials needs to be addressed.

**Justification:** Polysaccharide derivatives with controlled substituent distribution promise new up to now unachieved material properties. Potential high-tech applications include membranes, liquid crystals, medical applications, paper-like TV screens, biodegradable plastics, food additives etc.. New materials with controlled properties are always desired by engineers in all industrial sectors. Cellulose derivatives are produced since 100 years without major changes to their production processes and they are possibly the wood based products with the highest added value. Recent developments especially in the application of enzymes in chemical processes have the potential to improve those processes. Enzyme-catalyzed chemical processes – referred to as ‘green chemistry’ – are environmental friendly industrial processes, avoiding or reducing problematic chemicals and energy consumption. In the spotlight of the growing environmental consciousness and the knowledge of the limitation of the current main resource for polymer materials – mineral oil – the usage of renewable sources becomes a future necessity. Wood as abundant renewable and sustainable managed resource of biopolymers will play a key role.

**European relevance and collaboration:** Europe, as a net importer of mineral oil, needs to find alternatives not only for energy production but also for raw materials for polymer material production. Using enzymatic processes for the production of improved polysaccharide derivatives is a highly complex issue. It requires the expertise on the enzymes, the polysaccharides, the derivatisation chemistry and their material properties. This expertise is available in different research institutes around Europe. A combined effort can boost the development of the above described new materials and production processes. Some relevant research groups are: Friedrich Schiller Universität Jena, Germany (T. Heinze); Federal Research Centre for Forestry and Forest Products,

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Germany (J. Puls, B. Saake); University of Helsinki, Finland (Maija Tenkanen); STFI-Packforsk, Sweden (O. Dahlman); CEMEF, France (P. Navard); University of Natural Resources and Applied Life Sciences, Austria (A. Potthast); Chalmers University, Sweden (P. Gatenholm); VTT-Biotechnology, Finland (L. Viikari).

## **Sub-area 1.3 Creating new functionalities or improved to materials/products**



### ***1.3.1 Improvements in adhesives for bonded-in connections and reinforcements for timber***

**Positioning:** Applied

**Short Description:** Joining timber using bonded-in rods is a rapid method for construction and the repair and reinforcement of timber buildings. Rods are frequently reinforced plastic pultrusions. However there is a question mark over the durability of these joints in a range of environments and the choice of adhesive is critical. A concerted effort is required to assess the environmental stability of candidate resins in various bonded configurations. In addition standard methods for the application of resins should be embodied in new codes of practice.

**Justification:** The results are immediately applicable to the construction of new buildings and the repair of old buildings. In socio-economic terms wood waste is reduced in construction and the fabric of old buildings can be preserved.

**European relevance and collaboration:** The issue is very pertinent to Europe where levels of new building are high and there is a very large stock of old buildings that require repair. Research groups throughout Europe are already involved in research into bonded-in connections but environmental aspects of joint performance are little researched.

### **1.3.2 Forecasting multidimensional feature parameters for sawn softwood**

**Positioning:** Applied

**Short Description:** Sub-topics I. Multidimensional pre-conversion strength modelling for single boards a. based on traceable stand, tree and log predictors b. based on new technology for log quality assessment c. advanced physical and statistical modelling and analyses II. Improving accuracy of grading machines for sawn, dried boards by adding information from sub-topic I. III. Application and logistics in the production and merchandising chain a. discriminate when to apply such boards and when use traditional ones b. analyse the market potential c. calculating constructions with multidimensional strength parameters Multidimensional strength parameters: implies independent estimation for each of the strength parameters in question: rupture, stiffness, hardness, etc. Advanced modelling: physical models combining from molecular to full board level; involve the most recent multivariate statistical methods. Multi-disciplinary: involves foresters, engineers, architects, economists, mathematicians ...

**Justification:** In general, timber strength classification in use (EN 338) is one-dimensional, i.e. collinear for rupture, stiffness, hardness, density etc.. This implies per se a shortcoming of the system, which might also be related to strength assessment demonstrating generally low accuracy. Most grading systems, visual as well as machine stress grading, operates on a statistical basis for a timber lot, rather than on each single specimen. The struggle for better wood science analyses, grading technology, statistical approaches, and commercial implementation should continue, both to provide efficient European resource utilisation, and to improve the efficacy of timber as compared to competing building materials.

**European relevance and collaboration:** Historically, there has been European collaboration through CEN, and also Nordic projects, e.g. "Styrkesortering ger mervärde"; this cooperation should be continued. Specifically, the fundamental modelling approach of Lund University (SE), the wood property forecast model of Skogforsk (SE) and the partners in the first Wood Wisdom program should be involved. The Italian/Austrian company Microtec is the main supplier of innovative systems for the wood industries, and involves in turn RTD bodies in several countries. (The description is in no way exhaustive, but I didn't want to be too specific on all those topics well beyond my own competence.)

### **1.3.3 FiberPlastic - new eco-friendly fiber-based carriage material**

**Positioning:** Applied

**Short Description:** - Idea is to study & develop new fiber-based "plastic" as a replacement for normal petro-chemical thermoplastic products for the case of future crude oil shortage & high prices - FiberPlastic could be realized by utilizing wood(?) fiber treated so that critical material plasticity properties are improved - Fibers will be treated chemically, mechanically and also with special paper machine configuration increasing plastic-like properties of final product

**Justification:** - FiberPlastic would be new fiber-based eco-friendly product which could open new industrial possibilities in chemical, machinery and wood product engineering in europe and in scandinavia. - At this moment the price of "paper bag" is much higher compared to "plastic bag" - BUT, the price of petro-chemical products is dependent of the price of crude oil. As the price climbs up, final price of the petro-chemical products will also increase. Finally in future, at some level, price competitiveness of wood(?) -based fiberplastic is equal with normal plastic products. - The time span of the price increase is difficult to estimate, crude oil resources, however, are limited

**European relevance and collaboration:** - In future, fiber resources for normal papers will be located in south america and in asia. With they wood (eucalyptus, acasia) growth and manufacturing price level, european papermaking will be in great difficulties. - With this new product europe could fight back creating new products applied specially to nordic/european (long-fiber) resources - Research would need wide chemical-, wood-, machine supplier collaboration in order to fully reveal all beneficial polymer-like properties in each process in production of fiberplastic - Main role in research would be in skandinavian forest cluster

### ***1.3.4 Management of strength of sawn timber and laminations***

**Positioning:** Applied

**Short Description:** This is a coordinated European action for management of strength of structural timber. It includes representative (species, growth areas, dimensions) sampling of sawn timber to be first characterised by NDT-methods and tested in bending, tension, compression and shear. Models for strength prediction will be developed.

**Justification:** Results contribute to strength grading methods and to strength values of European wood given in EN-standards. It improves competitiveness of wood industries by enabling better optimisation of the use of raw material. It improves the competitiveness of wood as structural material by giving more reliable strength data. It is based on improved strength grading methods, which are developed in the project.

**European relevance and collaboration:** This is a common problem of wood producing countries, which can be solved more cost effectively as a joint effort. Leading research groups of major wood producing countries in the area of strength grading and testing should be included.

### **1.3.5 High strength glulam**

**Positioning:** Applied

**Short Description:** Modelling and understanding of strength of glulam needs to be improved. This includes bending and shear strength of large beams under long term loading in normal variable climate. Both numerical modelling and testing is needed. Theoretical background exists to large extent.

**Justification:** To improve competitiveness, strength glulam needs to be increased. Simultaneously, the capacity of different failure modes needs to be known to better accuracy than today because of structural safety concerns.

**European relevance and collaboration:** Best expertise is distributed in different institutions across the Europe. Best experts of fracture mechanics, moisture effects, modelling of bending strength, size effects, finger joints, and use of hardwood are working at different institutes.

### **1.3.6 Automatic grading of sawn timber and engineered wood products**

**Positioning:** Applied

**Short Description:** The objectives of the research project are: - to carry out a testing program that covers all relevant European origins of timber (acc. to EN 14081 machine settings have to be developed individually for each timber source) and all existing grading systems in order to identify the advantages and disadvantages of different systems and to find out which geographic areas of Europe can be identified as a common growth area (so that the same settings are applicable). - to develop new technologies which are capable of detecting strength reducing characteristics that cannot be detected with existing systems, such as local grain deviations caused e.g. by breakage of the top of the tree, in order to make machine grading more reliable. - to investigate whether the "output control" quality assurance is better suited for the European wood industries than the presently used "machine control" system.

**Justification:** The target of this project is to provide the technologies to produce reliable wood products with improved material efficiencies. Thus, the competitiveness of timber as structural material will be improved and the market share of timber in construction will increase. The project will be beneficial for sawmilling, glulam and wood construction industries. The increased use of wood will improve the economic situation of forest industries; it will contribute to maintain and create new jobs in rural areas. The main reasons for improved automatic grading systems are: - Traditional visual grading systems do not allow to make full use of the inherent properties of the material. - At processing speeds in modern sawmills and woodworking industries of up to 300 m/min visual grading is no longer feasible. - The presently available grading systems are not approved for all commercially important species, origins and dimensions and the quality assurance systems need further improvement.

**European relevance and collaboration:** The present development of machine grading has been slow. The main reasons for this are that many wood industries are not familiar with opportunities of grading, grading equipment developers are small companies, which have not enough resources for strong development; so far research activities were made as separate actions; a lot of resources are wasted in small non-coordinated projects. A co-ordinated effort is needed to wake the industry up and to form an economic platform for SME's to obtain setting for grading machines, and to obtain a public database of strength values. All relevant European origins of timber have to be included. Therefore, research groups from North, Central and South Europe have to participate in the project. Within the CEI-Bois Roadmap 2010 activities "building with wood" a joint research proposal is under preparation.

### ***1.3.7 Wood Modification to Improve the Properties of Timber***

**Positioning:** Applied

**Short Description:** There has been considerable activity in Europe in the development of new wood modification technologies (heat treatment, hot oil treatments, furfurylation, acetylation, resin impregnation, bio-treatments). Some technologies are already on the market, some are entering the commercial arena, and others are at an earlier stage of development. The developments of these technologies are being driven by current or impending legislation leading to conventional preservative systems being phased out. It is very important that these new developments are integrated within a pan-European framework, similar to that of the Thematic Network on Wood Modification. This will allow for exchange of information, clustering of researchers and an efficient use of the European research base. The development of these new technologies is important if wood is to remain competitive against non-renewable materials.

**Justification:** By adopting a pan-European approach, it will be possible to ensure that there is a critical mass of researchers to drive new developments to commercialisation. New appropriate standards can be developed for these novel wood products. Public awareness of modified wood will be raised. Timber obtained from plantation resources can be upgraded by using appropriate modification methods. New markets can be found for timber products. Timber will be more competitive against non-renewable materials. These impacts will only be achieved if a pan-European integrated approach is adopted, this will greatly enhance local initiatives.

**European relevance and collaboration:** Only by collaboration at a European level will it be possible to obtain a significant impact in this area. This project will build upon the highly successful Thematic Network on Wood Modification. The research groups in the original network (Uni. Bangor, BRE, Uni. Gent, SHR, Uni. Hamburg, Uni. Goettigen, VTT, CTBA, INF Poznan, Royal Veterinary and Agricultural University (Copenhagen), Uni. Limerick, Uni. Brasov, Uni. Chalmers, Uni. Ljubljana, plus industrial partners) will be expanded.

### **1.3.8 Improved use of European hardwoods**

**Positioning:** Applied

**Short Description:** Value-added use of European hardwoods is in target of this research area.

**Justification:** Improved / innovative use of European hardwoods to get more valuable products.

**European relevance and collaboration:** Analogical research is made all over Europe in the field of hardwoods for different hardwood species - technology/knowledge transfer between countries would bring more efficiency.



### ***1.3.9 Prevention of mould on wood-based packaging materials***

**Positioning:** Applied

**Short Description:** Wood packaging material for export to certain countries and for import into the EU market has to be heat treated according to ISPM No 15 standard (phytosanitary treatment). On most sapwood species which have undergone such treatment profound mould growth develops rapidly which is not acceptable. To temporarily prevent mould growth on packaging material before the wood has a chance to dry appropriate measures must be developed which do not include the application of wood preservative.

**Justification:** In Europe the production of wood based packaging materials (pallets, crates, boxes, cases, etc.) takes up considerable quantities of low value sawn timber. Since the phytosanitary heat treatment has to be carried out huge problems arise from mould development. Environmentally friendly methods for prevention of this damage would help to overcome substitution pressure on wood pallets (e.g. by plastic pallets). Up to now wood packaging material can be considered non-contaminated by wood preservatives, a situation which will certainly change if no appropriated means for mould prevention are developed.

**European relevance and collaboration:** Wood packaging material is produced and used in all European countries mainly by SMEs. The problem specially occurs in cross boarder trade and for this reason cross boarder collaboration in problem solving is needed. Cooperative research between universities and SMEs in two or three neighbouring countries provide considerable benefits.

### ***1.3.10 Durable wood materials and products with environmental and consumer friendliness***

**Positioning:** Basic

**Short Description:** "Environmental performance and long-term durability of wood materials and wood products, and the relationships with the quality of life for people". Identification and evaluation of the main European wood materials that: 1) can stand the in-situ use conditions of use in their natural physiological, anatomic and chemical form, 2) need different treatments for the durability. Basics and evaluation of selected treatments for improved weather, fungal and insect resistance, fire resistance, and, simultaneously, for long service life, easiness for maintenance and DIY installation as well as healthy living and working environment for human beings (physical health, thereafter "mental" features of the "wooden" environments). Basic anatomic, chemical and physical characterisation of wood materials. Comparative and benchmarking studies on the product performance woods vs. woods and woods vs. competing non-wood products in selected end-use segments. Main European species with assumed durability should be included. Empirical focused sampling from green and dried wood should be the basis for the chain of wood material-wood product-in-situ utilisation studies. The field of studies may become large, so focusing is essential. However, both indoor and outdoor uses of wood should be included.

**Justification:** Value-added of wood products based on long-term, consumer-friendly durability and easiness of use. This helps to position different wood and wood products realistically in medium-term and long-term market, indicate/justify product development efforts, develop the standardisation of wood products and improve wood sourcing for the end-uses to be defined. The results contribute positively to the environmental, carbon sink and climate change discussion, and the customer acceptance of wood products.

**European relevance and collaboration:** The theme is relevant for the consumer and public acceptance of wood in Europe, incl. environmental discussion, and, thus, contributes positively to the grounds of European wood products sector in the medium and long terms. The theme requires various competence and its developments from the participating research groups, thus, contributing to the scientific networking within Europe. The nature of the research is mainly basic research, however, with direct links to the industries ("applied basic research"). See also the justification (before). Wood scientists and technologists, chemists and molecular physicists as well as wood engineering scientists and medicine scientists should participate in the implementation. Simultaneously, different climatic zones and the representing groups should be included. I suggest research groups from Finland (Metla, VTT/HUT, Åbo Akademi/University of Jyväskylä) and Austria (BOKU) completed with experts from UK and Italy or Spain, maybe also from Sweden.

### ***1.3.11 Carefree wood surfaces with functional properties***

**Positioning:** Applied

**Short Description:** Wood and wood composite materials have many advantages. However, in order to conserve the competitiveness of wood material there are some material based disadvantages which should be improved with economical and technical feasible modification methods. The following properties are to be improved: hydrophobicity, dimension instability under fluctuating moisture conditions, poor UV-light and fire resistance. Emissions released to indoor air by wooden material have recently been an interesting research topic. The properties of wood material can be modified and functionalised by exploiting nanostructures, such as nanoparticle additives and nanocoatings. The properties to be improved are controlled water vapor permeability and release of wood based VOCs, moisture resistance, resistance against UV radiation and weather, resistance against soil and contaminants as well as mechanical durability of wood surfaces (scratch resistance and surface hardness). The approaches to produce improved and functional wood material for different end-use targets will include the exploitation of barriers formed by non film forming nanostructures, such as carrier mediated nanoparticles and nanobarriers, active particles and nanocoatings. Nanocoatings provide a new transparent coating system with controlled properties and functionality

**Justification:** The study will result in following products and innovations • carefree wood material for building and construction targets o cladding materials with multifunctional properties (anti-soiling, UV-resistance, micro-organism repellency fire-resistance, maintenance freeness, moisture repellancy) o self-repairing surfaces against cracking • multifunctional wood material for interior use o controlled water vapour and moisture behavior, abrasion and scratch resistance, controlled voc emission properties o carefree and abrasion resistant material for furnitures • wood material with good performance properties for vehicles • interior decoration films or wall boards with good fire resistance and/or acoustic properties The research area will be an "imago-lifting" activity for the timber and forest industry by resulting in highly value-added wood-based products. In the long run, maintenance intervals of building structures will be lengthened which reduces chemical consumption and overall costs. By producing clean (mould-free) and functional surfaces, welfare and safety in the society will be improved and health care costs decreased.

**European relevance and collaboration:** The topic on improvement of wood material has raised interest throughout Europe. In some European and Nordic research institutes, extensive work on interfacial phenomena of different materials and on surface activation effects and functional nanomaterials have been carried out, whereas in some institutes, focus has been on processes and on performance of wood products. Combining the expertise areas of the different institutes lead more cost-effective research concept.. The potential research groups implementing the research would be the following: Finland Sweden France UK Germany VTT, Technical Research Centre of Finland, Espoo, Dr. Anne-Christine Ritschkoff Dept. of Fiber & Polymer Technology Royal Institute of Technology (KTH), Stockholm, Dr. Lars A. Berglund Centre Technique du Bois et de l'Ameublement Dr. Laurence Podkorsky Coating Technology Centre, Teddington Fraunhofer Institute , Wurtzburg Dr. Klaus Rose Institute for surface Chemistry (YKI), Stockholm Universty of Göttingen, Göttingen Prof. Holger Militz

### **1.3.12 Inhibition of fungus on wood packaging material (wpm)**

**Positioning:** Applied

**Short Description:** According to the FAO – ISPM No. 15 “Guidelines for regulating wood packaging material in international trade”, heat treatment is one kind of requirement to reduce the risk of the introduction and/or spread of quarantine harmful organisms associated with wpm from raw wood. Based on various reports from operational practice, mainly fresh sapwood (that may have undergone a pure heat treatment without any kind of drying) shows a great affinity to fungus. The risk of mould increases with the heat-treatment process. The infestation causes no loss of the wooden strength property but it constitutes an optical and a hygienic problem. It is necessary to detect the reason for the increased mould risk by chemical analysis. Based on the result of this analysis different agents (environmentally compliant ) should be tested on their inhibiting effect to fungal attack.

**Justification:** As a result of this research different environmentally compliant agents should be found, which avoid or inhibit at least temporary a fungal contamination of wpm. It is essential to bridge the critical period between the moistured and fungal sensitivity status and the arid and fungal unalluring status. One searches for alternatives to conventional methods and preservatives. Beside the effectiveness these alternatives should be economically acceptable and practically convertible.

**European relevance and collaboration:** The problem with moulds on heat treated wood is a common one in the countries which have adopt the IPM No. 15. Especially European softwoods used as packaging material (pine..) are susceptible to moulds after heat treatment. In order to be in business in international trading operations, it is vitally important to solve this problem. Otherwise those European woods might be substitute by tropical woods with less mould-risk. The Federal Research Centre for Forestry and Forest Products in Germany should have the key role in the implementation of this research. The Cooperation of similar European research institutes and industrial European partners is supposable.

### **1.3.13 Mould-resistant wood based panels**

**Positioning:** Applied

**Short Description:** Throughout Europe there are plenty of damages of wood based panels in consequence of increased surface near relative air humidity and increased humidity of boards itself with different sorts of mould. The problem is described relating to a specific phenomenon, but knowledge of definite processes of genesis is still missing, such as the exact identification of ingredients of species of wood and involved species of mould which lead to increase mould growth. The influence of modern glueings on panel moisture in consequence of moisture cycles, the influence of production processes on the release of substances (drying, glueing process) or the influence of moisture absorption through cutted edges. E.g. a summarising question: Why is a plywood cave panelling out of mediterranean pine 2-4 times more affected by mould than a similar cave panelling out of douglas fir?

**Justification:** It is necessary to find out, what sort of changes of the production process or the glueing are reasonable and if it is possible to achieve through additives out of biogene-based substances in the production process an increased mould resistance, if necessary in cooperation with coating. In combination of basic research and applied research it is necessary to find out what sort of substances, which possibly release to a special degree through the production process and depending on the species of wood commonly used, lead to a special sensitivity towards mould. Furthermore it needs to be analysed what sort of steps could be taken in order to enable the dimerisation and neutralisation of these substances in the production process, for example through changes of the ph-value. In addition it is necessary to run laboratory tests with wood based panels with different glues (plywood, OSB, wood fibre boards, MDF, particle board) to analyse moisture content values of the boards in dependency on moisture cycles, which correspond to the cycle of a year of moisture changing of a not directly weather-exposed exterior board. Different climates have to be considered. From these tests perceptions for the further development of different sorts of glues have to be developed. Also it is necessary to develop and to test additional extended methods of coating and edge treatment of the boards, depending on special purposes of use (cladding, underside view of a roof, roof overhang).

**European relevance and collaboration:** The described infestation of mould on wood based panels spreads across Europe. Also manufacturers throughout Europe are affected (i.e. plywood and LVL- manufacturers in Scandinavia and France or OSB-manufacturers in Austria, Germany and France). The frequency of damage and the phenomenon have been evaluated so far in Scandinavia and Germany. In this case we suggest a cooperation between plywood, LVL- and OSB-manufacturers and groups of researchers of the Helsinki University of Technology (HUT), the Technische Universität München (TUM), possibly the CTBA and if necessary another East-European University. At these universities a cooperation between applied researchers and basic researchers of wood technology exists already.

### **1.3.14 Development of different function for a same material**

**Positioning:** Applied

**Short Description:** The aims of this research is to develop multi fonctions wooden materials. The objectives could be the study of all abilities of nanotechnologies for wooden materials in order to give properties such as : fire resistance, colour resistance, biology resistance, ... These particules would be integrated in the wood may-be in the matrix. Researches exist on others materials, may-be transfers may exist. At present, wood must be innovative to be more used in buildings with fire property. In furniture, it is difficult to use wood in th contract usage because it is too weak. The demand is to have wood with the behaviour of metal, plastics...

**Justification:** For this work, it would be mandatory to have links between the labs who work in the Nano, the chemists, the different Wood Labs and the wood industry. The impact of this research is to produce new wooden materials which can be use in the place of metal, plastics in buildings but also in automotive, aeronotics, ... These two last sectors will want to use wood but wood must integrate new functions : fire, colour resistance, heat resistance, new decors....Positive results would be able to open new markets for wooden components

**European relevance and collaboration:** This study must be a collaboration between Wood and furniture industry, chemistry,physics, processing, Labs to assess performances....

### **1.3.15 Fibre modification**

**Positioning:** Applied

**Short Description:** Find much better ways to modify kraft pulp fibres before papermaking. Methods could be chemical or biological. Methods should be economically and environmentally useable in millscale.

**Justification:** Better methods to tailor fibres according end-user/customer needs. Better quality, cheaper, bioproduct.

**European relevance and collaboration:** Europa cannot compete with China and S-America if same technology is used. We need to be ahead. KTH, Darmstadt Chem.

### **1.3.16 Nanostructures for improved stiffness of light products**

**Positioning:** Basic

**Short Description:** The development in paper and board products has led to increased use of mineral pigments. The products typically contain 20 to 40-45 % stone material in the structures. The idea here is to develop new technologies for paper industry to utilize in the design and manufacture of products containing less high density mineral materials in structures, having excellent stiffness and keeping the good printing properties. Utilization of nanotechnology.

**Justification:** Lower transportation and postage costs, improves ability to compete with other materials, could create new applications to the fibre based products. efficiency and thus the competitiveness of forest industry. This would also improve the competitiveness to are also evident for

**European relevance and collaboration:** The emerge of nano to public discussion has created once again oversized expectations, "hype", and lead to national research programmes of public funding throughout Europe and globally. Woodwisdom-net could utilize here networking in these programmes in Europe.



### ***1.3.17 Minimisation of emissions from wood-products with relevance for the indoor air quality***

**Positioning:** Applied

**Short Description:** In order to reduce and control potential indoor emissions (formaldehyde and VOC) sources, several national and European initiatives have been launched. Their main task is the establishment of a harmonised health-related assessment scheme. Additionally, target values for indoor air concentrations of some compounds indicate thresholds. Consequently, control and reduction of emissions will become relevant for the manufacturers of wood-based materials. But the knowledge to adapt product emissions is still limited and not sufficiently sophisticated (e. g. change of raw material). New approaches to minimise emissions have to be developed. Additionally, the measurement of emissions is time consuming and not applicable for the online-control of the production (e. g. for wood-based panels). Consequently, new methods have to be elaborated and evaluated.

**Justification:** This research issue delivers improved material properties in order to meet future requirements. On the one hand higher expectation on building products with respect to indoor air quality and consumer protection can be ensured, and additionally conservation and the European wood building industry will be strengthened.

**European relevance and collaboration:** This subject is particularly suitable for collaborative European research activities, because national and European initiatives have already been launched to establishment of health-related assessment schemes. Therefore this topic is on the agenda in most European countries. There is a need of collaboration on the European level in the wood research sector to minimise wood product emissions. This is to strengthen the competitiveness of the European wood industry mainly in the building sector against non-wood products.

### **1.3.18 Durability and life cycle costs in wood construction**

**Positioning:** Applied

**Short Description:** A long term, strong and goal-oriented R&D-program focussed on wood durability and life-cycle costs with relevance for modern timber construction is proposed. The main goal is to develop practically feasible engineering tools for decision making about and design of built facilities with wood. These tools should make it possible for developers and other decision makers to make reliable estimates of life cycle costs for wood structures. The scientific activities in the project consists of • Long term durability testing programs • Systematic evaluation of performance for existing built facilities • Documentation of practitioner's experience (carpentry tradition) • Development of risk-based engineering models and tools The project shall deal with untreated wood, modified wood as well as wood protected by new environmentally friendly methods, for applications • outdoors above ground • in the building envelope The results from the project are independent scientific verification and documentation of • methodology of design for durability and moisture safety for above ground timber outdoors and wood in the building envelope. • effectiveness of new environmentally friendly methods for wood protection (thermal treatment, acetylated wood etc) • requirements and associated costs for maintenance of wood in different parts of a building • service life and effectiveness of surface treatments

**Justification:** There is a large potential to increase the use of wood in construction significantly on the European market today. Although wood building concepts are very cost-competitive and favourable for sustainability, there is often a strong resistance among decision makers and building professionals. The most common argument against wood is that there is the risks related to durability issues and cost of maintenance. The present practice of durability design is more or less based on carpentry tradition, and is only to a limited extent scientifically documented. This type of experience is also difficult to transfer between generations in modern education systems. Furthermore, past research about wood durability has been concerned with chemical wood preservation, and with methods which are not accepted today from environmental point of view. Scientifically documented information about maintenance intervals and service life in wood construction and rational methods and tools for durability design are necessary if we want to expand the use of wood in construction from today's level in Europe. Thereby, one very important obstacle will be removed so that the obvious advantages with wood construction can be realized.

**European relevance and collaboration:** The proposed project is very suitable for collaborative research activities since • The ambitious goal and size of the project means that concerted, long-term effort is necessary • The results must be widely accepted and valid for different building traditions • A common view in Europe is that the built environment is part of the culture, rather than a commodity with limited service life A powerful project organisation with the best European competence and expertise, should be created. Researchers from fields such as Building Physics, Wood Chemistry and Biology, Wood Durability, Risk Analysis and Structural Engineering must work in

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collaboration. The following institutes/groups are mentioned initially, but further partners may be added as the project is developed further. • TU Munich, Germany, prof. Peter Glos, prof. Gerd Wegener • Univ of Hamburg, Germany, prof. Arno Fruhwald • VTT, Finland, prof. Alpo Ranta-Maunus • SP/Tratek, Sweden, prof. Carl-Johan Johansson • Lund University, Moisture Research Centre

### **1.3.19 Market relevant applications for lignin considering technological and environmental aspects**

**Positioning:** Applied

**Short Description:** The challenge is to develop large scale applications of products that are based on lignin with significant impact on economy, environment and wellness of European population. Firstly the end user has to be investigated as well as market aspects. For these product groups, specific data on different lignin applications such as quality and quantity requirements, properties, optimised formulations, toxicity tests, and implementation in the market must be raised. Secondly, in order to ensure that the most energy efficient, low emission and cost-effective conversion routes are encouraged for further development, parallel to this technical work, a sustainability evaluation on a life cycle basis has also to be taken into consideration. The integration of these aspects will enable a harmonized combination of market aspects, use of biomass raw materials, technological and environmental aspects.

**Justification:** Lignin is abundantly present on the waste of industrial processing of wood and in the biofuel production. It is a left over part which cannot be converted into ethanol. Due to the lack of sufficient fundamental data on these materials, the reuse of this important resource has been concentrated on their incineration with energy recovery for the paper industry or some limited commercial applications. Although the potential of these resources can be widely found in the literature, the presently available information was not sufficient for convincing an important fraction of the market to carry out more advanced and detailed application tests. So the need of high quality data for each product group, lignin production, modification and characterisation as well as end user related tests are clearly seen. On this the project will contribute. The overall use of biomass and sustainable aspects from a life cycle perspective should be also taken into consideration.

**European relevance and collaboration:** This issue is in agreement with the Waste Strategy Communication (CEC, 1990) and supports the EU 'Environmental Technology Action Plan'. The development and rapid implementation of bio-feedstock technologies can be an important route towards reduction in greenhouse gas emissions in the short and medium term and in line with Kyoto Protocol. With the assessment of the environmental impact in all stages -from planning to commercialization- the maximization of the environmental benefits and the minimization of potential risks are ensured. Therefore the goal of sustainable industries is also met. Moreover the potentially more labour intensive bio-feedstock compared to crude oil promises a positive net job-effect in rural regions of the EU and upcoming EU members. Partners: - EUROLIGNIN Network - International Lignin Institute, ILI, Switzerland - Institute for Chemical Technology, ICT; Germany - Stuttgart University, IKP, dept. Life Cycle Engineering, Germany

### **1.3.20 Chemical changes in wood during thermal treatments and resulting properties**

**Positioning:** Basic

**Short Description:** The changes and their extent during a temperature load depend considerably on the chemical structure of the used material apart from many other factors, such as the type and duration of thermal treatment. Due to the different chemical compositions of wood species, accurate predictions of the thermal behaviour and the respective product properties are extremely difficult. Moreover previous investigations on this topic could not reveal all basic processes. Often the results of the different research groups are not comparable, due to the lack of standard methods within this research and development field. The knowledge about existing and formed functional groups is however essential e.g. for further surface treatments like paintings/coatings or for the prevention of corrosion. In addition some products have an unpleasant odour, why measurements of volatile organic compounds (VOC) should be performed. The objectives of the research project are: - to characterise the basic chemistry of thermally modified wood species depending on the applied temperatures with several defined methods, e.g. to determine extractives, polyoses, cellulose, lignin, pH-values and in particular functional groups, - to analyse the formation of VOCs depending on process conditions, storing conditions and time by means of microwave thermodesorption and GC/MS, - to quantify durability performance by means of decay tests, - to specify quality parameters for the end-use.

**Justification:** The target of this project is to lead to further and improved applications and therefore to a wider range of wood products. The increased use of wood products would also enhance the economic situation of respective wood industries and their suppliers. One essential precondition for the realisation is an advanced knowledge about the properties of the different wood species after thermal modification. Beside that, a better European quality assurance system is needed for both existing and newly developed market products in order to avoid problems during use. Products which cannot fulfil the expectations of consumers will lead to a loss of prestige of all new technologies within the wood industry. Due to the improved natural durability of thermally modified wood this new technology furthermore will protect the environment by reducing chemical additives (e.g. toxic wood preservatives) and easier recycling or re-use of wood products.

**European relevance and collaboration:** Previous research activities have been carried out mostly on national level for the respective market requirements. An European network would be helpful to harmonise analytical methods, quality assurance systems etc. Potential partners in this project are VTT (Finland), FH Salzburg (Austria), University of Kuopio (Finland), Stora Enso Timber (Finland). Other research institutes may be included.

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***1.3.21 Wood property based multifunctional impregnation treatments based on using hydrophobic oils that are environmentally gentle.***

**Positioning:** Applied

**Short Description:**

**Justification:**

**European relevance and collaboration:** Groups in Sweden, Norway, Finland and Belgium.

### **1.3.22 New functional cellulose derivates (FUNCELL)**

**Positioning:** Basic

**Short Description:** There exists evidence on new alternative ways to manufacture functional derivatives of cellulose by enzymatic-chemical synthesis in various media. Additionally, more controlled synthesis offers possibilities in producing existing cellulose derivatives by tailored ways. The aim of the FUNCEL project is to develop new and controlled synthesis of derivatives. The hydrophilic-hydrophobic, physico-chemical, anti-microbial and rheological behaviour of the derivatives will be investigated. Specific application studies of the materials include film formation, blendability with paper and fiber formation.

**Justification:** The innovations of this issue are related to improved homogeneity and quality of present cellulose derivatives e.g. CMC. and additionally to create new derivatives e.g. with controlled side-chain properties and chain length. Manufacturing studies and related research on process parameters and product properties serves as the basic information for feasibility estimations of new products. Different shapes of controlled polymers, eg. films, fibres, beads, composite structures enable innovative applications of polymers for different end-uses.

**European relevance and collaboration:** The Northern and North-European (Finland, Sweden, Norway) forest resources are of a major share of total European forest resources. On the other hand the applications and end-users are mainly in big Mid-European countries. Thus, it is important to create collaboration with the producing pulp and paper research institutions and industries with end-users and research. A Nordic present practice of cooperation comprises Univ. Helsinki, Tampere (Tech.) and Turku, VTT Biotechnology Espoo, KTH Stockholm, pulp producers Domsjö, Metsä Botnia and Borregaard, and relevant industries, as well. Most of those end-user are operating World/European wide: Astra Zeneca, Akzo Nobel, Visko, CP Gelco, Vivoxid. The reasonable - project oriented - cooperation is fulfilled by finding research institutions and industries in Germany, UK, and France.

### **1.3.23 Fibre engineering and micro mechanical modelling for efficient materials design**

**Positioning:** Applied

**Short Description:** Detailed knowledge of the relation between the fibre level and the paper performance level is a prerequisite for efficient materials design. The ability to quantitatively control, design and optimise the properties of wood fibre based materials therefore requires detailed knowledge on the fibre properties, fibre-fibre joint properties and the applied processing conditions. An efficient procedure for materials design is only obtained by combining advances in fibre engineering with detailed knowledge of the deformation and failure mechanisms and advances in micromechanical modelling of fibrous networks process technology. The formulation and accurate calibration of micro-mechanical models is dependent on detailed information about the fibres and joints. Important is to experimentally and theoretically study the micro-mechanical properties of bio-chemically modified single fibres, fibre-fibre joints, assemblies of few fibres and fibre networks subjected to loading under different environmental conditions. Fibre materials with well-defined properties are valuable to considered in the initial phase of the experimental work in order to verify theoretical models. Today this type of materials design is primarily inhibited by the lack of detailed knowledge of fibre and fibre-fibre joints.

**Justification:** The results from this research will create direct links between biochemical modifications of fibres and fibre-fibre joints and the performance of paper and board. Such knowledge is indispensable in the design of wood-fibre based materials that can efficiently compete with for example plastics in packaging applications. Challenges that are essential for the competitiveness of the industry include the development of paper materials that are stiffer and dimensional stable than the materials of today without being brittle, and materials that are less sensitive to long time loading (creep resistant), particularly during varying climate conditions. The new materials that will be possible to develop using the results from the proposed research will strongly enhance the competitiveness of wood-fibre based materials made from renewable resources in applications where materials such as plastics today frequently is the choice of the customer. This of course also requires that the processes that will be used to manufacture these new materials can be made so efficient that the cost of the new materials can be kept at a reasonable level. Thus, micromechanical modelling of fibrous network process technology will be an important part of the research.

**European relevance and collaboration:** This is an extensive research effort that in order to be successful in a reasonable time requires utilization of the competence that today exists in a number of European countries. This list includes for example Lars Wågberg, Royal Institute of Technology, Sweden; Lars Berglund, Royal Institute of Technology, Sweden; Tom Lindström, Royal Institute of Technology and STFI-Packforsk, Sweden; Øyvind Gregersen, Norwegian University of Science and Technology, Norway; J.-F. Bloch, Ecole Française de Papeterie et des Industries Graphiques (EFGP), France. Tuula Teeri, Royal Institute of Technology, Sweden. It is, furthermore, of importance that



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Europe plays a leading role in the development of a sustainable society, and here particularly, design of advanced materials from renewable resources such as wood fibres.

### **1.3.24 Target oriented functionalization of fibres by biocatalysts**

**Positioning:** Basic

**Short Description:** There is a clear demand for increasing the science based development of value-added products of the forest sector. Novel, targeted methods for introducing novel functionalities into fibres have been recently developed. For the first time, this approach also allows to understand what the consequences of a single, designed chemical substituent on various fibre properties are, without simultaneously affecting other chemical structures. However, further improvements and optimization are needed for the full exploitation of the possibilities offered. Furthermore, discovery of novel functionalization biocatalysts may further expand the applicability and specificity of the method. Thus, eg the exact requirements of the enzymes involved, boosting their action on the fibre matrix and optimization of the various details will be needed for fully understanding the mechanisms. A knowledge based approach is needed for further improving this approach. In this context, it is also important to emphasize the possibilities offered by various biomimetic approaches, in which the natural reaction may be mimicked by chemical or chemo-enzymatic methods. The methods involve basic enzymology and fibre chemistry and physics, as well as knowledge on specialized product development areas.

**Justification:** Several possibilities for introducing novel functional properties into fibres are created. These functionalities can be explored both for improving the processability (for improved process performance or saving of resources), as well as for designing completely novel properties into fibres. The latter option is especially tempting with regard to extending the uses of paper for novel areas, such as a carriers for printed electronic circuits or novel consumer products. The proposed theme combines novel technologies, such as biotechnology and material sciences and is strongly oriented towards nanotechnologies, and consequently requires strong competencies in these areas.

**European relevance and collaboration:** Various expertise areas are needed to accomplish the goals. Partners can be identified among groups specialized in: enzymology, wood chemistry and pulping technology and will be named later.

### **1.3.25 Fibre engineering and micro mechanical modelling for efficient materials design**

**Positioning:** Applied

**Short Description:** Detailed knowledge of the relation between the fibre level and the paper performance level is a prerequisite for efficient materials design. The ability to quantitatively control, design and optimise the properties of wood fibre based materials therefore requires detailed knowledge on the fibre properties, fibre-fibre joint properties and the applied processing conditions. An efficient procedure for materials design is only obtained by combining advances in fibre engineering with detailed knowledge of the deformation and failure mechanisms and advances in micromechanical modelling of fibrous networks process technology. The formulation and accurate calibration of micro-mechanical models is dependent on detailed information about the fibres and joints. Important is to experimentally and theoretically study the micro-mechanical properties of bio-chemically modified single fibres, fibre-fibre joints, assemblies of few fibres and fibre networks subjected to loading under different environmental conditions. Fibre materials with well-defined properties are valuable to considered in the initial phase of the experimental work in order to verify theoretical models. Today this type of materials design is primarily inhibited by the lack of detailed knowledge of fibre and fibre-fibre joints.

**Justification:** The results from this research will create direct links between biochemical modifications of fibres and fibre-fibre joints and the performance of paper and board. Such knowledge is indispensable in the design of wood-fibre based materials that can efficiently compete with for example plastics in packaging applications. Challenges that are essential for the competitiveness of the industry include the development of paper materials that are stiffer and dimensional stable than the materials of today without being brittle, and materials that are less sensitive to long time loading (creep resistant), particularly during varying climate conditions. The new materials that will be possible to develop using the results from the proposed research will strongly enhance the competitiveness of wood-fibre based materials made from renewable resources in applications where materials such as plastics today frequently is the choice of the customer. This of course also requires that the processes that will be used to manufacture these new materials can be made so efficient that the cost of the new materials can be kept at a reasonable level. Thus, micromechanical modelling of fibrous network process technology will be an important part of the research.

**European relevance and collaboration:** This is an extensive research effort that in order to be successful in a reasonable time requires utilization of the competence that today exists in a number of European countries. This list includes for example Lars Wågberg, Royal Institute of Technology, Sweden; Lars Berglund, Royal Institute of Technology, Sweden; Tom Lindström, Royal Institute of Technology and STFI-Packforsk, Sweden; Øyvind Gregersen, Norwegian University of Science and Technology, Norway; J.-F. Bloch, Ecole Française de Papeterie et des Industries Graphiques (EFPG), France. Tuula Teeri, Royal Institute of Technology, Sweden.

### **1.3.26 wood-fibre based packaging providing enhanced product protection**

**Positioning:** Applied

**Short Description:** Good packages for easy handling and protection and efficient distribution chains will be an increasingly important feature of a service society. For achieving sustainability the growing society needs renewable and reus-able materials, which have non or low impact on CO2 emission. These mate-rials need to deliver the same or better performance than alternative mate-rials such as fossil based materials (metal, glass, aluminium) and synthetic, crude oil based materials. Packaging needs to respond to changes in society and in the customer and consumer base. It must be responsive to demographic shifts and closely fol-low the effects of changing habits in society amongst the young, middle-aged and elderly. New solutions need to be based on good understanding such areas like per-ception, social behaviour and social changes. They need to be customer value and consumer needs driven rather than process and production driven. Development and implementation of these solutions will require networking that includes partners from the entire value chain. Via this network, it is possible to develop on-demand innovative fibre-based packaging that is sophisticated, cost efficient and safe while also improving the post-use value and environmental impact of the package.

**Justification:** Enhanced barrier properties (water, vapour, gases, light) and specific, dedicated surface properties due to new, innovative surface coatings (“structure” polymers, nanoparticles...) Protection functions (preservation in high/low ambient humidity and temperature) and active conservation functionality: microbiology, chemical treatment (eg by using micro-encapsulation, micro-sorption..) New forms and packaging structures aimed to fulfil consumer demands for functionality, durability, transportation & storage, cost reduction, recyclability, biodegradation. Customer preferences, consumer perception of paper and board based packages. New, integrated logistic solutions, specific for certain products group

**European relevance and collaboration:**

### ***1.3.27 Paper as an efficient medium for communication and education in knowledge based society***

**Positioning:** Applied

**Short Description:** Communication will be an increasingly important human and social need. Dynamic information and education society will consume more and more information carriers of different shape and nature. Electronic media can not replace/perform the unique characteristics printed communication. Only printed paper can fulfill the sustainability criteria of the growing society. It is manufactured from renewable raw material, it is recyclable, biodegradable and also user friendly. Its unique features for communication, education and culture, as well as aesthetic and durability are well adapted to human perception. To provide value for the customer, paper document must be technologically superior, more cost effective, more user friendly and meets other demands and criteria important for the user.

**Justification:** Developing the printing process for improving the quality of printed communication products (consumer perception, novel printing technology demands,...) Developing new manufacturing concepts for superior fibre based substrates (advanced sheet structures, novel coating and surface treatment technologies ...) Developing on-demand printing and new services (business concepts, personalisation, ...) Enhancing Sustainability of printed paper value chain (recyclability of inks, adhesives, substrate components, ..)

**European relevance and collaboration:**

### **1.3.28 Fibre structures for new and improved material properties and products**

**Positioning:** Basic

**Short Description:** In papermaking, a wide spectrum of functionalities may be achieved through the engineering of fibre networks with different characteristics. Fibre networks are also utilized in many other types of products. The potential of developing new and improved products is large. In the project, different ways to create fibre networks with new and improved properties are studied and compared: Selection of fibre materials, processing and modification of the fibres, network structure (fibre distribution, layers, ...), etc. A number of fibre types, traditional and novel, of interest in fibre networks for different uses, are characterized with respect to their virgin properties in trees as well as to their state after processing. Models are extensively used to describe fibre materials used and network structure and for the estimation of resulting properties. Effects from use of various approaches on material and product properties are evaluated and compared. New possibilities are suggested. A holistic perspective is applied from the fibre resources in the forest to the functionalities of the products. This means, for instance, that even if generic properties are investigated, these are identified in close cooperation with the industry, to shorten the road to application.

**Justification:** New fibre networks, designed from a product perspective, may result in new and improved properties. Examples are better printability, stronger or more efficient packaging products, more functional hygiene articles, etc. They could also result in reduced use of material, chemicals and energy in the production of the products, reduced volumes/weights to transport. All these factors may contribute to increased industrial competitiveness, better products for the end-users and reduced environment load. New work opportunities could be created or existing employment secured, not the least in forest regions, with positive side effects for the regional society. Even though parts are rather basic there are close links to industrial applications.

**European relevance and collaboration:** Optimal use of the European forest resources in new products would be an important positive factor in the competition the industry is now facing from countries with wood raw materials from fast-growing plantations. There are strong European traditions in the research areas relevant for the project. Research groups at STFI-Packforsk, KCl, PFI, CTP, KTH and NTNU are expected to be able to make key contributions in this research. These groups have also good channels with industry and suppliers for the implementation of the project results.

### **1.3.29 Improvement of the relevant performance criteria for the service life of fire retardant impregnations and coatings**

**Positioning:** Applied

**Short Description:** Fire retardant coatings and impregnations improve the reaction to fire of wood and wooden components. Recent developments in this respective area (e.g. high performance fire protecting coatings) open up new end use applications. For example it will be possible to protect wooden floors or stairs against the impact of fire. The performance in service life of this novel generation of intelligent coatings is mostly unknown. The research will focus on the performance in service life, on the identification and improvement of the crucial factors in service life, and on the development of guidelines for such coating systems. The knowledge gained due to the new insights into the performance of such systems will build a basis for better and more reliable fire retardant coatings. Neither the mechanical, nor the chemical impacts on such coatings in service life have been analysed properly. In these research work the overall performance in conjunction with variances like UV stability, abrasion, aging, humidity or temperature will be observed. Subject to the utilization different classification requirements and levels of use and the necessary measures to be taken will be defined, e.g. the restoration intervals Furthermore it is planned to develop a care taking guide for such systems.

**Justification:** Fire retardant coatings and impregnations are limited to fields of application where no stresses (climatic, physical or mechanical) are applied. A common floor coating for example underlies certain stresses, e.g. abrasion. This abrasion results in a loss of optical properties, which is not a problem for normal applications and is renewed after a certain time. In case of fire retardant coatings or impregnations the problem is more complex. Simultaneously with the layer thickness, the performance of the flame retardancy is reduced. The interrelation of the decrease of function and the effective forces are not known. The fact that the fire retardant properties (due to safety regulations) need to be available unreduced at all time limit the use of such solutions in most cases. The definition of fire protection classes depending on the circumstances of use, resulting from these research work, will bring a calculateable solution for such problems. A even bigger impact will be taken on the development of new coatings. Tailor made solutions for special requirements will be possible. Increased basic knowledge of the breakdown reasons will lead to new approaches in formulation. In succession the overall safety in public buildings like in train stations or airports will advance, assuring the increasing need of security.

**European relevance and collaboration:** Fire safety is widely considered as one of the most significant obstacles for increased use of wood in construction. European fire regulations have traditionally been very prescriptive and based on experience from large city fires. The increased use of fire safe wood products will provide industry and society with new opportunities to increased use of renewable resources that will stabilize the CO<sub>2</sub> balance. Thus to foster the increased use of fire safe wood products, European research institutes and industrial R&D departments shall collaborate to develop a performance based approach. This should provide new means for achieving

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harmonisation for increased use of wood in construction across Europe. New research and effective information transfer to designers, national and European authorities is needed. Partners could be: The University of Innsbruck, Die Holzindustrie (Austria); Woodfocus, VTT (Finland); TU München (Germany); Skogsindustrierna, SP Träteknik (Sweden); UK Timber Frame Association, BRE (UK); CSTB, Blaise Pascal University (France)



### **1.3.30 Modification of functional groups on wood fibers using ligninolytic peroxidases**

**Positioning:** Applied

**Short Description:** The objective is to introduce reactive functional groups on lignin of wood fibers to increase hydrophilicity or to make linking of different compounds on fibers easy. These new functional groups may change physical or chemical properties of fibers and create new properties. Lignin can be selected as the target, and for that lignin modifying enzymes will be used. The most powerful enzyme known at present is manganese peroxidase (MnP) produced by efficiently lignin degrading fungi. MnP in a mixture consisting of Mn(II), a chelating organic acid, unsaturated lipid, and hydrogen peroxide is able to cleave benzene ring and create muconic acid residues, thus to increase the amount of carboxyl groups. It may further decarboxylate the created groups and phenolic groups are formed. MnP is a powerful oxidative enzyme found so far in almost 60 different species of white rot and litter decomposing basidiomycetes. It oxidizes Mn(II) to Mn(III) that in the chelated form with organic acids such as oxalate is the oxidizing agent. MnP may mineralize, when amended with a chelator and unsaturated lipid, in vitro <sup>14</sup>C-labelled synthetic lignin to <sup>14</sup>CO<sub>2</sub> (up to 16%) by a hypothesized mechanism including benzene ring-opening and formation of carboxyl groups.

**Justification:** The increase of carboxyl or hydroxyl groups in wood may decrease energy consumption during mechanical refining of wood. These modifications should make mechanical pulp smoother and stronger with good binding properties. Efficient biopulping fungi (fungi that degrade more lignin than cellulose in wood and decrease energy requirement in refining) produce manganese peroxidase, which indicates that it is the key enzyme in biopulping. In a French study, laccase treatment caused fiber separation near the middle lamella, and caused 53 % energy savings. The effect of manganese peroxidase has not been studied as much as laccase, but it is more efficient oxidative enzyme than laccase. The new compounds attached may e.g. react differently under different pH and temperatures, change surface charge, respond to different oxygen concentrations, air pressure, have antimicrobial properties etc. “Intelligent” properties can be introduced to fibers through linking compounds to reactive groups in lignin. E.g. for food packaging materials it is important to use non-toxic environmentally friendly materials. Cereal brans from gramineous plants and other agricultural wastes are sources of aromatic acids e.g. ferulic acid, which can further be enzymatically modified to different compounds, and attached to wood lignin.

**European relevance and collaboration:** Collaboration between mycology (production of enzymes), enzymology (enzyme properties, wood fiber treatments etc), wood chemistry and physics (wood fiber properties), pulp and paper research institutes (refining, preparation of paper samples, pulp and paper properties) and companies (test of the concept, applicability to industry). Different European laboratories can collaborate (e.g. mycology & enzymology from the University of Helsinki and CIB/CSIC in Spain, wood chemistry from University of Helsinki & KTH, Sweden; microscopy: SLU, Sweden & Grenoble, France etc). Pulp and paper companies may utilize the results for

the development of processes that save energy in mechanical pulping and improve the fiber properties to fiber surfaces. The production of enzymes for pulp and paper industry will create jobs in enzyme producing industry (biotechnology), and thus strengthen this industry in Europe. Some of these aspects have been studied, but with a small funding. Good ideas cannot be verified with too little research input.

### **1.3.31 Adding value to under-utilised European hardwoods**

**Positioning:** Applied

**Short Description:** The objective is to increase the value and profitability of selected under-utilised European-grown hardwoods using innovative sawing, bonding and secondary processing techniques. Across Europe there are specific hardwood species which are under-utilised due to their poor stem form, size and/or logistical constraints. Many of these species have good performance characteristics and/or highly attractive or unusual appearances which could make them desirable for a range of high value added end-uses (e.g. joinery). The project would: 1. Provide improved knowledge and guidance on the availability, quality, consistency, grades and sizes and mechanical and physical properties of the selected species. 2. Develop innovative sawing and drying methods that optimise for quality and 'fitness for purpose'. 3. Using innovative secondary processes (defect cutting, re-engineering and wet gluing techniques) transform sawn material (and round wood) into added value products. 4. Evaluate the mechanical and physical properties of the manufactured components to ensure they meet the performance requirements for end products. Produce a selection and end-use guidance tool that facilitates the specification, selection, design and use of these hardwoods. 5. Demonstrate that products perform in-service by carrying out commercial trials (with industrial collaborators) that spans the entire supply chain from forest to end-user.

**Justification:** There is very limited information relating specifically to the many under-utilised (secondary) hardwood species growing in European forests. The quantity and quality of this resource has not been well assessed and the potential for its use in high value-added applications has not been analysed. This material is often grown under different forestry regimes (low-intensity management, coppice forests, and agro-forestry plantations) and often exists as small-dimension lower-grade timber with poor stem forms and internal stresses. Many small hardwood plantations and woodlands are in a state of decay due to the difficulties and economics of selling lower quality material. In many cases, woodlands remain under-managed because economic returns are lower than management costs. New and innovative processing methods are required to produce outlets for this material and provide an incentive to manage woodlands productively.

**European relevance and collaboration:** This project will contribute to a concerted European approach to the sustainable evolution of forests by encouraging increased planting and management of a diverse range of species, which will also increase biodiversity. It will help to increase the competitiveness and optimise the value of forest resources through the development of new innovative products made from under-utilised hardwoods. The project also supports the pan-European forest policy on sustainable forestry. Community forest measures will also be addressed, in so far as these forest types are often comprised of mixed hardwood species. A number of European member states have verbally agreed an interest in becoming partners within such a project, these include Spain (AIDIMA), Slovenia (University of Ljubljana), Greece (Forest Research Institute of Athens), Poland (Agricultural University of Poznan), France (Ecole Du Bois) and Italy (CATAS).

### **1.3.32 Timber for foundations and civil engineering**

**Positioning:** Applied

**Short Description:** Aims: • Develop enhanced durability large section timber components for piles, poles, bridges and other civil engineering applications • Develop and provide guidance on the use of timber as an industrial/civil engineering material  
Project participants will develop improved durability large section timber for use as foundation piles, utility poles and other high value in ground contact or in seawater applications. Higher durability will be achieved through a combination of enhanced preservative treatment, wood modification, and through the application of polymer technologies, together with the development of installation and usage techniques designed to maintain the integrity of the protection systems. Full scale demonstration projects will be a feature of this work.

**Justification:** Timber is a highly capable material for engineering applications, but recent environmental legislation has discouraged its usage. Recently there has been increased interest in the use of sustainable materials for building foundations as alternatives to concrete. However, the limited durability of treated European timber above the water table is a major disincentive. Competing materials also include a new generation of fibre reinforced plastic lumbers and polymer composites. Major markets for timber such as utility poles and fender piles may be lost because of doubts about long term durability and environmental concerns over treated timber. Whilst timber piles below the water table may last indefinitely, the section of above the water table is vulnerable to decay. Traditional methods of preservative treatment alone may not provide sufficient lifespan for many potential construction projects. In order for timber to maintain its market share in foundation piles, utility poles and other in ground contact engineering applications reliable enhanced protection systems need to be developed. Innovative combinations of other materials with timber might be enabled from this project.

**European relevance and collaboration:** It will help to increase the competitiveness of forest resources through the development of new innovative products. The project also supports the pan-European forest policy on sustainable forestry. A number of European member states would be needed as partners within such a project, particularly national centres of expertise in civil engineering and timber.

### ***1.3.33 Delivering enhanced durability through wood modification***

**Positioning:** Applied

**Short Description:** Wood modification techniques provide an opportunity for timber products to effectively challenge potentially less sustainable construction products. The properties of many modified woods include features of enhanced biological durability, dimensional stability and coating performance, amongst others. The technologies do not sit comfortably with the existing framework for specifying and using treated timber. This barrier needs to be addressed by: 1. Providing a comprehensive performance and property database 2. Developing technical standards to enable the appropriate use of these materials 3. Developing a foundation for understanding and demonstrating the sustainability benefits of these materials Task groups will be formed to deliver solutions for technical specifications and to gather and process data for sustainability assessments.

**Justification:** The results will be: 1. A performance database to support application and use of modified wood 2. CEN Technical Standards for modified wood products 3. A tool for demonstrating the sustainability of the product technologies and to stimulate the continuous process and production improvements Modified wood products will be able to compete more effectively with metal, plastic and cementitious construction products. The focus will be on continuous improvement to minimise environmental impacts through process improvement and delivering long service life, predictable construction products. This work would enable innovation in wood products by offering opportunity to open new markets or diversify in established markets.

**European relevance and collaboration:** The wood modification production technologies are primarily concentrated in Scandinavia, Germany, the Netherlands and France. Collaborative research is required across Europe to bring together the commercial experts in these countries with the laboratory researcher groups, the manufacturers who might want use modified wood and the construction product markets. An excellent foundation of partners for this work would be from the former Thematic Network for wood modification funded in FP5.

### **1.3.34 Development of innovative forest-based products for changing markets and customer needs**

**Positioning:** Applied

**Short Description:** A multidisciplinary approach is needed. New enabling technologies will create opportunities for responding to the new habits and fashions of future consumers and to the increasing competition. This will be an opportunity for the European forest-based sector to change its product mix from mainly “bulk commodities” towards a new range of knowledge-demanding and high value-added products.

**Justification:** For example: Smart systems solutions for the use of wood and wood-based products. Future generations are characterised by a growing percentage of aged people and singles or small families. With respect to housing and living, this means that special attention needs to be given to lifestyle products, flexible building systems and innovative services. In a rapidly changing working and living environment, the flexibility and mobility of European citizens will increase. Wood and wood-based products for daily use and for the built environment will play an important role in this context. As an example, future buildings and furniture must take into account that its proprietor's expectations will change over the life span. They will either have to be multi-functional or highly flexible. Innovative and environment friendly solutions for wood-based packaging materials and transportation systems for goods must also be developed. Environmental, human well being and safety aspects will have to be addressed when novel solutions for fast and flexible e.g. wall cladding, flooring, packaging etc. are developed. Future solutions must focus on a stronger consideration of industrial hygiene, natural anti-septic properties of wood as well as on phyto-sanitary aspects in conjunction with world-wide transport of wooden goods. A second example: Wood-based specialty chemicals and particles. Wood has the potential to provide a substantial and renewable source for the production of a large number of specialty chemicals. This is, however, far from being utilised. The core idea of this research theme is to take full benefit from the structures and chemistry of different wood constituents (preferably as isolated in a wood biorefinery), from all tree parts (including bark, foliage, and different residues), and from specific features of different European tree species. Using this approach, it will be possible to convert wood into high-value added, CO<sub>2</sub> neutral and biodegradable products. They can generate new business opportunities and replace petroleum-based chemicals and polymers.

**European relevance and collaboration:** Please submit a targeted call with emphasis on multidisciplinary and co-operation.

### **1.3.35 Nanotechnology in wood protection**

**Positioning:** Applied

**Short Description:** Wood is an often used material for construction purposes, furniture and interior applications, caused by its good strength properties, easy handling and natural character. But there are some disadvantages limiting the use of wood. Variation of climate induces dimensional changes (swelling and shrinkage), reducing the adhesion of coatings and the precision of construction components. Danger of attacks by fungi or insects requires the use of biocides or resistant wood species (often tropical woods). The aim of this research project would be a detailed study of the possibilities nanotechnology gain to the field of wood protection. One main aspect is hydrophobicity. However, also easy-to-clean as well as hydrophobicity might be an aspect. On the other hand UV-protection has to be fulfilled and this needs quite intensive studies. Last but not least aspects of self-cleaning like photocatalysis should be investigated. After a screening of raw materials (maybe self-synthesized) by contact angle as well as weathering studies (QUV) and water-uptake studies an optimization regarding user-friendliness has to be done. Desirable effects are altering of sorption behaviour, improvement of durability and better UV- as well as dimensional- stability.

**Justification:** The general long run achievements of the project are to facilitate the exploitation and development of alternative nanobased wood protection treatments and decrease the use of biocides. In addition, the aim is to increase utilisation of hydrophobised European grown softwood products for future use in exterior constructions or niche markets where high quality materials are required.

**European relevance and collaboration:** Nanotechnology is a quite interdisciplinary topic. Thus, research networks are necessary.

### **1.3.36 Feeding properties of extractives from wood and conception of attractive baits.**

**Positioning:** Applied

**Short Description:** Termites cause damage in south of Europe or in French overseas department. There are two solutions to protect the house, or agricultural area or ornamental trees. Traditional termite treatments afford structural protection by creating a persistent chemical barrier in the soil. And termite bait, foraging termites consume the bait and share it with their nestmates, resulting in a gradual decline in termite numbers. The first step of the treatment consists to attract the termite with cellulose before the installation of the bait material. Some tropical wood contains various extractives that have some attractive effect on termite. The objective of this work consist to study some tropical woods (*Schefflera morototoni*, *Couatari guianensis*, *simarouba amara*, *virola michelii*...) non resistant to termites, to search the compounds which have an attractive effect on the termites. Lab tests will allow to identify the more interesting species, then determination of chemical composition in order to find relation between attractiveness and chemical composition. In a last step, fields tests in order to study the behaviour of the termites in real conditions (tropical and temperate fields).

**Justification:** One of the biggest challenges in baiting is getting termites to find the baits in the first place. The timetable for discovery will vary from property to property, depending on such factors as termite foraging intensity, time of year, moisture, and food availability. This study will allow to propose several species which have feedent properties against termite. They will be use as wooden monitor and allow a rapid infestation of the termites. Significant results will contribute to bring new information to the formulator biocide product and allow to propose a rapid treatment of the concerned zone. The biological activity of wood extractives had been often study but not the contrary. The results will bring new informations about the behaviour of termites against wood extractives. It will be also the occasion to promote secondary species which are less used on tropical forest or abandon after harvesting ; develop a effective use of wood waste for some species.

**European relevance and collaboration:** Termite infestation concern all the south of Europe: France, Italy, Spain, Portugal and also overseas department and they cause a lot of damage. Several institutes are interested about the behaviour of termites, the impact of wood extractives on termites like CIRAD (France), LERBI (CNRS in Dijon – France), LNEC (department of civil engineering in Madrid), Istituto per la Valorizzazione del Legno delle Specie Arboree (CNR-IVALSA in Spain). It will be possible to incorporate institute from French overseas department like CTBA in Reunion or CIRAD in French Guiana.



### ***1.3.37 Developing the use of wood in construction***

**Positioning:** Applied

**Short Description:** A multitechnical approach with regard to each of the essential requirements of the construction products directive (comfort, safety, etc) should give high performance building solutions. This issue will be derived in subprojects depending on the structural elements (eg floors, walls, roofs,...) and the requirements (eg mechanical behaviour, thermal comfort, acoustics, etc).

**Justification:** The increase of wood in construction gives a positive energy balance as well as a mean to encounter greenhouse effect by carbon storage.

**European relevance and collaboration:** This project depends on the building systems used in different countries, as well as specific environments and social issues. A European approach will facilitate European convergence.

## **Sub-area 1.4 Combining fibres with other materials**

### ***1.4.1 Improvement of dimensional stability and other material properties of wood-plastic composites.***

**Positioning:** Applied

**Short Description:** Wood-plastic composites (WPC) or natural fibre reinforced thermoplastic composites represent a relatively new class of hybrid materials which have gained significant market share in North America during the last decade, primarily as a substitute for wood decking. In Europe, WPC are currently being introduced to the market, with an annual production of approximately 10,000 t. Wood-plastic composites primarily consist of wood filler and a thermoplastic polymer matrix (polyethylene, polypropylene or polyvinyl chloride) and are most commonly produced by extrusion or injection moulding. Because of the limited thermal stability of wood, only thermoplastics that melt or can be processed at temperatures below 200°C are used in WPC. Wood or other natural fibres such as hemp, straw, sisal or kenaf, are added in particulate form (e.g., wood flour) or as very short fibres. In North America, commercial WPC formulations generally contain 65% wood filler or less. The objective of this research is to manufacture WPC based on a higher amount of natural fibre filler that display equal or improved product properties when compared to formulations containing a high amount of plastic. This will be achieved by chemical modification of the wood filler prior to combining with plastic using N-methylol-compounds, silanes and waxes.

**Justification:** Due to limited petroleum resources worldwide and increasing costs for petroleum it is desirable to limit the amount of plastics (polypropylene, polyethylene) used in WPC production. In addition, mechanical properties (strength and stiffness) of WPC may be improved when relatively high amounts of wood filler are used in formulations. However, a drawback of WPC with a high amount of hydrophilic wood filler, i.e., a low amount of hydrophobic plastic matrix, consists in increased swelling and shrinking of the material. This may lead to problems with interfacial adhesion, a reduction in strength and stiffness as well as biological durability of the composite. These drawbacks could be overcome if the filler was chemically modified prior to processing. Wood modification was shown to be an effective alternative for chemical wood protection of solid wood as well as an alternative to the use of naturally durable wood species which are in short supply and expensive. The application of products made from renewable resources contributes to the protection of fossil fuels and climate. Economical competitiveness of European WPC producers will be improved if high quality formulations containing up to 85% wood filler can be manufactured.

**European relevance and collaboration:** In contrast to North America, the European WPC market is still undifferentiated but significant market growth is being predicted. In 2003, 400.000 t of WPC were produced in North America, compared to approximately 30.000 t in Europe. This research project will contribute to promotion and market development of WPC on a European level and may demonstrate that high-quality WPC formulations can be produced which are based on significant amounts of renewable resources. This in turn will achieve economic competitiveness for WPC manufacturers

while increasing ecological friendliness of the product. European research groups that may contribute to the implementation of this research are: · The BioComposites Centre, Bangor, Wales: <http://www.bc.bangor.ac.uk/index.htm> · Fraunhofer Institut für Holzforschung WKI, Braunschweig: <http://www.wki.fhg.de/> · Institut für Werkstofftechnik – Kunststoff- und Recyclingtechnik – Universität Kassel: <http://www.kutech-kassel.de/> · Wood KPlus Kompetenz-Zentrum für Holzverbundwerkstoffe und Holzchemie, Linz, Österreich: <http://www.kplus-wood.at/> · Fraunhofer-Institut für Werkstoffmechanik, Halle/Saale: <http://www.iwm.fraunhofer.de/>

### **1.4.2 Novel WPC packaging materials**

**Positioning:** Applied

**Short Description:** Considerable quantities of wood are used for packaging. New packaging systems demand for high flexibility as far as form giving is concerned. In combining low quality plastic materials (e.g. recyclat) with wood or sawdust could be a very economic and environmentally friendly solution.

**Justification:** New packaging materials; considerable reduction of fossile oil resource; save, durable and environmentally friendly packaging;

**European relevance and collaboration:** Recycling issues in the field of wood and plastic materials is a Pan-European problem. Joint university and industrial research and development activities will help to speed up the process of intrduction of novell solutions.

### **1.4.3 Hybrid composites approaches**

**Positioning:** Basic

**Short Description:** Combinations of wood fibres with other materials may provide useful composites for many application sectors. However, there is comparative little reserach done in this area, compared to the effort in 100% wood-based composites or, for example, 100% glass-fibre based composites. Yet, there are cost reduction and mass reduction benefits to be exploited in trying to extract the best of combination of different fibres in composites, i.e. developing hybrid systems

**Justification:** Given the volume of the market, replacing even modest amounts of general purpose fibres,like glass, with wood fibres can be beneficial provided that the hybrid systems can combine effectively the relative advantages of the various fibres. Increasing the proportion of renewable, sustainable materials in composites in an important aspect of composites development

**European relevance and collaboration:** The issue of increasing the sustainability and biodegradability of composites is relevant across most of Europe. A large volume of composites suitable for introduction of wood fibres is used by the automotive industry which is increasingly looking at end-of-life issue and sustainable sources of structural or semi-structural materials.

### **1.4.4 Wood polymer composites development : Eco-Design and Life Cycle Assessment**

**Positioning:** Applied

**Short Description:** Wood polymer composites (wood flours or fibers associated to thermoplastics like PP, PE and PVC) are in higher development in Europe. To enhance the environmental issues of these innovative products used in Construction and furniture, it is necessary to have more informations on (1) performances of products in service life (resistance to weathering), (2) Life Cycle Assessment of such products (windows, cladding, ...), and (3) development of Eco-design methodology.

**Justification:** This work will be useful to enhance - the development of markets for these bio-composites by Eco-design approach, - contribute to use renewable resources instead petroleum olefins, - purpose easy maintenance and recycling wood based products.

**European relevance and collaboration:** Some countries (Belgium, Germany, Austria, France) are actively involved in definition of standards (CENTC264). Eco-design and LCA applied to these innovative materials will be studied by European groups involved in LCA (Belgium, Austria), in research (University of Austria, ...), in markets (Belgium, industrial groups, ...). The objective is to create a EU WPC Cluster.

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### **1.4.5 Fibrecomposites**

**Positioning:** Applied

**Short Description:** Use of chemical pulp fibres in plastic composites.

**Justification:** New materials, biomaterials.

**European relevance and collaboration:** To be able to compete with USA where they have started huge Nanotechnology program. KTH, STFI, NTNU



### **1.4.6 Composites of wood fibres with modified starches**

**Positioning:** Applied

**Short Description:** The ever increasing importance of the electronic media will ultimately diminish the need of printing paper. The use of paper based packages will increase especially because of depletion of oil resources. Plastic packages will be replaced by products made of renewable resources. Strong plastic like structures could be made of structured composites of wood fibres and modified starches. The possible alternatives of the wood fibre resources include current chemical and mechanical pulp fibres but also fibres liberated by high temperature treatments could be considered. The emphasis should be in hydrophobic fibres. The properties of starch could be tailored by depolymerization, oxidation and hydrophobization.

**Justification:** New packaging and construction materials could be developed. European forest industry could maintain its competitiveness through the new innovations. The alternative ways of using wood could also attract young talented people. Replacement of synthetic polymer materials with renewable ones would decrease Europe's dependence on imported oil.

**European relevance and collaboration:** Most of the last major investments of forest industry has been made in China and South America. The expanding EU urgently needs investments in local production sites in the new member countries.

### ***1.4.7 Development of new paper and nonwoven coating method based on cellulose formulations (CELCOAT)***

**Positioning:** Applied

**Short Description:** Selected cellulose-containing latex formulations are applied by various technologies on selected papers and nonwovens. The effects of coatings on bonding strength, durability and printing properties are investigated. The effect of coatings on hydrophobic nonwovens' hydrophilicity and durability are investigated.

**Justification:** Within the CELCOAT project, new methods of coating paper and nonwovens with cellulose are developed. The paper nonwoven industry could receive a new natural-polymer-based coating alternative for selected products.

**European relevance and collaboration:** The basic technology is developed in Biocelsol EU-project. Additional to the project working groups Solution, Films and Casings, paper and nonwoven industries are potential partners, as follows: TUT Fibre Materials and Paper Converting Finland, KCL Finland, Ahlström Finland, Visko Oy Finland, an international paper company to be discussed.

### ***1.4.8 long time durability of wood-plastic composites***

**Positioning:**

**Short Description:** long time durability of wood-plastic composites. Field test and speed up test in laboratory.

**Justification:** To find new target for WPC-material To find new target for sawdust material Find new easy materials to recycle

**European relevance and collaboration:** WPC materials can produce in many different ways. This material is possible to use in many products ( cars, buildings etc.)

## **Sub-area 1.5 Creating new innovative wood and fibre structures for different end-uses**

### **1.5.1 Compression Behavior of Fiber Composites**

**Positioning:** Basic

**Short Description:** Materials fail by separation. In other words, in a molecular level, failure always is tensile failure. Instability in compression occurs as plastic flow, or through some kind of buckling or splitting. In the case of non-brittle structures, macroscopic failure is preceded by damage evolution, often in the form of evolving damage bands. Most of the research, regarding fiber composites and laminates, has been of empirical nature, and of limited value for in-depth understanding of their compression behavior. Using modern techniques, damage evolution can be monitored during compressive loading of structures. The design of relevant experiments does require thorough analysis of the mechanics of composites and laminates.

**Justification:** Fiber reinforcement very effectively improves apparent tensile fracture energy in the fiber direction. Thus, such reinforced structures tolerate tension, but they are vulnerable to compressive loading. Compressive loading however appears rather frequently, in particular in the case of structural and packaging applications. Improved compression behavior not only prevents failure, but makes it possible to apply composites in lighter basis weight.

**European relevance and collaboration:** <http://power2.fsv.cvut.cz/qfs/>  
<http://cml.fsv.cvut.cz/~milan/> <http://www.chalmers.se/HyperText/Prof-E/Petersson-E.html> <http://www.byggmek.lth.se/> <http://joyx.joensuu.fi/~karenlam/petri/petri.htm>

## **1.5.2 Fatigue Behavior of Fiber Composites**

**Positioning:** Basic

**Short Description:** Under cyclic loading, materials get damaged at stresses and strains far below those typical for failure within single loading event. Mechanical fatigue is induced by some sort of local kinematic irreversibility. Such kinematic irreversibility may be manifested in the formation of slip bands or other kinds of shear bands, grazes, rotation or other changes in orientation of molecular chains, nucleation of pores, or a variety of other microscopic mechanisms. Fatigue damage does not need to be due to external mechanical loading – temperature or moisture variations, for example, may cyclically induce internal stresses. Surprisingly little is known of fatigue damage in fiber reinforced composites, or laminates made thereof. Careful analysis of the mechanics of such situations should lead to computer experiments, from which the most promising results should be subjected to physical experimentation.

**Justification:** Vast majority of structural failures is related to fatigue situations. Hygroscopic materials are particularly vulnerable due to cyclical hygroexpansive loading, which often is combined by external mechanical loading. Premature failure may be prevented through careful design of materials, as well as structural configurations, provided the necessary knowledge is available.

**European relevance and collaboration:**

<http://www.mct.ro/web/2/fp6/3/parteneri/Polonia/midi/data/57.html>  
[http://www.lms.polytechnique.fr/annuaire\\_nom.php?id=26](http://www.lms.polytechnique.fr/annuaire_nom.php?id=26) <http://www-mech.eng.cam.ac.uk/profiles/vsd/> <http://fb7-fg6.uni-duisburg.de/nowack/>  
<http://joyx.joensuu.fi/~karenlam/petri/petri.htm>

### **1.5.3 Solid Timber Constructio**

**Positioning:** Basic

**Short Description:** Solid wood constructions are, originally located in North America and Central Europe, the traditional technology for residential timber construction. Specific deficiencies of log constructions – subsidence, deflection and air leakage for instance – have recently led to advanced solid wood construction elements: large-scale, massive, monolithic elements, manufactured from small cross-section boards are massive, dimensionally stable, rigid and load bearing elements autonomously developed by several wood-working enterprises in Central Europe. Even though massive wood elements applied in (multi-storey) residential buildings, public and business facilities possess, compared to conventional construction methods, eminent economical and ecological advantages, missing standards and insufficient design rules often inhibit design and building permits and hinder implementation, opening of new markets and export. The aim of further research has to adapt basic principles of design, calculation and dimensioning. Assumption for heat requirement prognosis, thermal insulation and heat retention of massive timber structures will be identified by long-time investigations. Missing or inadequate calculation methods require measurement of full-scale experimental building, fundamentals of security levels and seismic design of massive timber construction are to be investigated in laboratory testing. Accompanying work groups have to ensure technology transfer and incorporation into accredited standards.

**Justification:** extend timber part in the construction area

**European relevance and collaboration:** standarisiation

### **1.5.4 Timber concrete construction**

**Positioning:** Applied

**Short Description:** In the last three years the Austrian market in wood construction for residential buildings has tripled. However the part of industrial and public buildings in wood remained constant. Wood-concrete connected slabs are used since 15 years but never a prefabricated system has been intended. The aim of the research cooperation is to provide a high performance wide-span slab with timber concrete elements in order to allocate a competitive floor system with an industrial production.

**Justification:** extend timber part in the construction area

**European relevance and collaboration:** standardisation since there is a large research activity in the field of timber concrete composites there is a high demand for collaboration



### **1.5.5 Structures made from imperfect logs using CNC machined connections**

**Positioning:** Applied

**Short Description:** At present, durable timber structures in Europe are only possible by either using structural protection, e.g. a building envelope, treated timber or naturally durable tropical timber. This presents a difficult competitive situation for timber structures like bridges. There are naturally durable species like *Robinia pseudoacacia* with high strength and stiffness properties and a high natural durability. European *Robinia* is not available, however, in straight, large diameter logs needed to economically produce sawn or glued laminated timber. Round timber even containing large imperfections is perfectly feasible for truss structures, where the member shape between the joints is not important. There are two research areas to be covered to enable the use of imperfect logs in structures: The load-carrying capacity of tensile or compression members with large geometrical imperfections and the production and the load-deformation-behaviour of precise mechanical connections for imperfect logs. The load-carrying capacity of members can be studied using both, tension and compression tests on full-size members as well as mechanical models based on the stochastic geometric and strength and stiffness properties of the logs. The production of precise connections in imperfect logs has to be studied in co-operation with CNC machine producers and the load-deformation-behaviour by calculation and testing.

**Justification:** The load-carrying capacity of timber is only known for members whose imperfections do not exceed limits defined by visual strength grading. Members having larger imperfections will have lower capacities and, due to bending, lower axial stiffness. On the other hand, round timber members show higher strength and stiffness values than sawn timber. With the knowledge regarding large imperfection timber and their connections it is possible to design and build weatherproof structures for bridges, masts and towers, if durable timber like *Robinia pseudoacacia* is used. The industrial competitiveness of the timber industry would be strengthened since new markets would open for timber structures. Examples are pedestrian and road bridges, masts and towers for power lines or windmills, or guard rails. Using imperfect round timbers of durable European species would significantly decrease material costs. The socio-economic impacts envisaged include the increased work in rural and forested areas, the increased value of hitherto low-value trees as well as the new opportunities for SMEs in the timber industry. The environmental impacts comprise the abandonment of chemical treatment and an increased lifetime for weather exposed timber and the decreased zinc deposit from corrosion protected steel members.

**European relevance and collaboration:** While the main producers of durable *Robinia* are situated in Eastern Europe, the main producers and operators of CNC woodworking machines as well as the main knowledge regarding mechanical timber connections are placed in Central Europe. Moreover, for the machine strength grading of imperfect round timber there is knowledge available in Finland. This necessitates a collaboration between the forest research institutes in Hungary and Slovakia, the timber structures research and

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the CNC development for the machining of imperfect round timber in Germany and the machine strength grading of logs in Finland. Possible European research groups are: VTT Finland Lehrstuhl für Ingenieurholzbau und Baukonstruktionen, Universität Karlsruhe, Germany Faculty of Forestry and Faculty of Wood Sciences, Sopron, Hungary Forest Research Institute, Zvolen, Slovakia

### **1.5.6 High capacity building systems from sustainable hardwoods**

**Positioning:** Applied

**Short Description:** The main species for structural timber in Europe are spruce and pine. These two species are mostly used as sawn or glued laminated timber or as laminated veneer lumber. Many structural applications are not yet possible in timber because of the low strength and stiffness values of coniferous timbers and hence the necessary large cross-sections. For sophisticated filigree structures like wood-glass-facades, steel or aluminium is therefore often used. European hardwoods, showing much higher strengths compared to softwoods, often cannot be used efficiently in sophisticated structures because of the missing strength and stiffness properties. Suitable European hardwood species have to be identified regarding availability, esthetical properties, durability, and strength and stiffness properties. Many species are not yet used structurally, but they will be increasingly available because of the changing supply in Europe's forests. The main strength and stiffness properties of European hardwoods have to be determined by testing in order to allow a classification into the European strength class system. For this purpose, also an efficient log grading procedure needs to be developed, based on non-destructive measurements. Additionally the suitability for the use of adhesives has to be studied and highly efficient mechanical connection systems need to be developed for hardwoods.

**Justification:** The timber supply from Europe's forests will change considerably in the future. While the share of softwoods is decreasing, hardwoods of different species will be abundantly available. It is necessary to find additional high-value applications for this future source of material. One example for sophisticated structures are wood-glass-facades where the load-bearing structure is made of timber and the building envelope of glass panes. Advantages of timber for these structures are the low thermal conductivity of wood, the low thermal elongation, the lower production energy and the lower costs. The results of the project will enable highly competitive structures for ambitious buildings in timber. The customers may then chose from different hardwood species according to different esthetical requirements. Invisible mechanical connections will contribute to the overall esthetical quality of the finished structures. The industrial competitiveness of the timber industry would be strengthened since new markets would open for timber structures. Examples are wood-glass-facades or visible engineered structures in public buildings. The socio-economic impacts envisaged include the increased work in rural and forested areas, as well as the new opportunities for SMEs in the timber industry. The environmental impacts comprise the decrease of the use of aluminium and hence a CO<sub>2</sub> reduction.

**European relevance and collaboration:** There are many hardwood species in Europe and the problem of finding suitable applications applies to any European country. Because of the large number of species, the effort to determine strength grading procedures and characteristic values for sawn and glued laminated timber will exceed the capacity of each single country. European cooperation therefore is the key to solve this

problem. This necessitates a collaboration between the forest and timber research institutes in most European countries. Possible European research groups are: Universität Karlsruhe, Germany: Determination of characteristic values, mechanical connections TU München, Germany: Forestry, wood supply, determination of characteristic values and strength grading VTT Finland: Determination of characteristic values and strength grading

### ***1.5.7 Alteration of wood based particles and fibres for building blocks of sensing and monitoring and special functionalities providing structures***

**Positioning:** Applied

**Short Description:** Biobased polymers, such as wood-based particles and fibres, offer an excellent substrate or matrix for integration of novel and more effective functionality. Cellulosic materials are known to have pronounced absorption properties. These properties, for instance, can be modified towards more specific and controllable functionality by means of enzymatic or nanotechnological approaches altering the porosity and/or the chemical properties of the material. The ability of biobased matrices to pass through moisture and volatile compounds (VOC) can be adjusted by making the materials breathable; the CoreTex-products are good examples of this concept. In these products, the mechanism is based on vapour transport through a microporous structure where small holes in the film allow the water vapour molecules to pass through but not liquid water. The same analogy can be utilized to trap molecules responsible for unpleasant odours. In addition, biopolymer network can be enzymatically modified to a matrix which contains capsules or capsule moieties for pigments, organic dyes in waterbased systems, functional dyes, active agents (monitoring and sensing materials), and other ingredients. The capsule systems may perform in a way that capsules or the components of the capsules react with (harmful) chemical or biological compounds and as an active barrier. capture of specific agents from the environment could lead to chemical and biological detectors. Enzymatic and nanotechnological modification methods themselves are environmentally friendly by minimising the consumption of chemicals and additives. The approaches to improved the properties and functionality of the matrix will be included the modification by tuning the pore size of the material or by binding functional groups to the matrix by means of nanotechnology, chemical or enzymatical reactions. The materials to be developed can be utilized in a variety of applications: controlled moisture behaviour, elimination of odours, encapsulation of emissions and controlled release of active agents are included in these applications.

**Justification:** The study will result in following products and innovations • lignocellulosic fibre/particle containing film-like matrix with moisture and odour absorption properties o for buliding material use (wall papers, inslulation materials) o for health care targets (daily sanitary products, such as diapers, sanitary towels, bandages) • lignocelluloic fibre/particle conatining matrices with active agents for monitoring and sensing purposes o moisture sensing /monitoring agents (colour indicators) o odour and emission sensing/monitoring agents • lignocelluloic fibre/particle containing matrices with antimicrobial properties The research area will intensify the exploitation of wood raw material side streams in a the most economically feasible phase and way. In addition, environmental aspects will be considered in the study by using waste wood in combination with other materials to make new high performance products.

**European relevance and collaboration:** The topic on improvement of the use wood material has raised interest throughout Europe. In some European and Nordic research

institutes, extensive work on wood based particles and fibres have already carried out. However, the utilisation of lignocellulosic material in the novel product applications as well as improvement of the degree of upgrading of wood -based products need more multidisiplinary research. Combining the expertise areas of the different institutes lead more cost-effective research concept. The potential research groups implementing the research would be the following: Finland Sweden France Germany VTT, Technical Research Centre of Finland, Espoo, Dr. Anne-Christine Ritschkoff, Dr. Salme Koskimies, Dr. Liisa Viikari Dept. of Fiber & Polymer Technology Royal Institute of Technology (KTH), Stockholm, Dr. Lars A. Berglund University of Bordeaux, Bordeaux Dr. Gilles Sebe University of Potsdam, Potsdam NN University of Helsinki, Department of Polymer Chemistry Prof. Heikki Tenhu Institute for surface Chemistry (YKI), Stockholm Max-Planck Institute, Potsdam NN

### ***1.5.8 Conceptualisation of wood based products for leisure, moving and transportation***

**Positioning:** Applied

**Short Description:** Based on user oriented setting and different future scenarios, the project aim to conceptualise products for leisure, moving and transportation. The wood based product applications will be composed and tested. The project creates opportunities to developing new type of constructions and aesthetic solutions.

**Justification:** The wood industry is currently renewing and expanding its product categories. In the field of wood industry in Northern Europe, new businesses are evolving. The main tendency is to develop products, which can utilize the wood materials from Finland and neighbouring regions. Kuopio Academy of Design is a part of Savonia-Polytechnic which is multidisciplinary institution of higher education. It offers degree programmes and R&D in seven fields of study and has 5000 students. Kuopio Academy of Design has 60 to 100 co-operation projects/year with enterprises. During 2005-2007 it has PUUMI-wood design project funding by ESF. Participators are wood working enterprises from East Finland.

**European relevance and collaboration:** International exchange of experts is essential in order to efficiently utilize the latest technology. The project brings together a versatile group of wood specialists from different countries. Furthermore the project utilizes know how and experience concerning the traditional ways to using and manufacturing wood products.

### **1.5.9 Prefabricated wall-elements out of biogene-based materials and timber for building and renovation**

**Positioning:** Applied

**Short Description:** Europe's dependency on fossil energy should be diminished, according to the political point of view of the European Union. One of the essential instruments to achieve this is the use of potentials to save energy. The reduction of energy consumption of buildings becomes more important due to the 25-30% part of the total energy consumption and the reduction potential of CO<sub>2</sub>-emissions resulting from this fact. Especially buildings, which have been constructed between 1950 and 1980, have extremely high consumptions of energy. In the new European countries also modern buildings offer additional potentials of saving energy. In addition to the huge demand for improvement of thermal insulation there is also a fundamental demand for renovation to improve protection against moisture and the architectural design. Nowadays such renovations are usually done with thermal insulation and stucco systems out of polystyrol or mineral wool. The implementation of these renovations happens in situ and leads, in addition to the use of predominant petroleum-based products, furthermore to long times of construction, as building with elements / prefabrication is not done. So in addition to the further development and standardisation of the application of pre-manufactured timber elements in reinforced concrete skeleton constructions the target is the development of a dimension-evaluation and fabrication system for the production of pre-manufactured timber parts including insulation, façade panelling and windows for the application on existing window facades (masonry, reinforced concrete).

**Justification:** This project should enable the timber engineering to get in touch with the amazing field of renovation of facades in order to make use of CO<sub>2</sub> neutral and easily manufacturable constructions when thermically renovating the necessary building stock. In doing so the existing methods of survey should be further developed, especially by using laser technics. Also CAD-based planning and fabrication instruments should be further developed. This requires a close cooperation between survey engineers, building engineers, civil engineers, architects and the manufacturing industry. A successful research and development would open up a complete new market for the whole area of timber engineering and it would contribute to the goals of saving energy by the European Union. In addition to design-engineering and questions relating to technical production especially questions regarding noise insulation, fire protection, thermal insulation and moisture protection should be considered.

**European relevance and collaboration:** A specific European relevance exists due to the reduction of energy consumptions of buildings by using low energy biogene-based construction and insulation materials. Particularly the building stock of the new European countries is predestinated for appropriate applications. This is also valid for concrete and masonry constructions of the sixties and seventies in all European countries. Therefore a cooperation between Scandinavian, East European, Middle European and South European institutes is necessary. In doing so the basic questions such as dimension evaluation and data transfer to production need to be solved in a collaborative way,



whereas for application, architecture and construction regional construction traditions need to be considered. The research could be done e.g. in cooperation of Technische Universität München, Helsinki University of Technology, Universität Innsbruck, Universidad Politecnica de Madrid and other interested groups from other European countries. The development needs to be done in close coordination with the manufacturing industry.

### **1.5.10 Wood-Concrete Composite Action for Prefabricated Housing**

**Positioning:** Applied

**Short Description:** Timber floors have been a long quest in research due to its low stiffness combined with a relatively high strength, which leads to vibrations resulting in uneasiness for residents. The combination of timber joists and a concrete slab is not new. The current practice is to install the timber beams and cast the concrete on top of these, then leaving the concrete to set for an appropriate time. For industrial construction (lean construction) this approach is impossible since the curing time for concrete would set back the production time severely. This research project is instead founded on the idea of establishing a connection useful for connecting timber to concrete after the curing of the concrete slab. Similar approaches can be found in bridge engineering where prefabricated slabs are mounted with studs to steel beams. Theoretically, the approach will lead to discrete points in the structure where forces are transferred i.e. the composite action of the structure is discontinuous. Currently, mechanical shear tests are carried out on potential connections, with the aim of testing a full scale timber floor with respect to load carrying capacity, stiffness and vibrations. A parametric FE model focused on the discontinuous composite action will be made.

**Justification:** The result from the research will present an efficient way of incorporating old technology into modern construction. It will combine two materials in a way that the components are separable after use, which is environmentally friendly and gives the possibility to enhance the system in use. For the timber housing industry it will present a high performance building component, enabling larger spans in timber buildings leading to a potential market share increase. Composite timber-concrete floors would also be a possible constituent in commercial buildings, where timber today has difficulties competing due to the large spans and open spaces required.

**European relevance and collaboration:** Research within the field timber-concrete components has been carried out in Europe for some fifty years. Knowledge on the composite action between timber and concrete is available. The idea behind this project is to introduce this technology into the modern construction industry, which is currently moving towards more prefabrication and less on-site work. In Sweden the lean construction trend is prominent, providing good settings for testing the product. However, research groups in Germany, Switzerland and Italy are the ones who are excellent on the theoretical framework behind composite action in timber-concrete components.

### **1.5.11 Strengthening of Glulam with Natural Fibres**

**Positioning:** Applied

**Short Description:** Glulam members are commonly used as high performance girders in timber floors, roof systems and bridges. The applications are sometimes limited due to the low strength perpendicular to the grain of timber. Strengthening in the direction perpendicular to the grain has been tested by others using glass fibres, nail plates, plywood, glued-in rods etc. All of these approaches, however, rely on technology which is not environmentally friendly in the sense that a structure not easily dismantled or combustible is created. Since one of the arguments for choosing timber as a material is the environmental friendliness, it is logical to look into the quest of strengthening timber using natural fibres such as hemp, flax, wool or even wood. To achieve the strengthening effect a matrix to carry the fibres is needed, commonly some plastic resin (polyurethane, polyester, epoxy etc.). This research investigates the possibilities of using natural fibres in combination with glulam to achieve high performance structural elements. Different types of natural fibres are currently investigated and the work is now focused on finding suitable matrices. Laboratory tests on simple coupons will commence the laboratory work which will finally focus on strengthening of full size glulam beams.

**Justification:** The result from the research will present a new technology to increase the competitiveness of timber yet preserving its environmental benefits. In the industry context, timber strengthened with natural fibres will lead to a high performance product that can be made competitive for demanding applications thus increasing the market for wood. Ongoing efforts in the field of wood composites can also be canalised towards the construction market, which is the largest recipient of sawn lumber and glulam. From an environmental point of view the use of natural fibres is commercialised and spread, which in the long run supports the development towards a sustainable material use in the construction industry.

**European relevance and collaboration:** Research within the field of composites and wood composites has been a growing area. However, there is currently a lack of large scale applications used in a real industry setting. This project idea is very much funded on the thought of establishing a cross industry setting for the product to develop. This means communicating between material scientists and construction scientists, two worlds with quite differing functional requirements on the product. The project can be seen as a technology transfer project guiding material science into the framework of construction.

### **1.5.12 Development of new cellulose fibres for nonwovens in hygienic and health-care products (CELCARE)**

**Positioning:** Applied

**Short Description:** A new patented method for production of regenerated cellulose fibres in lab scale for nonwovens has been developed in 2005. These cellulose fibres are specially suitable for hygienic and health care applications due to their purity, mechanical characteristics, and absorpency characteristics. The CELCARE project develops a pilot production line of 100 kg/d of biocelsol fibres and produces optimised fibres for carding, hydroentangling and blend-thermobonding processes. The properties of nowovens are investigated by the manufacturer and the end-users. The results of the CELCARE project are used for planning an industrial-scale fibre production line of 5000 kg/d.

**Justification:** The results offer to fibre producer a new environmentally friendly and economically feasible process and for nonwoven manufacturer competitive accepted products in hygienic and health care sector.

**European relevance and collaboration:** The basic technology is developed in laboratory scale in EU project Biocelsol. The fibre working group with research and industrial partners fullfilled by end-users could be the partners of CELCARE project as follows: TUT Finland, Inst Chemical Fibres Poland, VTT Processes, Säteri Oy, Suominen Nonwovens, Mölnlycke Health Care, Procter&Gamble

### **1.5.13 Incorporation of smart features into fibre-based materials**

**Positioning:** Applied

**Short Description:** During the recent years the research on smart, packaging related features has proceeded considerably. The trend is definitely to replace the separate labels with printed or material integrated solutions. First smart concepts based on printed, intelligent inks have been presented. However, the vast reservoir of biological molecules having the capacity to specifically react with numerous microbes and their metabolites has been underutilised. In this theme the research will combine the profound knowledge of biocatalysts, their modification and their reactions to technologies developing different printing methods for fibre-based products. Additionally, electronics will be combined to the system when biofuel cell based sensor constructions are developed. In addition to the main methods related to biocatalysts and their reactions, printing and electronics, the methodologies involved in the theme will include studies related to the correlation between the packaged product and the parameter to be measured using the new, smart features combined to the fibre-materials.

**Justification:** The high standard of living continuously supports new consumer demands for e.g. high-quality food products. Smart features incorporated into the packaging material offer a tool to enhance the quality of the packaged products. Concepts reacting to the time-temperature history or gas-space composition of the package (product) are already commercially available. The presently available concepts are, however, separate label-type structures. Other production methods, like printing, would enable the production of low-cost, package integrated systems. The goal of the present theme is to produce new, smart features to be utilised in fibre-based packaging applications. Among these are e.g. printed, indicator systems based on reactions catalysed by selective biological molecules. Even printable biofuel-cells can be utilised to introduce more sophisticated sensor functionalities into or on the fibre-based packaging material. The theme strongly supports the Vision 2030 by introducing a possibility to create new, high value-added products among fibre-based products.

**European relevance and collaboration:** Various expertise areas are needed to accomplish the goals. Partners can be identified among groups specialized in: enzymology, wood chemistry and packaging industry and will be named later.

### **1.5.14 Interactive and intelligent paper products:**

**Positioning:** Applied

**Short Description:** New enabling technologies will be strong drivers of industrial development. This will create opportunities for responding to the new habits and fashions of future consumers and responding to the increasing competition, from other material sectors and the electronic media. Cooperation and alliances with other industrial sectors and technologies offer opportunities for creating new, high-value added products and services. These will incorporate combinations of fibre-based materials with other materials, utilizing, micro-electronics, information technology and automation, biotechnology, nano-technology and other emerging technologies. This will be an opportunity for the European fibre-based sector to change its product mix from “bulk commodities” towards a new range of knowledge-demanding and high value-added specialty products. These specialties include both packaging solutions and new communication products.

**Justification:** Developing printed static markings, visible or invisible codes and information to be read by specific optical devices (e.g. cell phone cameras) Developing multilayered structures of electronics and optics for producing active components like displays, indicators, or batteries. Developing anti-counterfeit effects like decorations, tracking and identification features etc. Developing low-cost, printed, package integrated systems for controlling packed product quality (e.g. time-temperature history etc.) Developing intelligent components, printed optics and electronics (smart or intelligent codes, tags etc. like printed RFID) having the capability of being read and also updated.

**European relevance and collaboration:**

### **1.5.15 Enzymatic modification of cellulosic fibres with spatial control**

**Positioning:** Basic

**Short Description:** The uncontrolled degradation of cellulose occurring throughout the cell wall during enzymatic treatment of cellulosic fibres severely limits the use cellulose degrading enzymes for the manipulation of cellulose and fibre properties. The main reason for this is the porous structure of the fibres allowing for rapid penetration of enzymes into the interior of the cell wall. If the infiltration could be minimized or prevented selective manipulation on the true fibre surface (as opposed to the total surface, including all pore surface) could be achieved. A possible approach would be to increase the size of the enzymes. The possibility to specifically target e.g. tumour cells has led to the development of a large number of strategies for the coupling of proteins to different carriers. Such an approach can increase the apparent size of the enzyme to several  $\mu\text{m}$ . Different coupling strategies will be tested and evaluated by e.g. the measurement of conjugate activity, cellulose molecular weight and disintegration of treated fibers.

**Justification:** Possible applications could be e.g. selective degradation of surface cellulose increasing the number of short chain molecules extending from the surface or the selective removal of the outermost part of the cell wall improving the possibilities to disintegrate fibers into micro fibrillar cellulose (MFC). The molecular weight of surface cellulose has important implication for the formation of interactions with other fibers and other materials such as a polymer. The weakening of the S1 layer can have important implication both for the energy consumption during MFC production and more generally when activated cellulose is needed e.g. during cellulose derivative production. If successful the use of developed techniques would enable decreased energy consumption in industrially important processes.

**European relevance and collaboration:** Many countries in Europe have a large industry involved in the processing of cellulose or cellulose containing raw materials. In order to continue to be competitive in the future continued development of processing techniques are needed. This is recognized and many strong groups are active within the cellulose field in Europe. In order to develop new methodologies for enzymatic treatment of cellulose collaborations between different groups will ensure success.

### **1.5.16 Next generation wood based composites**

**Positioning:** Basic

**Short Description:** Four main research issues: 1) Impact of raw material changes on the production of wood based composites, short term and long term performance 2) Innovative processing parameter and its impact on the property of wood based composites 3) Bio-resin binding systems for the production of wood based composites. 4) Zero defect wood based panel production (on line quality control) Trends are towards the use of increased levels of recycled fibre and these bring problems of the need to sort, identify and classify types and identify contamination. Current press temperatures require large energy input and lead to internal stresses, which results in problems such as thickness swelling. The challenge is therefore to develop the use of lower, or even cold, curing adhesives for the panel industry, without a loss in performance. Bio-resin is currently being considered as an alternative for traditional formaldehyde based resin systems for wood based composite manufacture. This could lead to produce a true eco-composites for construction. However, the research to verify its viability has yet to be carried out.

**Justification:** This research will address the above issues and examine the impact of these innovations to the final performance of wood based composites and their life cycle costs. The production of zero defect wood based composites will be the goal of both panel and construction industries. Quality control procedures are currently based on destructive testing of small samples taken from each batch of production. Some non-destructive (e.g. ultrasound) tests are used for monitoring the panel manufacturing process, for example to check mat density, but are not in regular use for monitoring the properties of the finished panel. EN326-2 allows the use of alternative procedure for demonstrating compliance with the specification and this research will develop and apply non-destructive test procedures that can achieve this with the finished panel. Thus every panel produced could be inspected and accepted or rejected on a panel by panel basis, thus improving the consistency and reliability of the finished product. The results will enable: 1. high quality next generation wood based composites 2. innovative applications of composites in construction 3. efficient use of European resources

**European relevance and collaboration:** These issues are related to both European timber and construction industries. There is insufficient critical mass to address these issues through individual member states. The research should be carried out by a collaboration of major European research institutes in partnership with construction companies and composite manufacturers.



### **1.5.17 Highly stressable flexible connecting system**

**Positioning:** Basic

**Short Description:** We want to find a highly stressable connecting system for a modular timber construction in the housing sector. The system should be used for most timber construction details. This new product should be manufactured fast and easy. The customers are carpenters, joiner and prefabricated house sector. First we have to collect the data of the most timber construction details. With this informations we will develop a flexible connecting system for this sector.

**Justification:** The customers are joiner, carpenter and the prefabricated housing sector. With this new connecting system the customers can manufacture their products more cost efficient and faster. KNAPP delivers connecting systems all over the world, it results in a significant economic factor such as extensions for a large range of applications. KNAPP can save market shares and maximize the sales volume. For enviromental impacts we can save building material. Apart from that there is no positive or negative enviromental impact.

**European relevance and collaboration:** In the near future the housing sector will manufactures timber construction walls, ceilings and roofs faster and the production costs should decline. The demand of a flexible wood connecting system with low costs will be rise in the European countries, North-America and Japan. KNAPP will be develop this new connecting system with the European collaboration . In most of the European countries KNAPP requires for the new connecting system the national technical approvals from the testing laboratories.

### **1.5.18 Solid Mechanics for wood**

**Positioning:** Applied

**Short Description:** Wood has different mechanical properties in axial, radial, and tangential direction. Further it differs in strength between tension and compression. This makes it very hard to calculate the strength of different structures by use of modern software, e.g. the Finite Element Method. The project aims to examine how close it is possible to predict movements in different members of the structure because of applied known forces.

**Justification:** Finite Element calculations for wooden structures, such as furniture and buildings, will almost always fail to predict the true behaviour of that structure. Because of this, many structures are far too strong, while others collapse earlier than expected. In order to utilize wood efficiently we must therefore learn how to optimise wooden structures far better than is possible today.

**European relevance and collaboration:** Linköping University, Chalmers Institute of Technology and one university in Poland have contributed to research on small wooden structures, such as chairs and furniture. Larger structures are dealt with in civil engineering at many universities.

## **Sub-area 1.N Other**

### ***1.N.1 R&D of composite products. Researching emotions originated from sensing***

**Positioning:** Applied

**Short Description:** The project studies potential uses of composite materials and different material applications such as wood combined with plastics, metals, stones and stone ingredients. The project also maps the services and competencies of research institutions specialized on wood materials. Special interest will be concerned with reactions and emotions originated from the sensing of materials.

**Justification:** The project produces designs for products and environments, where the selecting of the materials and their combinations create new types of product appearances. Eventually the designs improve cosines, comfort and well being. The research and testing is needed for to consider the social and psychological influence of natural materials. Kuopio Academy of Design had 2002-03 a research project LUMA concerning sensing of natural materials. Results were published in LUMA report.

**European relevance and collaboration:** European organisations will develop activities like seminars and work shops as well also the exchange of experts. On basis of the cultural anthropology the project observes how new product concepts apply to different user groups as well as to the built cultural surroundings in different countries.

## **1.N.2 INFLUENCE OF WOOD-BASED PRODUCTS ON INTERIOR AIR QUALITY**

**Positioning:** Applied

**Short Description:** Nowadays, Wood is widely used in building industry, from walls, timbers, frames, floors to furniture and source of heating energy. But these different wood-based products have a significant influence on the quality of air indoor and could be somehow hazardous for our health. Indeed interior air quality constitutes a major topic for which the European Commission worked on many regulations in order to impose emission ceilings. Thus, it would be interesting to follow and characterize the emissions of Volatile Organic Compounds (VOC), Carbon Monoxide, Carbon Dioxide, Formaldehyde and Particle Matters generated by wood-based products (that could be composed of adhesives or preservation products, or during wood combustion, ...) in a room of a building. It would be necessary to define a standard way of measurement and a standard room in order to be able to compare the pollution of the emissions of different materials and different uses.

**Justification:** This study would enable to define clearly if some materials have a serious influence on the pollution of interior air and if they can be dangerous for our health. The results could lead to change the composition of some materials and to work on the production of new products, environmentally friendly and suitable for a use indoor. This study could also help industries to understand the influence of their made products on air pollution : everybody is concerned and directly exposed on his work place or inside his house.

**European relevance and collaboration:** Depending on weather conditions, cultural habits or architectural preferences, each country owns its proper style of construction and uses different materials to build or to decorate a house. Thus, it would be possible to compare the quality of interior air for different buildings representative of the European standard types of construction. This study would be interesting not only to collect data on the air pollution in Europe but would also interest scientists working on environment and sustainable development, chemistry, construction ...

### **1.N.3 The innovation system for sustainable materials development**

**Positioning:** Applied

**Short Description:** An important part of the innovation system is an end-user and an enduser that has the force to benchmark and also order the first products. When developing composite material from renewable resources it is important to remember that there has to be a potential buyer and that the benchmarking in order to select unique materials properties in order to justify a reasonable price has to be done in collaboration with the enduser. New production processes adapted to biofibres and biopolymers has to be developed in the project. Fibre composites that are dimensionally stable and has a controlled lifeexpectancy. Renewable polymers need to be developed that are compatible with natural fibres. Micromechanical modelling is needed in order to speed up development and to leave the empirical era of "blend and see what happens materials research" behind.

**Justification:** Renewable materials and products to be used in the interior of buses and trains, at hospitals and schools etc. Materials with superior acoustic properties, high performance per weight unit and being carbondioxide neutral. These materials will contribute to a sustainable growth and a better environment. Through the force of the collective public ordering of these new materials it will be easier to find risk capital for starting production units for renewable products. There also need to be a system for the recovery and reuse of these materials. The impact of the research depend upon the market and the strength of a European public buyer.

**European relevance and collaboration:** A European project with identified regions that strive to follow the Lissabon protocol on sustainable growth could together put some pressure on the market to develop renewable materials through the collective ordering of renewable products for the medical sector, public transportation, energy etc. In that way there will be a driving force for the development and also a strong incentive for the establishment of an efficient technology transfer to new or already existing industries.

## ***1.N.4 Modified wood – eco-efficient alternative to tropical and preservative treated wood***

**Positioning:** Applied

**Short Description:** The overall objective is to make an assessment of the long-term suitability, in a sustainable society, of wood modification methods that may serve as alternatives to conventional wood preservatives (toxic agents) and/or durable tropical timbers. Specifically: A) To reach a fundamental understanding the protection mechanisms of the new “non-toxic” preservation methods against decay by fungi, bacteria, insects and marine borers. B) To assess the environmental impacts of alternative wood preservation (i.e. wood modification) methods, and their effect on the products structural performance. Most non-tropical wood species are susceptible to moisture changes and decaying organisms. To increase the durability of non-durable wood species, wood is traditionally impregnated with toxic preservatives. However, alternative and more environmentally acceptable treatments, e.g. heat treatment and furfurylation are emerging on the market. Another treatment close to commercialisation is acetylation. These modified wood products show high resistance to microbial decay, insect and marine borer attack. They are also less moisture sensitive and thereby dimensionally stable, leading to less maintenance of the wood product. Preliminary ecotoxicological studies of preservative-treated wood and naturally durable wood species clearly indicate that the water leachates of these materials have a fatal effect on aquatic organisms unlike modified wood leachates.

**Justification:** Most studies indicate that an increased use of wood will contribute positively to a sustainable development of the society. The total environmental impact of wood products is highly influenced by the limited durability of the untreated wood material. However, methods to improve the durability by conventional wood preservation, may also lead to increased environmental impact due to the highly persistent toxic compounds introduced to the wood. Non-toxic alternative wood preservation methods should therefore be attractive in a life cycle perspective. The design of timber structures is very often governed by serviceability requirements. Insufficient knowledge exists especially when it comes to the climate effects on structures and material performance. More reliable data of the performance of new chemically modified wood materials will increase the understanding of the protection mechanisms of these new wood materials. It would strengthen wood manufacturing industry and end-users in their choice of product for a desired product life time with minimal environmental impact, and it also contributes to the fulfilment of central goals of the European Commission concerning human health issues.

**European relevance and collaboration:** The research group established within the European Thematic Network of Wood Modification (that ended 2003) would naturally be a suitable basis for further cooperation within this area and implementation of this research. Furthermore, these researchers have been cooperating in several EU-projects before. Members of this group were e.g.: Dr. Callum Hill, University of Wales, UK Waldemar Homan, SHR, the Netherlands Dr. Dennis Jones, BRE, UK Dr. Prof. Holger

Collaborative shaping of Research Agendas in WoodWisdom-net  
Workshop Feb 14 2006: New value added products and production  
Solicited issues

Militz, University of Göttingen Dr. Nils Morsing, DTI, Denmark Antti Nurmi, VTT,  
Finland Dr. Andreas Rapp, BFH, Germany Prof. Joris VanAcker, Ghent University,  
Belgium Dr. Mats Westin, SP Trätekt, Sweden Suitable additional partners would be: Dr.  
Morten Eikenes, Skogforsk, Norway Dr. Bartek Mazela, Agricultural University of  
Poznan, Polen



## **1.N.5 Knowledge-Based Building with Wood**

**Positioning:** Applied

**Short Description:** Erection of homes, offices and production sites account for a very significant part of all building activities in Europe. The role of wood and wood-based products as a sustainable construction material has a long history. Throughout Europe enormous differences exist in the way wood is used in construction and the assumption quantities vary to a large extent. Increasing the share of wood in construction helps to improve sustainability and to reduce CO2 emissions. For achieving this goal existing building products and novel concepts have to be optimised and further developed. In future living and working of European citizen will be closely related to urban planning and rural development. People will spend at least half of their time at work and an increasing part is consumed by travelling to workplace. Due to this fact, European citizen desire to live in dwellings which provide a pleasant living environment and which are located close to workplace and leisure activities. Character of the work (R, T, D): All types of research (generic, applied), technology development, transfer from and between different sectors, demonstration activities Major competence needed: Civil engineering, material sciences, process design, process engineering, process development, systems analysis, LCA, information technologies, standardisation

**Justification:** -Reduction of GHG emissions resulting from production and use of buildings by increasing the share of wood and wood-based products. -Securing of comfort and flexibility of European citizen taking into consideration the needs of the increasing share of aged population. -Improving the living quality of the European citizens by increasing the use of wood and wood-based materials for interior furnishings and furniture. Novel and improved concepts for realising environmentally friendly construction and erection of buildings. Provision of healthy and safe living and working conditions for European citizen. Realisation of sustainable building concepts in a large share of all newly erected buildings in Europe. Substantial contribution of the building industry to the GHG emission reduction targets in Europe. 2015 Newly erected buildings consume in average 30% less energy compared to 2000. Share of wood in construction has increased by 20% compared to 2000. Wood, concrete, steel and glass sector have fully realised the

**European relevance and collaboration:** Strong effort is needed to promote renewable building material systems. Competitiveness and efficiency can only be reached with harmonisation and industrialised pan-European systems. Too much overlapping and locally differentiated systems exist now. Competing materials more consolidated and rule the market.

## **1.N.6 Indoor environment in wooden houses**

**Positioning:** Basic

**Short Description:** Untreated wood emits natural volatile compounds, very often what you would recognize as the smell of wood. In softwood the terpenes are the dominating the emissions. Engineered wood also emits natural volatile compounds, and if glue has been added, these products might give increased levels of formaldehyde. Improvement of positive and negative aspects of wood emissions, as well as obtaining substantiated documentation on the positive properties of wood, will be central in this part of the project. This project will investigate and verify research already accessible, and supplement this with new knowledge if needed. - Health effects on the different emissions from wood and wood products will be investigated through existing knowledge and new research on the emissions effect on human health - New technologies for reducing or eliminating natural emissions from wood will be developed - New test methods and assessment/certification of natural emission from wood will be investigated

**Justification:** Indoor environment factors has become an important environmental argument in the wood industry. It is therefore important to gain knowledge and information on how the most typical indoor environmental factors influence human health. The project can be closely linked with projects dealing with other indoor environment factors. Germany has notified a draft decree “Principles for the health assessment of construction products used in interiors”, based on the German AgBB-scheme. This AgBB scheme is still subject to substantial debate and opposition from experts in the wood sector, because it does not take account of the fact that wood emits natural and non-harmful VOCs (Volatile Organic Compounds). So far no scientifically-based relationship has been established between emissions exceeding a threshold value and a risk to health. If such a decree is approved and implemented, products that do not achieve the requirements may no longer be used in interior applications in Germany. This could establish a dangerous precedent.

**European relevance and collaboration:** There are movement within CEN on emissions from construction products where VOC and formaldehyde are high in the agenda. A common European collaborative work will therefore be suitable as there should a common European understanding on the health effects of wood emissions. Key roles in this project will need to be established at a later stage, several research groups and types of research will be needed to implement this research.

### ***1.N.7 Analysis of wood demand structure of Chinese solid wood processing/using industries***

**Positioning:** Applied

**Short Description:** The research is to clarify the implication of the growing Chinese solid wood processing/using industry to the European wood industry as wood demand is concerned. China now has a fast-growing wood processing industry to supply both its rapidly surging domestic market and international market. This research is to analyse wood demand structure of Chinese industrial buyers of solid wood to understand its price pattern for wood raw material input in various processing degrees, quality requirements, operational environment and business practice etc. Special attention will be paid to the current wood supply sources, availability, tree species, quality features etc. Such industrial buyers would include sawmills, secondary processing mills, various wood products manufacturers ranging from wood floor factories, furniture mills to window/door mills, and building constructors. The research also address issues of quality, price level, market targets of the final wood products of those industrial buyers. A qualitative approach will be adopted for the research. Mill visits and field survey will be done to 30 representative Chinese solid wood processing/using companies ranging from small to large firms. A large literature review on the topic area will be carried out to collect secondary data for the research topic. Collaboration with some Chinese universities and research institute will greatly facilitate successful implementation of this research.

**Justification:** The research results will benefit European wood industry in following ways: • Help European wood industry to understand the solid wood demand structure of Chinese market along with operational environment, business conditions, and operational practice of Chinese wood business. • Provide information for spotting possible business opportunities, export of wood products or/and wood processing machines and investment ventures in China. • Provide useful information for European wood industry to develop its global business strategy. • Find opportunities for cooperation in business and research area between Chinese wood industry and European wood industry.

**European relevance and collaboration:** The issue is suitable for a collaborative European research project for following reasons: • Chinese wood industry is large and growing. It consumes a lot of both softwood and hardwood species for various end user products. So both European softwood and hardwood processing industries will be covered while assessing business implications of Chinese solid wood processing/using industries. Therefore wood species considered would include such as pine, spruce, larch, oak and beech etc from Nordic countries and middle and south European countries. • As European Wood Council (EWC) has been established to coordinate business development efforts of European wood industry, this research project would be in line with the business development spirit of EWC.

## **Sub-area 2.1 Modification and processing of wood raw material into innovative, eco-efficient products**

### ***2.1.1 Increasing permeability of refractory wood species***

**Positioning:** Applied

**Short Description:** Spruce (*Picea* spp.) represents 35% of the European forest resource and is therefore highly significant in terms of potential wood supply. While this timber has many of the physical attributes necessary to allow it to be used for a wide range of applications the species is refractory in nature. This means that any attempts to treat the wood with, preservatives, fire retardants, wood modifying chemicals etc is difficult to achieve thereby limiting the applications of the timber and making it difficult to add value to the product. The reason for the refractory nature of the wood is in the anatomical structure of the timber and novel research methods are required to address this issue. While some success has been achieved through incising and oscillating pressure treatments they have been hampered by cost and variable effectiveness. Recent patented research has established that fungal pretreatments can also significantly improve the penetration of solutions into sapwood and heart wood of spruce and pine species without significant detrimental effects on the timber. The effectiveness of these technologies however need to be established at industrial scale.

**Justification:** If this technology can be successfully scaled up to industrial production there are likely to be significant economic benefits as the range of potential markets for spruce and other refractory species can be increased. Although the technology can be seen as increasing preservative uptake into spruce it is likely to be more permanent in the timber as it is impregnated into deeper depths in the timber and is also a technology that can be used for many of the newer more environmentally acceptable wood preservation technologies that are currently being developed. Local socio-economic benefits for spruce producers are obvious given that the technology will add value to spruce products for the producers across a broad range of European countries.

**European relevance and collaboration:** Given the range of countries across Europe who are producers of spruce of different species and variable quality in terms of its growth properties in the different European regions, it is anticipated that there would be wide interest in any process that can improve the treatability of the material. Likewise there are a number of novel preservatives and wood modification chemical processes being developed in a number of European countries however all face the same basic problem when working with spruce i.e. how to get the active agent deep enough into the timber. It is envisaged therefore that a broad project could be developed with a range of European partners from a number of countries to examine the fungal pretreatment technology and perhaps any competing technologies for this purpose.

## **2.1.2 CATALYST-AIDED MECHANICAL DEFIBRATION**

**Positioning:** Basic

**Short Description:** The objective is to utilize the latest enzymatic technologies and new chemical approaches to reduce energy consumption in mechanical pulping and/or prepare pulps with new functionalities. Current CTMP processes are based on softening the wood structure by alkaline chemicals, but large amounts of caustic needed reduce pulp yield and deteriorate its properties. Small well-focused attacks on the wood fiber wall by chemical and enzymatic catalysts could enhance its opening and defibration during mechanical pulping. By oxidative treatments, modified pulp properties can be obtained. Three main approaches are explored in cooperation with the research partners. The most promising approaches are selected for more goal-oriented implementation studies together with the industrial partners 1) Enzymes, e.g. peroxidases and other oxidative enzymes 2) Biological catalysts; fiber-wall-opening and swelling enzymes 3) Chemical catalysts; biomimetics, e.g. metal-ligand complexes

**Justification:** If successful, the project will allow development of new wood processing alternatives for producing high-yield, eco-efficient mechanical pulps. The industrial competitiveness will be promoted by \* Reduction of alkali use in hardwood defibration \* Reduced energy consumption of mechanical defibration by catalyst- aided treatments \* Enhanced mechanical defibration of dry wood. \* Increases further the sustainability of the process

**European relevance and collaboration:** Increases the European competitiveness by enabling wider usage of European wood species in mechanical pulping. Mechanical pulping of wood is restricted by high energy costs. In addition, the range of tree species currently accepted as wood raw material is limited. New alternatives for mechanical processing of wider range of wood species and raw materials of lesser fiber properties are needed to be utilized. Current CTMP processes are based on softening the wood structure by alkaline sulfonation, but the use of caustic chemicals at higher dosages reduces pulp yield and deteriorates its properties. Catalyst and enzyme development needs cooperation on European level. Potential collaboration instances are: University of Helsinki: prof. Fagerstedt, Dept. of Biological and Environmental Sciences; Prof. Leskelä, Doc. Sipilä; Dept. of chemistry, KTH: prof. Teeri, Wood Biotechnology, Krause, TKK, University of Aveiro, Portugal, prof. Neto, University of Torvergata, prof. Galli, CTP, France, dr, Petit Conil Industrial partners: Genencor, Kemira

### ***2.1.3 Modification of semi-finished products***

**Positioning:** Applied

**Short Description:** Modification of semi-finished wood products in order to develop value-added products.

**Justification:** Patents / new enterprises

**European relevance and collaboration:** Knowledge spread all over Europe to small research groups

## **2.1.4 Full Strength of Wood and Wood Fibres Composites**

**Positioning:** Basic

**Short Description:** The high tensile strength properties of defect free wood and wood fibres are poorly utilised in practise. In engineered wood products the strength of wood can be increases up to the level of 50 MPa compared to the strength of 20...30 MPa sawn lumber. However, the tensile strength of 150...200 MPa can be reached in defect free wood and the tensile strength of wood fibre cell wall can be as high as 1 500 MPa. The aim of this research is to study theoretically and experimentally how the micro-structure of wood (cell wall, cellular structure of earlywood, latewood and ray cells) and wood based composites affect strength properties and what are the technical key factors (in wood material, in other components of the composite and in the interfaces between material components) to minimise effects of defects and to more efficiently or fully utilise wood fibre strength in bio-based composites. It is essential to study short- and long-term properties and the effects of moisture content and moisture content variation.

**Justification:** More fundamental understanding of wood and wood composites at nano- and micro-level strength behaviour and properties will be obtained. Based on this knowledge a new concept of innovative high tech eco efficient wood based products can be generated. At the long run new industry will be obtained. The increasing raw-oil price makes wood based composites more attractive for industry.

**European relevance and collaboration:** The research requires wide co-operation between different research laboratories to utilise existing knowledge, research equipments and other facilities optimally (Micromechanics, Environmental Scanning Electron Microscopy, AMF, Image Analysis Methods, surface analysis and advanced numerical calculation methods must support each other). The strong knowledge on the chemistry is also needed to understand the adhesion mechanisms and its development during production of wood composites. Possible research groups with key roles: 1) Helsinki University of Technology Laboratory of Wood Technology 2) Helsinki University of Technology Laboratory of Forest Products Chemistry 3) Department of Materials Sciences and Process Engineering Insitute of Physics and Materials Science BOKU – University of Natural Resources and Applied Life Sciences 4) Max Planck Institute of Colloids and Interfaces Department of Biomaterials 5) Swiss Federal Institute of Technology, Lausanne Laboratory of Construction Materials 6) Centre for Biomimetics School of Construction Management & Engineering Reading University 7) BioComposite Centre University of Wales



### ***2.1.5 Use of Bio-foam for production of novel light-weight materials***

**Positioning:** Applied

**Short Description:** Durable and water resistant bio-foams should be developed based on mais, wheat or other cereals or even based on wood derivatives. Such foams in combination with other materials could be developed into a new family of novel products

**Justification:** Bio-based materials with new properties and improved environmental behaviour are needed to overcome the expected shortage of fossile carbon resources

**European relevance and collaboration:** Joint trans-national and collaborative research and development between research institutes and industry will help to speed up the process of development of novel solutions.

### **2.1.6 Improving timber products from beech**

**Positioning:** Applied

**Short Description:** For European Beech, the discoloration red heartwood (red core) is very common, as well as it is the occurrence of tension wood. Both factors restrict the log quality of beech stems and end products significantly and lead therefore to severe economic losses. One of the goals of research of the institute is to investigate the reasons for red heartwood and tension wood formation, the consequences for the timber quality and the possibilities to compensate the unfavourable properties by innovative processing technologies. This work is based on detailed dendrometrical and wood technological analyses of beech trees of different sizes and growth characteristics, the resulting timber from these trees and wood processing trials to develop new or improved products. The results will be implemented into wood quality models on one hand and into innovative wood processing technologies and products on the other.

**Justification:** The results gained from this research are relevant for silviculture and wood utilisation as well: Silviculture: the findings will allow to emphasise the impact of silviculture on red heartwood and tension wood formation and to deduce recommendations for stand management strategies. In a long-term, wood quality of beech might be improved by adequate silvicultural treatment. Wood utilisation: innovative processing technologies (gluing, sawing) will improve the quality and the market opportunities of timber products coming from otherwise almost worthless beech wood, which will be for the profit of forest owners and beech wood processing industry as well. This will be decisive for the acceptance of this ecologically very important tree species.

**European relevance and collaboration:** The aspects mentioned above are relevant for the forestry and forest industry of all European countries, where beech is a relevant tree species. Therefore the research performed in this field will be of general interest for these countries as well. European research groups besides forest faculties being possibly interested in this work are for example INRA/ENGREF (France), FVA Baden-Württemberg, LWF Bayern, FVA Trippstadt (Germany), WSL Birmensdorf (Switzerland), and DFLRI Hoersholm (Denmark).

### **2.1.7 Wood based materials based on subarctical plantage shortfiber corps**

**Positioning:** Applied

**Short Description:** The fibers in eudicotyledonic wood (hardwood) are considerably shorter than the fibers from conifer wood (softwood). Pulp made from hardwoods is therefore called, short-fiber pulp, whereas pulp made from conifers are called long-fiber pulp. Long fiber pulp are suitable for strong papers as for instance liner, whereas short-fiber pulp are suitable for products where the formation and surface of the paper need to be of very high quality as fine paper. Often short-fiber- and long-fiber pulps are mixed. In northern Europe it is an excess of conifers for production of long-fiber pulp, but hardwood need to be imported as pulp or logs for the production of short-fiber pulps. There is however possibilities for produce large amounts of short-fiber raw material in Northern Europe - the plantage cultivations of Salix and Aspen can be used for the higher value of pulp and fiber production instead of the lower value of energy production. Special tailor made pulping procedures is then however needed to be developed due to the special chemical composition of these wood species, not only for traditional pulps for paper and board production, but also for novel composite type materials.

**Justification:** The use of non-renewable resources for production of materials of different kinds is not compatible with a long time resistant technical culture. Furthermore, the use of petroleum products for plastics is hazardous on the global climate, since it increases carbon dioxide to atmosphere, which lead to a green-house effect with increased temperature as a consequence. With the growing population and increased living standard in the third world, an increased need for cheap renewable raw materials is expected. Fast growing hardwoods is here one of the interesting alternatives, but the industry need have access to processes tailor-made for the properties of these materials.

**European relevance and collaboration:** Presently the production of short-fiber in plantage cultivations of for instance Eucalyptus for pulping is increasing very fast in tropical countries as Brazil and Indonesia. Except for the southernmost Europe, the climate in the EC does not allow production of these trees comparable to the tropical countries. However, cultivation of other trees suitable for a colder climate as different Poplar and Salix species, allow a comparable production per area as in Brazil even in Scandinavia. The farmers are in need of alternative crops and plantage type cultivation of fast growing hardwood can be an interesting alternative. The European industry, both the present and the future, have a large need for cheap, high quality short fiber. The project is therefore suitable as a common European project involving many laboratories. The project shall be coordinated by the department of Fiber and Polymer Technology, at the Royal Institute of Technology, Stockholm, Sweden.

## **2.1.8 Surface modification using biomimetic concept**

**Positioning:** Applied

**Short Description:** The maybe most resistant biopolymer that exists is suberin, that is located in bark and on the surface of roots. There is works as a resistant and hydrophobic barrier that efficiently protects the plant tissues from attack by microorganism and physical damage. Chemically it is similar to lignin, i.e., a product of radical polymerization of propylphenols, but it also contains strongly hydrophobic building blocks as fatty acids. The idea of this project is to construct a synthetic polymer similar to suberin according to a biomimetic strategy by combining phenolic by products from the pulp and paper industry – black liquor – with fatty acids that are produced in large scale in the agriculture. The obtained material will probably interact excellent with cellulose and other wood components simultaneously as it produce a hydrophobic and strongly resistant surface layer, that can be applied in novel high performing paper- and wood based products.

**Justification:** Poor resistance to water is in many ways the weak point in papers and other wood based products. This limits the use of these renewable and environmentally friendly materials toward the non-renewable petroleum based plastics. Thus methods to increase the humidity resistance on wood based materials by methods based on renewable resources, as described in this application, is strategically very important in the process for developing an environmentally resistant technical culture.

**European relevance and collaboration:** Europe has a large access to wood raw material, and has an over production of agricultural products. Contrary, the EU is a net importer of petroleum. Therefore it is of economical as well as environmental interest to increase the use of forest and agriculture products on the behalf of petroleum, and thus the present project is of common interest in the European Union. To manage the project many research groups with various specialities need to be involved and a European network is therefore the best form for the project. It will be coordinated by the department of fiber and polymer technology, Royal Institute of Technology, Stockholm, Sweden.

### **2.1.9 Improved coatings for wood**

**Positioning:** Applied

**Short Description:** Although there are finishes which are highly durable on metals or plastics, these finishes have a considerably shorter service life on wood. Therefore, this research should mainly aim at improving the coatings to significantly elongate the service life of coatings on wood materials. The research work should be carried out on the following contents: 1) Develop new or modified present binders based on waterborne, to enhance the bonds with wood substrate. The binders should be suitable to fast cure at room temperature or with irradiation; 2) Coatings with enough flexibilities to meet the dimensional changes of wood substrates; 3) Addition of effective UV absorber or HALS, and fungal biocides, which are leach-resistant; 4) Improve the water/moisture resistance of coatings by using hydrophobic additives; 5) Improve the coating properties by chemically modifying the wood substrates, for instance, grafting UV absorber or HALS onto wood surface before coating, or modified wood with chemicals.

**Justification:** Possible results expected from this research are: 1) The wet adhesion of coatings is increased, therefore reduces the damage at the moist condition. 2) The sufficient flexibilities of cured coatings will reduce the stress originating from the dimensional changes of wood substrates. 3) The UV absorber or HALS will prevent the coatings from photodegradation, therefore reduce the brittleness of coatings. The addition of fungal biocides may prevent the biodegradation. 4) Cured coatings should be high efficiency in blocking water penetration and reducing moisture ingress; 5) Modifying wood substrate may improve the coating properties from another side. The increased dimensional stability, reduced moisture level in the wood may reduce the cracks and prevent the biological attack. If the UV absorbers or HALS are grafted onto wood surface, the leachability of them is limited. If the researches are successfully carried out, the improved coatings may have longer service life, thus the times of maintenances are reduced. Therefore the costs and labours are saved. The products will be more competitive in the market. Waterborne coatings with low VOC would have little effects on people and environment.

**European relevance and collaboration:** Since the research involves the coatings and wood, it is particularly suitable for collaborative research activities. The suitable groups may be: 1) Institute of Wood Biology and Wood Technology, University of Goettingen, Germany. 2) LERMAB, Université Henri Poincaré, France 3) BRE, Centre for Timber Technology & Construction, Watford WD25 9XX, UK 4) PRA Coatings Technology Centre, UK 5) SHR Timber Research, Holland 6) VTT Building Technology, Finland

### **2.1.10 Thermal treatment of wood in a liquid phase**

**Positioning:** Applied

**Short Description:** The aim of the study is to destroy selectively the wood molecules, in particular hemicellulose material mainly responsible of the hygroscopic properties of wood and its low durability. The research activity consists in the development of a thermal treatment of wood in a liquid phase at moderate temperature in which is included a light chemical impregnation. The final step of the process should be a drying phase characterized by cycles of pressure and depression. The characterization of the final product obtained is requested (mechanical tests, measurement of the size variation coefficient, the durability of wood,...). The understanding of such a process should request to model heat and mass transfers between wood and its liquid environment and also during the last step of drying.

**Justification:** The main results expected are the following ones : - the development of a process that could improve the durability of European wood species for external uses. - a new process that could join the advantages of a chemical impregnation and the ones of a thermal treatment. This process could allow to improve the competitiveness of wood material compared to the other materials (plastics, metal, ...). The last interest of such a study is to develop the use of European wood species instead of tropical species.

**European relevance and collaboration:** Some thermal treatments of wood already exist in Europe. The problem is the level of the operating temperature that is required. With a moderate temperature of treatment and a simultaneous light chemical impregnation, a more eco-friendly process could be developed (lower energy cost, lower pollution).

### **2.1.11 High strength and slim timber structures**

#### **Positioning:**

**Short Description:** European timber strength information is not adequate, it is based on small separate projects, not on representative sampling. Testing of strength, bending, tension, compression and shear. Wide sampling of Central European and Nordic spruce and pine which at the same will be tested with new NDT detection techniques before actual strength tests. Renewed test and product standards to be developed.

**Justification:** Developing integrated strength grading processes from log raw-material to timber structures. Cost efficiency in whole value chain. Utilization and development of new NDT measuring tools to be integrated as total control systems in production. New performance values for EuroCodes and safety targets for timber structures. Attractive, slim and competitive structures for timber buildings.

**European relevance and collaboration:** At the moment there seems to be disagreement between countries and country groups for European approach for grading and standards. This eliminates the development of free market for building products in EU. The competitiveness of timber building needs full European level research and industry cooperation.

## **2.1.12 Chemical and physical changes in heat treated wood**

**Positioning:** Basic

**Short Description:** Heat treatment has become widely approved and utilized industrial process all over in world. However basic understanding of the chemical and physical changes in wood is narrow and restricts the product improvement and development. We need to finalize the missing basic research to enable real break through technology development in future.

**Justification:** The results might be as follows: - control over PH (acid acetics) in process - improved strength properties (less brittle product) - improved durability - better understanding of the durability of product in use - renewed production processes - possibility to develop new products with new modification processes

**European relevance and collaboration:** This issue should be researched on wide basis in Europe to get common knowledge and data base but also for education for universities. Recommended network: LTU Sweden, TUM Munchen, Boku Austria and VTT Finland



### **2.1.13 INNOVATIVE CHEMICALS AND POLYMERS FROM BARK (INNOBARK)**

**Positioning:** Applied

**Short Description:** Bark is one of the large volume residues in mechanical forest sector. Nowadays it is mostly utilized as energy source and landfill material. However processing of bark of certain wood species such as birch, pine and cork offers an interesting, reasonable and simple way to produce environmentally friendly potential new products in food, pharma, agrochemicals area as well as new intermediates for coatings and composites. In INNOBARK project modern chemical and biochemical methods, such as selective synthesis and enzyme catalysis as well as new separation techniques are applied to achieve targeted products.

**Justification:** Birch bark extracts, such as betulin or hydrolysates, especially phenol derivatives, can be used as raw material for potential new drugs, active ingredients in cosmetics as well as environmentally friendly plant protection agents. In addition the other large volume bark hydrolyzate fraction, suberin acids, is a potential new raw material for coatings and composites. Pine phloem again is interesting carbohydrate source for numerous down stream applications especially for functional food. INNOBARK project offers new feasible options to produce environmentally benign chemicals and polymers from forest residues. It will support local activities in undeveloped regions in Europe leading to new businesses in forest sector area.

**European relevance and collaboration:** Nordic countries, especially Finland, Sweden and Norway as well as Austria, Germany and Portugal should have key role in INNOBARK project because of their strong forest research activities.

### **2.1.14 Moisture-resistant wood based material through thermoplastic WPC pressed top layers**

**Positioning:** Applied

**Short Description:** A crucial criterion for the permanent durability of wood based materials (particle boards, fiber boards, OSB (Oriented beach board), plywood) are their hygrical properties. The hygroscopic properties of the wood first are causing irreversible swelling in wood based materials. Periodic swellings and shrinking can completely destroy the bonding of the wood particles. The material will become unusable. Therefore apart from the optical aspect all coatings have to protect the carrier material against substantial wetting. Conventional press coatings (duroplastic foils, melamine papers and laminates) can fulfil the requirements concerning water resistance of the material only under certain circumstances, since at least water can penetrate from the boundary area via the joints. Thick thermoplastic coatings however would be expressively water-resistant. Thermoplastic plastics (PP, PE) are clearly more expensive than the usual foils and melamine papers. Due to cost factors until now no procedures have been developed with those thick coatings from PP or PE to be applied. If the thermoplastics are mixed before with particles from laminar lignocelluloses (fibers, splinters), clearly lower material costs would result, since such mixtures can utilise up to 90 % wood fibers or wood particles. Mixtures of this kind are used for the production of WPC (Wood Polymer Composite) as well. In the focal research material and process engineering solutions are to be compiled for the functional coating of wood based materials with a thermoplastic mixture containing wood (WPC).

**Justification:** The technical emphasis of the project lies in a process development in combination with higher in-use properties of coated wood based materials. If a WPC material can be applied on a wood based material, the permanent durability of the wood based material would considerably improve. In relation with today's coatings thermoplastic coatings have considerably technical advantages. Coatings of this kind are nonporous and alkali resistant, therefore water cannot penetrate into the carrier board. The regenerating raw material wood could thus be used in fields not being applicable before due to its hygrical properties and/or lost market shares can be gained back (external fronts, covering boards, garden furniture). Thus e.g. the market share of covering boards of wood based material as carrier material has extremely decreased in the last 10 years. This is neither ecologically meaningful nor economically justified, because concerning the price wood based materials as carrier material can fully compete with alternatives. The project serves to secure the operation of mainly medium-size enterprises, who are producing improved wood based materials for the industrial and private use and/or are producing special products of high real net output for the external application and/or special niche applications. Enterprises using this technology to be developed could offer a unique product. The carrier material is less expensive and more ecological with lower weight than other competing products. In addition, its durability is improved.

**European relevance and collaboration:** The wood-based material industry is beside the saw mill industry (without paper and cardboard) the most significant utiliser of various wood raw materials. Today European-wide more than 50 millions m<sup>3</sup> wood based materials are manufactured per year. Just a few years ago the transport of wood based material over larger distances was considered as uneconomically. This has fundamentally changed. The interior European trade and export to overseas are meanwhile of great importance. Furthermore the wood based materials industry is European-wide set up, the important industrial enterprises have production plants in different countries. Nevertheless the wood based materials industry and manufacturers have been faced with a strong competition pressure. The strong position of the wood based materials industry in Europe could so far resist only by their production of particularly high-quality or special nice products. Further product improvements will provide better compatibility for new markets and strengthen the economic position of the wood based materials industry in Europe. With regard to the development of wood based material several institutes of wood research are active (Trätek, CTBA, DTI, VFF, BM TRADA, WKI, HFA), which could compile in close collaboration new coating technologies for WPS. In addition, with this special development R&D institutes active in the plastic technology should be considered as partners as well. This could form a interdisciplinary approach.

## **2.1.15 Fine chemicals from wood based key precursor (LIGFINE)**

**Positioning:** Applied

**Short Description:** The goal in LIGFINE project is to develop new environmentally benign products, especially pharmaceuticals and food additives, from easily available wood precursors such as  $\alpha$ -pinene, hydroxymatairesinol and levulinic acid. A new way to separate sulfur free  $\alpha$ -pinene from saw mill volatiles will be explored. New chemical and biochemical options to transfer  $\alpha$ -pinene to geraniol, citral and ionones and further to medically active compounds and vitamins (A and E) will be studied. In addition synthetic procedures for new potential drugs, enterolactones, will be developed from hydroxymatairesinol, a product which occurs in large amounts of fir tree branches. Possibilities to utilize levulinic acid, produced for instance from saw mill waste, will be also studied. Potential products will be tested in co-operation with participating industry.

**Justification:** In recent years there has been a growing interest to develop fine chemicals especially pharmaceuticals and food additives eg. vitamins and antioxidants from wood. This is because some of the key precursors such as  $\alpha$ -pinene, hydroxymatairesinol and levulinic acid can be easily separated from wood waste. These molecules also have a chemical structure which minimizes the number of synthesis steps needed to reach the final active product. In addition their metabolic decomposition is mostly known, making them easier to use than totally new synthetic products.

**European relevance and collaboration:** LIGFINE project will create new business opportunities for fine chemical industry in Europe and will support local activities in undeveloped regions of Europe while leading to better utilization of mechanical forest sector residues. Nordic countries, especially Finland, Sweden and Norway as well as Austria, Germany and Poland should have a key role in LIGFINE project because of their strong forest research activities. In addition pharmaceutical companies, SMEs as well as large ones, should participate.

## **2.1.16 BioRef - Sustainable wood based refinery products**

**Positioning:** Applied

**Short Description:** The objective is to develop new competitive and breakthrough eco-efficient process and synthesis routes for the manufacturing of high added value chemical products and materials, exploiting the potential that is offered by renewable materials. Regarding actual tendencies of oil prices economic competitive materials have to be developed. BioRef makes use of an integrated approach by means of the 'bio-refinery' concept. The bio-refinery is operated comparable to an oil refinery, which also produces numerous chemical intermediates for further processing. In this project the whole chain from biomass feedstock to materials and markets / applications will be covered. BioRef will develop cost-effective and environmental friendly processes for basic materials, substances, plastics and intermediates that are attractive to investors and acceptable to planning authorities and the public in general. Those materials will have a basic impact on the sustainability of key industries in Europe (e.g. automotive, construction, durable goods, consumer products, etc). To come to an early decision support, a sustainability analysis, regarding the whole life cycle of the products, will be done in parallel to their development, comparing the wood based bio products to conventional products, to get innovative eco-efficient products.

**Justification:** The cost and security risks of fossil feedstock imports, the environmental concerns with increased pollution, the global greenhouse gas emissions from fossil feedstock use and the desire to improve the rural economy should stimulate Europe's interest in bio-based feedstock for basic materials. The potentially more labour intensive beneficiation of bio-feedstock compared to crude oil promises a positive net job-effect in rural regions of the EU. BioRef will provide society with the breakthroughs in science and technology that will be necessary to successfully address these challenges. Further aim of this proposal is to establish Europe as the technology development and technology commercialisation leader in this field. Providing a competitive manufacturing sector to achieve Europe's long term economic, social and environmental targets -Fostering Europe's lead in chemical technologies, and increasing the share of target chemicals that are based on renewable resources to a higher share -Contributing to cost reduction of chemical processes by the development of new and safe industrial process concepts that consume less energy, produce less waste and are characterized by a significantly reduced number of process steps -Decreasing Europe's dependence from fossil feedstock - Contributing to new employment opportunities.

**European relevance and collaboration:** Providing a paradigm shift in energy and material consumption patterns towards sustainable use of natural resources creating new opportunities for Europe's materials transformation industry in existing and new markets and applications. Further results will be -Fostering Europe's lead in chemical technologies, and increasing the share of target chemicals that are based on renewable resources to a higher share -Decreasing Europe's dependence from fossil feedstock - Results will meet the future needs of key markets and industries in Europe. The consortium should consist of a critical mass of expert organizations throughout Europe

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(industry, academia, institutes, SME's) and interdisciplinary research teams with members in the fields of forestry, chemistry, process technology, materials science, market development, economy and life-cycle analysis, such as -TNO MEP, Netherlands Organisation for Applied Scientific Research -Deutsche Gesellschaft für Holzforschung, DGfH, München -Biomass Technology Group BV -Stuttgart University, IKP, dept. Life Cycle Engineering

### ***2.1.17 Wood property based separation and sorting of wood components for a biorefinery***

**Positioning:** Basic

**Short Description:** Wood property based separation and sorting of wood components for a biorefinery.

**Justification:**

**European relevance and collaboration:** Groups in Sweden, Norway, Finland, France a.o.

## **2.1.18 Forest biorefinery for green chemicals and polymers**

**Positioning:** Basic

**Short Description:** A variety of technologies is available for the conversion and upgrading of the different raw material streams. Among these, biotechnical methods offer some advantages due to their specificity. Presently, a number of enzymes is available for converting the lignocellulosic residues into their building blocks. More rare are, however, enzymes which eg. stereo- or regioselectively transform the desired building blocks into target products. The theme will focus in the development and use of biotechnical methods for production of novel biobased products. More importantly, the theme will also search for optimal choices and combinations of methodologies, including physical, chemical and biotechnical methods. Advanced analytical methods will play a key role in exploring the potential functionalities of these products. The potential products could find uses in food, feed, fine chemical or chemical industries, and comprise polymers, adhesives, composites, surfactants or bioactive compounds. In addition to products based on structural functionalities, the formation of simple building blocks (sugars) will be optimized from the unused residues or wastes for further conversion or fermentation into chemicals or fuels.

**Justification:** An extended use of renewable resources for the production of a new range of knowledge demanding and high value added products is a central goal of the FTP. In addition to niche products for new small scale and specialized industries, also bulk products based on renewables will be needed for energy and chemical sectors. Woody raw materials contain a wide variety of chemically interesting compounds with potential functionalities, already recognized or to be still explored. Some of these chemicals and polymers are separated during the pulping processes, but to a large extent incinerated, and utilized only for the heat value. Such sources of potential starting materials and intermediates are fractions separated during the processes, such as bark and extractives, as well as waste liquors containing lignin and other dissolved polymers. These fractions can be upgraded based on the existing or targeted functional structures present in the original woody material. Another type of raw material are the carbohydrates often in waste streams which can be potentially degraded into sugars and further converted into fuel or chemicals. The goal of this theme is to develop novel biotechnology based methods for upgrading these fractions.

**European relevance and collaboration:** Various expertise areas are needed to accomplish the goals. Partners can be identified among groups specialized in: enzymology, wood chemistry etc and will be named later.



## **2.1.19 Sustainable bio-based methods for paper manufacture**

**Positioning:** Applied

**Short Description:** Biotechnical methods applicable in the pulp and paper industry are emphasized by two specific features; sustainability and specificity. Sustainability means that biotechnical methods do not introduce harmful chemicals and can even diminish the consumption of chemicals or energy. Enzymes are generally considered as the most specific catalysts for fibre modification. During recent years, knowledge on cellulose or the polysaccharide modifying enzymes has been substantially increased, and novel enzymes are entering markets with a wider divergency and improved specificity. The performance of enzymes has been significantly improved; thus on one hand novel cellulases with low hydrolytic, high fibrillative activity, and on other hand more efficient hydrolytic enzymes have been identified. Additionally, these novel enzymes often are more temperature tolerant, allowing development of combined physical and enzymatic treatments. The proposed theme will focus at exploring novel uses of these enzymes in innovative applications. The methodologies will involve comparison, choice and improvement of enzymes for various applications including combined treatments to improve fibrillation, fractionation of recycled fibres into higher and lower value fractions or hydrolytic degradation of value-less fractions into other potential products.

**Justification:** The goal of the present theme is to design new combined processes, where bio-based unit operations are intelligently combined with traditional or novel physicochemical/mechanical unit operations, resulting in sustainable hybrid processes with substantial energy or chemical savings, or alternatively in improved product quality. The enzymatic unit operations can facilitate refining by eg. increasing the fibrillation, improve the bonding ability or the quality of recycled fibres. Beneficially, the new combined methods could also lead to an optimal fractionation leading to reuse of fibres with higher quality and utilization of the lower quality fibres for production of eg. biofuels. Thus, this proposal meets well the future challenges; improved sustainability and eco-efficiency by advanced recycling and increased use of renewables for energy production.

**European relevance and collaboration:** In Europe, only few research laboratories have so far expertise on these novel cellulases and other hydrolytic enzymes. Combined competencies and close collaboration of both top quality laboratories of biotechnology and fibre engineering.

## **2.1.20 Cellulose-based polymers**

**Positioning:** Applied

**Short Description:** At present, the use of cellulose for higher technology products is marginal as compared to the volume for paper and board products. One reason is that this is due to very strong fibrillar structure of cellulose, which complicates its chemical processability. Thus, most of the regenerated cellulose items as well as the modified cellulose for a wide range of products are currently manufactured by the derivatisation of cellulose. Existing derivatives demonstrate inhomogeneities at different hierarchical levels, which results in poor performance of the products. If it would be possible to prepare new derivatives with controlled chemical and supramolecular structure, there is a large potential to apply them for high value products, such as sophisticated pharmaceutical and fine chemical applications and in composites. By developing knowledge about how the accessibility of crystalline and amorphous regions in different morphologies, it will be possible to use new polymerisation reactions, which results in a better control over the degree of substitution, molar mass and molar mass distribution.

**Justification:** The research area as such is directly relevant to the search for new value added products, i.e. made by use of modified cellulose fibres from renewable resources. The products that might be formed from these modified fibres are of large interest for the industry where the development of new products has been given large interest. Apart from this it is not difficult to envision the start-up of new entrepreneurial companies around the products described above. Due to increasing prices on oil based raw materials, there is a renewed interest in products made from renewable raw materials. The results can create new routes for producing sustainable products based on modified wood based fibres. It is obvious that these new types of products would be ideal for the creation of small start-up companies. In the longer perspective this development will most probably create a more modern image to the use of wood based fibres/products and in conjunction with the already existing forest industry this will attract skilled young students that are so important for an efficient use of the renewable resource we have in our forests.

**European relevance and collaboration:** Due to the strong competence within this area at universities and institutes in Europe the possibility to success is large. Competence can be found at KTH (Ek, Karlsson), Boku (Rosenau, Pothast), Cermav, Hamburg (Saake), Finland VTT ,...

### **2.1.21 Phenols in wood and bark**

**Positioning:** Applied

**Short Description:** Phenolic compounds play a key-role in tree defence against wood decaying fungi and bacteria. However, they have also shown to have health promoting properties. More and detailed chemical analysis is needed to characterise these compounds in various tree species and how they could be processed and used.

**Justification:** New chemical compounds could be purified during traditional wood processing from wood residue and bark. New products could be developed as anti-fungal and anti-bacteria agents and health promoting compounds.

**European relevance and collaboration:** Chemical analysis and product development as well as testing is suitable for European collaboration. Several laboratories work with the issue.

## **2.1.22 Reduce the overall material usage of fibre based products**

**Positioning:** Applied

**Short Description:** Sustainability will be an increasingly important value and overriding goal in the society. The growing affluence needs to be created with a smaller environmental footprint. These goals are supported by various political initiatives and public concerns. Awareness among customers and consumers about environmental and social responsibilities will grow. Supply of clean water and climate change will be critical issues. These issues need to be considered both in the selection of manufacturing technologies and in product design. Getting “more-from-less” needs to be an overriding criterion of all industrial operations and systems. To achieve sustainability the growing society needs to be economizing on resources. At the same time the materials need to deliver the same or better performance than today’s fibre based or alternative materials such as fossil based materials (metal, glass, aluminium) or synthetic, crude oil based materials.

**Justification:** Reducing specific wood consumption: Increasing the material yield from wood raw material and its processing Improving fibre properties through better control of processes and fibre engineering Further reduced fresh water consumption Developing improved sheet structures Fostering creative converting and end product design Re-engineering the value chain and logistics

**European relevance and collaboration:**

### ***2.1.23 Modified wood as structural material – reliable relationship between important properties***

**Positioning:** Applied

**Short Description:** The good knowledge of mechanical and physical properties of modified timber (MT) is essential when using it as a load-bearing member in a structure. There are at least three modification methods; heat treatment, acetylation with acetic anhydride and furfurylation, for example, which are produced industrially and sold as durable alternatives. However, the knowledge about these products structural properties is limited and construction industry has to rely on the information provided by the producers. Often Eurocode 5 for design of timber structures does not apply to modified wood. The aims are to define the requirements and create both the opportunity to apply modified version of Eurocode 5 and the quality control system for MT products and components to ensure fitness for purpose and optimal value. Studies include: · summary of the performance requirements for finished components/elements/structures imposed by society for safety and by commissioners for functional and aesthetic reasons where MT would be superior to conventional timber, · produce reliable inter-relationship between important mechanical material properties, · inter-relationship between performance requirements and grading parameters for MT products, · mechanical properties of connections and joints when using MT, · quality control techniques for MT products and use of suitable equipment for ND measurements to facilitate quality control.

**Justification:** In order to stay competitive, the producers of MT must increase their knowledge about other aspect than durability of their products. Durability and maintenance are very important for the load-bearing timber components especially for out-door applications. The scientific programme focuses on developments related to defining structural and moisture properties as well as assessment of distortions, strength, stiffness, connection properties and stress grading system. By identifying new measuring and assessment techniques this project will promote increasing application of MT to the specific needs of building sector as well as support the development of reliable, cost-efficient quality control systems. It will also provide the basis for improved specifications for timber products and contribute to economic optimisation of production so that the full environmental and sustainability benefits of timber can be realised. Timber is very attractive sustainable alternative to steel and concrete in many structural applications. The trend of increasing timber production is expected to continue. As durability is one of the main weaknesses of timber, the advantage of modified wood is obvious. However, the mechanical properties must be reliable to make the impact on the market.

**European relevance and collaboration:** Within this project, collaboration is essential to gather and generate qualitative and quantitative knowledge about modified wood in European countries. In order to revise and validate Eurocode 5 to include modified timber, the collaboration within this project is essential. Improved quality control systems will help to increase the competitiveness of the wood sector, ensure that MT is optimally processed and that European wood industry provides wood products which are well adapted to end user requirements. Identifying the performance and relevance of non-

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destructive testing (NDT) and grading technologies on the European level is essential to propose quality control techniques for modified material and modified-wood products and NDT's suitability for measuring parameters to facilitate quality control systems.

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### ***2.1.24 Measuring, characterizing and bucking wood with logging machines***

**Positioning:** Applied

**Short Description:** The project proposal 3.1.28 will support this sub-area

**Justification:**

**European relevance and collaboration:**

## **2.1.25 Expanding use of tree species for wood modification**

**Positioning:** Applied

**Short Description:** In Germany the commercial use of wood is concentrated on only few tree species. A lot of more unknown or less used species would also be able for wood utilization, if special wood properties could be improved. During the last years an increasing number of wood processing factories made use of wood modification in order to enhance the quality of wood. Wood modification is a well accepted technique to increase the utilization of wood additional use. In case of wood modification also less suited wood species can be used for more qualified use, especially for outdoor use under wet conditions. In order to increase the number of useable tree species for wood utilization, additional research has to be done to get more information about the natural properties of less known European wood species. Special treatments of species-adapted wood modification techniques have to be developed to increase the wood quality. Those modified wood materials would be able to enter to different wood processing industries.

**Justification:** The growth and use of native wood species help towards a sustainable production of industrial raw-materials. Fossil raw-materials can be saved and the less sustainable use of tropical rain forest species or traditional input of toxic compounds in wood protection can be reduced. In order to enhance also the ecological stability of forests, an increased diversity of tree species is necessary. The use of this additional species would lighten the consumption of the main tree species. The availability of those important commercial species is limited, the price of better wood qualities is high. A higher utilization of less used and cheaper wood species with modified and enhanced properties would help to increase the consumption of local and sustainable produced wood.

**European relevance and collaboration:** Big efforts have been made to increase the healthy condition and the stability of European forest with the help of different pan-European environmental programs. In order to support the ecological and economical basis of the sustainable development of our forests and their diversity a commercial use of all potentially useable tree species is necessary. Treatments to enhance the sustainability of forests and the quality of wood by wood modification have been developed by many European research institutes and several COST-Actions (e.g. COST-E21, COST-E37, COST-E44), which can help the to improve the economical situation of the European forests and the wood industries. The IfHH in Goettingen is already cooperating with different German and European companies and institutes working on the field of sustainable forestry, wood modification and quality tests (e.g. BFH/D, IHG/D, LCSVB/F, LWT/Ghent, NFRI/N, SHR/NL, SLU/S, UWB/UK).



## ***2.1.26 Development of wood modification treatments and special tests to improve wood properties***

**Positioning:** Applied

**Short Description:** Wood is a natural and sustainable produced raw-material which is suited for many industrial uses. The commercial utilization of wood for special use, above all outdoor utilization under wet conditions, is concentrated only on few local growing tree species. For higher quality use the input of less sustainable produced materials like natural protected wood from tropical rain forest, wood protected with toxic compounds or further industrial materials like polymers, metals or concrete is necessary. The technique of wood modification with non-toxic compounds is able to decrease the consumption of those less sustainable materials. Wood modification is able to increase the properties and the utilization of wood for additional use. In case of wood modification also less suited wood species can be used for more qualified use. A number of wood modification techniques are already used in the wood processing industry, for example the treatment with silicone-, furfuryl- or acetyl groups, with oils or waxes or with heat. The example of wood linked with N-methylol-compounds developed for the textile industry and the increased wood properties after treatment shows the potential of property-increasing chemicals already existing in the chemical industry. A survey of various chemicals, which can be able to improve the wood quality, has to be carried out in order to enhance the input of local grown wood and the economical situation of the local forestry and the local wood industry.

**Justification:** The addition of special chemicals to wood can help to increase various wood properties. A number of such non-toxic chemicals are already used in other industrial products to improve the quality of non-wooden materials like agricultural fibres, animal products or chemical polymers. The growth and use of native wood species help towards a sustainable production of industrial raw-materials. Fossil raw-materials can be saved and less sustainable use of tropical wood species or traditional input of toxic compounds in wood protection can be reduced. This helps to improve the ecological and economical status of the local wood producing and wood processing industry.

**European relevance and collaboration:** Treatments to enhance the sustainability of forests and the quality of wood by wood modification have been developed by many European research institutes and several COST-Actions (e.g. COST-E21, COST-E37, COST-E44), which can help the to improve the economical situation of the European forests and the wood industries. The IfHH in Goettingen is already cooperating with different German and European companies and institutes working on the field of sustainable forestry, wood modification and quality tests (e.g. BFH/D, IHG/D, LCSVB/F, LWT/Ghent, NFRI/N, SHR/NL, SLU/S, UWB/UK).

## **2.1.27 New pulping process for high-end use fibres, bio-based energy and chemicals.**

**Positioning:** Applied

**Short Description:** The processes for production of chemical pulps for use in high brightness products do not in an efficient way make use of the wood raw material. About half of the wood substance is dissolved in the cooking liquor and subsequently burnt for production of energy and recovery of cooking chemicals. The use of sulfurous compounds also reduce potentials for an efficient use of the dissolved wood material. This research is aimed to develop a new process for chemical pulping of wood and production of fibres with new potentials. The side-streams with dissolved wood components are additionally thought of as product streams for production of bio-based energy and chemicals. The research comprise studies on oxidative low-temperature delignification of wood by the use of designed conditions including catalysators. Post-treatment methods of pulp for design of fibre properties. Processes for extraction of e.g. organic substances from pulping streams for further purification and tailoring. Recovery systems for re-use of pulping chemicals. Economical assessment of the process through system analysis and process simulation.

**Justification:** are these impacts dependent on? (max 200 words) More efficient and adaptable chemical sulfur-free pulping process for wood than compared to the current dominating kraft process of today would improve and strengthen many of the ideas for new and emerging biorefinery concepts. Further refining techniques and prerequisites for further refining of process streams containing dissolved wood components for the production of biobased chemicals and fuels are greatly facilitated. A substantial increase in pulp yield, as compared to the kraft process, would also improve the potential and economy for production of biobased fibres with different properties. The lower temperatures used in the pulping process also implies a better utilisation of the strength properties of the fibres impairing possibilities for a better targeted pulps. A process that from the beginning is designed for accomodating ideas within the biorefinery concept and production of pulp fibres with high potential for further tailoring would broaden the business opportunities related to the new pulp mill. Since side-streams previously regarded as waste streams instead are transformed into product streams, new emerging business areas will be created. Earlier sulfur-free processes suffers, apart from generally low fibre qualities for use in high-valued products, efficient recovery systems. Traditional or modified kraft-based recovery systems were used resulting in processes without remedies for economically justified recovery of pulping chemicals. Recent developments however, e.g. black liquor gasification, give new possibilites for in-house production of efficient sulfur-free delignifying chemicals.

**European relevance and collaboration:** The competition within the area of forestry is continuously increasing as a result of the development in e.g. South America and Asia. The cost of the wood raw material in Europe is increasing and considerably higher than in competitive countries. In fact the cost structure in Europe is in all aspects unfavourable compared to the main competitive countries. In order to maintain the European pulp

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industry it will be necessary to improve the effectiveness within the European pulp plants as well as to develop the pulping qualities to expose more qualified and designed properties. This type of research could well be suited for collaborative efforts between teams in Sweden, Finland, Germany, France and Austria.

## ***2.1.28 Upgrading wood and wood-products characteristics and behaviour by novel bio-based and biochemistry-based treatments***

**Positioning:** Basic

**Short Description:** The expected results lay the foundation for the development of enhanced as well as new sustainable and cost-effective products for the European woodworking industries. During evolution nature has "invented and further developed" wood to fulfil a number of functions for the survival of plants. These functions are not necessary identical with those, which humans expect when using wood as a raw material. The use of wood shows a wide range of applications from sawn timber to wood-based products. Despite its manifold and very positive characteristics wood exhibits properties, which need improvement for strengthening wood and wood-based products in competition with non-renewable materials. A new generation of such products will allow a shift from bulk commodity products to highly specialised products. By utilising, activating, modifying (biologically, chemically, mechanically) the unique and very versatile natural properties of lignin, cellulose, hemi-cellulose and the other natural constituents of wood, bio-based materials with new and improved property mix will be developed, forming the basis for a new generation of wood and wood-based products. This research theme deals with development and application of methodologies and techniques to upgrade existing and create novel characteristics for wood and wood-based products. In a knowledge-bio-based European economy stakeholders in science and industry actively try to improve the raw material base and the properties and characteristic behaviour of the produced products. Many of our modern "artificial" man-made materials, especially plastics, are based on fossil carbon sources, which are broken down in small units and re-modelled to form new materials. Learning from nature will help us to gradually become independent from fossil carbon sources and at the same time save energy by using the embedded solar energy in biomass. Bio-technology, genetic engineering, chemical and physical treatments as well as modification processes are well advanced and allow the design and production of materials with tailored properties. A new generation of bio-based materials will combine the advantages of natural and artificial materials leading to products with excellent environmental profile and at the same time homogenous, predictable and reliable properties which allow the use of such materials for product design and engineering. Wood-based materials with high durability, good shape stability and low demand for maintenance have proved to be competitive compared to non-renewable materials. In few words: "A new Bio-based carbon chemistry and new physical-chemical treatments for innovative products and functionalities" Major competence needed: Biotechnology, nanotechnology, chemistry, genetic engineering, mechanical, thermal and chemical engineering, standardisation, product design, market research, etc.

**Justification:** Better knowledge and advanced utilisation of the natural wood constituents. Implantation and improvement of specific characteristics of wood and wood-based properties for adaptation of the behaviour to specific end-use related requirements. Improvement of competitiveness of wood in relation to non-renewable

materials in terms of biological, physical and chemical behaviour and service life under a wide range of environmental conditions, in full respect of the environment. Provision of a new generation of bio-based materials with improved properties, including wood polymer composites. Provision of a new generation of novel biological and chemical treatments and modification methods for better bonding, gluing and surface treatment.

**European relevance and collaboration:** Society/economy: Successful innovation along the proposed lines will enhance competitiveness of the EU industry and hence increase economy. Another aspect of this, particular important in rural areas, is the preservation of jobs in the industry. Environmental and other gains from reduced reliance on fossil fuels and carbon sources are other benefits from Society's point of view. Energy: Depends a lot on the new production technologies of the advances made. Competitiveness: Obviously positive Consumers: New, sustainable bio-based products along the lines described will of course be a benefit seen from the consumers point of view EU's R&D-policy objectives: This directly addresses the ambitions concerning sustainability, competitiveness, knowledge-based etc. Key role for the leading wood and wood chemistry institutes

## **2.1.29 Novel biotechnical tools from soil organisms**

**Positioning:** Basic

**Short Description:** The wood degrading organisms, especially the fungi, have given man a large number of useful biotechnical tools. Today hydrolytic enzymes attacking cellulose, hemicelluloses and pectin are the most technically used of all enzymes, and are found in textile industry, laundry detergents, food industry and pulp and paper industry. In one aspect the wood degrading micro-organisms have been a disappointment – it has not been possible to develop an efficient and specific enzymatic method for degrading lignin, which can be applied in the pulp and paper industry for bleaching and pulping. This is due to that the wood degrading organisms do not use the classical enzymatic concept with substrate enzyme binding in the lignin degradation. Instead low molecular weight reactive and non-specific species as the hydroxyl radical is generated. Therefore also polysaccharides as cellulose are damaged by treatment of these lignolytic enzyme systems. However, soil organisms that lives on the degradation of humic acid, that mostly consist of incompletely degraded lignin, appears to degrade lignin by a more classical concept with enzyme substrate binding. The purpose of this project is to unveil the mechanisms of these very little studied enzyme systems.

**Justification:** Enzymes are by the high specificity and mild working conditions the ideal catalysists for an environmental industrial production of high quality materials. The lack of specific lignolytic enzymes have been an obstacle for the development of biotechnological, environmentally friendly and cost effective processes related to the pulp and paper industry. But the knowledge of how the humic acid/lignin is degraded in soil is very low, and need to be increased before large scale production of such enzymes can be started.

**European relevance and collaboration:** The future of the European industry is high technological production, since Europe probably cannot in the long time perspective compete with low production costs with Far East and Latin America. Biotechnological solutions fit well into this, since Europe traditionally have a leading position in this field. The forest industry is also an important branch in Europe, which however is challenged by industry in for instance South America and Indonesia. The biotechnology can be the possibility for Europe to keep its leading position in this branch, but for this efficient and specific lignolytic enzymes must be available. The project need cooperation between microbiological, biochemical and wood chemical laboratories and is well suited for a European cooperation. The project shall be coordinated by the Department of Fiber and Polymer Technology at Royal Institute of Technology, Stockholm, Sweden

## **Sub-area 2.2 Effective utilization of side streams**

### **2.2.1 Evolving business opportunities from wood processing side streams**

**Positioning:** Applied

**Short Description:** Chemical wood composition is relatively well known, though many new opportunities for wood use are not utilised as they do not belong to the industries core business areas. Information on these opportunities should be collected and new entrepreneurship actively developed on this information. Research could include pooling the existing information, analysing chances for new business opportunities and development of new business concepts.

**Justification:** With this research, new knowledge based entrepreneurship and innovative use of wood as chemical material can be developed. The impacts on industrial competitiveness as well as on socio-economic and environmental impacts can be markable, if the traditional chemical use of wood can be extended for new business areas. Key will be to attract new entrepreneurship to extend the use of wood.

**European relevance and collaboration:** To find new business opportunities on the use of wood chemicals is a challenging issue. European collaboration is necessary to find the dispersed but existing information. Technical universities and research institutes provide a solid network for joint research.



## **2.2.2 INCREASING VALUE OF SIDE STREAMS OF FOREST INDUSTRY**

**Positioning:** Applied

**Short Description:** In addition to its main products the forest industry handles a wide range of side streams. The intention of this project would be to systematically map the side streams, their volumes and potential utilization ways throughout the value chain. One target would be the identification of possibilities to bioconvert the side products into high-value-added products instead of low-value bulk-products. Possibilities for production of biofuels and bulk chemicals would also be studied. The research results on utilization of agro biomass could be utilized for wood-based biomass and synergy should be sought for the two sectors.

**Justification:** Overall utilization of wood-based material, increased demands for sustainability, need for high-value-added products and biobased processes are important themes in both FTP and SusChem draft SRA documents which were recently published. An important theme that is also supported by this research area is the replacement of petrochemicals with natural polymers and their derivatives. Increasing the value of side streams improves sustainability of forest sector, gives possibilities for new businesses and reduces costs for handling of waste. This improves the overall competitiveness of the sector.

**European relevance and collaboration:** In different parts of Europe the forest industry processes, products and research fields vary. By combining research groups around Europe all relevant areas of this wide research area can be covered. Raw materials are also different in the Southern and Nordic countries.

### ***2.2.3 Value added products of hemicellulosa and lignin***

**Positioning:** Applied

**Short Description:** High value products of hemicellulosa and lignin of black liquor or wood. Nanotechnology. Separation techniques?

**Justification:** New products: nanorods, carbon fibres. Possible use also in papermaking eg. to give strengthness to paper web or coating.

**European relevance and collaboration:** USA has large Biorefinery program, too. Europe must be at the same level or better.

## **2.2.4 Technical lignins for use in carbon fibres**

**Positioning:** Basic

**Short Description:** Carbon Fiber (CF) is a high strength light weight material which originally was developed for the aerospace industry. CF composites are applicable when high strength, stiffness, lower weight, fatigue characteristics, corrosion and heat insulation are the major requirements. Modern aircrafts use large quantities of CF with other major users being sport goods and engineering industries. The major part of CF is produced by heat treatment and pyrolysis of polyacrylonitrile (PAN), a synthetic material made from petroleum. Petroleum pitch is also being used. An increased use of CF in composites in e.g. the automotive industry would be attractive since vehicle weight, and consequently also fuel demands, could be reduced substantially without compromising performance, safety or recyclability. In order to achieve such a goal, however, the production costs of CF must be reduced substantially. Preferentially, the CF should be made from renewable resources such as lignin. In order to be competitive, the lignin must be tailor-made for use as CF precursor involving a broad development work on structure – property relationship. The major lignin source is as a side stream from kraft mills.

**Justification:** The reduction of organic material entering the recovery boiler in kraft mills will add to the productivity of the mill since a higher through-put of wood might be possible. At the same time, a low-value source of renewable organic carbon, available in large quantities, would find use in a high value added product. The introduction of carbon fiber composites in the large European automotive industry would result in a considerable reduction of the steel consumption in this industry and result in positive consequences for the overall fuel consumption. The high technological knowledge on the European level about wood and lignin chemistry as well as polymer and high temperature chemistry makes this research area suitable for collaborative work

**European relevance and collaboration:** The forest-based sector in Europe is widespread, has a strong economic and social weight and a global technological leadership. The traditional production of solid wood, pulp and paper products is, however, challenged by similar production in other parts of the world enjoying much lower raw material and labour costs. At the same time, the manufacturing technology is available everywhere. The strongly growing competition will result in successively decreasing margins in traditional forestry products. A development of new areas of use for side streams such as lignin from the kraft pulp industry resulting in a high value added product of considerable societal impact therefore seems highly justified. Suitable academic and institute participants in such a development are available throughout Europe thus making this area very suitable for joint research efforts. The presence in Europe of world-leading companies within the automotive, the forestry and the chemical sectors should give a strong industrial backup.

## **2.2.5 Utilization of Reaction Wood**

**Positioning:** Applied

**Short Description:** Reaction wood, like compression wood, juvenile wood or tension wood, is considered as a major wood defect. In sawn timber it causes distortion as well as a substantial loss in stiffness and strength. Recently compression wood came back in the focus of the international research community (e.g. EU-project QLRT-2000-00177). In this project mainly occurrence and identification of CW was assessed. The objective of this research was to optimise the value of the wood by a reduction of the compression wood content in the raw material. Another approach is to optimise the value of such wood by creating a market for reaction wood. Because the mechanical, chemical, optical and structural properties of reaction wood differ from normal wood it should be possible to develop wood based products, which benefit from these special features. Prototypes of products (e.g. MDF, OSB, parquet) based on reaction wood have to be assessed on their performance. Therefore standard material testing procedures have to be carried out. Another point to be considered is the quantity, availability and dimensions of reaction wood. Furthermore the economical aspect needs to be addressed by evaluation raw material and production costs as well as market surveys.

**Justification:** The knowledge how reaction wood influences certain engineered wood products has two effects. If it is negative the production process should aim to avoid reaction wood in the raw material. Problems in the production process or with product quality could be avoided and increase competitiveness of the wood processing industry (especially the wood panel industry). On the other hand engineered wood products made from reaction wood could have superior properties in certain aspects. This would result in new products designed for special purposes. Since reaction wood is normally found in low quality timber, it should be a cheap raw material. The development of new products will effect two industry sectors – forestry and wood processing. First, the new tailor made products ensure innovation and therefore competitiveness of the wood processing industry. Second, this will create a market for reaction wood. This puts the forestry sector in the position to earn money from timber containing reaction wood, so far regarded extremely low quality timber. Additionally also the saw milling industry will be able to increase revenues by selling rejects containing reaction wood from their production.

**European relevance and collaboration:** Compression wood is abundant in softwoods from all over Europe. Its occurrence varies between different species. For example French Norway spruce contains compression wood only in the late wood whereas in British Sitka spruce it is found also in the early wood. This might result in different performances. A European collaboration will assure that the aspect of varying sources is assessed. Internationally in many countries forestry shifts to fast-growing short-rotation plantations. This wood is of lower quality, because among other things due a high amount of juvenile wood. Utilisation of this wood needs to be optimised and is a issue important for the wood industry all over Europe.

## **2.2.6 Wood Fatty Acids – new options (WOODFAS)**

**Positioning:** Applied

**Short Description:** The goal of WOODFAS project is to find new products and processing systems for tall oil and for the other less studied wood based organic acids (eg suberin acids) leading to environmentally friendly, feasible new product options especially in coatings, adhesives, paper sizing agents as well as in wood protection and composites business areas. In WOODFAS project modern chemical and biochemical methods, such as selective synthesis and enzyme catalysis together with new separation techniques are applied to achieve targeted products. Application specific tests will be also performed in the project and results will be evaluated in co-operation with participating industry.

**Justification:** Recent environmental legislation, especially reduction of volatile organic compounds, has caused dramatic changes on well established down stream businesses of tall oil leading to urgent to need for new modifications, such as water born, powder or high solid binders for coatings, adhesives and composites. In addition neutral sizing is rapidly replacing traditional rosin based products in paper production, forcing tall oil producers to develop new products and markets also for this raw material. WOODFAS project offers new feasible options to produce environmentally benign speciality chemicals and polymers from wood based organic acid fractions.

**European relevance and collaboration:** WOODFAS project will create new wood based business opportunities for European industry and will support local activities in undeveloped regions of Europe while leading to better utilization of forest resources. Nordic countries, especially Finland, Sweden and Norway as well as Austria, Germany and Poland should have a key role in WOODFAS project because of their strong forest research activities.

## **2.2.7 Pulp Mill Biorefinery**

**Positioning:** Applied

**Short Description:** In chemical pulp production, only half of the pulpwood is found in the product. The rest of the organic material (mainly lignin and hemicelluloses) is in most cases used as a fuel together with bark. Modern science would make it possible to develop techniques for refining almost all of the wood, including pulp mill side streams and bark compounds, into platform chemicals, high quality fuels and structured feed-stock for chemicals and materials. Methods need to be developed for separation and refining of organic substances and fibres from pulp mill process streams and forest residues. Research is also needed in order to refine and utilise the different wood-based organic substances for different end uses, including tailored pulp fibres for composites. System aspects need also to be addressed. Adequate combinations of bio- and nanotechnologies with traditional techniques should be explored. Examples of interesting technologies: low temperature delignification, enzymatic and ionic liquids processes, new routes in sulphur-free pulping, steam explosion, pyrolysis, new extraction routes (e.g. supercritical extraction), high-performance membrane and chromatographic techniques, integrated targeted processes for specific substances from the pulping processes e.g. chemically (catalytic) and biotechnologically (white) assisted derivatisation reactions.

**Justification:** Pulp production is an important industry in Europe and is based on a renewable and carbon dioxide neutral raw material: wood from forests. Most of this pulp is used for paper production. However, increasing competition from countries with fast-growing forests makes it necessary to increase the competitiveness and to find new and highly refined products to complement the existing pulp-based products. Annual crops could also be refined in future wood refineries avoiding oversized annual crop refineries due to seasonal variations. The research would create new possibilities for efficient large-scale production of high-value speciality chemicals, polymer materials and bulk chemicals, based on renewable, CO<sub>2</sub>-neutral and abundant raw material. Wood resources would be better utilised. Both the economic and environmental performance of the pulp mill could be improved. The dependence on fossil raw materials would decrease.

**European relevance and collaboration:** The environmental incentives makes the area well suited for European co-operation: decrease of emissions of greenhouse-gases, decrease of the dependence on fossil raw material, better utilisation of natural resources. Expertise from a wide range of disciplines will be needed: organic chemistry, biochemistry, chemical engineering, energy technology, system analysis, material sciences, environmental sciences etc.

## **2.2.8 CARBON DIOXIDE RECYCLING IN PULP AND PAPER INDUSTRY**

**Positioning:** Basic

**Short Description:** The main objective of the research is to obtain new information on carbon dioxide recycling in the pulp and paper mill processes. The research aims to increase knowledge about the quantities of CO<sub>2</sub> in secondary material streams, their modification possibilities and reusability in various processes. The idea behind the approach is to recycle CO<sub>2</sub> at its source and improve the sustainability of pulp and paper mills. The research will contain the following tasks: - Purification of the combustion gas originating in a lime kiln and recovery boiler - Analysis of the combustion gas - Treatment of the combustion gas using pilot-scale system - Preliminary techno-economic-environmental analysis of gas purification - Production of methanol and formaldehyde from carbon dioxide by catalyst - Production of methanol and formaldehyde from carbon dioxide - Preliminary techno-economic analysis of the process - Environmental impact analysis of the process - Catalytic purification of methanol from methylmercaptan - Utilisation of carbon dioxide, methanol and formaldehyde in the processes of pulp and paper industry - Bleaching of pulp - Washing of pulp

**Justification:** This kind of interdisciplinary research sets the scene for the reduction of carbon dioxide emissions from pulp and paper industry while improving the LCA-value (Life Cycle Assessment) of pulp and paper products and enhancing the principles of sustainable development. The research forms a valuable foundation for the environmental performance by improving actions that are nowadays required in a modern and environmentally conscious society. One example of these actions is the implementation of following the Kyoto Protocol.

**European relevance and collaboration:** CO<sub>2</sub>-problem is hot topic today, less CO<sub>2</sub> less problems with climate

## **2.2.9 IMPROVEMENT ECOLOGY OF KRAFT PULP MILL – FOCUS ON SULPHUR RICH SIDE STREAMS UTILISATION**

**Positioning:** Basic

**Short Description:** The main objective of the research is to obtain new information on the utilisation of sulphur rich side streams in the kraft pulping. The research aims to increase knowledge about the quantities of sulphur compounds in secondary material streams, their modification possibilities and reusability or utilisation in various processes.

**Justification:** This kind of interdisciplinary research sets the scene for the utilisation of sulphur rich secondary material streams. Research also improves the LCA-value (Life Cycle Assessment) of pulp products and enhancing the principles of sustainable development. The research forms a valuable foundation for the environmental performance by improving actions that are nowadays required in a modern and environmentally conscious society.

**European relevance and collaboration:**



## **Sub-area 2.3 Development of recyclability characteristics**

### ***2.3.1 Recycled paper production***

**Positioning:** Applied

**Short Description:** The chain of producing of paper through recycling should be studied as whole. All efforts should be made to ensure the maximum utilization of the existing fibre raw material. A key issue in the development of paper production should be the recyclability of paper.

**Justification:** The target should be in development of new technology for manufacture of recyclable paper. Europe will survive the global competition and maintain its production sites if it will be able to increase the rate and efficiency of recycling.

**European relevance and collaboration:** European pulp and paper industry is increasingly competing with South American and Chinese production. A major advantage of the sites in South America is the low cost of the wood raw material. Europe could maintain its position by putting more effort for recycling of paper products.

### **2.3.2 Organic compounds in water cycles**

**Positioning:** Basic

**Short Description:** The main objective is to study the origin and nature of organic loads in a wood processing integrate. Different internal treatment methods such as catalytic and thermal wet oxidation can be used. Special attention is given to the cost-effectiveness of the internal treatment methods and to the quality and reusability of the treated water. Possibilities to have some process water exchange between the pulp and paper plants could be considered.

**Justification:** Makes the process greener and more acceptable - the society hopes for this. Water cycles become possible and the technologies used can be economical. The technology can be used also in other application areas.

**European relevance and collaboration:** Europe is rich in catalyst know-how. Why not to utilize it also in pulp and paper industry?

## **Sub-area 2.4 Advanced production of bioenergy**

## ***2.4.1 Optimization of supply chains for energy wood production***

**Positioning:** Applied

**Short Description:** The aim of this research issue is to develop an efficient and sustainable concept for the mobilization, harvesting, conversion and transport of energy wood. Therefore new procurement systems are developed and tested. Additionally innovative silvicultural and sorting concepts are examined. The impact of the newly developed supply chains and the silvicultural and sorting concepts on sustainability, productivity and costs are researched with field studies. Furthermore, the regional potential of woody biomass for the energy production will be estimated in dependency of the possibilities and constraints of the tested supply chains and silvicultural and sorting concepts.

**Justification:** The expected results will lead to an increased efficiency of the procurement of energy wood and hence help to propagate the utilization of wood for CO<sub>2</sub>-neutral energy production. An economically efficient energy wood production chain can be of economic importance for forest owners and forest contractors and enhance the acceptance of renewable energies in the society. The raised usage of renewable biomass for energy production will enable societies to reduce the CO<sub>2</sub>-emissions significantly. Additionally rural structures will be strengthened and the added value will remain in regional cycles.

**European relevance and collaboration:** The propagation of the sustainable and renewable energy source 'biomass' is in the interest of all European countries, since they have to fulfil the Kyoto-Protocol. As the natural settings and technical possibilities differ between European countries, the researched concepts have to be adapted to these specific conditions. Therefore a transfer of knowledge and technology combined with collaborative research activities is necessary. Potential European research groups: VTT Finland, EFI, Finland, FVA Freiburg, Germany, FAWF Trippstadt, Germany, StoraEnso bioenergy, Freiburg, Germany, AFOCEL, France, Skogsforsk, Uppsala, Sweden, Timberjack Oy, Finland, WSL Birmensdorf, ETH Zürich, Switzerland, IVALSÀ, Sesto Fiorentino, Italy, Metla, Finland, SLU, Umea, Sweden

## **2.4.2 Modelisation of wood logs combustion in stoves**

**Positioning:** Applied

**Short Description:** The modelisation of combustion is very difficult because of the mixing of different sciences : thermal transfer, fluid mechanics, thermodynamic and chemistry. Some models of gas combustion can now modelize precisely the behaviour of the process in furnaces. The modelisation of solid combustion is really more difficult. Two approach can be used : first for some particules of wood which can be considered as particules of gas, and then, we use a combustion of gas model ; secondly, and that is the purpose of the proposition of program research, we need to modelize primary the wood devolatilization and then the combustion in gas phase. To reach this way, we need to determine precisely the behaviour of wood submitted to thermal transfer and the composition of the gases emitted by the degradation and the condition of emission. Then, these results can be used to modelize the combustion of wood logs in small stoves.

**Justification:** All over the world, the combustion is the main utilization of wood. Moreover, the really main part of this combustible wood is burnt in small stoves and can generate pollution due to non complete combustion and lost of energy with poor yields. To optimize the combustion process of these small stoves quicly, we need to modelize the combustion process. The main problem is to take into account all the parameters since the wood thermal degradation to the chemical reaction via flows into the stove and pollutants production. The objective is federate various european competences to reach the purpose of this program.

**European relevance and collaboration:** The diversity of the scientific knowledge to answer the objectives of this program need a diversity of European actors, from specialists of measurements, fluid mechanics, thermal transfer, modelisation, thermodynamics, ... An European program is then the best way to reach it.

### **2.4.3 How to create markets for wood energy?**

**Positioning:** Basic

**Short Description:** In the world of for example increasing energy prices, emission trading there competitiveness of woodbased bioenergy has increased. However the markets for woodenergy from different sources are not fully functioning. The potential rawmaterial for wood energy is much higher than the amount used to day. If there would be wood energy markets this potential would be used in higher extent. The research question is how to create markets for wood based bioenergy.

**Justification:** The side products from industry and forestry would be utilitised. This would create employment, value added products and profitability.

**European relevance and collaboration:** In Europe the potential wood energy supply is high. In the world of increasing energyprices Europe may obtain competitive advantage from bioenergy.

#### **2.4.4 Land use of forest-products in the context of sustainable development**

**Positioning:** Applied

**Short Description:** Considering the impact of land use within the life cycles is in its infancy. With respect to bio-energy and renewable resources, an account of the eminent importance of land use must be secured to enable the comparison of alternatives on an objective basis. The likelihood of a trade-off between bio energy in terms of decreasing greenhouse gas/emissions with increasing land use requirement must be reckoned with, to be able to identify and quantify most promising pathways towards sustainable wood products. Sustainable decisions can only be reached if land use and emissions reduction are interpreted collectively within the same method. Therefore the development of an evaluation and information tool for assessing both quantity of used land and the intensity of this usage (towards sustainable land use) has to be performed. The new method needs to be applied to existing systems that already contain environmental data and can thus be interpreted together with existing knowledge. Therefore it is necessary to differentiate between the assessment of land area, of land use intensity and of the type of land used. Therefore, an environmental indicator system of the land must be developed, which can be integrated into scheme of the standard Life Cycle Assessment evaluation.

**Justification:** Up to now it wasn't possible to evaluate land utilisation. Integration of data and knowledge into the everyday practice of analysing land intensive processes (similar to the integration of greenhouse gas emissions in the analysis of CO<sub>2</sub> intensive processes) is necessary. The integration of land utilisation information into existing methods that have been approved and applied in practice (such as the standard LCA procedure) will be a step to solve this problem. Land surfaces can carry out a variety of functions. Special forest systems have alternative functions. The impacts of land utilisation should be credited with great significance in comparison to industrial product or process options. From a social standpoint, a reduction in land consumption has been a goal for a long time. However suitable methods and tools with which to effectively achieve this social consensus in the context of a complex, sustainable industrial/economic development were unfortunately still missing. Now that an evaluation technique is foreseeable, it is important that it is implemented into the decision support system (planning reliability, resource availability, sustainability). Accepted LCA methods (ISO) are available. A prerequisite to achieve this research goal is to use already existing networks of experts (Cost actions, company networks).

**European relevance and collaboration:** Europe is very densely populated, which makes land often rarely available. Loss of natural territory became an increasing point of public discussion during the last years. A tool to evaluate land use within life cycle approaches throughout Europe is meanwhile more than necessary to enable reliable decision support. To develop this kind of method, the involvement of LCA groups, geo-ecologists, forest and agricultural scientists is necessary. A key goal is to integrate the method into everyday decision processes.



### **2.4.5 Identification of the best wood-based strategies for achieving CO<sub>2</sub>-neutral mobility**

**Positioning:** Applied

**Short Description:** Region specific strategies for short-term implementation of CO<sub>2</sub> reduction potentials using forest products in the European transportation network. The increase in the significance of 'biofuels' (BTL) is a viable option since they possess characteristics that are certainly comparative to conventional fuels (sometimes even better). Hence, we can expect biofuels to become more accepted by car manufacturers/users. Moreover, there is no need for a conversion/reorganisation of the current fuelling infrastructure (as is the case for hydrogen). Information on theoretically possible pathways for producing fuels based on biomass (agriculturally cultivated biomass, wood, wood residues, wooden waste, etc.) exists on a European level and this can be built upon (e.g. wheel-to-wheel studies). Wood products could become important since their quality and volume flow makes them an interesting candidate for conversion into fuels and the proven technology already exists. The regional occurrences of wood availability and its acceptance onto markets are the decisive factors for the success or failure of the pathways. These are not considered in the above mentioned works. The different cultivation and production processes of wood must be investigated in an integrated approach with consideration of regional distinctions. Using life cycle approaches guarantees that all established ecological aspects are accounted for, enabling the best available short-term implementation of CO<sub>2</sub> reduction potentials in mobility to be achieved for the respective region.

**Justification:** The result will be the identification of effective and regionally-suited pathways areas or countries of Europe, reducing fuel dependency on non-renewable resources such as crude oil. The various pathways of producing biomass-based fuels are an innovation within the European oil industry as new areas of business are opened up. Many European oil companies are already involved in developing new strategies for wood/biomass-based fuel production. The use of biomass for fuel production leads to a new significance for forest products. This creates new perspectives for the turnover of forest products and thereby generates a new kind of value-added chain. In addition, this development would lead to innovations in the context of fuel and car manufacturing in Europe. This would lead to a shift in the added value from oil producing countries outside of the EU to forest-growing countries within the EU. The increased use of biomass-based fuels is a promising step towards CO<sub>2</sub>-neutral mobility and can be implemented quickly. A direct result of this would be the creation of new jobs in the forest industry and in fuel production. The reduction of risks from oil transportation through Europe is a further factor. The availability of technical and ecological know-how in the field of wood-based fuel production and forestry is necessary. An appreciation of the existing information and studies carried out by the EU is a further prerequisite.

**European relevance and collaboration:** The increased use of biomass-based fuels as a fundamental contributor to CO<sub>2</sub>-neutral mobility is not just a national problem, rather one of international relevance. Since the results of national studies are difficult to transfer

due to each country's climatic differences, it is essential to identify the best technology for each EU country or region. Within the framework of this study, the results of the COST Action E9 "Life Cycle Assessment on Forestry and Forest Products" will be referred to, through which a scientific platform of ecological questions along the forest-wood chain is already available. Partners, having been active in the COST Action E9, could play a key role. Collaboration between forest scientists with country-specific knowledge and key players for each of the different pathways is crucial. The involvement of political decision makers would be beneficial assuring the implementation of the best identified strategy for each country and/or area. For this it is necessary to create an international network of experts throughout the EU.

## **Sub-area 2.5 Utilization of enabling technologies to improve productivity and reduce capital costs**

### ***2.5.1 Raising productivity in wood processing by advanced tool technology***

**Positioning:** Applied

**Short Description:** Developing tool techniques in wood processing in order to get more productivity and lower capital costs.

**Justification:** Applied research in co-operation with wood processing industries and tool manufacturing companies.

**European relevance and collaboration:** The processing and manufacturing companies are working globally.

## ***2.5.2 On-line drying of wood***

**Positioning:** Applied

**Short Description:** To use up-to-date experimental devices, modeling tools and knowledge of wood properties (transfer, rheology, thermal degradation) to imagine a process able to ensure on-line drying of wood at the industrial level

**Justification:** On-line drying of wood would allow : - stacks to be formed only for final product, without stickers - product quality to be assessed once all potential defaults (grain angle, reaction wood...) have been revealed

**European relevance and collaboration:** A former COST action (E15) devoted to wood drying continues to be active as a European group

### ***2.5.3 Improved headbox design allowing paper products applying twin-wire roll dewatering***

**Positioning:** Applied

**Short Description:** The basic idea is to produce superior paper products applying dewatering by only twin-wire roll units. This will require a high quality jet to be delivered, containing a minimum of fibre flocculation. This will be possible by suitable fibre properties (including surface friction) combined with extensional flow fields in the headbox to disrupt fibre flocs

**Justification:** Pure roll forming is the simplest way of dewatering a fibre suspension to form a paper web. It allows an inexpensive wire section with high time efficiency and low operating costs. The properties of the paper/board produced will be superior in comparison with the dominating techniques applied today, which also include blade dewatering. The blade pressure pulses involved have a negative effect on paper properties. This is avoided with pure roll dewatering.

**European relevance and collaboration:** Worldwide, activities within the area of paper forming is mainly taking place in Europe. The two main paper machine manufacturers are European: Metso Paper and Voith. Research within the area is carried out also by VTT Jyväskylä and STFI-Packforsk in Stockholm. The STFI FEX pilot paper machine is suitable for process/product evaluation. Technical universities are also involved, like those in Stockholm and Tampere.

## **2.5.4 Holistic production concepts for the wood-working industry**

**Positioning:** Applied

**Short Description:** The aim of the research issue is the development of new machine and production concepts to raise the productivity as well as the environmental friendliness of the manufacturing process. This can be achieved by the development and implementation of simulation tools which represent stand-alone machines and their integration in the manufacturing process under technical, economical and ecological aspects. Therefore a simulation environment linking different simulation and evaluation techniques (finite element method (FEM), multi-body simulation (MBS), material-flow simulation, life-cycle assessment (LCA)) has to be created and adopted to the requirements of the wood-working industry. Simulated variables are for example machine vibrations and thus noise emission, processing times and energy consumption. Based on this simulation model new machines and production concepts will be developed allowing a faster, more beneficial and more ecological manufacturing of wood-based products. The prediction of the manufacturing process will also increase process stability and quality. The branches covered by this issue might range from the furniture industry to the building industry (timber construction).

**Justification:** The result of the research activities is a holistic model of production processes which supports the design and construction of new wood-working machines, the evaluation of new investments for wood-working companies and moreover the optimization and development of new production concepts. This way, wood-based products ranging from pieces of furniture to timber-frame houses can be produced and thus sold to lower prizes, raising interest and demand in eco-friendly high-quality products. This will strengthen the entire wood-working industry and promote the use of the sustainable resource 'wood'.

**European relevance and collaboration:** The research issue will lead to a more economical production of wood-based products and thereby to an increased competitiveness of the European market compared to other economic areas like Asia. Therefore the expertise of European research groups, machine manufacturers and end-users has to be concentrated. A cooperation of researchers dealing with machine tools, production technology, life cycle assessment, factory planning, wood working and timber construction is the precondition for a successful research activity.

### ***2.5.5 New machine concepts in stationary and throughfeed technique for furniture production***

**Positioning:** Applied

**Short Description:** The issue is about new concepts for machine tools in wood machining. A very progressive approach is to replace the nowadays primarily used serial kinematic structures of machine tools by modern parallel kinematics. Thereby the main aim is to raise machine rigidity and to enhance dynamic behavior and thus to increase productivity of the machines. The requirement for low moved masses causes the development of lightweight structures for machine tools, primarily in combination with parallel kinematics. Further equipment for optimized dust and chip removal as well as image processing systems for quality assurance are developed to integrate them into common and newly developed machines. A detailed process control in furniture production, for example by the use of a CCD-camera, is important for a timely cognition of incorrect aligned workpieces, missing bores, cracks in the edge, faultily clotted edge bands or similar. There has to be knowledge in machine tools, parallel kinematics, construction, fluid mechanics, material science, production and measurement technology (image processing) to study the issue.

**Justification:** Development of new machine concepts based on parallel structures and lightweight constructions, which enable a raise in productivity of machining because of a higher structural stiffness, acceleration ability and accuracy. On-line quality assessment of processed workpieces in furniture production and thus a minimum of unrectifiable rejects and a maximum of quality. Reduction of power consumption and environmental pollution by process- and flow-optimized suction hoods for dust and chips in wood machining.

**European relevance and collaboration:** The issue deals with the development of new concepts for machine tools in wood machining. Mechanical engineering is a traditional and important part of European economy, so that research in this domain has to be raised. The issue includes many different fields of research (parallel kinematics, lightweight construction, measurement technology or fluid mechanics), so that a co-operation of various researchers suggests itself. Institutes etc. that deal with machine tools, production technology, measurement engineering, fluid mechanics, lightweight construction or quality assurance are predestined for this research.



### **2.5.6 Active noise and vibration reduction by integration of adaptronical systems in wood-working tools and machine structures**

**Positioning:** Applied

**Short Description:** In the last few years the wood-working and furniture industry are demanding a high flexibility and productivity from production systems. At the same time a continuous improvement of production efficiency with a simultaneous improvement of product quality is required. This can only be achieved by increasing machining speeds, better dimensional and shape accuracies and better tool life. The consequence of higher machining speeds is the occurrence of dynamic loads and vibrations. These cause on the one hand a high noise level at the workplace; on the other hand a negative effect on the manufacturing quality of the wood-working machines. To achieve a better dynamic behaviour of the machines, the structural stiffness and damping properties have to be improved in order to interrupt the transmission path of the vibration energy. In the past years, active and passive damping systems are used more and more for vibration reduction. Compared to the passive ones, active (adaptronical) systems have the ability to influence the properties of the structure with the help of new materials in form of sensors and actuators, which are completely integrated in the tool or machine structure. These materials can be designed in different shapes. They have good flexibility, functionality and poor fault tolerance properties. To accomplish an optimal integration of these adaptronical systems in wood-working tools and machine structures, besides engineering design, accompanying finite-element and multi-body simulations have to be done.

**Justification:** By using adaptronical systems new design strategies for wood-working machines are possible to achieving an improvement in production efficiency and manufacturing accuracy. To these systems belong for instance: active frame bases to isolate the machine structure from ground vibration, adaptive workpiece clamping systems to reduce vibration of plane workpieces during processing, vibration reduction on tools, drive units and guidance systems, as well as adaptronical balancing systems for high-frequency spindles. Thereby new concepts emerge for reducing machining time, improving and monitoring manufacturing quality, increasing tool life and reducing overall noise level. The last one can reduce the percentage of industrial disease like noise-induced hearing loss.

**European relevance and collaboration:** The field of adaptronics sustain on new and further developments in the area of new functional and structural materials (e.g. piezoelectric ceramics, electro- and magnetorheological fluids), which becomes in the last years an important research field in Europe. In next years the design and development of these materials will advance to series-production readiness. Therefore, to obtain a high accuracy and performance of wood-working machines and to maintain the development leading position of these in Europe, research groups in the field of production technology, structural mechanics, control and engineering design have to collaborate interdisciplinary. Thus, new adaptronical systems for wood-working machines will be faster integrated in industrial applications and will be profitable.

### ***2.5.7 Knowledge-based defibration for eco-efficient mechanical pulps***

**Positioning:** Basic

**Short Description:** The ultimate goal is to reduce refining energy consumption in mechanical pulping of wood through applying precisely controlled breaking work for opening the fiber structure at refiner plate gap. During mechanical pulping of wood, fibers should be separated from each other and peeled without cutting them. The forces applied should be targeted in breaking the outer layers of fibers without any elastic by-work, which just turns into heat. Currently the distribution of applied shear and compression forces at the refiner plate gap as a function of the radius of the refiner are not known. This arises from the lack of appropriate measurement techniques, and results in inefficient and excessive refining energy consumption. The precise information of the peeling work put on fibers at each radial position within a refiner is required to understand the energy wasting mechanisms. This requires measurement of shearing and compressing forces as a function of refiner radius and sampling as a function of radius, which shows the progress in peeling degree of fibers. The precise influence of changes in refiner segments/plates is impossible to follow without good measurements and thus leads refiner-developments to be based on trial and error.

**Justification:** This research would develop measurement techniques for obtaining realistic shear and compression forces at different positions within refiners. This in turn would guide in developing more effective refiners for mechanical pulping of wood. The stepwise energy savings up to 50 % are possible through precise control of the forces that affect the fibers.

**European relevance and collaboration:** For keeping competitive, the European paper industry needs to find more eco-efficient ways of producing paper and paperboard products. Some of the key means are more efficient use of wood raw material for given amount of products (shift from chemical pulps towards higher-yield mechanical pulps) and more efficient pulp production (reduced energy consumption in defibration of wood and modification of fibers). Possible collaboration partners include: measurement instrument manufacturers, pulping equipment manufacturers, research groups familiar with measuring and modelling of wood, wood fibers and pulp fibers, flows within systems, engineering, and pulp usability.

## **Sub-area 2.N Other**

## ***2.N.1 Energy efficient pulp and paper production***

**Positioning:** Applied

**Short Description:** Improvements are needed both in energy generation and energy consumption in pulp and paper production. CO<sub>2</sub> emissions from production need to be further reduced and the use of renewable and CO<sub>2</sub>-neutral forest-based materials needs to be increased and streamlined. The overall energy efficiency of the manufacturing processes of forest-based industry can be significantly improved. This can be done by improved energy and material management in all manufacturing stages and by integrating the benefits of strategic energy management and technology development by optimum integration of less energy consuming and energy recovery technologies.

**Justification:** • Substitution of energy intensive process steps by innovative less energy intensive processes, e.g. o new refining technology, more efficient fibre flexibility via e.g. new mechanical pulping technology and enzyme pre-treatment, o high consistency forming, new pressing technologies, new dry-ing, technologies, e.g. dry air laid forming technologies, new bonding mechanisms, multistage drying technology, o new techniques for concentrating black liquor, o alternative coatings (e.g. ultra high solids, dry coating technology) • Establishing process integrated energy recovery installations of the non-paper fraction of recovered paper (internal or external). • Efficient process control technology for enhancing energy efficiency. • Fractionated treatment of fibres and other material and integration into bio-refinery concepts.

**European relevance and collaboration:**

## ***2.N.2 Catalytic abatement of VOCs and malodorous compounds in pulp and paper industry***

**Positioning:** Basic

**Short Description:** The emissions from paper mills to air are mainly volatile organic compounds and malodorous compounds. In paper mills the VOCs formed include alcohols, formaldehyde, ketones, phenols and solvents used for cleaning machine fabrics, organic acids and residual monomers of polymers. Although the released VOC emissions are rather small, there is a need in pulp and paper mills for a VOC and odorous substances control unit or separate units for odorous sulphur components (catalytic or thermal oxidation, biological oxidation, scrubbing) and VOC control (catalytic oxidation). The main objective is to develop catalytic combustion unit for simultaneous VOC and malodorous compounds' emissions abatement.

**Justification:** The odour problems can be diminished also during those periods when the process is not running normally (odorous and VOC compounds from e.g. chip bins; shut-downs and start-ups).

**European relevance and collaboration:** Those active in catalysis.

### **2.N.3 Recovered wood – reuse and recycling options**

**Positioning:** Basic

**Short Description:** Recovered wood includes all types of wooden material that is available at the end of its use as a wooden product. Areas of using recovered wood already exists for many purposes. Production of bio-energy is one, while other areas, such as reuse of materials, almost exist only on a research level. However, more research should be performed to better find better means of utilising used wood. The work in this project will consist of investigating amongst others the following tasks: - Legislation - Statistical information regarding flows of timber - Simulate the flow of timber, from cradle to grave - Carbon repository and stored energy - Investigate material vs. thermal use of recovered wood, including substitution for other energy carriers - Market conditions for recovered wood, i.e. costs and benefits and socio-economic - Environmental burdens of recovered wood treatment - Properties of recovered wood

**Justification:** Used wood, preferably the clean fraction, ought to have good possibilities for utilization in a large area of application areas. Polluted and chemically treated wood also could have possibilities in the area of reuse and recycling, but new methods of reuse and recycling must be developed in order to make this economically feasible. There will definitely be huge environmental gains, by better planning on how to treat used wood. Not least in proportion to CO<sub>2</sub> and the Kyoto protocol there will be a potential for increasing the Nordic contribution to the reduction of emissions of climate gases. Investigating the end of life possibilities for wooden materials will further support wood as a sustainable material and part of a natural cycle. Performing a study as described above will seek to reduce environmental loads by creating recovered wood management options that minimise landfill and incineration without energy use. It will also mobilise additional biomass as a sustainable energy source, contributing an increased share of renewable energy in the European primary energy supply, and help meeting the reduction of EU GHG emissions as declared within the Kyoto process.

**European relevance and collaboration:** There is already a European collaboration on recovered wood in COST Action E31 – “Management of Recovered Wood”. Through this COST Action there already exist a European forum for the management of recovered wood which can be used for establishing research groups.

## **2.N.4 Micro-biological life in trees**

**Positioning:** Applied

**Short Description:** A large amount of wood must be wasted as a result of growth of fungi and bacteria. These organisms like the hot and humid climate which is present in wood kiln dryers. A well-known example is the golden oak phenomenon caused by a fungi called *Paecilomyces variotii*. There are, however a very large number of other fungi, and bacteria, which have not been examined in detail. It is also of great importance to find fast and reliable methods for identification. If the problem could be avoided, e.g. by treating the wood with low pH fluids large amount of money can be saved in the parquet and furniture industry.

**Justification:** Fungi and bacteria are present everywhere and take part in the natural degradation of wood. Sometimes the attack comes a little too fast because humans want to use the wood after harvest. If the conditions for the fungi and bacteria could be made unpleasant but not lethal much of the problem with discolored wood can be avoided. Important is to avoid growth but in an environmental friendly way. Impregnation with harmful poisonous solubles is used today but these are hazardous for humans as well.

**European relevance and collaboration:** Industry for furniture and flooring is present everywhere in Europe. Problems common in one factory are also present in the others. All factories have kiln dryers where the problem with discolored wood are observed every day. In order to address this problem experts on microbiology must co-operate with technical scientists in fields like humid air, heat transfer, dryers and so forth.

## **2.N.5 Life Cycle Assessment Academic Teaching Tool Development**

**Positioning:** Applied

**Short Description:** To look at the feasibility of developing a student friendly computer based software interface for the study of the life cycle assessment process in relation to the raw materials supply, product manufacture, use and fate of selected forest products. This would involve simulating products such as generic pulp, paper and types of packaging and allowing students to investigate LCA concepts. This would involve basic manipulation of important primary raw material flows such as those for electrical energy and fuels, minerals, construction materials and chemicals. The project involves the production of a user friendly LCA simulation environment in which students are free to explore the conceptual aspects of LCA to help generate a shared view of environmental priorities in general, helping to achieve a common understanding of generic product shadows. In addition the software could also include other basic study materials useful in the field of environmental management. The tool would be aimed at university and polytechnic level (Finnish yliopistot, korkeakoulut, ammatikorkeakoulut), and would compliment existing well known software tools available to forest products students such as “KnowPulp” and “KnowPap” etc.

**Justification:** Existing LCA software tools are powerful but hard to utilize for teaching purposes due to their target market being that of definitive application by manufacturers armed with detailed product information. The development of such a tool dovetails with the general need to introduce students to the sustainability aspects of product design, manufacture, use and disposal.

**European relevance and collaboration:** Sustainability issues in education in general. Links to forest industry’s sustainability and use of renewable energy/bio-fuels. Links to use of IPPC and BAT specified plant (types and performance.)



## **Sub-area 4.1 Combining social and natural/engineering sciences**

### **4.1.1 Economic relevance of internal labour in small scaled forestry**

**Positioning:** Applied

**Short Description:** About 46% of the 10.700.000 hectares forest area in the Federal Republic of Germany is managed by private forest enterprises. One third of these enterprises are smaller than 50 hectares with characteristic small-scaled management units. The general condition for these small-scaled forest enterprises have changed fundamentally within the last two decades. The economic development is extremely difficult. The ownership structure and the objective targets of many, primarily urban forest ownerships change continuously. The owners reduce their internal labour and silvicultural activities, try to submit the management responsibility to other organizations or tend to adjust the classic management at all. These results in combination with insufficient wood harvesting technology in low profitability, the usual wood structural practices hardly anymore practicable in the future. For example the possible increase of forest utilisation by 2 m<sup>3</sup> per hectare and year the small- scaled forestry set about 3.000.000 m<sup>3</sup> of rough timber aside for the commercial use in the wood industry. The negative effects of this trend on the developments of rural regions be hardly to assess. Prerequisite for the development of instruments which seem suitable for the mobilization of these rough timber reserves is the knowledge about the exact business and owner structures, their dynamics as well as its inner and outer influence factors, which shall be analysed by statistical and social scientific methods.

**Justification:** The meaning of the cluster forest and wood in Germany is already stressed considerably in various well-known studies. Decisions affecting sustainable forest management shall be based on a differentiated knowledge of forest ownership structures, particularly its dynamics and influence factors like development, range and costs of typical equipments or the trend of internal labour workload. The relevance of the small-scaled ownerships the into cluster forest and wood doesn't fade only in Germany but also in the rest of Europe

**European relevance and collaboration:** Already numerous scientists and working groups have dealt with the extraordinary significance of forestry and wood industry for the development of rural regions in Europe, which are characterized by high rates of unemployment, narrow occupational bases, poor new job opportunities and rapid emigration. By foundation of an international research network the previous research results could be collected, experiences exchanged and synergy effects used. This research network is especially important for the European forestry policy priorities, which has to deal with rural development, employment and income in rural areas, increased utilisation of forest products, renewable energy and climate change aspects.

### **4.1.2 Improving the competitiveness of wood products with a credible substance brand**

**Positioning:** Applied

**Short Description:** Although wood has been used in construction for centuries, there are still problems with the quality and usability of wood products. In many cases wood in its end use application either does not last as long as or does not look as aesthetic as it is supposed to. The visually observable problems weaken the image of wood and the competitiveness of wood products. The aim in this research is to find solutions for wood products industry to eliminate the sources of the most common problems. This is achieved by indicating the deficiencies in the wood product chain, which cause the problems in end use. The emphasis is on analyzing what the connection between the chain and the competitiveness of wood products is from the viewpoint of 1) the technical properties and usability of wood products and 2) the profitability of wood product companies, i.e. value generation in the different stages of the chain. Both qualitative and quantitative methods are applied: in-depth interviews, statistical analysis of the numerical data provided by companies, usability research and product and material testing. In this study wood product chain is perceived in a broad sense, including also such activities as architects, constructors and coating producers.

**Justification:** For wood to be competitive against other materials in different end use applications, one of the most important issues is to build a credible substance brand for wood. This requires collecting and evaluating research information as well as delivering the information efficiently across the actors in the wood product chain. Thorough understanding of the end use environment and the wood product chain can be utilized to improve the quality and competitiveness of wood products. Although the idea of grading the wood according to the end use seems self-evident, it does not realize in practice. The interactions in the wood product chain and the connections between technical and economic aspects are analyzed to develop a procedure for directing the wood material to different wood products and wood products to different end uses correctly. This would yield in improved competitiveness of the wood products industry as whole and better profitability of the individual wood product companies. Higher-quality products, in their turn, yield in a more sustainable living environment. The key quality issue is to develop more durable wood products, which in its turn have positive environmental impacts in the form of longer product life cycle and easily and safely disposable products.

**European relevance and collaboration:** Understanding the end use environments in different countries is extremely important, because there are great differences between different wood species and the quality and types of wood products across Europe. Combining studies in Finland and Central European countries provide a broad view and the results can be generalized to other areas, such as Russia, too. Other European research groups working with similar aspects of the use of wood include the Technical University of Munich and the University of Hamburg. The first investigates durability problems of wood products, such as blue stain, from the perspective of building physics. The latter carries out biological research of wood material. Both support the proposed research

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theme well. In Otaniemi, Finland, there is a large knowledge reservoir combining expertise from the areas of wood technology, architecture and building physics. The group consists of different university laboratories and the Technical Research Centre of Finland.

### **4.1.3 Wood and timber constructions for development and disaster areas**

**Positioning:** Applied

**Short Description:** Development of houses and housing units based on wood/timber constructions and wood-based materials (panels, flooring, insulation) for disaster and development areas, which are pre-fabricable, need a few transportation space, are easy to assemble and dismountable; self-sufficient with regard to energy and conditioning, offer multifunctional applications such for housings, hospitals, administrations.

**Justification:** Business goals is the increase of wood sales from EU producers (saw mills, houses, wood based products; Connections of opening a new market for wood products with social and humanitarian engagement of the EU and support to both disaster and war areas and development areas. R&D in this field will increase the use of wood as a renewable material for new applications and value-added products. Additional effects: development of new assembly systems; creation of "intelligent" houses and modular housing units, reduction of waste material to "0"

**European relevance and collaboration:** Comprehension of woodworking industry, construction specialists. In result of the project in the participating countries different solution concepts may be developed, such as different solutions for various demands and applications, e.g. for different climate conditions.

#### **4.1.4 Increasing the quality of life by using new wood products**

**Positioning:** Applied

**Short Description:** Increasing the quality of life is a pan-European challenge; leads to an improvement of the image of wood and paper products; Intelligent connections for wood and paper products within the living environment; variable flat and building systems (i.e. variable number of rooms and room size):Targets are : multi-purpose intelligent and healthy and environmental friendly solutions (e.g. furniture, interiors) for all living ages; concepts for flats with removable inner walls.

**Justification:** The ageing of the population is, as far as permanent and global nature of the problem is concerned, a pan-European challenge for science, politics and social work. Predictions assume that by 2010 appr. 25 % of the European population will belong to the category of old people. These have special needs to their living environment. There are a lot of products from wood and paper industry around people in their living environment e.g. construction materials for cladding, flooring, interiors, furniture such as for wellness and hygienic applications. The research area includes facts like individuality, barrier-free living, ergonomics, communication, reduction of harmful substances, mobility, safety, intelligent linkage of products, connected with an increase of the sale and use of wood and paper products, based on renewable resources. In the living (private) environment products from both wood and paper industry meets at the customers direct environment. Improvements will have a strong effect on their health, well-being and ability. Business goals are: increasing of wood and paper product sells; development of solutions based on products for constructions, interiors, furniture, wellness and hygienic applications; use of healthy and environmental friendly material and coatings.

**European relevance and collaboration:** Increasing the quality of life by use of new wood and paper products for accommodation: after studies on life types (domiciles, interiors, furniture)in EU member states (the different and typical requirements are compiled. This is basis for development of new wood and paper based products which leads in turn to an increased quality of life. Key research groups: social research, futurology, wood and paper related research

#### ***4.1.5 Factors influencing on perception of wood in interior use and their potential influence on human well-being***

**Positioning:** Basic

**Short Description:** The objective is to research the factors of attractiveness of various wooden surfaces and peoples`prefencies in different european cultural surroundings. The study should be made in comparison to certain substituting materials and the influence of mode or traditions should be separated from attractiveness factors.

**Justification:** Goals are: - to test survey methods - to build a common knowledge base for product & marketing development - to build scientific basis to better understand consumer behaviour - to evaluate the efficiency of marketing and trade in different areas - to develop understanding what does it mean to human person if he/she lives in "attractive surrounding"

**European relevance and collaboration:** The study should be made among 4-5 different countries in Europe and this leads to network structure.

#### **4.1.6 Woodwisdom-net**

**Positioning:** Basic

**Short Description:** To aim for a sustainable wood production in Europe, related technical, ecological, economic and social aspects have to be integrated. Ecological criteria are effectively and efficiently covered in a life cycle perspective, applying the proven method of LCA. With an LCA, global, regional and local impacts on the environment can be analysed. But social criteria are derived from either conditions stipulated by law, regulations/conventions, or by the direct consequences of a decision, which could affect an individual or the society in general. For example, in changing a harvesting procedure or the kind of grown wood job profiles can change and jobs can be created or eliminated. In the wood production e.g. the question of accidents is very relevant as the wood production has one of the highest rates of accidents per Euro of created added value. However so far there is no agreed method to assess these social effects. Therefore the relevance of different social indicators should be examined with regard to the requirements and particularities of the wood industry and the necessity of further indicators should be identified.

**Justification:** For the use and production of wood the social dimension will play a major role, as the agricultural production is rather labour-intensive and creation of additional jobs – especially in rural areas – can be shown using this method. It can be used to evaluate certain social impacts under a life cycle perspective and demonstrate how the gained knowledge can be used for decision support, by fostering the sustainability approach. For consideration of the social effects related to the production of wood a life cycle based approach is needed for the same reasons as in the ecological field: • to avoid shifting of social problems from one life cycle phase to another and • to locate “hot spots” where it is most pressing to change something. • to avoid shifting from the environmental realm to the social field As supplement of the classical Life Cycle Assessment (LCA)-approach the social aspects of the wood production so far have not been thoroughly assessed concerning their potential integration.

**European relevance and collaboration:** Social assessment includes employment, working conditions and qualifications as well as health and safety aspects. These issues are important to ensure safe and healthy work places for European citizens in the future. The wood industry – not only in Europe – did/does have some serious challenges, especially regarding accidents. However, from a European perspective it is not enough to only consider these single numbers, but an improvement should on the other hand side not cause any impairment in another field of social, environmental or economic measures. This is also in Line with the aim of the EU to promote corporate social responsibility (CSR). Therefore a holistic approach dealing with all of the mentioned aspects in the different European countries is needed. Possible Research Groups are: • National Board of Forestry, Sweden • University of Stuttgart, IKP, Dept. Life Cycle Engineering • Finnish Forest Industries Federation • Timber Trade Federation (TTF)



### ***4.1.7 landscape and woody plants for energy***

**Positioning:** Applied

**Short Description:** Increasing area of abandoned agricultural land with natural succession of woody plants changes dramatically the scenery of landscapes and nature protection values. Public perception of these changes is negative but public funding to maintain the character of the landscape is likely to diminish. Using the natural regeneration of woody plants on those areas, combined with partially enriched plantings, to produce materials for bioenergy in short rotation could essentially contribute to keep the patchiness of the landscape and at the same time to provide a valuable product. Natural succession composition, harvesting techniques, population of rare species, but also socio-economic effects such as income to local people and public perception of the landscape has to be studied on test sites on a European scale.

**Justification:** The results and innovative techniques will possibly enable a balanced and cost-efficient landscaping in a multifunctional way. At the same time local bioenergy factories can be based on an extended supply of a scarce resource and income for employers will be generated along the production chain to counteract the loss of population in rural areas. Also the impacts on the environment are predominantly positive. As the effectiveness and utility of using abandoned agricultural land for woody energy plants are very much site dependent and at the same time directly determined by the socio-economic and legal frame a broad variety of situations throughout Europe have to be taken into account.

**European relevance and collaboration:** The demand for energy and the use of woody biomass for energy will most probably increase throughout Europe. At the same time landscape protection is an important issue emerging in many European countries. There are many research groups in Europe working on different ends of the problem (bioenergy, energy plantations, harvesting technique, landscape management, rare species protection, economic situation and rural development etc.). What is needed is a cooperative effort to bring these ends together for an integrated, transdisciplinary approach.

#### **4.1.8 Conservation of painted wooden panels from European cultural heritage**

**Positioning:** Applied

**Short Description:** Artistic paintings performed on wooden support require special care because of the effect of hygrothermal conditions of the movement of the wooden substrate and resulting deformation of the paint layer. Inappropriate conservation techniques of the 19th century followed by the wide-spread of temperature control in buildings in the last decades have often resulted in dramatic damage. The wood-workers and cultural staff involved in conservation operations are in high demand of technical help from wood scientists to rationalize their decision regarding modification of frames, or condition for allowing movement of paintings or public access. A multidisciplinary approach is required to address this type of problem: structural mechanics of the wooden support, physico-chemical analysis of the paint layer, conservation issues. The projects consider the development of numerical tools based on simplified finite-element analysis of the hygrothermomechanical behaviour of asymmetrically painted wooden panels. Validation can be done through non-destructive observations of real paintings and more extensive experimentation of imitations.

**Justification:** The considerable added value of this type of wooden products motivates a considerable scientific input taking advantage of the latest advances in the field of wood mechanics, especially the hygromechanical couplings, ageing processes, crack propagations analysis. The benefit for wood scientists lies in the prestige often associated with the handling of such problems, but also in the increased knowledge on the long-term behaviour of wooden structures that can result from such studies.

**European relevance and collaboration:** The issue concerns major European museums and organisations responsible for the conservations of historical buildings, where wooden painting can be found. Often the research is performed locally but would benefit from co-operation of involved laboratories.

#### **4.1.9 Social network determinates of organizational inquiry in forestry**

**Positioning:** Basic

**Short Description:** This research issue considers how different features of informal organizational structures affect organizational learning in forest industry organizations. By using social network analysis and an organizational learning inventory instrument, we investigate relational and formal characteristics that facilitate knowledge utilization in forest industry organizations. The research is dedicated to helping forestry organizations improve performance through better knowledge transfer and enhanced learning processes. The analytical model in this research will relate organizational learning and social network characteristics. Data on social network information and organizational learning will be collected in case studies through surveys and interviews.

**Justification:** Increasing market globalization, the complexity of linked economic relationship structures and modern information and communication technologies have led to radical changes in many sectors of business and social life. Knowledge is increasingly becoming recognized as a critical resource in many fields of endeavours, yet its importance in the forest sector is undervalued. The forestry industry is subject to changes from many different sources, which are characterized by an increased mechanization and capitalization, and the increasing pressure of competition through internationalization and globalization. This leads to the requirement for improved productivity. One important step in this direction is to focus on knowledge utilization and learning in forestry organizations.

**European relevance and collaboration:** Work environments of the 21st Century place people in an information-rich world. New technologies and new information come to people every day. Organizations and their members need to deal with the changing environment in order to live well in the world. The research programme sets out to develop a Europe of knowledge and thus better cater for the major challenges of this new century.

#### **4.1.10 User centered design of interior wood products**

**Positioning:** Applied

**Short Description:** Project aims at identifying: a) information needs related to designing and deciding about interior wood products b) decision making and material acquisition practices c) preferences concerning such products. Research methods: survey and interview based documentation of design and decisionmaking practices and participatory design sessio. Carried out in three european areas: Scandinavia, eastern and western central Europe.

**Justification:** Results: requirements for interior wood product design, product and customer needs information and new delivery channels Information can be used as basis for implementing new design practises into the wood industry.

**European relevance and collaboration:** As the end-product markets of interior products are global should the information be gathered within different European market areas. Marketing, design and social sciences orientated research groups could have a key role in the implementation.

## **Sub-area 4.2 Values and perception**

### **4.2.1 Preference studies on wood products**

**Positioning:** Applied

**Short Description:** It is to see which factors influence peoples preferences and appreciations of wood products. It include sensory and aesthetical aspects, but also preferences with regard to origin, service, env. labeling. The approach involves using accepted methods from marketing and from the psychological and behavioural sciences. The correct methodological approach should be emphasized Data could be collected through surveys and panel studies etc. It would be an advantage to conduct international comparative studies.

**Justification:** It would assist in implementing a greater conciousness about the final consumer in the otherwise too "production-oriented" European wood industry. The results could be used indirectly in product development. In some case maybe even directly. Development of methods for consumer-led product-development.

**European relevance and collaboration:** The problem of marketing of wood products and communication with consumers is a common European issues. Europe's wood industry (including building sector) is also an important exporting sector. The European scope would facilitate international comparative studies and enhance the methodological relevance of the study by involving research parties with complementary and specialist knowledge.

## **4.2.2 Landscape effects of energy woods - conflict potentials and acceptance**

**Positioning:** Basic

**Short Description:** Expanding the production of energy wood may impact to a greater or lesser extent on the cultural landscape. The shape of the landscape varies depending on the production system, the (spatial) dispersion of energy woods, and their integration into the greater landscape; say on the production management. However, the public's perceptions of the newly composed shape of the landscape will decide on whether the expansion of energy wood production gains the acceptance of the public or not. Landscape changes implicate conflict potentials that may lead to considerable economic costs if appropriate conflict resolution strategies are not successfully implemented. Hence, research is needed in order to find forms of energy production which gain the acceptance of stakeholder and other affected groups and minimise economic conflict costs. The scenario method is an appropriate instrument to display future shapes of the landscape and to provide a basis for decision-making. Based on an acceptance analysis perceptions and the public acceptance of energy wood production and its impact on the shape of the landscape can be revealed. These research methods are particularly qualified to be employed in an international context as differences in perceptions and acceptance between several countries can be elaborated.

**Justification:** One of the main targets of the EU's energy policy is to increase the share of the renewable energy sources to 12% by 2010. In order to successfully embark on this strategy research is needed not only on technical innovations, but also on the human and societal dimension. The proposed research topic reveals preferences of the public what kinds of landscapes are preferred and how energy woods may be integrated in a societal appreciated shape of the landscape. This knowledge provides the basis for further research activities as well as for product development in order to implement appropriate management strategies for energy wood production and product innovation.

**European relevance and collaboration:** Perceptions of energy wood – like of all management measures – differ between countries because of cultural differences and institutional weighting of wood policies. The experiences of different European countries can build the starting point for future strategies of increasing the acceptance of energy wood production. Research is engaged in analysing perceptions and appreciations of nature by the public and different stakeholder groups. While the scenario method is applied to a certain degree in landscape research, to our knowledge there do not yet exist any studies on the perception and acceptance of energy wood and biomass production. The innovative approach of the proposed topic is the combination of an instrument of strategic planning with empirical social research. Research can be based on conducted acceptance analyses of nature conservation strategies and recent projects on sustainable impact assessment of different land-use forms and policies which are financed by the EU 6th framework programme.

### **4.2.3 Customer Perception of Wood or Wood based Products Surfaces**

**Positioning:** Applied

**Short Description:** Marketing strategies will more often direct appeal to human senses. Therefore it is necessary to know, what customers perceive or feel, when they get in contact with wood or wood based materials. Up to now, many factors in this perception process are not researched. So the effects of the material on the receptors of the different senses should be examined in field research or in laboratory situations.

**Justification:** We assume, that customer's perception is different in the various culture areas in Europe. Innovation processes and new product developments in the industry could better meet the requirements and perceptions of the customers. The better understanding of customers feelings and needs create a competitive advantage in the markets. The fit of wood products to the articulated or unconscious needs of customers creates a value added for both partners in the buying process. So the results of this research could improve product developments and marketing strategies with better information for market segmentations.

**European relevance and collaboration:** As we assume, that the perception of customers is different culture areas in Europe, the determination of the shared and divided preferences of various culture areas could be done best with the knowledge of local habits and requirements in the surrounding of the research. So a network of local partners would be the ideal form of organisation. Research groups in the fields of market research, psychophysics and surfaces of wood and wood based products could play a key role in this research.



#### ***4.2.4 Leading concepts of woodland nature by different stakeholders in the EU and their social relevance***

**Positioning:** Basic

**Short Description:** Up to now the relation between the (scientific and public) perception and understanding of woodland nature on one hand and forestry or woodland management on the other hand is not understood. Due to differences in cultural meaning of woodlands and tradition in forestry a broad range of leading concepts is to be assumed at different actors and stakeholders in the various European nations. Needed is (especially) qualitative empirical data on various EU nations (comparison studies) but also on common interests and differences in nature relation, i.e. perception, reflection and understanding of wood natures, the herein hidden normative and social relevant implications and their influence on managing concepts and their acceptance.

**Justification:** To detect the included social concepts and values in woodland management concepts of stakeholders will offer new perspectives on arrangements for public participation and discourse on woodlands management concepts, on the understanding of the function and connection between social and natural aspects and therefore on the possibilities for changing the relation between nature and society.

**European relevance and collaboration:** The sustainable management of natural resources is not ending at national borders. Basic knowledge about social conditions for acceptance, ignorance or refusal of management concepts is needed in all European countries and should be analysed on developmental possibilities for common strategies to change the attitude to woodlands in cooperation with stakeholders due to the sustainable development approach.

### **4.2.5 Urban Wilderness in Central Europe. Concepts, Projects and Perspectives**

**Positioning:** Applied

**Short Description:** Focal question: Contribution of the wilderness approach to urban woodlands to public perception/Understanding of nature and acceptance of wilderness, to support biodiversity and ecological performance of woodlands and to create a new professional habitus of foresters or wilderness managers. State of the art: National efforts to "create" or allow wilderness in urban / suburban woods. Impact on forestry, economic and working situation (change in staff, in professional skills, in economic demands and success). Socioeconomic analyses and analysis of ecological performance (biodiversity,ecosystemic parameteres)

**Justification:** Results will show the actual situation in Europe (description of the present urban woodland wilderness, of the cultural conditions and backgrounds leading to the performance, public understanding and social acceptance of such areas...); results will show, wether urban woodland wilderness could serve as spezific nearby recreation regions in the understanding of "wilderness learning centres" and their sustainable economical, social and ecological utilization.

**European relevance and collaboration:** The wilderness understanding and the amount of wilderness regions in Eurpe are different due to geographical conditions and population density. It should be interesting to get an idea of europeanwide urban wilderness amounts, the national specifities and the possibilities of mutual benefitting from experiences.

#### **4.2.6 Measurement of biodiversity**

**Positioning:** Basic

**Short Description:** Biodiversity is a central concept when use of forests is discussed. However, the concept is only vaguely defined and this may lead to major misunderstanding. Biodiversity is a multifaceted concept (genetic/species/ biotypes; geographical scale; in relation to "natural state") and thus quantifying it with small set of characteristics is not plausible. The concept should be analyzed from measurement information theory point of view where entropy is a measure of disorder/diversity. This research would consist of conceptual analysis and systematic development of measuring methods for finer aspects of biodiversity. One basis for measurements are digital images (not in genetic biodiversity).

**Justification:** This research would explicate the concept of biodiversity for stronger basis of political discussions. The aspects of biodiversity made measurable would systemize the analysis of the impacts of actions (political, industrial, technological) on biodiversity.

**European relevance and collaboration:** The concept of biodiversity has different aspects in different environments and thus a pan-European approach is a necessity. The research consortium needs to have groups with backgrounds in biology, information theory and measurement technology.

#### ***4.2.7 Identifying, communicating and promoting the sustainable potentials of wood***

**Positioning:** Applied

**Short Description:** Wood has always been in focus during political discussions on “Sustainable Development“. This product group offers many advantages concerning environmental, economic and social aspects. Nonetheless, at present, only specific products are assessed regarding their environmental impact. The complete picture is missing. An assessment to identify and communicate the possible environmental advantages and potentials of wooden products and their economic and social impacts has to be carried out Europe-wide and on a scientific and reliable basis. Initially a market analysis of wood products and their corresponding material flows must be carried out to identify application fields and quantify relevant flows and products. The most important competing products need to be characterized and evaluated regarding their relevance. In order to assess strengths and weaknesses of the relevant products and their competitors, a characterization of their technological and economic criteria will be the next step. Only then can the respective ecological performance analysis be conducted in a purposive way since only then will it be representative, close-to-reality and relevant. This leads to final guidelines addressing the relevant products and not niche products. A subsequent detailed analysis of selected wood products will present optimization potentials over the life cycle of the products.

**Justification:** This project combines and evaluates knowledge of the different disciplines of wood products and their competitors (economy, technology, environment and social aspects). This enables the channelled promotion of wood products to areas where they are of high importance for sustainable development and where the benefits in sustainability are greatest due to their relevant market volumes. Aim is to assess the sustainable market potentials resulting from a shift from non-wooden products to wooden products and from the increase in demand for wood products. It will deliver guidelines for companies active in the wood product market or other (political) actors interested in market potentials. The study supplies the most important arguments for a target group oriented communication. The holistic approach of determining environmental as well as socio-economic impacts over the life cycle, allows the realisation of product-specific information for each individual product. A comparison with other products with the same function provides arguments for advantages and disadvantages and identifies optimisation potentials. This research approach is only possible with an integrated co-operation between science and economics/industry. With the early involvement of partners from industry, trade and politics and the subsequent guaranteed expansion of the project results, the sustainability of this approach is ensured.

**European relevance and collaboration:** EU-wide a multitude of different environmentally political frameworks, promotion concepts and incentive programmes on national levels do exist. In most cases, little is known about the interaction with other environmental policy objectives. Objective information regarding potentials towards sustainability in relation to the respective market is not only in demand in Germany,

where a project is currently underway, but is also creating great interest in the rest of Europe. It appears necessary, to carry out similar studies in other EU-countries since the market shares and volumes of wood products differ significantly between them. The study enables future activities to be focused on areas with high sustainability potential. Within this study, the results of the COST E9 "LCA on Forestry and Forest Products" will be referred to, through which a scientific platform on sustainability questions along the forest-wood chain is already available and partners play a key role in this work again.

#### ***4.2.8 Lifestyle-changes and future economic potentials for wood products***

**Positioning:** Applied

**Short Description:** The differentiation und pluralization of lifestyles has resulted in a highly differentiated market for nearly all consumer products. Marketing studies show that changes in lifestyle will have far reaching consequences for housing and furniture demands and accordingly for the demands for timber and high class wood for furniture and other products. This is even true for the demand for firewood and wood products for energetic use. Furthermore, it is to be expected that the acceptance of new wood products strongly depends on lifestyle. Thus, for reliable prognosis for the future wood market a detailed analysis of attitudes and preferences of the different lifestyle groups and their future development should be made. For such an analysis the Sinus milieus could act as a suitable basis, since they take into account all dimensions of the social situation as well as value orientation, lifestyle, and aesthetic preferences, have been used in many marketing studies, and are used in a current study within the German Sustainable Forestry-Research Program. A suitable method to determine attitudes relating to wood and wood products are milieu specific focus groups.

**Justification:** The aim of the proposal is a prognosis of the future development of lifestyles and the consequences for the demands for wood products that at least in the private household sector strongly depend on lifestyle patterns. The study thus would give valuable information for the development of wood products and their economic potentials.

**European relevance and collaboration:** The wood market to a large extent is a transnational market. The processes of the differentiation und pluralization of lifestyles can be observed in all European countries with strong common trends but also with developments, that are specific for individual countries. The Sinus milieus are available for several European countries. In addition, there is a supranational Everyday Life Model ("Meta Milieus") available both for Western Europe (Austria, Belgium, France, Germany, Great Britain, Italy, Luxembourg, The Netherlands, Spain, Sweden) and for Central / Eastern Europe (Bulgaria, Croatia, Czech Republic, Hungary, Poland, Slovakia, Slovenia) which is based on empirically validated national Lifestyle Models. European research groups that could have a key role in the implementation of this research are: Sinus Sociovision (based in Paris (F) and Heidelberg (D)), ECOLOG-Institute for social-ecological research (based in Hannover (D)); studies on milieu-specific consumption patterns and communication strategies).

#### ***4.2.9 Wood products for an economic growth and climate change mitigation***

**Positioning:** Applied

**Short Description:** Carbon fluxes in the forest sector can be influenced directly by carbon stock changes in forests or forest products, and by substituting bioenergy for fossil fuels. They can be influenced indirectly by using wood products in place of more greenhouse gas intensive materials and products, such as steel, aluminium, concrete, etc. The aim of the research is to establish the importance of wood as a substitute for other resources to mitigate climate change and to increase economic growth, and to understand the implications of such substitution by integrating engineering, natural and social science perspectives on the subject.

**Justification:** The wood substitution allows for a viable transition towards a society that is less dependent on energy and material resources that cause higher greenhouse gas emissions. Such a transition will improve the competitiveness of forestry industries and improve the market conditions for wood-based products. However, analysis of wood substitution is a very complex issue, since the underlying system is complex. The influencing factors can be found along the entire wood chain; they include several industries, socio-economic and cultural aspects, traditions, cost dynamics, technical and structural change etc. Research in this field is also still quite limited. Furthermore, the prerequisites for wood and biofuel substitution are also affected by climate change. Hence, we have to improve our knowledge about how to consider effects of climate change in forest management practices.

**European relevance and collaboration:** A viable transition towards a society that is less dependent on energy and material resources that cause higher greenhouse gas emissions is of general importance of Europe. Fruitful research in this area requires cooperation among several research groups in Europe. Here, only a few examples of groups are listed. Department of Ecology and Natural Resource Management, Agricultural University Norway; Finnish Forest Research Institute, Finland; Institute of Energy Research, Joanneum Research, Austria Utrecht University - Copernicus Institute for Sustainable Development and Innovation - Utrecht, The Netherlands

## **Sub-area 4.3 New business models**



### ***4.3.1 New innovative business concepts for SMEs in the wood processing industry***

**Positioning:** Applied

**Short Description:** The main aim of this is to strengthen the business concepts of SMES in the wood working industry. The basis for this area are R&D oriented concepts that will be developed e.g. from research projects (spin-offs).

**Justification:** New business concepts, better knowledge/information platform in SMEs

**European relevance and collaboration:** Information exchange / export oriented business

### ***4.3.2 Construction of multi-storey timber houses, business and process development***

**Positioning:** Applied

**Short Description:** The goal of the research project is to develop models and methods to strengthen the business- and process development in the industrialised building of multi-storey wood houses, as well as methods to ensure continuous learning from project to project. The following research questions will be answered: How can coordination between the wood component and building industry be achieved so resource-limiting method development take place? What demands do economically stable business models place on suppliers? How can methods documenting the experiences of demonstration building be developed further to increase learning? The theoretical focus on business and process development and learning between projects makes the efforts of research interdisciplinary where the object of research (the demonstration project) provides a focal point for theory building regarding the integration of technology, market and organisational development. From our point of view the concept of business- and process development is the bridge between timber frame/construction technology and market. Business development is studied in terms of “the value constellation”. Our view of development is influenced by “lean thinking” – a resource-limiting philosophy. Research to develop the above methods and models is built on the “multiple case” methodology in the form of demonstration projects, i.e. real construction projects.

**Justification:** A concept for multi-storey construction of timber frame houses is by VINNOVA pin-pointed as important to achieve a wood-products innovation system. Development of industrialised (lean construction) systems will act as a catalyst to achieve cost effectiveness and sustainability, generally speaking, in construction. However, house building activities, requires the integration of all elements and components of a building and actors/members in the supply chain i.e., the developer, the builder, the contractors and the timber frame suppliers. The research will focus on finding and adapting methods to apply and integrate supply-chain control and lean construction to the building and wood industries. Distinct advantages of a industrialised multi-storey housing concept to achieve better economics, business economics and environmental impacts are: Timber frame construction is cost effective and a systematic development can help to decrease the building costs further; timber has excellent prefabrication qualities making prefab. systems easily manufactured with a higher control (moisture, tolerances, transportation) than any other building material; practical experiences indicate that the working environment is increased for timber frame construction (i.e., the conditions are improved for the construction personnel); a lean philosophy is elsewhere shown to be a tool to achieve efficient process and production innovation processes.

**European relevance and collaboration:** During the 60s and 70s, the production-focused and non-customer oriented systems building approach was developed and used in European countries like Sweden and Great Britain.. However this form of industrialisation was not successful from a socio-economics perspective. The whole European house building sector is affected by the present debate around economic,

environmental and social sustainability in the society and is discussing and evaluating technological changes in supply and production methods. The solid wood value chain is a large supplier of products and services for the European construction industry, approximately 70 % of total sawn timber production are used for constructional purposes. The European house building sector produces about 1.7 million apartments per annum. Successful implementation of new innovations (i.e. multi-storey timber frame housing) depends on factors which are often nationally or regionally defined why an European perspective and involvement is crucial.

### **4.3.3 Innovation of the forest-based sector by integrated rural development**

**Positioning:** Applied

**Short Description:** Integrated cross-sector development is the major strategy for rural areas in Europe. The basic idea is that all sectors cooperate closely together in developing the region. The cooperation is done by joint cross-sector programs, new cross-sector institutions comprising state and private institutions and civil society and integrated financial support. New governance instruments are used to integrate stake holders from different sectors and different levels. The expectation is that integrated development will foster additional innovation which cannot be developed by a insulated sector. The research theme is whether and how integrated rural development can foster the transition into a sustainable market and a knowledge driven forest-based sector: - Scenarios of the short and long term, linkages and contributions of the forest-based sector to different types of rural areas - Cross-sector potentials of the forest-based value chains - Options for an active role of the forest-based sector within rural governance - Multi-level political strategies for fostering forest innovation by partnerships of stakeholders from private, state and civil society within integrated rural development  
Methods of research: 1. Basic analysis and scenarios: - National case studies in the potential for innovation of the forest-based sector by integrated rural development - European wide comparative studies in the potential for innovation of the forest-based sector by integrated rural development  
2. Pilot projects in implementation - Joint development and implementation of national strategies for the forest-based sector within rural development - Joint development and implementation of international strategies for the forest-based sector within rural development  
3 Evaluation reports of the progress of the forest-based sector within rural development - Scientific evaluation reports - Communication with the national and international stake holders of the forest-based sector and rural development

**Justification:** Integrated rural development is a most promising strategy to strengthen the contribution of the forest-based sector for consumers as well as for society, environment and energy demands. The cross-sector integration is aimed to open additional potentials for the competitiveness of the sector. Enhanced cross-sector cooperation with all stake holders in rural areas will improve the locations for all business activities of the forest-based sector where it is most important, namely, in rural areas Bringing the development strategies for rural areas and for the forest-based sector together will create a reasonable potential to improve the economic and ecological situation in rural areas throughout Europe. The project contributes strongly to the priority of the EU to develop rural areas.

**European relevance and collaboration:** Integrated rural development is an important issue for most European countries. Nevertheless the concepts are highly divers and the potential to learn from other countries is very high. Additionally integrated rural development is a priority strategy of the European Union and needs a common concept which can only be developed by a joint research effort. A key role in the research could have the group "Integrated Regional Development" at the Unviersity of Göttingen

Collaborative shaping of Research Agendas in WoodWisdom-net  
Workshop Feb 14 2006: New value added products and production  
Solicited issues

([www.modellregionen.de](http://www.modellregionen.de)) (2005-2006) and the international group of the European Union  
(STREP): New Modes of Governance for Sustainable Forestry in Europe (2005-2007).

#### **4.3.4 Business development and innovation through new manufacturing concepts**

**Positioning:** Applied

**Short Description:** Dynamic and flexible responsiveness to new market needs, ability to introduce and implement innovations quickly will be key success factors in the competition between different industries. This needs to be a design criterion for future manufacturing concepts. The EU is today the global technology leader throughout the fibre based value chains but the existing technology has definite handicaps. The pulp, paper and converting value chain is very capital intensive. The present technologies have lead to very large production unit sizes. New machines tend to operate within a very narrow window with little flexibility to produce different grades or to take advantage of market swings or emerging technologies. The result is a value chain that is inflexible, causes long transportation distances and warehousing between processing stages. This increases investment and manufacturing costs and risk in exploiting emerging technologies. New production concepts that facilitate introduction of new technologies and enhance/support product and process innovations are needed. Also smart logistics systems are needed to counteract the negative environmental and economic impacts of transportation.

**Justification:** Paradigm for high integrated development and production networks (enlarged value-chain integration, local industry network concepts, life-cycle and overall efficiency assessment, data-networking..) Adapted and optimised scale of production units (degree of integration of production processes, decreasing specific capital intensity, adaptation to material supply and consumer needs, transport ..) Flexibility and modularity of production units (operating window, time-to-market, efficiency) Simplification of units and stability of processes (on-site-additive production, maintenance, man-machine-interface)

**European relevance and collaboration:**

### **4.3.5 Strategies of forestry contractors coping with structural change**

**Positioning:** Applied

**Short Description:** The overall research objective of this project is the development and implementation of new business models for forestry contractors in European countries for the reason of competence development to improve entrepreneur's competitiveness in the forestry-wood-chain. Forestry contractors need competences to meet the actual requirements on work performance and business development. Competence development will improve the competitiveness of forestry contractors to cope with current problems. This leads to the following objectives: (1) Forestry contractors will cope with competence development through new business models. (2) The share of SMEs in the added value on the forestry-wood-chain has to increase. (3) Factors, contributing to the improvement of the market position and economic integration of SMEs will be identified. (4) The attractiveness of the job needs improvement. Projects need to be based on a participative research approach. Forestry entrepreneurs will be partner in this project to ensure valid development and evaluation. It guarantees access to active SMEs in the forestry sector in the different regions, problems are detected and reported from bottom to the scientific level and during piloting innovative business models results can be discussed immediately.

**Justification:** Knowing that the phenomenon of continuous changes and the need to cope with new situations in a best possible way, SMEs have to find solutions to meet these new demands and challenges. Therefore the approach of new business models needs to be successfully developed and introduced in forestry harvesting and logging SMEs. New business model is the innovative mechanism by which a business intends to generate better value or revenue and increase their profits in a social and sustainable way and at the same time a tool for competence development. It is a summary of how an enterprise plans to serve its customers, namely forest owners and fortified wood processing industries. Such new innovative business models will be developed, piloted and evaluated within this project. It involves both strategy and implementation.

**European relevance and collaboration:** The Ministerial Conferences on the Protection of Forests in Europe (MCPFE), starting in the 1990s in Strasbourg and its follow-up conferences in Helsinki, Lisbon and Warsaw highlighted the need to manage forests in an ecological, economical and social way. Therefore, forestry needs competent and viable work. Trends in Europe show an ongoing shift towards forestry contractors carrying out the work during the last two or three decades. In many countries throughout Europe the forestry sector has been moving backwards in terms of skill levels, work safety and health, working conditions and work quality. Lack of qualified entrepreneurs and workforce might be the most crucial barrier for competitiveness of forestry and forestry based industries in Europe. Research groups from all European countries should participate in order to collect various samples for benchmarking and to transfer experiences and results to other countries.

### **4.3.6 Developing sustainable future markets for wood**

**Positioning:** Applied

**Short Description:** The main objective of this research activity is the identification and development of sustainable future markets for wood in Europe. Suggested approaches to exploit market innovations are network cooperation and customer integration concepts. These approaches will eventually enable the European forest and wood industry to enter sustainable future markets and drive business towards higher competitiveness in the international markets.

**Justification:** The European forest and wood industry is situated in an economic crisis which demands structural change and innovative approaches for sustainable development. Side effects are the difficult profit situation for small and medium companies but also their need to increase the efficiency within the forestry-wood-chain. The need to identify and explore future markets as well as to comply with sustainability standards in the product chains earmark the current business situation. Furthermore, the use of wood has in a number of applications compared to other materials some advantages regarding the sustainability implications, i.e. regarding social and environmental effects. On this background research is needed that investigates and provides market innovation processes in the forest and wood industry. This type of research could contribute to the improvement of competitiveness of and employment by the European forest and wood industry.

**European relevance and collaboration:** The research regarding the development of sustainable future markets for wood has just been started in Germany. At the European level there has virtually no research done in this area. However, the similar and interlinked market condition within Europe require a research activities at the European level.



### **4.3.7 Do different Corporate Cultures in Forestry Organisations affect their function?**

**Positioning:** Basic

**Short Description:** Recently, new tasks have been added to the traditional tasks of the German and other European forestry services. These include the function as an intermediary between the forest and the society. For this, the service will need a new sensitivity for modern social perceptions, ideas and developments in a national and international context. The German Forestry Service is, compared to other European forestry services, strongly affected by the traditions and ideas of military, hierarchic and bureaucratic organisations like the armed forces or the Prussian civil service. It can be questioned, whether the German forestry service is equipped for the new tasks. We propose that the service will need more and different competences and a reorganisation of its corporate structure to perform the new tasks.

**Justification:** The corporate culture of an institution is the universal set of the commonly shared, conscious and preconscious perceptions, values, ideas, patterns of thought and patterns of behaviour. Thus, corporate culture is extremely effective in manipulating the perceptions, thoughts and behaviour of organisations and their members. We assume that the corporate culture of German forest services is highly effected by tradition and therefore these services show a low tendency to perceive the changing (needs of the) society, social developments and other trends. Thus, this corporate culture is more an obstacle for exchange than a intermediary between forest services and society. Consequently, the service acts autonomously and is dysfunctional towards new challenges and dynamic changes in society. The assumption will be verified by describing and analysing the origins of the corporate culture in the German forest services, its function in the structure of the service and its impact on the functioning of the service. The results of this study will be used to compile tools and recommendations for the reorganisation of the German forestry service, therewith leading to an improved functioning of this service in view of its new tasks.

**European relevance and collaboration:** The increasing significance of a common European policy towards forestry issues (e.g. FFH guidelines, Natura 2000 Initiative, certification of wood and wood products, Kyoto Protocol and Process) will inevitably have an enormous impact on the function and structure of the national forestry services. They will have a key role in the design of a structural and socio-economic framework for the realisation of an European-wide sustainable forest economy. Therefore, the integration of the national forestry services in a wider European network is inevitable. The integration process will be greatly aided by a thorough understanding of the individual national corporate cultures. Research groups also working on this or on related topics are situated at the forestry/environmental departments/faculties of the Universities in Vienna/Austria, Wageningen/The Neatherlands, Florence/Italy, Bangor/UK, Nancy/France, Zurich/Svizerland and at the EFI, Joensuu/Finland.