Collaborative shaping of Research Agendas in WoodWisdom-net

RESEARCH AREA 2 Biorefinery concept for efficient utilization of wood raw material

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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 therby limiting the applications of the timber and making it difficult to add value to the product. The reason for the refractory natue of the wood is in the anatomical structure of the timber and novel reasearch 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 inductrial scale.

Justification: If this technology can be sucessfully 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 ogf the newer more environmentally acceptable wod preservastion 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 anty 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 develope 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 matierials with new properties and inproved 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 shor-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 word, 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 hydrophibic 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. 3) 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 ingression; 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 mollecules, in particular hemicellulsic 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 characterize by cycles of pression 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 competitivity of wood material compare 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 developped (lower energy cost, lower polution).

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. Reniewed 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 performace values for EuroCodes and safety targets for timber structures. Attractive, slim and competive 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 competitivess 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 - reniewed production processes - posibility 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 begin 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 actities.

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 circum-stances, 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 coat-ings 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 ap-plied 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 hygri-cal 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 appli-cations. 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 m³ 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 collabora-tion 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 begin products, especially pharmaceuticals and food additives, from easily available wood precursors such as á- pinene, hydroxymatairesinol and levulinic acid. A new way to separate sulfur free á- pinene from saw mill volatiles will be explored. New chemical and biochemical options to transfer á-pinene to geraniol, citral and ionones and further to medically active compounds and vitamines (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 brances. 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.vitamines and antioxidants from wood. This is because some of the key precursors such as á- 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

(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 an 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 compunds play a key-role in tree defence againts 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 initia-tives 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 prod-uct 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 syn-thetic, 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-

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.

2.1.24 Measuring, characterizing and bucking wood with logging machines

Positioning: Applied

Short Description: The project prosposal 3.1.28 wwill 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 acccepted 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 furhter 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 prerequisits 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 possibities 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

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 Iinstitute 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 reletively well know, 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, analysisng chances for new business opportunities and development of new business concepts.

Justification: With this research, new knowledge based entreprenurship 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 disperse 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 technics?

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 wide-spread, 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 contend 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. Fore 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 legistlation, 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 begin 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 actities.

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, CO2-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 utlisation 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 CO2 in secondary material streams, their modification possibilities and reusability in vari-ous processes. The idea behind the approach is to recycle CO2 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 fomaldehyde 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 Kioto Protocol.

European relevance and collaboration: CO2-problem is hot topic today, less CO2 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 Assess-ment) 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 CO2-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 CO2-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, IVALSA, 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 potiential 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 CO2 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 achive 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 every-day decision processes.

2.4.5 Identification of the best wood-based strategies for achieving CO2-neutral mobility

Positioning: Applied

Short Description: Region specific strategies for short-term implementation of CO2 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 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 CO2 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 promising step towards CO2-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 CO2-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 wxood 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 view 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 with out 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 in-efficient 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 affects on 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 an paper production

Positioning: Applied

Short Description: Improvements are needed both in energy generation and energy consump-tion in pulp and paper production. CO2 emissions from production need to be further reduced and the use of renewable and CO2-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 en-ergy and material management in all manufacturing stages and by integrat-ing the benefits of strategic energy management and technology develop-ment by optimum integration of less energy consuming and energy recovery technologies.

Justification: • Substitution of energy intensive process steps by innovative less en-ergy 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 tech-nology) • 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 CO2 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 Paecillomyces 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.)