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Sustainability Impact Assessment of the Forestry - Wood Chain

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EFORWOOD

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1. INTRODUCTION (responsible: BRE)

This report is part of an EU project called EFORWOOD, which aims to provide methodologies and tools that will integrate Sustainability Impact Assessment of the whole European Forestry Wood Chain (FWC). This deliverable has been produced by Module 4, which focuses on the processing and manufacturing stages of FWC in Europe. This output follows on from PD 4.2.5 *Report on conditions and consequent timing of technological developments*. The report continues with the same structure and core information as PD 4.2.5. The focus and add-on in this report is regional variation of each technology as well as obstacles and conditions which the technologies adoption is dependent on. This report has also streamlined the existing content editorially into a common format. There is a planned sequel for this report in a few months time that will reflect changes and development in relation to overall work on ToSIA (Tool for Sustainability Impact Assessment) PD 4.2.9 *Sequel to the report on conditions and consequent timing of technological developments in processes in relationship to response functions*. This report brings new views on the technologies adoption from the European regional point of view.

All partners contributed to this report based on their expertise in a particular field. The partner responsible for each chapter is shown in the heading of each section. It should be noted that this report is a non-scientific report which aims to provide methodology and tools that will integrate Sustainability Impact Assessment rather than to obtain specific scientific conclusions. There is no scope within this WP to establish a viable scientific method of estimations for future development. However, it is essential to understand the current understanding of future developments potential in order to inform other parts of EFORWOOD about the nature of manufacturing in the FWC, It is essential to put forward concerns about upcoming technologies and their particular nature to the rest of the Consortium in respect of work on ToSIA and future scenarios (as described in A1 and B2).

This report starts with a general note on drivers for change, stages of development and agreed regional representation. The main body of the report follows up on appropriate technologies as identified in PD 4.2.5. Each technology follows the same template; it starts with a brief description of the technology followed by the drivers for change for each technology including expected time and level of uptake. A series of tables is used to identify:

- stages of adoption for each technology is currently at in the different regions of Europe
- estimates of uptake of the technology up to the year 2025
- reasons for regional implementation differences
- obstacles to and conditions which the adoption of this technology is dependent on
- pros and cons of the adoption of the technology

1.1 Drivers for change

The drivers for change are the factors which are pushing the development of new technologies in order to achieve the desired improvements. The drivers fall into four broad categories:

1. Social

These drivers are related to changes in household sizes, consumer demand for specific value added products, and those which are seen as 'greener', 'more sustainable and natural', or less of a health hazard. These are mainly consumer driven. Other social drivers include health and safety on the work-floor.

2. Economic

These drivers balance costs of changes to technology against the benefits in terms of lower production costs and/or increased profit i.e. cost benefit analysis. Important elements here are reduction of waste and subsequent reduction of expenditure for disposal of any waste material, reduction in energy and increased productivity.

3. Environmental

These drivers focus on improved quality of the environment and good performance in environmental indicators as used by EFORWOOD. One of the areas of interest in this field is reduction of the use of fossil fuels and emissions to air and water.

4. EU legislation and policy

These drivers can be grouped in accordance with regulatory objectives and are often linked to one or more of the drivers above:

- Increased recycling, a target of 15% for timber and about 56% for paper
- Reduction of emissions of SO_2, NO_x, PM, VOCs, and O_3 (Ambient Air Quality Directive and Large Combustion Plants Directive)
- Limiting emissions of formaldehyde from wood-based panels

- Improving the use of wood and wood-based products from sustainably managed forests (Green (public) Procurement) (forest and wood certification)
- Prevention of illegal logging
- Increased use of renewable energy
- Waste disposal legislation

1.2 Stages of development

The development of each technology generally follows a typical sequence shown below. It must be noted that not all technologies follow this path and a technology can be rolled out in several stages simultaneously. In this report, the stages of development for each technology described relates to the following time scale for introduction:

- Research and development phase - the technology is still being developed at research level
- Industrial trials - the technology is being trailed at industry level to obtain greater understanding
- Adopted in some SME's - the technology is adopted by some companies but not the majority, it should be noted that in some cases in particular recycled paper the larger companies are more likely to adopt the technology before the small and medium enterprises.
- Generally adopted - the majority of companies have adopted the technology.

1.3 Regional representation

This report will contribute to analysis of the solid wood, pulp & paper and biomass technologies acceptance and implementation as well as further refining developments by identifying their regional (European) timing. This is to reflect the differences and similarities in the developments that are aggregated in these four regions (for pulp & paper stream). Although in some sections (technologies relevant solid wood products) only three regions are appropriate. The reasons regional variations are described in each section for each technology analysed; general differences are being elaborated on in the discussion section of this report.

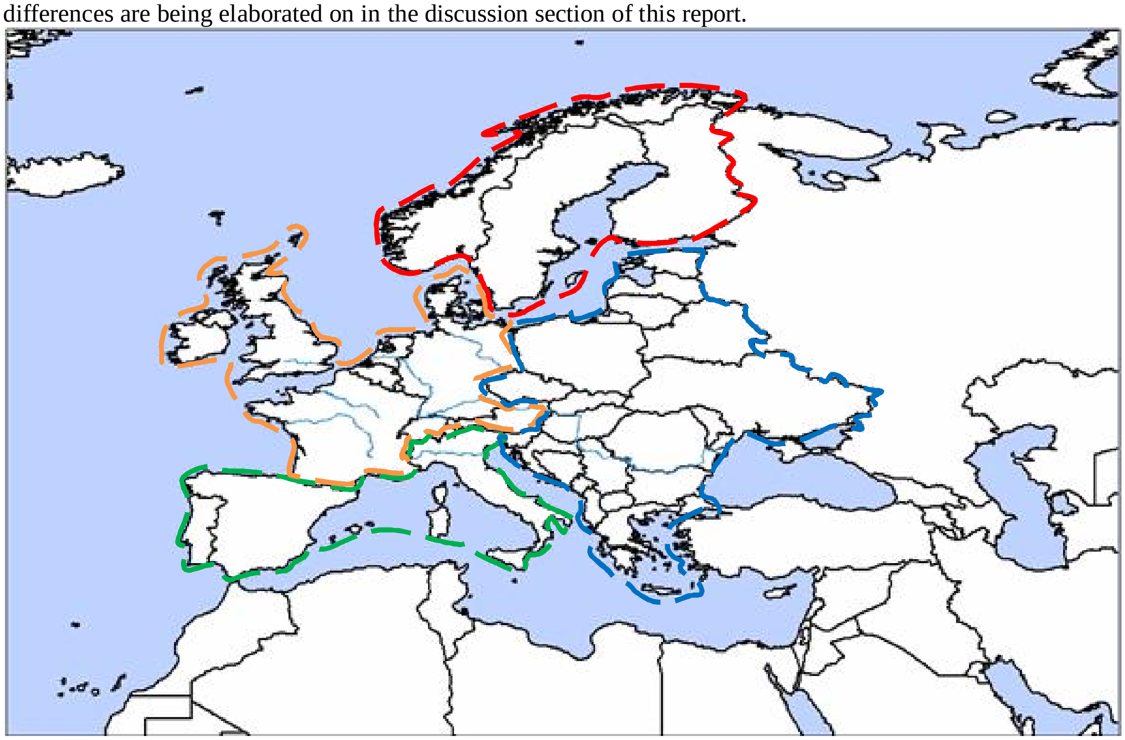

Figure 1.3 – Division of Europe area for the purposes of this report

Key		
— — — — (red)	North Europe	Finland, Norway, Sweden
— — — — (orange)	Central Europe	Austria, Belgium, Denmark, France, Germany, Ireland, Netherlands, Switzerland, United Kingdom
— — — — (green)	South Europe	Italy, Portugal, Spain
— — — — (blue)	East Europe	Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovak Republic

1.4 Keys used for drivers

For the drivers for change most of the sections have displayed these in a table format showing the applicability of each of the various drivers. With these tables it should be noted that the driver's applicability is rated between 1-5 stars with 5 being the most applicable as shown in the example table below.

Driver	Applicability	Comments
Example driver 1	*****	Most applicable
Example driver 2	*	Least applicable

1.5 Contribution to Scenario storylines

This report will contribute to analysis of the impact of technology development trends on module specific models and thus will provide a platform for PD 4.2.9 in which technologies explored here will be analysed in relation to the scenario A1 and B2.

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies.

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population, intermediate levels of economic development, and less rapid and more diverse technological change than in A1 storylines. The full description of both scenarios is in Appendix A. The storyline descriptions and any background information can also be found at www.eforwood/ToSIA/Scenarios.

2 PULP AND PAPER (responsible: KCL)

2.1 Use of enzymes

Use of enzymes in pulping processes can both reduce energy consumption in refining and/or improve fibre properties. Effects on refining were tested in pilot trials in early 2000s, and also mill scale trials were conducted shortly after that. The trials proved that use of enzymes in refining is a viable and applicable method in mill conditions, with 10-15% energy saving potential in reject refining and about 4% in total pulping system[1]. The method requires a storage tank or tower before refining, so this will cause some investment costs, e.g. for a thermo-mechanical pulping (TMP) process with daily capacity of 400t/d, the investment costs would be approximately 500000€ [1]. There have been estimations, that the maximum uptake of enzyme-aided pulping could be 20-30% by 2010, 30-60% by 2020 and 50-80% by 2030[1]. The estimated development of this technology is shown in Table 2.1.3.

When compared to traditional TMP pulping, enzyme-aided refining does not increase consumption of other chemicals, but instead decreases energy consumption and thus energy costs, and as a consequence may decrease fossil CO_2, NO_x and SO_2 emissions[1]. Emissions to water are difficult to estimate before large scale trials are complete, but there might be small increases in emissions when enzymes are used. Enzymes should not provide any threat to occupational safety and health.

The following table shows the applicability of the drivers for change with respect to use of enzymes.

Table 2.1.1 – Use of enzymes drivers for change

Driver		Applicability	Comments
Economic	Improved profit	*****	Less power bought
	Production cost savings	*****	Less power bought
Environmental	Decreased use of fossil fuels	*****	
	Reduced energy demands	*****	
	Fewer emissions and waste	***	Due to smaller electricity consumption.

The following table shows what stage of development each region of Europe is at with respect to use of enzymes.

Table 2.1.2 – Use of enzymes stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials	✓	✓		
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to use of enzymes.

[1] Kallioinen, A. Pere, J. Siika-aho, M. Lehtilä, A. Mälkki, H. Syri, S.& Thun, R. *Biotechnical methods for improvement of energy economy in mechanical pulping.* VTT Research notes 2183, Espoo, Finland, 2003. www.vtt.fi/inf/pdf/tiedotteet/2003/T2183.pdf

Table 2.1.3 – Use of enzymes future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

Central and North Europe are currently ahead in the development of this technology as can be seen in Table 2.1.2. It is expected that Southern Europe will catch up however the technology is not expected to be adopted in Eastern Europe before 2025. It would seem that as Central and North Europe are more open to new ideas there development is more advanced than the other regions. They also have more funds available to look into new technologies.

Another reason for the differences is that mechanical pulp is mainly produced in Nordic Countries and Central Europe. Less mechanical pulp is used in Southern and especially Eastern Europe. Also Energy prices have a big influence on the amount of mechanical pulping in Europe.

Conditions and obstacles

The conditions are that mechanical pulping requires certain wood species, i.e. softwood and as fore-mentioned energy prices are high and affects energy-intensive mechanical pulping processes

One obstacle facing this technology is that use of recycled fibre can decrease the consumption of the mechanical pulps, further obstacles include on the price of enzymes and energy prices as these affect energy-intensive mechanical pulping processes

The following table lists the pros and cons of use of enzymes.

Table 2.1.4 – Risks and costs to the industry from use of enzymes

Cons	Pros
Investment costs	Energy savings in mechanical pulping
	Increased efficiency
	Decreased emissions

2.2 Development of bio-refinery plants

The concept of bio-refinery is still discussed, and at present there is no common and widely accepted definition for this concept. Modern pulp mills are already bio-refineries of a sort, but if bio-refinery should include e.g. production of transportation fuels, more studies and research are needed. The time-scale for bio-refineries is difficult to estimate, but by 2025 there might be some industrial trials. The estimated development of this technology is shown in Table 2.2.3
Estimated benefits from bio-refineries are promising. New products could be produced in form of chemicals, fuels, additives, etc., bringing added value to the process. At the same time less fossil fuel would be needed, and even external energy for local consumers could be produced. The raw material requirements could be lower, so recycling possibilities could increase. The technology could even provide pharmaceuticals, so added value and social acceptance could be gained. However, these technologies would need more studies and trials.

The following table shows the applicability of the drivers for change with respect to development of bio-refinery plants.

Table 2.2.1 – Development of bio-refinery plants drivers for change

Driver		Applicability	Comments
Consumer demands	Move to greener energy	**	
	Pressure for local energy production	**	
Economic	Improved profit	***	
	Added value	***	
	Exploitation of by products	**	
Environmental	Decreased use of fossil fuels	***	

The following table shows what stage of development each region of Europe is at with respect to development of bio-refinery plants.

Table 2.2.2 – Development of bio-refinery plants stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓		
Industrial Trials				
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to development of bio-refinery plants.

Table 2.2.3 – Development of bio-refinery plants future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
As previously mentioned North and West Europe are generally more open to new ideas and have more funds available to them to develop these technologies. As shown in Table 2.2.3 South and East Europe are only expected to be in the industrial trial stage of development by 2025 whereas in West and North Europe the technology is expected to be generally adopted or very near to being so.

Conditions and obstacles
The technologies adoption is dependent on the high-quality management needed on the complicated technology. The technology also requires high funding and the new value added products from the bio-refinery will need new markets.

The following table shows the pros and cons of development of bio-refinery plants.

Table 2.2.4 – Risks and costs to the industry from development of bio-refinery plants

Cons	Pros
Investment costs	Public image of the forest industry will be improved by the green energy, chemicals and pharmaceuticals.
	Energy cost savings
	Increased efficiency
	Decreased emissions
	New and green products

2.3 Improvement of black liquor utilisation

Two black liquor utilisation technologies were presented in deliverable PD 4.2.3. Black liquor gasification has been tested in small scale trials, but large scale mill trials would require big investments (approximately 200-300 million €) and maybe 5 years of successful operation before becoming widely accepted. At the moment it is difficult to expect that kind of trial in the near future. The small scale trials have given inconsistent information about the benefits of this technology. There is also a question about safety, since the process is highly pressured and includes oxygen, so there is a risk for explosions. Thus black liquor gasification is not further analyzed in this deliverable.

Separating lignin from black liquor is more likely to be adopted in common use in the forest industry than black liquor gasification technology. Several small scale trials have been completed, and one can expect some (perhaps 5-10) mill scale trials by 2015. Depending on the results of those trials, the technology may be adopted as best practice in some point, but it is very hard to predict that before the large scale trials have been done. The best estimation of the development of this black liquor utilisation is shown in Table 2.3.3.

The separated lignin is most likely to be consumed in the same mill as energy source. Thus it would replace fossil fuels. It is also possible, that the technology would improve the profit of the mill, since adoption the technology can increase production capacity. Some demands to use more renewable energy may come from consumers or legislation, and here lignin will provide one solution, even though it is already used efficiently in pulp mills in energy production from black liquor. The technology will not be likely to affect social aspects.

The following table shows the applicability of the drivers for change with respect to improvement of black liquor utilisation.

Table 2.3.1 – Improvement of black liquor utilisation drivers for change

Driver		Applicability	Comments
Consumer demands	Move to greener energy	**	
	Pressure for local energy production	**	
Legislation	European legislation	**	
	National legislation	**	
Economic	Improved profit	*****	Increased production
Environmental	Greater use of renewable fuels	*****	
	Decreased use of fossil fuels	*****	
	Reduced energy demands	*****	
	Reduce transport impacts	**	Less transportation of fossil fuels

The following table shows what stage of development each region of Europe is at with respect to improvement of black liquor utilization.

Table 2.3.2 – Improvement of black liquor utilisation stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development Phase			✓	✓
Industrial Trials	✓	✓		
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to improvement of black liquor utilisation.

Table 2.3.3 – Improvement of black liquor utilisation future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
Central Europe and Southern Europe consume more recycled fibre than the other regions so chemical pulping process doesn't need to be developed further than it already is. Also Kraft pulping process is a traditional pulping process in Nordic Countries and the competence is therefore high there.

Conditions and obstacles
The technology can only be applied to Kraft pulping process.

The following table shows the pros and cons of improvement of black liquor utilisation.

Table 2.3.4 – Risks and costs to industry from improvement of black liquor utilisation

Cons	Pros
Investment costs	Smaller fossil fuels consumption
Safety risks in gasification?	Improved production capacity
	Increased profit
	Excess energy to local needs would increase

2.4 Changes to lime kiln technology

Improvements in lime kiln technology aim mainly at decreasing air emissions and increasing efficiency of the process. Improved technologies will be adopted depending on the need for new equipment. If technologies can be applied with old machinery, they will become widely accepted sooner than in cases where totally new machinery is needed. It is estimated that the technology will be adopted at some scale by 2025 as shown in Table 2.4.3.

Legislation will affect the rate of adoption of the technologies when in addition to CO_2 other emissions to air are controlled more strictly. Improving efficiency of the lime kiln will enable savings in production costs and improve profit. Improvements in the lime kiln technology should not affect social aspects.

The following table shows the applicability of the drivers for change with respect to changes in lime kiln technology.

Table 2.4.1 – Changes to lime kiln technology drivers for change

Driver		Applicability	Comments
Legislation	European legislation	*****	Air emissions
	National legislation	*****	Air emissions
Economic	Improved profit	***	
	Production cost savings	****	
Environmental	Fewer emissions and waste	****	

The following table shows what stage of development each region of Europe is at with respect to changes in lime kiln technology.

Table 2.4.2 – Changes in lime kiln technology stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development Phase	✓	✓	✓	
Industrial Trials				
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to changes in lime kiln technology.

Table 2.4.3 – Changes in lime kiln technology future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
Central Europe and Southern Europe consume more recycled fibre than the other regions so chemical pulping process doesn't need to be developed further than it already is. Furthermore Kraft pulping process is a traditional pulping process in Nordic Countries and the competence is therefore high there.

Conditions and obstacles
At the moment, the main concern in environmental issues is greenhouse gas emissions. This technology focuses more on other air emissions. The technology can only be applied to Kraft pulping process.

The following table shows the pros and cons of changes in lime kiln technology.

Table 2.4.4 – Risks and costs to the industry from changes in lime kiln technology

Cons	Pros
Investment costs	Decreased emissions
	Increased efficiency
	Improved profit

2.5 Changes to recovery boiler technology

Improved recovery boiler technologies minimize air emissions and improve energy production. The recovery boiler produces particularly NO_x emissions, but they can be decreased using several technologies. Deliverable 4.2.3 presented Selective Non-Catalytic NO_x reduction SNCR-technology, but there are even more efficient ways to reduce NO_x emissions from the recovery boiler. Well designed air staging conditions and vertical air systems have a great potential in that area, enabling perhaps a 40-60% reduction in NO_x emissions in the best cases. Implementation of this technology requires some investments in the furnace size and materials. In vertical air systems, primary air is fed into the furnace the same way as in traditional boilers, but the secondary and tertiary air levels of traditional boilers are now replaced by air feeding vertical fingers. They strongly promote mixing in the furnace and result into very low emissions.

Industrial trials of vertical air systems are expected to be complete before 2015, and the technology has a possibility to become generally adopted by 2025, if the results of the mill trials are promising. Also improved energy production with increased steam pressure and temperature might be adopted with similar time scale. The estimated development of this technology is shown in Table 2.5.3.

The technology will be affect environmental aspects, but it is likely that legislation will also require NO_x emissions to be decreased even further. Reducing the use of fossil fuels will be possible with this technology, and can lead to better acceptance from society.

The following table shows the applicability of the drivers for change with respect to changes in boiler recover technology.

Table 2.5.1 –Recovery boiler technology drivers for change

Driver for change to new technology		Applicability	Comments
Consumer demands	Other	**	Better acceptance
Legislation	European legislation	*****	NO_x–emissions
	National legislation	*****	NO_x–emissions
Economic	Production cost savings	**	
	Exploitation of by products	**	
Environmental	Greater use of renewable fuels	*****	Improved energy production
	Decreased use of fossil fuels	*****	Improved energy production
	Reduced energy demands	*****	Improved energy production
	Fewer emissions and waste	*****	

The following table shows what stage of development each region of Europe is at with respect to changes to recovery boiler technology.

Table 2.5.2 –Recovery boiler technology stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓	✓	
Industrial Trials				
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to changes to recovery boiler technology.

Table 2.5.3 – Recovery boiler technology future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

Central Europe and Southern Europe consume more recycled fibre than the other regions so chemical pulping process doesn't need to be developed further than it already is. Also Kraft pulping process is a traditional pulping process in Nordic Countries and the competence is therefore high there.

Conditions and obstacles

At the moment, the main concern in environmental issues is greenhouse gas emissions. This technology focuses more on other air emissions not studied in this project. The technology can only be applied to Kraft pulping process.

The following table shows the pros and cons of changes to recovery boiler technology.

Table 2.5.4 – Risks and costs to the industry from changes to recovery boiler technology

Cons	Pros
Investment costs	Less emissions, especially NO_x
	Increased energy production
	Less fossil fuels needed
	Fewer waste would be generated

2.6 Changes in effluent treatment

Effluent treatments in Totally Chlorine-free TCF or Elemental Chlorine-free ECF Kraft mills are mainly based on activated sludge treatment, as presented in PD 4.2.3. There are several chemical treatment options for tertiary treatment if "normal" treatment capacity is not enough. There will be more trials in pilot and mill scale, and some of the treatments may be generally adopted before 2015. The estimated development timescale is shown in Table 2.6.3.

The biggest drivers for even better effluent treatments are legislation and pressures from NGOs. Naturally, the image of companies will be better if emissions are reduced. Tertiary treatments have to be cost effective in order to be generally adopted.

The following table shows the applicability of the drivers for change with respect to changes in effluent treatment.

Table 2.6.1 –Effluent treatment drivers for change

Driver		Applicability	Comments
Consumer demands	Other	****	NGOs
Legislation	European legislation	****	
	National legislation	****	
Environmental	Fewer emissions and waste	****	

The following table shows what stage of development each region of Europe is at with respect to changes in effluent treatment.

Table 2.6.2 –Effluent treatment stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase		✓		
Industrial Trials				
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to changes in effluent treatment.

Table 2.6.3 – Effluent treatment future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The main difference between the developments of this technology is the various regions are due to the quality of water. As South Europe has a greater need for this technology it is going to develop fastest here than in other areas where the need is not so great. As water treatment plants in Nordic countries are so efficient that is no need for tertiary treatments.

Conditions and obstacles
Other problems need to be overcome first before this technology will be adopted. There are no particular obstacles preventing the adoption of this technology.

The following table shows the pros and cons of changes in effluent treatment.

Table 2.6.4 – Risks and costs to the industry from changes in effluent treatment

Cons	Pros
Investment costs	Less emissions
	Better social acceptance
	Better quality of raw water

2.7 Development of fibre fractionation

Fibre fractionation is expected to be tested in industrial trials probably by 2015. The possibility of using raw material more efficiently and improving paper properties are promising. Depending on the results of industrial trials, the technology may be adopted in best practice or generally by 2025. The estimated timescale for this technology is shown in Table 2.7.3.

The most important drivers for fibre fractionation are efficiency in raw material use and possible cost savings, since each fraction of fibres can be treated separately. The separate fibre fraction treatments may save energy, but the fractionation process uses large amounts of water. The technology will not affect social aspects, but it can improve paper properties and thus benefit fibre products in general.

The following table shows the applicability of the drivers for change with respect to development of fibre fractionation.

Table 2.7.1 –Fibre fractionation drivers for change

Driver		Applicability	Comments
Consumer demands	Other	***	Improved paper properties
Legislation	European legislation		
	National legislation		
	Other		
Economic	Added value	****	More efficient raw material use
	Production cost savings	**	Smaller energy consumption in e.g. refining
Environmental	Reduced energy demands	***	

The following table shows what stage of development each region of Europe is at with respect to development of fibre fractionation.

Table 2.7.2 – Fibre fractionation stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓		
Industrial Trials				
Adopted by some SME’s				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to development of fibre fractionation.

Table 2.7.3 –Fibre fractionation future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

One of the reasons for the difference between the regions is that efficient use of raw material is important in areas where the forest cluster is strong.

Conditions and obstacles

The main problem with adoption occurs in regions with high water scarcity. The main obstacle is that the technology consumes high amount of water.

The following table shows the pros and cons of development of fibre fractionation.

Table 2.7.4 – Risks and costs to industry from development of fibre fractionation

Cons	Pros
Investment costs	Improved efficiency of material use
High water consumption	Improved paper properties
	Production cost savings

2.8 Development of closed water loops

This technology has not been developing according to prior assumptions and it now falls out of the scope of this report. It will not be studied unless there are changes in the status of adoption.

2.9 Water treatment - ultra filtration and removal of calcium and magnesium

This technology has not been developing according to prior assumptions and it now falls out of the scope of this report. It will not be studied unless there are changes in the status of adoption.

2.10 Development of stratified forming techniques for paper and board making

Stratified forming improves layer purity of papers and boards and enables savings in raw material costs. It is likely, that this technology will be tested in industrial trials by 2015 and may be adopted more widely by 2025. The estimated timescale of the development of this technology is shown in Table 2.10.3.

Savings in raw material costs will be possible with this technology, and the purity of layers might give additional benefits by creating different layer properties. The technology will not affect social aspects, and it is not likely to provide clear benefits to other industries.

The following table shows the applicability of the drivers for change with respect to development of stratified forming techniques for paper and board making.

Table 2.10.1 –Stratified forming techniques for paper and board making drivers for change

Driver		Applicability	Comments
Consumer demands	Other	***	improved paper properties
Economic	Production cost savings	****	more efficient raw material use

The following table shows what stage of development each region of Europe is at with respect to development of stratified forming techniques for paper and board making.

Table 2.10.2 –Stratified forming techniques for paper and board making stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓		
Industrial Trials				
Adopted by some SME’s				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to development of stratified forming techniques for paper and board making.

Table 2.10.3 –Stratified forming techniques for paper and board making future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
As had been said before, North and West Europe are generally more open to technologies and therefore have more funding are generally more developed than the other regions.

Conditions and obstacles
The technology requires a large amount of water which may become an obstacle. In bulk products this technology is not applicable / necessary.

The following table shows the pros and cons of development of stratified forming techniques for paper and board making.

Table 2.10.4 – Risks and costs to industry form development of stratified forming techniques for paper and board making

Cons	Pros
Investment costs	Savings in raw material costs
	New/improved paper properties
	Improved raw material efficiency
	Cost effective

2.11 Improving measurement and control of pressure in pressing boards and paper

On-line measurement and control of pressure in wet pressing has been tested in pilot trials and may be tested on a mill scale by 2015. Depending on the results of the mill scale trials, this technology might be adopted more widely by 2025, but this is difficult to estimate. Another possible improvement in the wet pressing section is impulse drying, where pressing is combined with high temperature treatment. Similar time scale can be expected for that technology. The estimated timescale for the development is shown in Table 2.11.3.

On-line controlling of pressing could improve efficiency of water removal, may reduce amounts of web breaks in some cases, and possibly would equalize the sideward quality of the paper. These improvements could save production costs and bring some added value to the paper. This technology should not affect social aspects in any way. Impulse drying could also improve paper/board surface qualities.

The following table shows the applicability of the drivers for change with respect to improvement of measurement and control of pressure in pressing boards.

Table 2.11.1 –Measurement and control of pressure in pressing boards and paper drivers for change

Driver		Applicability	Comments
Economic	Improved profit	**	Less web breaks
	Added value	***	Equalized sideward quality of paper
			Improved surface quality
	Production cost savings	***	Energy savings in drying section
Environmental	Decreased use of fossil fuels	*	
	Fewer emissions and waste	*	From energy production

The following table shows what stage of development each region of Europe is at with respect to improvement of measurement and control of pressure in pressing boards and paper.

Table 2.11.2 –Measurement and control of pressure in pressing boards and paper stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓			
Industrial Trials				
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to improvement of measurement and control of pressure in pressing boards and paper.

Table 2.11.3 –Improvement of measurement and control of pressure in pressing boards and paper future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The main difference between the developments of this technology is the various regions are due to the quality of water. As South Europe has a greater need for this technology it is going to develop fastest here than in other areas where the need is not so great.

As water treatment plants in Nordic countries are so efficient that is no need for tertiary treatments.

Conditions and obstacles

Other research is needed with this technology. There are no particular obstacles preventing the adoption of this technology.

The following table shows the pros and cons of improvement of measurement and control of pressure in pressing boards and paper

Table 2.11.4 – Risks and costs to industry from improvement of measurement and control of pressure in pressing boards and paper

Cons	Pros
Investment costs	Improved energy efficiency
	Improved paper properties
	Reduced web breaks lead to better cost production
	Savings in production costs
	Energy efficiency could be improved

2.12 Improved drying technology – high intensity driers – impingement drying

Improved drying decreases production costs and may increase process speed. High intensity driers and impingement dryers, where hot air is directed towards the paper, are being tested and will be tested further, and may be adopted by 2015. Infra red dryers for coated papers are already widely used and are not discussed further in this document. The estimated timescale of the development of this technology is shown in Table 2.12.3.

Traditional drying section requires huge amounts of energy. Shortening the drying section with more efficient technologies would also decrease space requirements. These would lead to machinery and energy costs savings. At the same time, less fossil fuel would be needed for heating, so emissions might be reduced also. Social aspects should not be affected.

The following table shows the applicability of the drivers for change with respect to improved drying technologies.

Table 2.12.1 – Drying technologies drivers for change

		Applicability	Comments
Economic	production cost savings	*****	
	other	**	Decreased space requirements
Environmental	decreased use of fossil fuels	****	
	reduced energy demands	*****	
	fewer emissions and waste	***	From energy production from fossil fuels

The following table shows what stage of development each region of Europe is at with respect to improved drying technologies.

Table 2.12.2 –Improved drying technologies stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase			✓	✓
Industrial Trials				
Adopted by some SME's	✓	✓		
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to improved drying technologies.

Table 2.12.3 –Improved drying technologies future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
There is very little difference between the regions regarding this technology.

Conditions and obstacles
The only condition of the adoption of this technology is the investment costs needed. There are no particular obstacles preventing the adoption of this technology.

The following table shows the pros and cons of improved drying technologies.

Table 2.12.4 – Risks and costs to industry from improved drying technologies

Cons	Pros
Investment costs	Savings in production costs
	Decreased energy consumption

2.13 Change in use of existing coating techniques for papers and boards – curtain and spray coating

Curtain coating is more likely to be generally adopted than spray coating, since it has more benefits than spray coating. Curtain coating is already used in some mills, and it can be generally adopted by 2015. However, since coated papers are being replaced by uncoated papers, it is not wise to expect curtain coating to be adopted in all of the industry. The estimated timescale of the development of this technology is shown in Table 2.13.4.

Curtain coating and spray coating technologies are non-contact methods, so they allow lower strength for base papers, so requirements for the raw materials are also lower. Thus recycled fibres can be used. Non-contact method also causes fewer breaks, so the amounts of paper produced can increase, and the company will gain increased profit. These methods also provide better coverage of coatings, which will allow thinner coating and cause savings in production costs. Spray coating uses nozzles which must be changed quite often, but curtain coating does not require any equipment that would wear out quickly, so the material costs and amounts of waste will be reduced. Multilayer coating is also possible. Since the layers may be dried simultaneously, it will allow savings in energy consumption. Also there is a possibility of decreasing the moisture content of the coating mix which will reduce energy consumption.

The following table shows the applicability of the drivers for change with respect to changes in use of existing coating techniques for paper and boards.

Table 2.13.1 – Change in use of existing coating techniques for paper and boards drivers for change

Driver		**Applicability**	**Comments**
Consumer demands	Pressure for recyclability / reuse	**	DIP may be used in base paper
	Changes in packaging needs	**	
	Other	**	Better product properties for e.g. printing
Economic	Improved profit	****	
	Added value	****	
	Production cost savings	****	
	Other	***	Better coverage -> less coat weight
Environmental	Decreased use of fossil fuels	***	
	Reduced energy demands	****	
	Fewer emissions and waste	***	Less waste, no part wear in curtain coating
	Other	****	No parts that wear in curtain coating

Improvements in coating technology will not affect social aspects. However, since de-inked pulp (DIP) may be used in base papers, this technology might improve consumer acceptance. The coating can provide better barrier properties than traditional coating, so less packaging will be required. The coated paper may be a bit problematic in recycling, since the coating may act in different ways in recycling process. If the coating process is across the entire width of the paper, small amounts of coating mix will be collected as a by-product from the edges of the paper. This coating mix surplus might be difficult to utilize. Another option is to leave a thin edge of the paper uncoated, trim it and recycle the edge.

The following table shows what stage of development each region of Europe is at with respect to changes in use of existing coating techniques for papers and boards.

Table 2.13.2 –Changes in use of existing coating techniques for paper and boards stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials	✓	✓	✓	✓
Adopted by some SME’s				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to changes in use of existing coating techniques for papers and boards.

Table 2.13.3 – Changes in use of existing coating techniques for paper and boards future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations

There is no difference between the regions regarding this technology.

Conditions and obstacles

The technology can be used only for coated papers. There are no particular obstacles preventing the adoption of this technology.

The following table shows the pros and cons of changes in use of existing coating techniques for papers and boards.

Table 2.13.4 – Risks and costs to industry from changes in use of existing coating techniques for paper and boards

Cons	Pros
Investment costs	Savings in production costs
Problems in recycling of the product	New / improved paper properties
	Lower quality of raw materials acceptable
	Increased production amounts
	Less waste from the coating process
	Recycled and virgin fibres can be applied

3 RECYCLED PAPER (responsible: KCPK)

3.1 Alternative wires for recovered paper

In summary, the new concept entails the substitution of metal wires for paper bales with alternative equivalents in form of plastic wires and paper ropes. This will reduce the impact of the non recyclable and non paper fractions in recovered paper and help prevent accidents.

Currently this technology is on the level of industrial trials. Industrial trials have shown that PET wires can be a good alternative to metal wires for the reason stated above.

Drivers for change
Benefits for the paper industry are becoming larger with increasing raw material (recovered paper) prices, since PET wires have lower weights then metal wires. As costs of waste disposal increase benefits for the paper industry will be higher. Furthermore, new EU legislation will require traceability of the raw materials, which will encourage the use of PET wires as compared to metal wires, as they can be better printed.

Expected time and level of uptake
The expected level of uptake of this technology in 2015 and 2025 is extremely difficult to predict, since the technology is not implemented by the paper producing industry itself but by its suppliers: the recovered paper processing companies/collectors. Benefit for the paper producing industry are large and expected to be larger with increasing raw material prices and increasing costs of waste disposal. However, large scale implementation is only expected under new EU legislation, if not it will be hard to get the technology implemented at all. The estimated development of this technology is shown in Table 3.1.2.

The following table shows what stage of development each region of Europe is at with respect to alternative wires for recovered paper.

Table 3.1.1 –Alternative wires for recovered paper stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase		✓	✓	✓
Industrial Trials		✓		
Adopted by some SME’s				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to alternative wires for recovered paper.

Table 3.1.2 – Alternative wires for recovered paper future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The adoption of the technology varies from region to region because of various factors. The type of raw material i.e. virgin fibres or recovered paper will be different; along with the availability of the raw material which is turn will be dependent on the recycling rate. Other differences will be incurred due to legislations and directive differences, Sector structures and the cost of waste disposal.

Conditions and obstacles

An obstacle towards large scale introduction of this technology is that it is only beneficial if all recovered paper bales processed in a mill have the same type of wires. Since most mills obtain their raw material sources from different suppliers, all potential suppliers would need to adopt this system more or less simultaneously. Since suppliers can also be outside of Europe, this will be hard to accomplish without legislation. Additionally the lack of standards may prove to be an obstacle.

The conditions on which the adoption of this technology is dependent on are that it is has to be generally accepted by the industry, and internal agreements must be made with recovered paper suppliers. This technology is only relevant in regions with large scale recovered fibre based production.

Contribution to Sustainable Development

This new concept contributes to economical aspects by the savings in production costs (from decreased waste disposal), to environmental aspects by the prevention of landfill waste and to social aspects through increased occupational health by the prevention of accidents that occurred in the paper industry during the last few years because of springing metal wires.

The following table shows the pros and cons of alternative wires for recovered paper.

Table 3.1.3 – Risks and costs to industry from alternative wires for recovered paper

Cons	Pros
Extra costs for rebuilding the recovered paper presses	Positive impact on sorting, transportation, pulp preparation and rejects handling
	Decreasing waste disposal
	Better traceability possible
	Less accidents
	Decreasing production costs

3.2 Recovered paper sorting and quality control by sensor development

Various types of sensors are currently under development, from laboratory scale to full-size mill trials and market introduction.

1. Image analysis sensors to assess the composition (newsprint/magazine/boards) of recovered paper stream to be de-inked on-line; raw material variations can propagate from the pulper to the paper machine and the efficiencies of processes are affected by these fluctuations.
2. A volatile compound sensor is also under development; this sensor allows the identification of chemical and microbiological contaminants. It can be used to control raw material at the factory gate but also to control chemical substances in the final paper products intended for contact with food.
3. Another sensor, using NIR (near infrared) spectrometry, is under development, based on a coring device to control paper bales directly at delivery. The sensor will determine humidity percentage, unusable material presence and ratio and raw material compositions according to EN 643.

Drivers for change

Decreasing recovered paper quality can be a driver towards the further utilisation and implementation of quality control sensors in the paper industry. Currently many sorting activities are still performed by humans; the use of sensor fits the increasing automation in sorting lines.

Expected time and level of uptake

The expected level of uptake of these technology is expected to increase towards 2015 and 2025; the quality of recovered paper is decreasing (we are further down the recycling loop) and we need to exploit recovered paper of lower quality to meet the increasing demand for recovered paper. Since we expect quality to decrease over the years, the use of sensors to measure recovered paper quality at the mill gate can become more useful. Besides, controlling devices will replace human sorting and the ongoing automation process in paper mills. The estimated timescale of this technology is shown in Table 3.2.2.

The following table shows what stage of development each region of Europe is at with respect to recovered paper sorting and quality control by sensor development.

Table 3.2.1 –Recovered paper sorting and quality control by sensor development stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓	✓	✓
Industrial Trials	✓	✓	✓	✓
Adopted by some SME’s	✓	✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to recovered paper sorting and quality control by sensor development.

Table 3.2.2 – Recovered paper sorting and quality control by sensor development future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The adoption of the technology varies from region to region because of various factors. The type of raw material i.e. virgin fibres or recovered paper will be different; along with the level of recycling (industrial and households). Also the quality of the raw material varies regional. For recovered paper the collection systems of raw materials also will affect the adoption. Other differences are mainly financial with the cost of waste disposal, raw material and personnel varying. In addition to these the lack of money for research and development in some regions is an issue.

Conditions and obstacles

The conditions on which the adoption of this technology is dependent on are an increase in the funding for research and development. The increase in raw material cost as we are facing today will push towards the need for this technology, as will the lower quality of raw materials and the lowering availability of the raw materials.

New EU legislation that requires the traceability of raw materials makes it easier to recognise the source of raw materials. This will also mean that quality problems can be more easily linked directly to the suppliers, which reduces the need for mill gate quality controls. Quality control today is mostly still offline and puts large constraints on personnel costs and there is thus a need to further improve and atomise these technologies. Also the low performance of sensor-based sorting today makes it not cost effective at the moment.

Contribution to Sustainable Development

The sensors will contribute to saving in production costs by increasing the quality of the raw material, the control and removal of unusable material and reducing the time needed for manual control of recovered papers. Furthermore it will lead to increased recyclability and thereby secure recycling of paper in the future.

The following table shows the pros and cons of recovered paper sorting and quality control by sensor development.

Table 3.2.3 – Risks and costs to the industry from recovered paper sorting and quality control by sensor development

Cons	Pros
Reduction of employment, due to further automation of manual sorting	Decreasing production costs (raw material costs and labour costs)
	Increased recyclability
	Less waste and waste costs
	Increased quality of recycled waste
	Increased quality of final product
	Decreased personnel costs

3.3 Enzymatic Upgrading Of Recycled Paper

Due to the increasing recycling of paper, the quality of fibres decreases, and the amount of fines and organic compounds increases at a rate of 1% per year. This is as a result of recycling paper with an already recycled component. This results in a decrease of production (decreased de-watering), lower efficiency of process and functional chemicals, and a decrease of the quality of the end product. Recycled paper and board can be upgraded by adding virgin fibres, large quantities of chemicals or removing fines from the pulp and discarding the fines into waste. These measures are both from an economical and ecological point of view less favourable. Results from recent research has shown that specific enzymes are able to modify fibres and fines in such a way that strength of paper can be increased, de-watering of pulp can be enhanced, and the efficiency of chemicals can be improved. The recycled paper industry demands very specific technological developments of the enzyme preparations. Enzymes are needed to improve de-watering as with every cycle the drain ability decreases. This implies specific enzymes targeting the small fines causing the problems. Secondly, enzymes are needed to improve fibre quality and so maintain recycled paper quality.

Drivers for change

With increasing energy costs, the use of enzymes that decrease the water retention values of the recovered fibres, will be enhanced. Furthermore, decreasing recovered fibre qualities will enhance the use of enzymes.

Expected time and level of uptake

The expected level of uptake of this technology is expected to increase towards 2015 and 2025; the quality of recovered paper is decreasing (we are further down the recycling loop) and we need to exploit recovered paper of lower quality to meet the increasing demand for recovered paper. The benefits that the use of enzymes could bring to the recovered paper industry are large; upgrading its fibre raw material quality and also reducing energy use at the same time. The costs of the use of enzymes, however, are currently still higher than the benefits its use brings. The use of enzymes is common in other industries, e.g. the food industry, which might accelerate its application in the paper industry. It can be expected that with increasing R&D efforts and industrial trials, the costs of the use of enzymes in the paper industry could go down in the near future. The estimated timescale of the development of this technology is shown in Table 3.3.2.

The following table shows what stage of development each region of Europe is at with respect to enzymatic upgrading of recycled paper.

Table 3.3.1 –Enzymatic upgrading of recycled paper stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓	✓	✓
Industrial Trials		✓		
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to enzymatic upgrading of recycled paper.

Table 3.3.2 – Enzymatic upgrading of recycled paper future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The main differences between the regions for this technology are the type and quality of raw material available. Also the cost of raw materials and enzymes varies between the regions as does the money available for research and development of this technology.

Conditions and obstacles
The major condition of the adoption of this technology is a greater amount of funding for research and development. The price of enzyme application is currently an obstacle towards its use throughout the paper industry. Another obstacle might be the incomplete understanding of the effects of enzymes in the paper industry on the longer term.

Contribution to Sustainable Development
Enzyme technology in the recovered paper industry might lead to savings in production costs and less use of fossil fuels and chemicals (by better dewatering and less chemical use), to increased profit (by increased machine speed) to better recyclability and less waste (due to improved recovery of raw material), more renewable raw materials and improved properties considering end use (by improvement of the fibre properties).

The following table shows the pros and cons of enzymatic upgrading of recycled paper.

Table 3.3.3 – Risks and costs to industry from enzymatic upgrading of recycled paper

Cons	Pros
Costs of the enzymes	Decreasing production costs
Incomplete understanding of the long term effects	Decreasing energy use and hence costs
	Decreasing chemical use and hence costs
	Better and increased recyclability
	Decrease of waste
	Increase in renewable raw material inputs
	Increase in the quality of raw materials

3.4 Production of secondary fuels from recovered paper industry rejects

In many countries in Europe, waste disposal is restricted and very expensive. Rejects from paper industry can contain mineral debris, sand, metal particles, glass etc. but the largest part is combustible substances consisting of mainly fibrous material, plastic and wood. By pressing and drying the sorted reject stream, dense energy pellets with energy contents comparable to coal can be produced. The processed material can also be used as a fuel in a loose fluffy form. Fluff and pellets can be used as an alternative fuel in energy plants or other industries (i.e. cement industry).

Drivers for change

The two main drivers of large scale implementation of this technology are energy prices and costs of land filling (influenced by waste policies, that are (currently) national, not EU, and legislation). Increasing energy prices and land filling costs will both enhance the production of secondary fuels out of recovered paper industry rejects. In our projection, we assumed both of them to increase towards 2025.

Expected time and level of uptake

The level of uptake of this technology in 2015 and 2025 can be very large as the technology is neither new nor extremely complicated. The industry-wide uptake of this technology will be the result of external drivers (like energy prices and waste legislations/ landfill policies) and is hard to predict. It is assumed in this report that the technology will be adopted in all SMEs by 2025, however, we include in this case the option that several smaller plants will combine their reject streams and have energy production at a central site. The estimated timescale of the development of this technology is shown in Table 3.4.2.

The following table shows what stage of development each region of Europe is at with respect to production of secondary fuels from recovered paper industry rejects.

Table 3.4.1 –Production of secondary fuels from recovered paper industry rejects stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials			✓	
Adopted by some SME's		✓		
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to production of secondary fuels from recovered paper industry rejects.

Table 3.4.2 – Production of secondary fuels from recovered paper industry rejects future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations

The main differences between the regions for this technology are the type and availability (and scale) of raw materials. Also the cost of waste disposal and energy vary regionally. Another difference between the regions which will affect the adoption of this technology is the legislation relating to land filling.

Conditions and obstacles

The adoption of this technology is dependent on the conditions of waste disposal costs, energy prices, the scale of the reject stream and the legislation relating to waste disposal.

Increasing land filling bans put more materials on the market, increasing the competition and reducing profitability. Improvements in collection and sorting activities might reduce the amount of contamination already in the input of the mill. As a consequence, the output of contamination in the form of rejects can become very small (which is of course a desirable development, but not favouring this particular technology). The costs of waste disposal in some countries is very low which may be prove to be an obstacle as will the fact that in some countries land filling is still allowed. In addition to this the scale of the reject streams need to be large enough.

Contribution to Sustainable Development

This new concept contributes to economical aspects by the savings in production costs (from decreased waste disposal) and to environmental aspects by the prevention of landfill waste and the replacement of fossil fuels.

The following table shows the pros and cons of production of secondary fuels from recovered paper industry rejects.

Table 3.4.3 – Risks and costs to industry from production of secondary fuels from recovered paper industry rejects.

Cons	Pros
Increasing investments	Decreasing production costs
Non-core business	Prevention of landfill waste
	Increasing energy generation
	Replacement of fossil fuels
	Increased added value

3.5 De-inking sludge rejects as an alternative raw material for other applications

In many countries in Europe, waste disposal is restricted and very expensive. De-inking sludge is a reject of paper mills that have a de-inking process, the sludge contains approximately 50% non-organic elements as inks, coatings adhesives, dyes and fillers and approximately 50% of organic cellulose fibres. The de-inking sludge can be treated in special installations by means of an exothermic reaction into meta-kaolin and calcium carbonates, calcium oxide, heat, vapour, and CO_2. The mineral product produced in this process is a good alternative material for use in the cement industry.

Drivers for change

The two main drivers of large scale implementation of this technology are added value generation (dependent on the developments in the cement industry) and costs of land filling (influenced by waste policies, that are (currently) national, not EU, legislation). De-inking sludge amounts are expected to increase with the increasing use of (de-inked) recovered paper.

Expected time and level of uptake

The level of uptake of this technology in 2015 and 2025 is expected to be very large even though the technology is rather new and not very simple. The industry-wide uptake of this technology will mainly be driven by external developments (e.g. developments in the cement/construction market and land fill costs/policies). It is estimated, in this report, that the technology will be adopted in all relevant SMEs by 2025, however, we include in this case the option that several smaller plants will combine their de-inking streams and have material production at a central site. The estimated timescale of the development of this technology is shown in Table 3.5.2.

The following table shows what stage of development each region of Europe is at with respect to de-inking sludge rejects as an alternative raw material for other applications.

Table 3.5.1 – De-inking sludge rejects as an alternative raw material for other applications stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials			✓	
Adopted by some SME's		✓		
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to de-inking sludge rejects as an alternative raw material for other applications.

Table 3.5.2 – De-inking sludge rejects as an alternative raw material for other applications future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The main differences between the regions for this technology are the type and availability (and scale) of raw materials. Also the cost of waste disposal and the legislation relating to land filling create regional variance.

Conditions and obstacles
The adoption of this technology is also dependent on the price on waste disposal and the legislation relating to this disposal. The scale of the reject stream is another condition as is the development of other industries for example the cement industry as these will have an influence of this technology.

The production of alternative materials for use in the cement industry is a non-core business exercise. It probably will also need the cooperation of several de-inking mills. The costs of waste disposal in some countries is very low which may be prove to be an obstacle as will the fact that in some countries land filling is still allowed. In addition to this the scale of the reject streams need to be large enough.

Contribution to Sustainable Development
This new technology contributes to economical aspects savings in production costs (from decreased waste disposal) and to environmental aspects by the prevention of landfill waste and the replacement of virgin materials.

The following table shows the pros and cons of de-inking sludge rejects as an alternative raw material for other applications.

Table 3.5.3 – Risks and costs to industry from de-inking sludge rejects as an alternative raw material for other applications.

Cons	Pros
Increasing investments	Decreasing production costs
Non-core business	Prevention of landfill waste and costs
	Increasing energy generation
	Replacement of fossil fuels
	Increased added value

4 SAW MILL INDUSTRY (responsible: VTT - Arto Usenius)

4.1 Scanning of internal properties of stems and logs for characterisation wood raw material and for optimisation of sawing operations

Sawing yield very much depends on the size and quality of the logs. Sawing set up should be determined based on the size and quality of the log to be sawn. The conversion value of good quality log may be double compared to the value of low quality log. Currently only geometrical properties of stems and logs are measured providing data such as small and large end diameter, length, taper and shape of the log. In some cases logs are graded visually into quality classes. Information about internal quality is not available.

Much R/D effort in different countries in the last years has been concentrated on developing commercially available scanners for internal log characterisation for sawmill implementations. Some scanner systems have been implemented in industrial environment however mainly to trace how to use the systems in real life business.

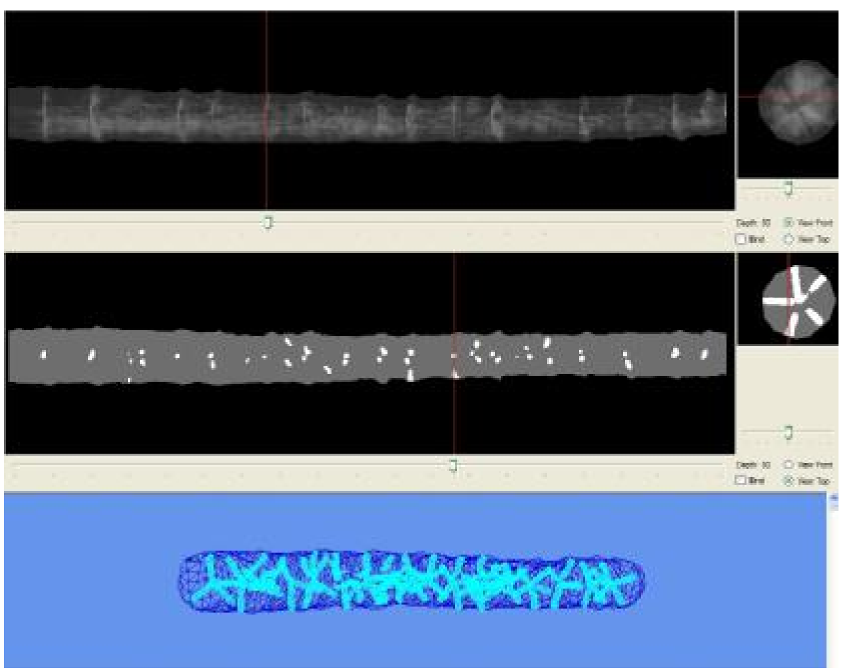

Figure 4.1 - Special reconstruction software of X-ray data showing the X-ray images, a binary image (knot/clear wood) and 3D-mesh image with knots and surface modelled

New technology will enable precise characterisation of the logs and stems. Scanners are based e.g. on x-ray technology combined with true shape data through laser applications. Depending on the system configuration, scanners provide different levels of detailed information about knottiness, individual knots, density, annual ring orientation, moisture content etc. Scanners can be implemented at log sorting station, cross cutting terminals for stems and also just before sawing machines.

Scanners provide data for planning systems and process control for sawing optimisation. The scanner results provide precise shape co-ordinate description of the log or stem, internal characterisation of the log including all features affecting on the quality of sawn timber products like knottiness. Description of the knots may be given with different levels of accuracy. Rough accuracy gives only the total volume of the knots. In the most sophisticated cases all the features of every individual knot is described. Scanning, image processing and mathematical reconstruction algorithms generate virtual logs or stems. Virtual logs are input data for sawing simulator which mathematically converts logs into sawn timber or components. The best sawing set up will give maximum value yield of demanded products with high prices.

The following table shows the applicability of the drivers for change with respect to scanning of internal properties of stems and logs.

Table 4.1.1 – Scanning of internal properties of stems and logs drivers for change

Driver		Applicability	Comments
Consumer demands	Customer oriented products	***	
	Competitive product prices	*	
	Fitness secondary conversion	**	
	More homogeneous products	***	
Economic	Improved profit	***	
	Added value	***	
	Production cost savings	*	
	Minimising by products	*	
	Minimising waste	*	
	Other	*	
Environmental	Saving wood raw material	***	
	Reducing amount of waste	**	
	Reducing energy demand	*	

The following table shows what stage of development each region of Europe is at with respect to scanning of internal properties of stems and logs.

Table 4.1.2 –Scanning of internal properties of stems and logs stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				✓
Industrial Trials			✓	
Adopted by some SME’s		✓		
Generally adopted	✓			

The following table shows the estimated future uptake for each region of Europe with respect to scanning of internal properties of stems and logs.

Table 4.1.3 – Scanning of internal properties of stems and logs future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles

The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of scanning of internal properties of stems and logs.

Table 4.1.4 – Risks and costs to industry from scanning of internal properties of stems and logs

Cons	Pros
Investment costs	Increased profits
	Better allocation of raw wood material

4.2 Measuring systems for characterisation and grading of sawn timber as well as supporting secondary conversion

Sorting by dimensions and quality grading are very essential parts of sawmill processes. Grading provides more homogenous batches or groups of sawn timber or components. Different grades are sold at different prices. Customers demand certain dimensions and grades based on their final products.

Grading is currently visually made by human graders especially at small mills. Manual work is very stressful and mistakes may cause large economic losses. It's difficult for a human grader to learn and adapt to new grading rules fast. This is why automated grading is replacing human grading especially at bigger sawmills where the production volumes are high. Colour and B/W cameras are used. Limited parameters are measured. Current systems do not support further conversion and upgrading sawn timber into components.

Much R/D effort in different countries in the last years has been concentrated on developing commercially available scanners for internal log characterisation for sawmill implementations. Scanner systems have been implemented in the industrial environment with good results, however big steps are still expected in the future such as the capability to detect wood properties which are difficult to measure for example detection of internal defects of logs.

New technology implementation: Multi-sensor scanning systems are provided with several sensors like RGB-camera, IR-camera, microwave detector, ultrasound detector, x-ray camera etc. in order to detect all wood properties of interest. Data fusion – combining information from different sensors together ensures high resolution, detection and identification. System configuration depends on the type of wood raw material and products and the size of the mill. Information produced can be exploited in grading and processing. Low cost systems for SMEs should be developed.

New technology will enable precise characterisation of sawn timber. Scanners are based on different technologies. Scanners provide data for planning systems and especially for process control and grading of sawn timber. The scanner results provide precise shape co-ordinate description of the sawn timber and internal characterisation of the sawn timber piece including all features affecting on the quality of sawn timber products like knottiness, wane edge, rot, splits, checks, mechanical damage, annual ring orientation etc... Description of quality features may be provided with lower or higher accuracy. Scanning, image processing and mathematical reconstruction algorithms generate virtual timber pieces. Virtual sawn timber is the input data for the grading simulator which mathematically calculates different quality grade options for sawn timber or component piece.

Scanners are very good tools for data collection providing data and information for overall planning systems concerning harvesting, production and sales operations in short and log term.

The following table shows the applicability of the drivers for change with respect to measuring systems for characterisation and grading of sawn timber.

Table 4.2.1 – Measuring systems for characterisation and grading of sawn timber drivers for change

Driver		Applicability	Comments
Consumer demands	Customer oriented products	***	
	Competitive product prices	**	
	Fitness for secondary conversion	**	
	More homogeneous products	***	
Economic	Improved profit	***	
	Added value	***	
	Production cost savings	*	
	Minimising amount by products	*	
	Minimising waste	**	
	Other	*	
Environmental	Saving wood raw material	***	
	Reducing amount of waste	**	
	Reducing energy demand	*	Drying batches

The following table shows what stage of development each region of Europe is at with respect to measuring systems for characterisation and grading of sawn timber.

Table 4.2.2 – Measuring systems for characterization and grading of sawn timber stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				✓
Industrial Trials			✓	
Adopted by some SME's		✓		
Generally adopted	✓			

The following table shows the estimated future uptake for each region of Europe with respect to measuring systems for characterisation and grading of sawn timber.

Table 4.2.3 – Measuring systems for characterization and grading of sawn timber future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles

The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of measuring systems for characterisation and grading of sawn timber

Table 4.2.4 – Risks and costs to industry from measuring systems for characterisation and grading of sawn timber

Cons	Pros
Investment costs	Increased profits
	More homogenous products.

4.3 Upgrading of sawn timber into value added components

Saw mill companies are currently selling standard sawn timber, bulk products, at low prices. Bulk production is easier and not so demanding as manufacturing value added products. New technology implementation offers a good opportunity to transfer from bulk production towards production of sawn timber with precisely defined properties according to the actual customer's requirement.

There are several concepts for upgrading sawn timber. For example: the sawmill is provided with machine vision system and smart decision making system with optimisation algorithms for grading and selecting sawn timber pieces into different classes. Some of the classes continue in traditional way and the final product is sawn timber for example high quality sawn timber. Low quality sawn timber pieces are converted into smaller pieces giving value added components with high price.

In the first phase of the manufacturing the sawn timber piece is evaluated by machine vision system providing precise map of surface defects affecting the quality of final potential products. This mathematically described piece is virtually converted into value added product using all potential manufacturing options. That option resulting best possible profit is selected for use. The processing may consist of cross-cutting, ribbing and edging phases.

The following table shows the applicability of the drivers for change with respect to upgrading of sawn timber into value added components.

Table 4.3.1 – Upgrading of sawn timber into value added components drivers for change

Driver		Applicability	Comments
Consumer demands	Customer oriented products	***	
	Competitive product prices	*	
	Fitness secondary conversion	**	
	More homogeneous products	***	
Economic	Improved profit	***	
	Added value	***	
	Production cost savings	*	
	Minimising by products	*	
	Minimising waste	*	
	Other	*	
Environmental	Saving wood raw material	***	
	Reducing amount of waste	**	
	Reducing energy demand	*	

The following table shows what stage of development each region of Europe is with respect to upgrading of sawn timber into value added components.

Table 4.3.2 – Upgrading of sawn timber into value added components stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase			✓	
Industrial Trials		✓		
Adopted by some SME's	✓			
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to upgrading of sawn timber into value added components.

Table 4.3.3 – Upgrading of sawn timber into value added components future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's	■			
	Generally Adopted		■	■	■
Central Europe	Research & Development phase				
	Industrial Trials	■			
	Adopted In some SME's		■		
	Generally Adopted			■	■
South Europe	Research & Development phase	■			
	Industrial Trials		■	■	
	Adopted In some SME's				■
	Generally Adopted				
East Europe	Research & Development phase		■		
	Industrial Trials			■	
	Adopted In some SME's				■
	Generally Adopted				

Regional variations

The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles

The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of upgrading of sawn timber into value added components.

Table 4.3.4 – Risks and costs to industry from upgrading of sawn timber into value added components

Cons	Pros
Increased production costs	Customer orientated products
	Increased added value

4.4 Flexible manufacturing systems for sawmills

Present production systems are effective, however they are very much volume and bulk production orientated emphasising the minimisation of costs. They are not flexible and production of components with specified quality features and properties is impossible. Manufacturing produces products which are not wanted and ordered.

Future production systems consist of following integrated key elements:

1. Control and optimisation of information and material flows in planning and production systems.
2. Intelligent, flexible and self learning measuring, production and logistic systems.
3. Integrated information systems covering entire conversion and delivery chains.
4. Creation and utilization of the feed back information in order to make business self learning.
5. Advanced mechanics for complex manufacturing.

Drivers for change

For this technology better customer orientation as well as improved quality of the products goes hand in hand with higher flexibility in manufacturing. The following table shows the applicability of the drivers for change with respect to flexible manufacturing systems for sawmills.

Table 4.4.1 – Flexible manufacturing systems for sawmills drivers for change

Driver		Applicability	Comments
Consumer demands	Customer oriented products	***	
	Products with specified properties	***	
	Competitive product prices	*	
	Fitness secondary conversion	*	
	More homogeneous products	***	
Economic	Improved profit	***	
	Added value	***	
	Production cost savings	*	
	Minimising by products	*	
	Minimising waste	*	
	Other	*	
Environmental	Saving wood raw material	***	
	Reducing amount of waste	**	
	Reducing energy demand	*	

The following table shows what stage of development each region of Europe is at with respect to flexible manufacturing systems for sawmills.

Table 4.4.2 – Flexible manufacturing systems for sawmills stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase		✓		
Industrial Trials	✓			
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to flexible manufacturing systems for sawmills

Table 4.4.3 – Flexible manufacturing systems for sawmills future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles
The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of flexible manufacturing systems for sawmills.

Table 4.4.4 – Risks and costs to industry from flexible manufacturing systems for sawmills

Cons	Pros
Decreased production capacity	Customer orientated products
	Increased value added
	Saving raw wood material

4.5 Adaptive production and business processes

Learning and teaching is currently a human activity and is very much depends on the nature, capability and will of the people. The procedure is very sensitive. Feed back information is not created. Business and production is not adaptive or self learning. This situation means ineffective use of human resources and of machinery.

New technology solutions and their implementation will provide smart, self learning and adaptive business, measuring, production and logistic processes and systems. The creation and utilization of feed back information will make business self learning.

Planning operations for production, harvesting and sales as well as process control are supported by decision support models or software. These systems need input data and they provide numerical instruction for different processes i.e. parameter values for machinery. The model systems also predict the output from the process concerned i.e. dimensions and quality of sawn timber. Normally the output is not measured. In the adaptive system the output is measured. This output is compared with the predicted one. If both of these outputs are exactly same the prediction is perfect. If there is a large difference between these two outputs, parameters or algorithms have to be changed. Adaptive systems contain these kinds of loops.

The following table shows the applicability of the drivers for change with respect to adaptive production and business processes

Table 4.5.1 – Adaptive production and business processes

Driver		Applicability	Comments
Consumer demands	Customer oriented products	***	
	Competitive product prices	*	
	Fitness secondary conversion	**	
	More homogeneous products	***	
Economic	Improved profit	***	
	Added value	***	
	Production cost savings	*	
	Minimising by products	*	
	Minimising waste	*	
	Other	*	
Environmental	Saving wood raw material	***	
	Reducing amount of waste	**	
	Reducing energy demand	*	

The following table shows what stage of development each region of Europe is at with respect to adaptive production and business processes.

Table 4.5.2 – Adaptive production and business processes stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase		✓		
Industrial Trials	✓			
Adopted by some SME’s				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to adaptive production and business processes.

Table 4.5.3 – Adaptive production and business processes future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations

The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles

The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of adaptive production and business processes.

Table 4.5.4 – Risks and costs to industry from adaptive production and business processes

Cons	Pros
Advanced ERP and process control system must be available	Better production planning
	Increased profit

4.6 Information systems and intelligent material flow control

Forest –Wood chain provides a lot of data and information. Data is gathered but only locally used and then the data is lost. It is not possible to link together products with their properties, wood raw material and processing parameters, which are very important for planning operations. Information systems about forest operations, production, machinery, sales and marketing are isolated and not communicate with each other.

In the future a "company global" information system will cover the whole chain –from the forest to the end products and business processes. Integration of data throughout whole conversion chain can be achieved by marking wood raw material, logs, in the forest and storing data in an information system. Marking can be e.g. by electronic tag which provides address in the information system. When a piece is passing a process phase the tag is read and the measured data stored in the information system. The linked data and information is available for planning systems and process control ensuring precise management of business processes.

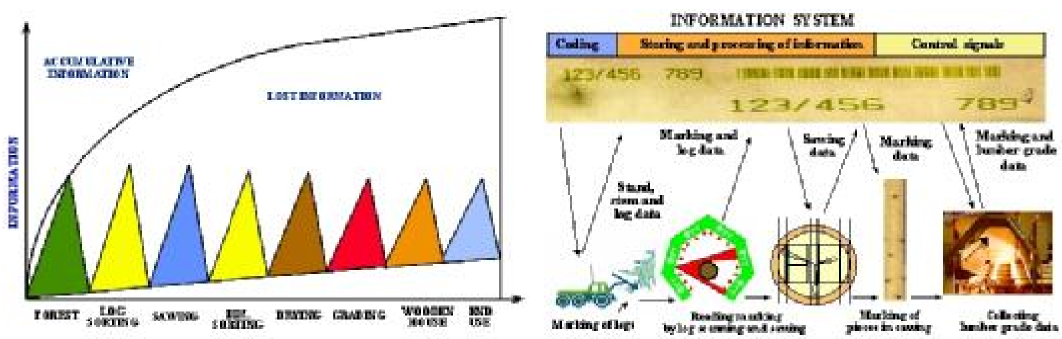

Figure 4.6 Recorded and lost information can be recovered through marking / reading pieces and advanced data processing.

The following table shows the applicability of the drivers for change with respect to information systems and intelligent material flow control.

Table 4.6.1 – Information systems and intelligent material flow control drivers for change

Driver		Applicability	Comments
Consumer demands	Customer oriented products	*	
	Competitive product prices	***	
	Fitness secondary conversion	*	
	More homogeneous products	***	
Economic	Improved profit	***	
	Added value	***	
	Production cost savings	*	
	Minimising by products	*	
	Minimising waste	*	
	Training	**	
Environmental	Saving wood raw material	***	
	Reducing amount of waste	**	
	Reducing energy demand	*	

The following table shows what stage of development each region of Europe is at with respect to information systems and intelligent material flow control.

Table 4.6.2 – Information systems and intelligent material flow stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase			✓	
Industrial Trials		✓		
Adopted by some SME's	✓			
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to adaptive production and business processes.

Table 4.6.3 – Information systems and intelligent material flow control future regional uptake

<table>
<tr><th>Region</th><th>Expected Time</th><th>2010</th><th>2015</th><th>2020</th><th>2025</th></tr>
<tr><td rowspan="4">North Europe</td><td>Research & Development phase</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Industrial Trials</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Adopted In some SME’s</td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td></tr>
<tr><td>Generally Adopted</td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td></tr>
<tr><td rowspan="4">Central Europe</td><td>Research & Development phase</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Industrial Trials</td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td></tr>
<tr><td>Adopted In some SME’s</td><td></td><td bgcolor="#d9d9d9"></td><td></td><td></td></tr>
<tr><td>Generally Adopted</td><td></td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td></tr>
<tr><td rowspan="4">South Europe</td><td>Research & Development phase</td><td bgcolor="#d9d9d9"></td><td></td><td></td><td></td></tr>
<tr><td>Industrial Trials</td><td></td><td bgcolor="#d9d9d9"></td><td bgcolor="#d9d9d9"></td><td></td></tr>
<tr><td>Adopted In some SME’s</td><td></td><td></td><td></td><td bgcolor="#d9d9d9"></td></tr>
<tr><td>Generally Adopted</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">East Europe</td><td>Research & Development phase</td><td></td><td bgcolor="#d9d9d9"></td><td></td><td></td></tr>
<tr><td>Industrial Trials</td><td></td><td></td><td bgcolor="#d9d9d9"></td><td></td></tr>
<tr><td>Adopted In some SME’s</td><td></td><td></td><td></td><td bgcolor="#d9d9d9"></td></tr>
<tr><td>Generally Adopted</td><td></td><td></td><td></td><td></td></tr>
</table>

Regional variations

The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles

The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of information systems and intelligent material flow control.

Table 4.6.4 – Risks and costs to industry from information systems and intelligent material flow

Cons	Pros
Marking costs	Better production planning
Markings are not always be successfully read	Better process control
	Increased profit

4.7 Traceability

Currently, no information is available about the origin of wood raw material. In the future, marking pieces with visible or non-visible markings in the forest and forwarding this information to the customers and end users will allow traceability this is strongly linked to marking of pieces and information systems presented in 4.6.

Traceability is very important in order to prevent illegal sales of wood raw material. Traceability offers good tool to forward information from producers to further conversion and end users.

The following table shows the applicability of the driver for change with respect to traceability.

Table 4.7.1 – Traceability drivers for change

Driver		Applicability	Comments
Consumer demands	customer oriented products	**	
	competitive product prices	*	
	fitness secondary conversion	*	
	more homogeneous products	*	
	customer service	***	
Legislation	preventing illegal sales	***	
Economic	improved profit	*	
	added value	*	
	production cost savings	*	
	minimising by products	*	
	minimising waste	*	
Environmental	saving wood raw material	***	
	reducing amount of waste	**	
	reducing energy demand	*	
	other		

The following table shows what stage of development each region of Europe is at with respect to traceability.

Table 4.7.2 – Traceability stage of development

Stage	**North Europe**	**Central Europe**	**South Europe**	**East Europe**
Research and Development phase			✓	
Industrial Trials		✓		
Adopted by some SME’s	✓			
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to traceability.

Table 4.7.3 – Traceability future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles

The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of traceability.

Table 4.7.4 – Risks and costs to industry from traceability

Cons	Pros
Marking costs	Better consumer service
	Prevention of illegal logging

5 PLYWOOD INDUSTRY (responsible: VTT - Jorma Froblom)

5.1 New technologies in Plywood industry

In PD 4.2.3 Report on Review of Technology Development Trends within the Various Processes, chapter 4.2 dealt with ‘Plywood industry’.

New technologies in plywood industry are:

1. Log scanners and peeling
2. Introduction of new peeling parameters
3. Introduction of more automated veneer scarfing lines
4. Introduction of automated dry veneer scanning
5. Development/introduction of automatic composing
6. Introduction of automatic patching
7. Automation.

They are already introduced in best practice and are expected to be introduced in use general manufacturing by 2015 and to SMEs between 2015 and 2025. Some new automation, ICT –systems and x-ray and machine vision systems are at research level and is expected to be introduced from small scale trials into best practice in the near future.

The following table shows what stage of development each region of Europe is at with respect to new technologies in plywood industry.

Table 5.1.1 – New technologies in plywood industry stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials				
Adopted by some SME’s	✓	✓		
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to new technologies in plywood industry.

Table 5.1.2 – New technologies in plywood industry future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The regional variation of this technology is related to the different wood species, industrial structure and mill sizes. There is also a difference in the general level of technology and education. The integration between the sawmill companies and machinery companies can also be different.

Conditions and obstacles
The development and adoption of this technology is based on the condition that its implementations are profitable. There are no obstacles in the long run

The following table shows the pros and cons of new technologies in plywood industries

Table 5.1.3 – Risks and costs to industry from new technologies in plywood industries

Cons	Pros
Investment costs	Increased volume yield
	Increased profit
	Improved quality of products

Table 5.1.2 – New technologies in plywood industry drivers for change

Level of development of Technologies / Drivers for change	In general use (still to be introduced to SMEs)	Used in best practice	Developed to small scale trials	Research level
Time scale for Introduction	2015 (SME 2025)	2005	2005◊	2010→
Social; overall evaluation	**	**	*	**
• increase occupational health	** 1)	* 1)		
• increase consumer acceptance				
• influence on manpower needed	** 3)	* 3)		
• increase the regional employment rate, and/or		* 4)		
• Increase production of bio-based excess energy e.g. in form of pellets for local society.				
Economic; overall evaluation	**	***	***	***
• increase the profit			** 1)	*** 1)
• give additional value to products			** 2)	*** 2)
• have savings in production costs			** 3)	*** 3)
• have savings in transportation costs, and/or				
• increase the exploitation of by-products			** 5)	
Environmental; overall evaluation	***	**	**	*
• increase the use of renewable fuels				
• decrease the need of fossil fuels			* 1)	
• decrease energy consumption			* 2)	
• cause less emissions and/or waste			* 3)	
• use more renewable raw materials			* 4)	
• require less transportation, and/or				
• increase the recyclability and reusability of products and co-products				
Legislation; overall evaluation	**	*	*	*
• REACH				
• Biocidal products directive				
• IPPC	* 3)			
• Illegal logging	* 4)			* 4)
• Renewable energy – biomass discussionsEcolabel discussions (wood based furniture)	* 5)			
• European Pollutant Release and Transfer Register	* 6)			
• VOCs				
• Wood dust	9)			
• Formaldehyde	* 10)			
• Waste discussions	* 11)			

Technologies as referred to in the table above:

1. Log scanners and peeling
2. Introduction of new peeling parameters
3. Introduction of more automated veneer scarfing lines
4. Introduction of automated dry veneer scanning
5. Development/introduction of automatic composing
6. Introduction of automatic patching
7. Automation.

Importance of drivers:

* - small; ** - medium *** very important

◊ for technologies 1, 4, 7

6 PANEL BOARD INDUSTRY (responsible: Pöyry)

6.1 Development of powder coating

Powder coating technology is already used in best practice and is expected to be introduced into general practice and the majority of SMEs by 2010. The estimated timescale of the development of this technology is shown in Table 6.1.3.

The following table shows the drivers for change with respect to development of powder coating.

Table 6.1.1 – Development of powder coatings drivers for change

Drivers in consumer demand: - Effects on health	- No risk / reduced risk for emission of hazardous substances when newly processed products are used inside houses.
Technology's effect on economic aspects: - Improved profit - Production cost savings	- Through savings in energy and environment related costs.
Technology's effects on environmental aspects: - Reduced energy demand - Fewer emissions and waste - Reduce transport impacts	- This technique produces less waste than the conventional one. - It reduces energy demand because there is no need for drying process – even though the product must be heated up. - Reduced transport of hazardous chemicals.
Technology's effects on social aspects: - Occupational health - Consumer acceptance	- Less solvents and volatile organic compounds
Possible changes in risks and costs in the industry as a whole?	-

The following table shows what stage of development each region of Europe is at with respect to development of powder coating.

Table 6.1.2 – Development of powder coatings stage of development

Stage	**North Europe**	**Central Europe**	**South Europe**	**East Europe**
Research and Development phase				
Industrial Trials				
Adopted by some SME's	✓	✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to development of powder coatings.

Table 6.1.3 – Development of powder coatings future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
There are not big differences between the different regions of Europe; however MDF production and consumption are estimated to grow only in Eastern Europe in coming years. Consumption and production in all other regions of Europe are estimated to remain at current levels. One difference is that MDF consumption and processing is limited in Nordic Countries.

Conditions and obstacles
The obstacles which may prevent the adoption of this technology are new substitutive technology developments and the need for investment needed. Usage of powder coating applications is also dependent on MDF usages i.e. demand of furniture and wooden doors (kitchen doors etc).

Powder coating of MDF is already generally adopted method in industry in all regions in Europe where MDF is processed in industrial scale. Powder coating is already so acceptable method by industry that some MDF panel producers have already even developed specially designed MDF boards which offer improved conductivity for powder attraction and thus reduce energy costs. To ensure the quality of the powder coating there need to be only small density variations in the panel edges to avoid surface cracking.

The following table shows the pros and cons of development of powder coatings.

Table 6.1.4 – Risks and costs to industry from development of powder coatings

Cons	Pros
Investment costs	Reduced risk for emission of hazardous substances
	Savings in energy and environmental costs
	Less Waste
	Reduced energy table
	Reduced transport of hazardous chemicals

6.2 Dry Gluing

Dry gluing technology is already used in best practice and is expected to be introduced into general practice and the majority of SMEs by 2015. The estimated timescale of the development of this technology is shown in Table 6.2.3.

The following table shows the drivers for change with respect to dry gluing.

Table 6.2.1 – Dry gluing drivers for change

Dry Gluing	
Drivers in consumer demand:	- No large changes in consumer demand, the main drivers are in production
Technology’s effect on economic aspects: - Improved profit - Production cost savings	- Reduced energy and raw material costs
Technology’s effects on environmental aspects: - Reduced energy demand - Fewer emissions and waste	- Reduced energy and glue consumption when applied on dried MDF panels. - Reduced formaldehyde emissions due to reduced use of glue.
Technology’s effects on social aspects: - Occupational health	- Reduced formaldehyde emissions due to reduced use of glue - Dry process is easier to keep clean
Possible changes in risks and costs in the industry as a whole?	-

The following table shows what stage of development each region of Europe is at with respect to dry gluing.

Table 6.2.2 – Dry gluing stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase			✓	✓
Industrial Trials		✓		
Adopted by some SME’s				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to dry gluing.

Table 6.2.3 – Dry gluing future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The main regional differences are that the European MDF production and consumption is concentrated in Western Central Europe and Eastern Europe. Currently there is only one MDF mill in Nordic countries. The Largest MDF producers and the biggest production volumes are in Western Central European countries where panel related R&D operations are also concentrated.

Conditions and obstacles

The conditions that the adoption of this technology is dependent on are the sustained or growing demand of MDF. Also stringent regulations on occupational health have an effect. They will boost the development of the new technologies. Dry gluing decreases the formaldehyde emissions of the panels by decreasing the glue usage.

The obstacles facing this technology are investment costs related to new gluing technology, high maintenance costs and the uneven resination of the fibres compared to the current technology.

The following table shows the pros and cons of dry gluing.

Table 6.2.4 – Risks and costs to industry from dry gluing

Cons	Pros
Investment costs	Reduced risk for emission of hazardous substances
High maintenance costs	Savings in energy and raw material costs due to reduced energy and glue demand
Uneven resination.	

6.3 MDI-resin as substitute of urea-formaldehyde in MDF production

MDI technology is already used in best practice and is expected to be introduced into general practice and the majority of SMEs by 2015. The estimated timescale of this technology is shown in Table 6.3.3.

The following table shows the drivers for change with respect to MDI-resin as a substitute of urea-formaldehyde in MDF production.

Table 6.3.1 – MDI-resin use in MDF production drivers for change

MDI-resin as substitute of urea-formaldehyde	
Drivers in consumer demand: - Legislation - Health effects	- Less formaldehyde in the product - Formaldehyde has been reclassified to a confirmed carcinogen to humans - Pending EU decisions regarding indoor air quality limits will be the main factor to determine the impact of new regulations on panel industry. - Germany is currently implementing rigorous testing procedures and stringent limits for building products and formaldehyde emissions. A result of this is for example the fact that within the last 2 years since the discussion started, OSB has moved way from formaldehyde containing resins towards MDI resins
Technology's effect on economic aspects: - Others	- Increased production costs
Technology's effects on environmental aspects: - Fewer emissions and waste	- Both in production and final product
Technology's effects on social aspects: - Occupational health - Consumer acceptance	- MDI is more hazardous than UF before the product is dried. In dried product the situation is the opposite.
Possible changes in risks and costs in the industry as a whole?	- Less hazardous emissions but higher costs -> risk for decreased production

The following table shows what stage of development each region of Europe is at with respect to MDI-resin as substitute of urea-formaldehyde in MDF production.

Table 6.3.2 - MDI-resin use in MDF production stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase		✓	✓	
Industrial Trials				
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to MDI-resin as substitute of urea-formaldehyde in MDF production.

Table 6.3.3 – MDI-resin use in MDF production future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The difference between the regions is that MDF production being limited in Nordic Countries. In addition to this MDF producers acting in Eastern Europe have most of their research and development in Western Central Europe.

Conditions and obstacles

MDI resin is already generally adopted in OSB production. The tightening restrictions of formaldehyde emissions may drive MDI resin consumption. The only obstacles facing this technology are that MDI resin costs significantly more than urea-formaldehyde and MDI resin is an occupational hazard in panel production.

The following table shows the pros and cons of MDI-resin as a substitute for urea formaldehyde in MDF production.

Table 6.3.4 – Risks and costs of industry from MDI-resin used as a substitute of urea-formaldehyde in MDF production.

Cons	Pros
Higher production costs	Reduced emissions of hazardous substances in dry form both in production and in final product
More hazardous production material	

6.4 Mat pre-heating

Mat pre-heating technology is already in use in general manufacturing and is expected to be in use in the majority of SMEs by 2015. The estimated timescale for the development of this technology is shown in Table 6.4.2.

The following table shows the drivers for change with respect to mat pre-heating.

Table 6.4.1 – Mat pre-heating drivers for change

Mat pre-heating	
Drivers in consumer demand: - Others	- Thicker panels
Technology's effect on economic aspects: - Production cost savings	- Reduced energy costs
Technology's effects on environmental aspects: - Reduced energy demand	- Reduced energy consumption - Possibility to increase production capacity in current mills, because press capacity (which limits production) grows
Technology's effects on social aspects:	-
Possible changes in risks and costs in the industry as a whole?	-

The following table shows what stage of development each region of Europe is with at respect to mat pre-heating.

Table 6.4.2 – Mat pre-heating stage of development

Stage	**North Europe**	**Central Europe**	**South Europe**	**East Europe**
Research and Development phase				
Industrial Trials				
Adopted by some SME's		✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to mat pre-heating.

Table 6.4.3 – Mat pre-heating future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The technology will be adopted in the regions where are the modern wood based panel production lines.

Conditions and obstacles
This technology is dependent on requirements on higher line speeds, low moisture variation in the mat and resins with lower formaldehyde content. The obstacles currently facing this technology are the investment costs needed and the competing technologies to save energy and production costs.

The following table shows the pros and cons of MAT pre-heating.

Table 6.4.4 – Risks and costs to industry from MAT pre-heating

Cons	Pros
Investment costs	Reduced energy consumption and costs
	Possibility to increase production capacity in current mills

6.5 Light and super light MDF

Light and super light MDF technology is already used in best practice and is expected to be introduced into general practice and the majority of SMEs by 2015. The estimated timescale of the development of this technology is shown in Table 6.5.3.

The following table shows the drivers for change with respect to light and super light MDF.

Table 6.5.1 – Light and super light MDF drivers for change

Light and super light MDF	
Drivers in consumer demand: - Others	- Thick and light panels
Technology's effect on economic aspects: - Added value	- Less material utilised per m^3
Technology's effects on environmental aspects: - Reduced energy demand - Fewer emissions and waste - Reduce transport impacts	- Reduced energy and raw material demand, due to reduced amount of material processed. - Less waste after the use - Reduced transport effects due to the lightness of the product.
Technology's effects on social aspects: - Occupational health	- More ergonomic to handle.
Possible changes in risks and costs in the industry as a whole?	-

The following table shows what stage of development each region of Europe is at with respect to light and super light MDF.

Table 6.5.2 – Light and super light MDF stage of development

Stage	**North Europe**	**Central Europe**	**South Europe**	**East Europe**
Research and Development phase				
Industrial Trials				
Adopted by some SME's		✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to light and super light MDF.

Table 6.5.3 – Light and super light MDF future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

European MDF production and consumption is concentrated in Western Central Europe and Eastern Europe. Also there is currently MDF mill in Nordic countries limiting the adoption of this technology in this region.

Conditions and obstacles

The conditions are that the problems with high raw material and high transportation costs, and design trends in furniture manufacturing favouring thick panels are resolved. As the light and super light MDF panels are already produced in best practice production units there can not be seen any major obstacles that would prevent the production of light or super light MDF in large scale in near future although the development of other competing light or super light panel products may have to be considered.

The following table shows the pros and cons of light and super light MDF.

Table 6.5.4 – Risks and costs to industry from light and super light MDF

Cons	Pros
Investment costs	Reduced energy and raw material demand
	Reduced transport effects
	Less waste at the end of life stage
	Product more ergonomic to handle

6.6 Light particle board

Light particle board technology is already used in best practice and is expected to be introduced into general practice and the majority of SMEs by 2015. The estimated timescale of the development of this technology is shown in Table 6.6.3.

The following table shows the drivers for change with respect to light particle board.

Table 6.6.1 – Light particle board drivers for change

Light particle board	
Drivers in consumer demand: - Others	- Thick and light panels
Technology's effect on economic aspects: - Added value	- Less material utilised per m^3
Technology's effects on environmental aspects: - Reduced energy demand - Fewer emissions and waste - Reduce transport impacts	- Reduced energy and raw material demand, due to reduced amount of material processed. - Less waste after the use - Reduced transport effects due to the lightness of the product.
Technology's effects on social aspects: - Occupational health	- More ergonomic to handle.
Possible changes in risks and costs in the industry as a whole?	-

The following table shows what stage of development each region of Europe is at with respect to light particle board.

Table 6.6.2 – Light particle board stage of development

Stage	**North Europe**	**Central Europe**	**South Europe**	**East Europe**
Research and Development phase				
Industrial Trials				
Adopted by some SME's		✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to light particle board.

Table 6.6.3 – Light particle board future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

Generally there can not be seen any major differences between the different parts of Europe. Particleboard is widely produced in all regions of Europe with the biggest volumes being produced in central Europe where the fastest product development is expected to be.

Conditions and obstacles

The adoption is dependent on the continued demand of light reconstituted panels. The high raw material and high transportation costs are significant drivers for the development of lighter panels. The production of light particleboard does not need major changes or additions to the standard production line i.e. investment costs are not nor will be the key issue constricting the usage of light particleboard. The main obstacles facing this technology are other competing new light panels, disposal and recycling of panels including other materials other than wood as well as and high production costs.

The following table shows the pros and cons of light particle board.

Table 6.6.4 – Risks and costs to industry from light particle board

Cons	Pros
Investment costs	Reduced energy and raw material demand
	Reduced transport effects
	Less waste at the end of life stage
	Product more ergonomic to handle

6.7 Dyed MDF

Dyed MDF is already used in best practice and is expected to be introduced into general practice and the majority of SMEs by 2015. The estimated timescale for this technology is shown in Table 6.7.3.

The following table shows the drivers for change with respect to dyed MDF.

Dyed MDF related technologies	
Drivers in consumer demand: - Others	- "Limited design options"
Technology's effect on economic aspects: - Added value	- Increased production costs - Higher price of the final product
Technology's effects on environmental aspects: - Fewer emissions and waste	- No separate painting / surface treatment needed - No surface treatment chemicals, reduced use of solvents (please see also "Powder coating")
Technology's effects on social aspects: - Occupational health	- Reduced use of solvents
Possible changes in risks and costs in the industry as a whole?	- Increased production costs - Less process stages in value chain

The following table shows what stage of development each region of Europe is at with respect to dyed MDF.

Table 6.7.2 – Dyed MDF stage of development

Stage	**North Europe**	**Central Europe**	**South Europe**	**East Europe**
Research and Development phase				
Industrial Trials				
Adopted by some SME's		✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to dyed MDF.

Table 6.7.3 – Dyed MDF future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

There is not a lot of difference if any between the regions with the exception of Nordic countries where the MDF production is limited as discussed previously. The technology is in use in at least one company which has mills in different regions of Europe.

Conditions and obstacles

The adoption of this technology is dependent on the development of a feasible product and markets. Furniture productions also need a wide range of products. The main obstacles facing this technology are increasing production costs, a lack of investment costs and difficulty getting consistent colours.

The following table shows the pros and cons of dyed MDF.

Table 6.7.4 – Risks and costs to industry from dyed MDF

Cons	Pros
Investment costs	Reduced energy and raw material demand
Increased production costs	Reduced transport effects
	Less waste at the end of life stage
	Product more ergonomic to handle

6.8 Process control and measurement device technologies

These technologies are already used in best practice and are expected to be introduced into general practice and the majority of SMEs by 2015. The estimated timescale for the development of this technology is shown in Table 6.8.3.

The following table shows the drivers for change with respect to process control and measurement device technologies.

Table 6.8.1 – Process control and measurement device technologies drivers for change

Process control and measurement device technologies	
Drivers in consumer demand: - Others	- More uniform quality
Technology's effect on economic aspects: - Production cost savings	- More uniform quality
Technology's effects on environmental aspects: - Reduced energy demand - Fewer emissions and waste	- Smooth run and better control of processes give: - Increased amount of first quality products - Narrower tolerance limits - Better saw-cut -More even panel surface and thus less grinding/polishing needed
Technology's effects on social aspects: - Occupational health	- Increased meaningfulness of the work
Possible changes in risks and costs in the industry as a whole?	

The following table shows what stage of development each region of Europe is at with respect to process control and measurement device technologies.

Table 6.8.2 – Process control and measurement device technologies stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials				
Adopted by some SME's	✓	✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to process control and measurement device technologies.

Table 6.8.3 – Process control and measurement device technologies future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

Process control automation is already widely in use throughout European MDF, PB and OSB plants. Generally new technologies are implemented in new production lines and in line modernisations.

Conditions and obstacles

The conditions affecting the adoption of this technology are the increased requirements of reducing quality fluctuations. Also tight competition in the market leads to the need to utilise new technologies to better control processes. Technology transfer from other industries is an important way of improving the process measurement systems. The obstacles facing this technology are the need for investment funding and the difficulty of handling and utilising all the collected production data.

The following table shows the pros and cons of process control and measurement device technologies.

Table 6.8.4 – Risk and costs to industry from process control and measurement device technologies

Cons	Pros
Investment costs	Smooth and better control of processes
	Increased amount of first quality products
	Reduced energy demand
	Reduced amount of reject, waste and emissions

7 JOINERY INDUSTRY (responsible: BRE)

7.1 Wood welding

Wood welding is a method of joining wood by melting two surfaces of wood as a result of rapid friction. As the wood surfaces are rubbed together rapidly, some of the components in the wood (mainly the lignin) melt and these flow between the two timber sections. As these melted sections, they solidify. The whole process is a series of melting, inter-timber linkaging, bond breaking (as the timber is moved causing shear fraction), melting and reformation of links. The use of wood welding can reduce the use of synthetic adhesives, resulting in what may be perceived as a more environmentally friendly product. Wood welding can be divided into three sub-groups; wood welding of solid timber in laminate form, for curing adhesives, and wood welding of dowels. The following table shows the drivers for change in respect of wood welding.

Table 7.1.1 – Wood welding drivers for change

Wood welding	
Drivers in consumer demand: – Effects on health – Effects on the environment	– No or reduced risk of emission in buildings when wood welding is used to join timber rather than conventional adhesives – At end of life welded wood can be recycled reused or sent for energy recovery
Technology's effect on economic aspects: – Diversity of products expanded – New businesses – New applications for glued wood	– Savings in adhesive costs – Reduce consumption of adhesives – Opportunities for new wood welded products to develop markets
Technology's effect on environmental aspects: – Fewer emissions and waste – Improved environmental profile	– Reduce transport and consumption of petrochemical based adhesives – The glued (welded) product can easily be recycled at end of life as there is no adhesive present in the glued product
Technology's effect on social aspects: – Occupational health – Consumer acceptance	– Less adhesives based on solvents and petroleum derivatives
Possible changes in risks and costs in industry as a whole?	– Better environmental profile for glued wood but at much higher cost

Expected level of uptake
The wood working industry technique of wood welding is at an advanced stage of pilot trials in Europe and it is highly probable that by 2015 there will be a number of viable businesses wood welding either using reduced volumes of adhesive or no adhesive at all. This technology is highly relevant to the needs of modern forest products businesses and the use of wood in construction. A large number of SMEs will have adopted this technology and will be producing the materials and/or will be manufacturing using the modified wood substrates into the joinery and wood working markets – adding significant value to this chain by 2015. In addition other modification technologies will have emerged and be available for adoption by 2025. The estimated timescale of the development of these 3 sub-sections of wood welding can be seen in the Tables 7.1.3, 7.1.5 and 7.1.7.

The following table shows what stage of development each region of Europe is at with respect to wood welding of solid timber in laminate form.

Table 7.1.2 – Wood welding of solid timber in laminate form stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials				
Adopted by some SME's	✓			✓
Generally adopted		✓	✓	

The following table shows the estimated future uptake for each region of Europe with respect to wood welding of solid timber in laminate form.

Table 7.1.3 – Wood welding of solid timber in laminate form future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

The regional differences come from where the existing technological centres are already in place for this technology. There is already considerable investment in certain region such as central Europe. There is also a desire in certain regions to minimise the use of synthetic materials such as adhesives which is pushing this technology forward in those regions. Other regions notably east Europe are currently satisfied with traditional methods are therefore are reluctant to adopt this type of wood welding.

Conditions and obstacles

The long terms performance of the product needs to be evaluated in terms of stability and durability. There is also a need for capital investment in welding facilities along with the continued research and development of the technology to demonstrate its uses compared to adhered products.

The obstacles facing this technology are the need for investment in equipment capable of oscillating medium to large dimensions of timber, the perceived energy costs compared to adhered means of bonding. Also there are limited technological standards and a limited use of material due to instability of the wood weld bond line in presence of moisture. One of the main obstacles with wood welding is the limited funding available to regions outside central Europe.

The following table shows what stage of development each region of Europe is at with respect to wood welding for curing adhesives.

Table 7.1.4 – Wood welding for curing adhesives stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓		✓	✓
Industrial Trials	✓		✓	
Adopted by some SME's				
Generally adopted		✓		

The following table shows the estimated future uptake for each region of Europe with respect to wood welding for curing adhesives.

Table 7.1.5 – Wood welding for curing adhesives future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The regional differences come from where the established links are between research and development to industry. These links are mostly in central Europe and hence the development is more advanced in these regions. Also in central Europe notably there is already capital investment for this wood technology. Elsewhere the funding for research and development is limited.

Conditions and obstacles
The stability of different type of adhesives needs to be assessed. The accuracy in the adhesive application as well as the type of adhesive also needs to be developed. The adoption is also dependent on capital investment in welding facilities for different dimensions of timbers.

The three main obstacles facing this technology are that investment is needed to equip facilities capable of welding medium and large dimensioned timbers. As well as this, investment costs for accurate application of the adhesive line to timber material to be bound is needed. The perceived energy cost compared to traditional adhesive bonding compared to time delay associated with conventional curing systems.
Many regions will await commercial developments by companies linked to the research and development centres based in central Europe.

The following table shows what stage of development each region of Europe is at with respect to wood welding of dowels.

Table 7.1.6 – Wood welding of dowels stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓		✓	✓
Industrial Trials	✓		✓	
Adopted by some SME’s		✓		
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to wood welding of dowels.

Table 7.1.7 – Wood welding of dowels future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
Where there are already existing technological centres such as France the advancement of this technology will be faster than in other regions. The novelty of this technology has also led to other areas of Europe not yet embracing it. There is also a reluctance to adopt this technology where the idea of reducing metal fixings is not an issue.

Conditions and obstacles
The adoption of this technology is dependent on the long term performance of the product in terms of stability, durability, performance of fixings being analysed and evaluated. The process also needs to be further demonstrated and tested to increase market acceptance, and also compared to traditionally adhered products. There are no financial considerations since the dowel fixing can be achieved using conventional drills and hence the invested needed is not that high.

One of the obstacles facing the technology is the accuracy needed for the welding process of the dowel. This accuracy is needed otherwise shattering will occur. In addition to this it needs to be proven that it can conform to standards. There is also a limited use of material due to instability of the wood weld bone line in the presence of moisture. Another major obstacle is the need for this technology as some of Europe prefers the conventional methods.

The following table of pros and cons, and drivers is representative for all 3 welding processes.

Tables 7.1.8 – Risk and costs to industry from wood welding

Cons	Pros
Investment costs	Low or zero emissions
Stability in wet conditions is poor	No petrochemical based adhesive
Long term durability is not known	Decorative appeal
Independent approval is needed	Can be readily recycled, reused or energy recovered with impact
	Less waste

7.2 Short-burst microwaves for improved drying performance

Microwave drying has been in existence for many years. Short bursts of microwaves initiate localised damage to the rays and surrounding tissues which result in improved drying of many refractory hardwood timber species. If longer bursts of microwaves are used, the voids created can be resin impregnated to enhance or change timber properties. The timber research technique of using short burst microwaves is in its very early stages in the UK, although it has been proved and investigated in some depth in Australia. Before industrial up-take of the technology in the UK, an in-depth study will be required. The technique lends itself to improving the drying of many refractory hardwood species which will be used predominantly in the joinery sector.

The following table shows the drivers for change in respect of short-burst microwaves for improved drying.

Table 7.2.1 – Short-burst microwaves for improved drying performance drivers for change

Short burst microwave drying	
Drivers in consumer demand: – Improved timber quality – Effects on the environment – Reduced drying costs	- Less rejects - Reduced energy use - Improved quality
Technology's effect on economic aspects: – Reduced drying costs – Improved wood quality – New applications for wood if impregnated	- Enhanced environmental credentials - Improved durability - Possible to resin impregnate material to change properties - Enhanced movement characteristics
Technology's effect on environmental aspects: – Reduced energy use – Improved durability	- Less waste product - Reduced transport
Technology's effect on social aspects: – Consumer acceptance	- Reduced use of non-wood products

Expected level of uptake
If the technology is proven in the UK, the level of up-take would be expected to be country wide. The expected improvements in timber quality and the reduction of energy required to dry the material would be a large incentive to the industry. The estimated timescale for the development of this technology is shown in Table 7.2.3.

The following table shows what stage of development each region of Europe is at with respect to short-burst microwaves for improved drying performance.

Table 7.2.2 – Short-burst microwaves for improved drying performance stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase		✓		
Industrial Trials				
Adopted by some SME’s				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to short-burst microwave drying for improved drying performance.

Table 7.2.3 – Short burst microwaves for improved drying performance future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations

In general north and central Europe are more open to new technologies and as a result there development is more advanced than the other regions of Europe. In addition to this north and central Europe also have more funding available for looking into new technologies. Other areas of Europe have problems with current technologies and need to address these problems first.

Another difference is that as the quality of wood varies from region to region, some regions in particular Scandinavia will not be so dependent on such technologies

Conditions and obstacles

This technology is dependent on the energy requirements needed in the drying process. The cost and amount of energy required during this process may prove to be an obstacle preventing the adoption of this technology.

The following table shows the pros and cons of short-burst microwaves for improved drying performance.

Table 7.2.4 – Risks and costs to industry from short-burst microwaves for improved drying performance

Cons	Pros
Investment costs	Improved dryness
Increased level of workforce skill	Improved movement characteristics
	Reduced drying costs
	Greater resources as difficult to dry timbers can now be used

7.3 Heat treatment (Thermally Modified Timber)

The technology of heat treatment (thermal modification), is an active business now and can be adopted through licensing by any forest business. By 2015 this technology will be significantly important in the provision of durable and stable long life wood products for indoor and outdoor use as well as providing effective challenges to less sustainable substrates such as uPVC in window manufacture.

The following table shows the drivers for change with respect to thermally modified timber.

Table 7.3.1 – Thermally modified timber drivers for change

Heat treatment	
Drivers in consumer demand: – Effects on health – Effects on the environment	- No or reduced risk of emissions in buildings when thermal modification of timber is used to enhance durability of timber rather than conventional techniques - At end of life TMT can be recycled, reused or sent for energy recovery
Technology's effect on economic aspects: – Diversity of products expanded – New businesses – New applications for wood	- New markets for stable and more durable wood based product - Reduced consumption of wood preservatives - Reduced maintenance painting activity - Outside BPD legislation?
Technology's effect on environmental aspects: – Fewer emissions and waste – Improved environmental profile	- Easy to handle and manage at end of life - Less waste product - Reduced transport
Technology's effect on social aspects: – Occupational health – Consumer acceptance	- Reduce emissions in production - Reduced use of non-wood products
Possible changes in risks and costs in industry as a whole?	- Fewer process stages in the value chain - Increased production costs - Replacing existing wood businesses? - Reduced maintenance painting activity

Expected level of uptake

This technology is highly relevant to the needs of modern forest products businesses and the use of wood in construction. A large number of SMEs will have adopted this technology and will be producing the materials and/or will be manufacturing using the modified wood substrates into the joinery and wood working markets – adding significant value to this chain by 2015. In addition other modification technologies will have emerged and be available for adoption by 2025. The estimated development of this technology is shown in Table 7.3.3.

The following table shows what stage of development each region of Europe is at with respect to thermally modified timber.

Table 7.3.2 – Thermally modified timber stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials				
Adopted by some SME's			✓	✓
Generally adopted	✓	✓		

The following table shows the estimated future uptake for each region of Europe with respect to thermally modified timber.

Table 7.3.3 – Thermally modified timber future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations

There is no regional differences with this technology with the exception of north and central Europe being slightly more developed due adopting this technology earlier.
The main places of adoption for this technology are Finland, the Netherlands and France, where the technology has been adopted for 10, 7 and 5 years respectively.

Conditions and obstacles
This technology is dependent on the development of standards on which the technology can conform to. There are no obstacles facing this technology as it is mostly already adopted.

The following table shows the pros and cons of thermally treated timber.

Table 7.3.4 – Risks and costs to industry from thermally modified timber

Cons	Pros
Investment costs	Reduced emissions
No standards	No wood preservatives
Independent approvals needed	High dimensional stability
	Can be recycled, reused or energy recovered with impact
	Low equilibrium moisture content
	New opportunities for wood
	Stable surface promotes extended coating performance delivery extended maintenance intervals

7.4 Chemical modification (acetylation and furfurylation)

The technology of chemical modification is an active business now and can be adopted through licensing by any forest business. By 2015 this technology will be significantly important in the provision of durable and stable long life wood products for indoor and outdoor use as well as providing effective challenges to less sustainable substrates such as uPVC in window manufacture. The following table shows the driver for change with respect to chemical modification.

Table 7.4.1 – Chemical modification drivers for change

Chemical modification	
Drivers in consumer demand: – Effects on health – Effects on the environment	- No or reduced risk of emission in buildings - At end of life can be recycled, reused or sent for energy recovery
Technology's effect on economic aspects: – Diversity of products expanded – New businesses – New applications for wood	- New markets for stable and more durable wood based product - New production facilities across Europe - More effective products with extended maintenance intervals - Enhanced wooden joinery businesses - Reduced consumption of wood preservatives - Outside Biocidal Products Directive (BPD) legislation?
Technology's effect on environmental aspects: – Fewer emissions and waste – Improved environmental profile	- More wood based products used in joinery and other end uses - Easy to handle and manage at end of life
Technology's effect on social aspects: – Occupational health – Consumer acceptance	- Reduced emissions to workers and indoor air - More vibrant forest based businesses and their rural communities
Possible changes in risks and costs in industry as a whole?	- High costs of product? - Increased production costs

Expected level of uptake
The technology of chemical modification is an active small scale business now and can be adopted through licensing by any forest business. By 2015 this technology is expected to be medium scale and significantly important in the provision of durable and stable long life wood products for exterior joinery. The estimated timescale of the development of this technology is shown in Table 7.4.3.

The following table shows what stage of development each region of Europe is at with respect to chemical modification.

Table 7.4.2 – Chemical modification stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase			✓	✓
Industrial Trials				
Adopted by some SME’s	✓	✓		
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to chemical modification.

Table 7.4.3 – Chemical modification future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations
The main regional difference for this technology is due to where the technology was funded. With acetylation this was the Netherlands who have recently merged with a company in the UK and have been licensed for nearly 2 years. With furfurylation this was Sweden where it has been licensed for 5 years.

Conditions and obstacles
This technology is dependent on the development of standards on which the technology can conform to. Also this technology is dependent on other emerging markets. There are no obstacles facing this technology as it is mostly already adopted as long as the standards can be developed.

The following table shows the pros and cons of chemical modification.

Table 7.4.4 – Risks and costs to industry from chemical modification

Cons	Pros
Investment costs	Reduced emissions
No standards	No wood preservatives
Independent approvals needed	High dimensional stability
Timber imported into EU	Can be recycled, reused or energy recovered with impact
	Low equilibrium moisture content
	High durability
	New opportunities for wood
	Stable surface promotes extended coating performance delivery extended maintenance intervals

7.5 Surface oils

This technology has not been developing according to prior assumptions and it now falls out of the scope of this report. It will not be studied unless there are changes in the status of adoption.

7.6 DMDHEU (dimethyldihydroxymethyleneurea) treatment by vacuum

The use of DMDHEU as a reagent for wood modification is an active business now and can be adopted through licensing by any forest business. By 2015 these technologies will be significantly important in the provision of durable and stable long life wood products for indoor and outdoor use as well as providing effective challenges to less sustainable substrates such as uPVC in window manufacture.

The following table shows the drivers for change with respect to DMDHEU treatment by vacuum.

Table 7.6.1 – DMDHEU treatment by vacuum drivers for change

DMDHEU	
Drivers in consumer demand: – Effects on health – Effects on the environment	– Reduced risk of emissions in buildings – At end of life can be recycled, reused or sent for energy recovery
Technology's effect on economic aspects: – Diversity of products expanded – New businesses – New applications	– New markets for stable and more durable wood based product – Reduced consumption of wood preservatives – Factory controlled – better reliability and uniformity of product – Enhanced wooden flooring, outdoor wood and decking businesses
Technology's effect on environmental aspects: – Fewer emissions and waste – Improved environmental profile	– Stable and hard wood surfaces – Improved performance of wood surfaces – Reduced waste
Technology's effect on social aspects: – Occupational health – Consumer acceptance	– Improved products for consumers
Possible changes in risks and costs in industry as a whole?	– Long term performance of products – Higher costs Higher costs – Replacing existing wood businesses?

Expected level of uptake
This technology is highly relevant to the needs of modern forest products businesses and the use of wood in construction. A large number of SMEs will have adopted this technology and will be producing the materials and/or will be manufacturing using the modified wood substrates into the joinery and wood working markets – adding significant value to this chain by 2015. In addition other modification technologies will have emerged and be available for adoption by 2025. The estimated timescale for this technology is shown in Table 7.6.3.

The following table shows what stage of development each region of Europe is at with respect to DMDHEU treatment by vacuum.

Table 7.6.2 – DMDHEU treatment by vacuum stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials				
Adopted by some SME's			✓	✓
Generally adopted	✓	✓		

The following table shows the estimated future uptake for each region of Europe with respect to DMDHEU treatment by vacuum.

Table 7.6.3 – DMDHEU by vacuum future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The development of this technology is mostly where there is already a level of expertise due to prior funding. These regions are notably central and north Europe. These regions also have money readily available for the research and development needed. This technology will also be market driven by public acceptance of enhanced products having higher unit cost

Conditions and obstacles
This technology is reliant on a supply of good quality timber being available for impregnation / polymerisation. There also need to be an improved perception of the product by users. The material performance compared to other materials, and in line with technical specifications / standards also needs to be analysed.
Other issues are ensuring surface quality of treated timber (minimise polymer build up on surface, limit risk of charring etc) and the acceptance of the treatment method as means of avoiding use of biocidal compounds (as conventionally used in preservation treatment), registering the product as environmentally friendly (as achieved with one process)

This technology needs to combine traditional impregnation treatment plant with temperature curing plant, this increases the costs associated. Another obstacle is the double processing nature of process increases energy requirements. In spite of these this technology is already seen as commercially viable and several large companies are already associated with this technology.

The following table shows the pros and cons of DMDHEU treatment by vacuum.

Table 7.6.4 – Risks and costs to industry from DMDHEU treatment by vacuum

Cons	Pros
Investment costs	Reduced emissions
No standards	No wood preservatives
Independent approvals needed	High dimensional stability
Long term performance is being generated	Can be recycled, reused or energy recovered with impact
	Improved hardness
	High durability
	New opportunities for wood
	Coating performance is enhanced on stable substrates

7.7 Green Gluing of timber (Polyurethane)

The following table shows the drivers for change with respect to green gluing of timber.

Table 7.7.1 – Green gluing of timber drivers for change

Green gluing of timber	
Drivers in consumer demand: – Effects on resource – Effects on the environment	- The ability to add value to the resource. - Improved stability - Reduced waste stream - Better use of the standing timber resource
Technology's effect on economic aspects: – Diversity of products expanded – Value adding to resource – New applications for glued wood	- The use of minor species previously considered unsuitable due to long size or log shape. - The use of low qualities materials previously deemed unsuitable due small Dimension or defects. -Structurally it can offer potential for better performing structural elements
Technology's effect on environmental aspects: – Less waste – Improved environmental profile	- Better whole log utilisation greater potential to use the whole standing timber supply - Added value to the resource leading to better managed hardwood forest leading to greater bio-diversity
Technology's effect on social aspects: – Consumer acceptance	- Increased value for money allowing cost effect purchasing of aspirational timber furniture, flooring, fittings stairs

Expected level of uptake

Green gluing is a natural progression from conventional dry gluing made possible by polyurethane adhesives with excellent grab at high moisture contents. Though a relatively new concept many trials have taken place demonstrating the potential for the technology. The technology is poised for industrial trials on joinery components within the UK. Several feasibility studies haven taken place regarding industrial costing and commercial benefits. The feasibly trails have been built on work to demonstrate the potential of the technology, not only for joinery components but for glue laminated structural components. There is one study currently drawing to a conclusion that is expected to result in a pilot production plant within the next 5 years. Therefore, by 2015 the technology is expected to be increasing adopted for the production of joinery blanks for a range of joinery end uses, primarily of hardwood origin. The use for structural application has been well studied and trialled and several major sawmills have explored the possibility of using the technology to aid production and one sawmill has already adopted the use for specific end use products, which can not be discussed for client confidentiality reason. The estimated timescale of the development of this technology is shown in Table 7.7.3.

Because of the many processing benefits green gluing offers the level of uptake is expected to be to be considerable, particularly for industries that already defect cut and laminate as part of their current production processes. The two major examples would be the window industry and furniture manufacture, much of the production for both is from laminated material. Many manufactures already have the plant and equipment that is necessary for green gluing therefore for many industries investment cost is not the inhibiting factor, that comes in identifying the products that can best carry the cost of the re-engineering processes but many already carry this cost as part of their current production. Structurally one company is already green gluing for specific applications, a second is making both structural and non-structural components (cladding/flooring) and several others are exploring the potential. In both joinery and structural applications it is the potential to add value to a modest starting resource that will drive the market and adoption of the technology. The following table shows what stage of development each region of Europe is at with respect to green gluing of timber.

Table 7.7.2 – Green gluing of timber stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase				
Industrial Trials				
Adopted by some SME's			✓	✓
Generally adopted	✓	✓		

The following table shows the estimated future uptake for each region of Europe with respect to green gluing of timber.

Table 7.7.3 – Green gluing of timber future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The development of this technology is mostly where there is already a level of expertise due to prior funding. These regions are notably central and north Europe. These regions also have money readily available for the research and development needed. This technology will also be market driven by public acceptance of enhanced products having higher unit cost

Conditions and obstacles
This technology needs to combine traditional impregnation treatment plant with temperature curing plant, this increases the costs associated. Another obstacle is the double processing nature of process increases energy requirements. In spite of these this technology is already seen as commercially viable and several large companies are already associated with this technology.

This technology is reliant on a supply of good quality timber being available for impregnation / polymerisation. There also need to be an improved perception of the product by specifiers and users. The material performance compared to other materials, and in line with technical specifications / standards also needs to be analysed. Other issues are ensuring surface quality of treated timber (minimise polymer build up on surface, limit risk of charring etc) and the acceptance of the treatment method as means of avoiding use of biocidal compounds (as conventionally used in preservation treatment), registering the product as environmentally friendly (as achieved with one process)

The following table shows the pros and cons of green gluing timber.

Table 7.7.4 – Risks and costs to industry from green gluing of timber

Cons	Pros
Investment costs for new start manufactures	Less wastage
Current market confidence	Better resources with added value
	Affordable products to a wider target audience
	Greater use of small dimensioned hardwood
	Current manufacturers of laminated joinery already have required plant

7.8 Pattern Moulding – polymer pellet moulding

This technology has not been developing according to prior assumptions and it now falls out of the scope of this report. It will not be studied unless there are changes in the status of adoption.

7.9 Development of inside-out beams

The following table shows the drivers for change with respect to the development of inside-out beams.

Table 7.9.1 – Development of inside-out beam drivers for change

Inside-out beams	
Drivers in consumer demand: – Effects on the resource	– Add value to a low value resource – Reduced waste
Technology's effect on economic aspects: – Increased management of small to medium sized forests – New business opportunities – New applications for small diameter stems	– Increased utilisation of stem – Reduced generation of co-products – Opportunities for new wood related product markets
Technology's effect on environmental aspects: – Increased utilisation and less waste – Improved environmental profile – New applications for bonded wood	– Increased utilisation of stem – Reduced generation of co-products – Opportunities for new wood related products markets
Technology's effect on social aspects: – Open up under managed woodland – Improved access for social activities	– Create a more diverse ecosystem – Encourage social interaction

Expected level of uptake

The timber research technique of producing inside-out beams (incorporating green gluing technology) is at an advanced stage in the UK. It is expected that by 2010 there will be a number of viable businesses using this technique to produce components such as structural beams, stair parts and roadside bollards. Using 'Green' gluing technology (bonding wood whilst the timber is 'wet') it is possible to convert small diameter hardwood and softwood stems into usable components, ensuring that a much larger percentage of the stem is utilised in comparison to normal processing methods.

These technologies are highly relevant to the needs of modern forest products businesses and the use of wood in construction. A large number of SMEs will have adopted these technologies and be producing the materials and/or will be manufacturing using the modified wood substrates into the joinery and wood working markets – adding significant value to this chain by 2015. In addition other modification technologies such will have emerged and be available for adoption by 2025. The estimated level of development is shown in Table 7.9.3.

The following table shows what stage of development each region of Europe is at with respect to development of inside-out beams.

Table 7.9.2 – Development of inside-out beams stage of development

Stage	**North Europe**	**Central Europe**	**South Europe**	**East Europe**
Research and Development phase		✓		
Industrial Trials				
Adopted by some SME's				
Generally adopted				

The following table shows a general estimated future uptake of new raw materials for each region of Europe. In many countries, the dominating new implemented raw material is likely to be agrobiomass (not studied within Eforwood)

Table 7.9.3 – Development of inside-out beams future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
Central and north Europe are more open to new technologies and as a result this technology is developing faster in these regions. Central and north Europe also have more funds available for research and development.

Conditions and obstacles
There are no conditions or obstacles facing this technology.

The following table shows the pros and cons of development of inside-out beams.

Table 7.9.4 – Risks and costs to industry from development of inside-out beams

Cons	Pros
Investment costs for new start manufactures	Improved utilisation of low value resources
Long term durability is not known	Increase value
Independent approvals required	Decorative appeal
	Can be readily recycled or reused
	Less waste
	Improved woodland management
	Improved wood beam quality
	Improved utilisation of wood thinnings

8 FURNITURE INDUSTRY

Due to difficulties with work load at CEI-Bois a there is no input on the furniture industry in this report.

9 BIOENERGY (responsible: VTT)

A short overview of the time scale of wood related bioenergy technology implementation that may have significant positive influence on certain sustainable criteria was given in report 4.2.5. As the bioenergy processes further studied within Eforwood are – due to very small resources - only focusing on pellets, this review will not include other processes.

Some processes earlier reviewed:
- New technology within large scale energy production
- Small scale combined heat and power production (CHP)
- Waste-to Energy processes
- Liquid biofuel production

9.1 Pellet production from new raw material

The resources of dry saw dust (forest industry by-products) are very limited. To increase pellet production, utilisation of wet saw dust as well as introduction of completely new raw materials will be needed. The first and presently ongoing development is implementing a drying step to the pellet plant to be able to use wet saw dust in the process. When the supply of this additional raw material is in use completely new raw material are needed. Instead of using forest residue directly as a fuel it may also be upgraded to pellets. The utilisation of new wood raw materials with poor properties (e.g. higher ash content than saw dust) for pellet production might not be the best way to enlarge the production of upgraded fuels so there might be changeover to other technologies/fuels when saw dust resources do not allow pellet production to increase.

The following table shows what stage of development each region of Europe is at with respect to pellet production from new raw materials.

Table 9.1.1- Pellet production from new raw materials stage of development in 2005

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓		
Industrial Trials	✓	✓		
Adopted by some SME's				
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to pellet production from wet saw dust and new raw materials. The development of saw mill industry in different regions will have a major influence on the development of pellet production.

Table 9.1.2 –Pellet production from new material future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations

Developing pellets production in regions with a large range of tree species will be more challenging than eg. in Scandinavia.

Conditions and obstacles

Development of saw mill industry affect introduction of pellet production. Saw mill integrated pellet production processes are more likely to success as energy demand will grow remarkable when wet raw materials are used.

The following table shows the pros and cons of pellet production from new raw material.

Table 9.1.3 – Risks and costs to industry from pellet production from new raw material

Cons	Pros
Investment costs for new processes	Increased production costs but also added value
Changes (decrease) in production level of saw mill industry (affect amount and prices of raw material) is a risk for pellet industry	Increased production amounts
Remarkable increase of energy input due to low quality material	Costs can be lowered by using eg. saw mill integrated drying processes

10 OTHER INDUSTRIES (responsible: TUZVO)

10.1 Isolation and development of wood protection chemicals from natural substrates

Isolation and development of wood protection chemicals from natural substrates is not entirely new. Extracts from sawmill residues of the naturally durable white cypress Callitris glaucophylla were tested for fungicidal activity in a series of laboratory bioassays. Sawdust from sapwood of Eucalyptus maculate was also used. Studies have shown that the resinous material extracted from the guayule plant (Parthenium argentatum, Gray) has both insect- and microbial-resistant properties. For controlling the stain and rot fungi, the efficacy of natural biocides used in agriculture and of new molecules isolated from fungi such as Mycena species with anti fungal properties was being investigated. Work involved the biological performance of water and organic solvent soluble extractives of four naturally durable wood species, namely; Matumi, Tamboti, Sneezewood and the Turpentine tree.

The pressure on ecologically friendly preservatives will lead to the development of new natural preservatives and to new effective techniques of their isolation and implementation. The withdrawal from classical inorganic compounds in wood preservation can be expected.

Expected level of uptake
The following table shows what stage of development each region of Europe is at with respect to isolation and development of wood protection chemicals and natural substrates.

Table 10.1.1 – Isolation, wood protection chemicals and natural substrates stages of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓	✓	✓
Industrial Trials	✓	✓	✓	✓
Adopted by some SME's	✓	✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to isolation and development of wood protection chemicals and natural substrates.

Table 10.1.2 – Isolation, development of wood protection chemicals and natural substrates future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
There is a strong regulations from the viewpoint of ecological sustainability which can lead to substantial increase in using these preservatives.

Conditions and obstacles
The main condition is a sufficient supply of appropriate wood species and strong legislation measures. On the other hand, the main obstacle is that not all the species are suitable for the production of wood based chemicals and preservatives. Other obstacle can be in the total distribution of wood according to the utilization, e.g. wood will be used more for the production of energy.

The following table shows the pros and cons of isolation and development of wood protection chemicals and natural substrates.

Table 10.1.3 – Risks and costs to industry from isolation and development of wood protection chemicals and natural substrates

Cons	Pros
Higher prices	Ecologically friendly chemicals
Not all species can be used	No problems with reused wood or its liquidation

10.2 Introduction of laser cutting

Laser cutting has been and still is used for the production of flooring. Complicated parquets are effectively cut with use of CO_2 lasers. The cutting speed is relatively high for the “veneer” of the thickness of 5-7mm. More over the waste-less technology uses the system of positive – negative when parts of dark veneer (e.g. walnut) are placed into light veneer (e.g. maple). Utilization of power lasers offers even more possibilities. The great advantage of this technology is the ability to deliver a desired amount of energy to the place chosen. With the knowledge of the mass of wood evaporated with this amount of energy we can create three dimensional surfaces.

The precise cutting by laser can be also utilized for the products with high added value. The study of the relationship between the amount of energy delivered and the respective colour change can lead to the new technologies of surface finishing. The utilization of laser cutting for high thickness wood based materials is hardly to be expected.

Expected level of uptake

The following table shows what stage of development each region of Europe is at with respect to laser cutting.

Table 10.2.1 – Laser cutting stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓	✓	✓
Industrial Trials		✓	✓	✓
Adopted by some SME’s		✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to laser cutting.

Table 10.2.2 – Laser cuttings future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME's				
	Generally Adopted				

Regional variations
The laser cutting was well developed in former Czechoslovakia. Some furniture factories (like Uhrovec) used this technology for the production of front parts of furniture. Technical university in Zvolen used laser cutting for the production of parquets in Žarnovica. Both factories went into bankruptcy. The technology is used for the production of Christmas decorations, maps and similar products in Brezno (ROZA). Laser cutting devices are produced in Great Britain, Italy, Germany.

Conditions and obstacles
The technology is waste-less and can be adopted for the production of parquets and special furniture. On the other hand it cannot be used for thick materials because the quality of cut surface is not sufficiently good even when quality optics is used.
The price of the products is high. So the technology is appropriate only for more sophisticated products.

The following table shows the pros and cons of laser cuttings.

Table 10.2.3 – Risks and costs to industry from laser cuttings

Cons	Pros
No possibility to cut chemically treated wood	Possibility to deliver the desired amount of energy to any place
	Effective and fast cutting for complicated shapes

10.3 Drying techniques such as use of microwaves

(see also section 7.2)

Microwave drying technology can substantially decrease the drying time. The research of the relationship between the absorption of microwaves and wood moisture content of wood indicate that the temperature and moisture distribution in wood can be much more effectively controlled by microwave or radiofrequency heating than by any other way of heating. The devices required are becoming cheaper and the price of energy increases. The effective delivery of energy can prevent from losses common in classical technologies.

The massive exploitation of these new technologies cannot be expected very soon. On the other hand their application for drying valuable assortments, like resonance wood for the production of musical instruments can be expected very soon.

The following table shows what stage of development each region of Europe is at with respect to microwave drying.

Table 10.3.1 – Microwave drying stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓	✓	✓
Industrial Trials	✓	✓	✓	✓
Adopted by some SME’s	✓	✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to microwave drying.

Table 10.3.2 – Microwave drying future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations
The energy crisis will force the industry to use more effective technologies from the viewpoint of energy use. The advantage of microwaves is that they easily interfuse wood and substantially decrease the drying time so it leads to energy savings.

Conditions and obstacles
The technology is convenient but the main obstacle is uneven absorption of energy in wood. Therefore it requires that either MW source or dried wood should move. This fact contradicts big energy savings. For some assortments, however it can be efficiently used.

Up till now this drying technology is mainly used in SMEs. One of the reasons is that a more effective utilization of this technology would require a good feedback between the moisture content of wood and the energy amount delivered.

The following table shows the pros and cons of microwave drying.

Table 10.3.3 – Risks and costs to industry from microwave drying

Cons	Pros
Problems with different energy absorption	Substantial decrease of drying time
Possible damage at wrong schedule	At a good schedule quality drying

10.4 Hydrothermal treatment – also for wood bending

Hydrothermal treatment of wood can be defined as a desired change of wood properties in order to prepare it for further processing or utilization. It could be steaming for veneer slicing, peeling, plasticization for bending, colour change etc. The depth of penetration with RF heating using i.e. the 27.12 MHz frequency is in the order of meters. The output of RF systems is usually from dozens of kW to 1500 kW. With output over 50 kW, the RF heating is usually more economical than MW heating. The most important area of using the RF heating in wood industry is drying of timber.

RF heating is massively used also in plywood production, where electrodes function simultaneously as press plates. The RF energy removes wet spots in veneer and equalizes the moisture without the creation of steam bubbles and interference of board lamination. The RF energy affects also the glue in plywood, fibreboard and chipboard.

The softening (plastification) time of wood, dried to 18-24 % with uniform moisture in the whole profile, is reduced by RF heating to a few minutes compared with standard steaming.

The above mentioned properties show that microwave and radiofrequency heating will find a broad application in wood processing technologies. The main reasons for this are increasing prices of wood and energy costs.

The following table shows what stage of development each region of Europe is at with respect to hydrothermal treatment.

Table 10.4.1 – Hydrothermal treatment stage of development

Stage	North Europe	Central Europe	South Europe	East Europe
Research and Development phase	✓	✓	✓	✓
Industrial Trials	✓	✓	✓	✓
Adopted by some SME’s	✓	✓	✓	✓
Generally adopted				

The following table shows the estimated future uptake for each region of Europe with respect to hydrothermal treatment.

Table 10.4.2 – Hydrothermal treatment future regional uptake

Region	Expected Time	2010	2015	2020	2025
North Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
Central Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
South Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				
East Europe	Research & Development phase				
	Industrial Trials				
	Adopted In some SME’s				
	Generally Adopted				

Regional variations

The energy crisis will force the industry to use more effective technologies from the viewpoint of energy use. The advantage of microwaves and radio frequency heating is that we can deliver a certain amount of energy to the desired place. For example at the production of peeled veneer it is not necessary to heat the whole log but we heat just the layer to be peeled.

Conditions and obstacles

The technology is convenient but the main obstacle is in the high price of sophisticated peeling lines. For the production of furniture, e.g. chairs the technology is very appropriate and it is in industrial use in SMEs.
This technology can be implemented in sophisticated peeling lines so it requires higher investment.

The following table shows the pros and cons of hydrothermal treatment.

Table 10.4.3 – Risks and costs to industry from hydrothermal treatment

Cons	Pros
High price of production lines	Energy savings
	Lower times of treatment at wood bending

11 DISCUSSION (responsible: BRE)

This report is based on PD 4.2.5 *Report on conditions and consequent timing of technological developments* including regional and time adoption element. The presented tables and projections are estimates only and are not quantitative in nature as this is not possible to obtain in the scope of this project. It is of note that the development of response functions progressed differently to expectations, therefore, it was essential to evaluate to what degree this report could contribute to the further refinement of that work package. Several time-related questions on adoption of each technology were included as the best option to include time element in this report. The work on scenarios goes hand in hand with the work on response functions. It was anticipated that it would be possible to include these scenarios in this report but this was not practical. Thus, it is planned to include these in the sequel report PD 4.2.9. *Sequel to the report on conditions and consequent timing of technological developments in processes in relationship to response functions.*

The focus in this report was to capture reasons to regional variation in adoption of individual technologies and conditions that preclude or support their adoption. Within the scope of this report it was not possible to investigate any cross-industry similarities between the nature of technologies and their developmental characteristics in the market. These elements of relationships could be included in this report's sequel PD 4.2.9.; as, once finalised, response functions will be able to indicate similarities, correlation and similar issues for groups of technologies.

Some of the technologies fell out of the scope of this report despite being included in the previous report PD 4.2.5. This is based on real-life developments where a particular technology might have appeared promising but failed to secure its uptake for various reasons such as lack of a need for the technology, long term tests shown more negatives than positives, and newer technologies have emerged on the market which show more promise.

11.1 Drivers for change

In the pulp and paper industry raw material and energy efficiency are the most important goals in developing new technologies. They bring both economic and environmental benefits which are linked together very strongly. Some of the technologies are driven by legislation such as reduction of CO_2 and NO_x emissions.

In the recycled paper industry changes relate in the main to improving the quality of the recovered material and reducing waste. This is driven by increasing energy prices, legislation and costs of land-filling/waste disposal and increasing recycling rates (and targets).

Sawmilling technology changes are towards improved quality and value of products and to meeting specific consumer demands for value added products and also towards reducing waste by better utilisation of the raw material. Methods which improve the traceability of the timber products are driven by legislation to prevent illegal logging and by Green (public) procurement.

In the panel board industry changes are mostly driven by cost efficiency. Other drivers are reduction of waste, glue use, and energy consumption. In some cases the driver can also be consumer demand for reduced emissions from newly manufactured boards.

In the joinery industry changes are also driven by consumer demand for reduced emissions in buildings and for more durable products. Legislation drives moves towards reduced consumption of wood preservatives which can be achieved with a number of the new technologies such as chemical and thermal modification of wood. These technologies also have the added benefit of improving the ability to recycle the timber at end of life and reduce amounts of landfill this is driven by legislation and costs of land-filling/waste disposal. They also improve stability of the timber and increase maintenance intervals for joinery so reducing use of petrochemical resources. Wood welding and inside-out beam technology also reduce waste by better utilisation of the timber resource particularly of small dimension and lower quality timber, and provide economic advantages by adding value.

In the bioenergy industry (pellet production) changes are mostly driven by changes in energy demand (increasing) and raw material supply (quality decreasing). Development of saw mill industry also affect pellet production volume and choice of technology.

The furniture industry remains unattended due to the changes in partner's remits (CIE Bois), however, a new partner, FCBA, joined EFORWOOD consortium recently might be able to participate in the work on the PD 4.2.9. This is a great opportunity to bring the furniture section of this field into play once again.

Other industries The isolation and development of natural biocides such as those from timber and plant extracts will be driven by legislation for use of less toxic products and by consumer demand for 'greener' preservatives. The decline from oil based wood preservatives can be expected. On the other hand the price of such products can be high. Laser cutting techniques are waste-less and offer high precision and the potential for value added products. For the more extensive use it is necessary to develop better and more power full laser sources with good absorption (probably CO_2) and better optics. Microwave drying and radio frequency heating use less energy than conventional methods and therefore offer cost savings. The possibility to deliver the desired amount of energy to any place can simplify the technology. On the other hand such sophisticated production lines can be very expensive. All the technologies here are not decisive wood processing technologies and can be used only as supplemental ones.

11.2 Expected level of uptake, regional variations and obstacles

Expected level of uptake
All the technologies reported on in this report are expected to be developed and have some level of uptake by 2025. For various regions as mentioned in the introduction a few of the technologies which were reported on in PD 4.2.5 are not expected to be developed very much and little level of uptake is expected therefore they have not been reported on in this report. In most cases the technology is expected to be adopted by a proportion of its respected field by the year 2025.

Regional variations
In the majority of the technologies the most developed regions were north and central Europe. The main reasons for this general trend are that these regions are more open to the new ideas and have more funding available to research the technologies and develop them through industrial trials. In most cases gap between the regions is expected to decrease as the less developed regions are expected to use the research and testing results from the more developed regions.

The most developed regions for most technologies also appears to be either where the technology was first developed, where there is the most need for it or where there are the most resources for it. Although very often these conditions occurs simultaneously.

Obstacles
The majority of obstacles facing the technologies are based on the investments costs needed to develop and set up the technology. Some of the technologies also require long test runs to establish results which can then be published to gain support and publicity for the respective technology. This will help provide funding for the investment costs needed. The test runs also need to indicate that the technologies will have a positive output in terms of economic, social; and environmental issues.
Most of the other obstacles are technology specific.

APPENDIX A – Scenario storylines descriptions

A1 Storyline

Forestry Sector developments

Forest functions are clearly spatially separated. The free trade of goods leads to cheap wood raw material (and commodities) being imported from outside Europe, and thus to less harvesting from European forests. The rate of gain in market share by the wood based construction industry has slowed to almost 0% per annum. Since there is less focus on environmental issues and less pressure on wood prices, the recycling rate of paper products is not increasing above today's values.

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in midcentury and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. In general public awareness concerning environmental issues is low. (IPCC SRES)

Forest resource and forestry to Industry

The forest owners remain in a difficult financial position with reduced supply potential and markets dominated by imports. Where the forestry industry survives, it invests a lot in technological innovation, mainly with the aim to increase cost efficiency. The cheap woody raw material is being imported from plantations in tropical countries, Russia etc. This leads to little investment in forest management and low harvesting levels in Europe. However, the hardwood sector (and forest owners) is doing relatively well because specific high quality assortments are very expensive and because high quality tropical hardwood resources are getting depleted.

Processing and manufacturing

Most of the heavy industries will move to Eastern Europe and the developing world where wages are still lower. However, in Western-Europe there are high levels of technical development, innovation and education with high rates of investment. Production will focus on a wider range of products and more on high-tech value added niche markets.

Industry to consumer

The paper industry has seen mergers into fewer and larger global multinationals and profits from the availability of a cheap woody fibre resource. The bulk of the paper, however, will be produced further away outside Europe, but transport costs are relatively low. The European paper industry focuses on innovative value added products.
Industries meet consumers' needs regarding type and quality of paper and size of product.
The basis weight of the paper used in printing, publishing as well packaging sectors is half of that of today.
The performance requirements of the printing technology have increased.
Increasing education standards in the South will cause a growth in paper consumption of approximately 70% as a result of the necessary production of educational material.
There is an increase in packaging demand associated with this increase in smaller households and increased transportation of goods.

B2 Storyline

Forestry Sector developments

The slower economic growth leads to low overall consumption levels and a relatively large demand for lower quality furniture and finishing.
At the same time the emphasis on bio -energy, leads to a high rise in the use of woody biomass.
The high sustainability credentials of the forest industry attract high levels of political interest and support. Forestry is viewed globally as having a key role to play in this programme which leads to increased planting programmes for carbon sequestration (but in competition with demand for agricultural land). There is strong support for low carbon footprint homes, which benefits the forest industry.

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population, intermediate levels of economic development, and less rapid and more diverse technological change than in A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels. (IPCC SRES)

Forest resource and forestry to industry

Reduced wood imports in combination with the high demand for wood products for building and biomass increases the demand for European wood (e.g. increase in fellings of 1.5% a-1). This is favourable for the forest owner who makes high profits from harvesting and who invests in his estate. Increased investment in IT infrastructure by forest industry companies has resulted in enhanced interaction in the value chain and in reduced costs and increased efficiency.

The forest industry takes advantage of new multi-modal forms of transport to optimise its costs within this framework.

Processing and manufacturing

The demand for biomass for bioenergy has pushed raw material prices up. Because of the high environmental awareness and high raw material prices the recycling and recovery rates are higher than today and recycled material supply chains are very sophisticated. But there is also strong competition from the energy sector for supplies.
The panel industry is strong but also sees increased competition from wood plastic composites as more plastics are recycled into environmentally friendly products.
Because of high raw material prices together with the high energy costs the paper industry is faced with high production costs.

Industry to consumer

The overall per capita consumption levels decreases and there is more demand for cheaper and lower quality goods. There is more emphasis on the full chain and re-use, recyclability and/or biodegradability are important trends. Products are locally produced and transport distances are limited.
Lower wealth combined with high material costs will lead to lower consumption of paper for printing and publishing and paper for packaging.
In the packaging sector, there is a trend for material reduction (lighter packaging) and the avoidance of redundant packaging.