EFORWOOD
Tools for Sustainability Impact Assessment

Reference futures and Scenarios for the European FWC source Databases

Eric Arets, Taru Palosuo, Alex Moiseev, Gert-Jan Nabuurs, Dorotea Slimani, Carl Olsmat, Jobien Laurijssen, Bill Mason, Denis McGowan, Diana Vötter

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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a "front-page", the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
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CO	Confidential, only for members of the consortium (including the Commission Services)	

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Summary

The aim of this document is to define, quantify and downscale the reference futures A1 and B2 to European forest wood chain specific input material. The quantified material serves as consistent input to the model runs in the Modules. The full input material is available on the Eforwood portal. Furthermore this document describes the actual scenarios to be used in Eforwood. Scenarios are neither predictions nor forecasts, but are used to create a consistent image of a future. Each storyline assumes a distinctly different direction for future developments, and does not necessarily aim to be realistic. Conclusions should not be drawn from these storylines; nor do they represent an expressed view of the Eforwood consortium on the future of European forests and the European forest industry.

Contents

1 Reference futures and scenarios in EFORWOOD

1.1 Introduction

By 2050 the world will have changed in ways that are difficult to imagine – as difficult as it would have been at the end of the 19th century to imagine the changes of the following 100 years. Scenarios that are based on contrasting storylines can be used as a tool to explore the different ways in which the future may develop and their impacts on the sustainability of the European Forestry Wood Chain (FWC).

These scenarios are neither predictions nor forecasts, but are used to create a consistent image of a future. Each storyline assumes a distinctly different direction for future developments, and does not necessarily aim to be realistic. Conclusions should not be drawn from these storylines; nor are they an agreed view of Eforwood consortium on the future of European forests and the forest industry.

A set of scenarios aims to describe divergent futures that encompass a significant portion of the underlying uncertainties in the main driving forces. These drivers cover a wide range of key characteristics such as demographic change, economic development, and technological change. For this reason, their plausibility or feasibility should not be considered solely on the basis of an extrapolation of *current* economic, technological, and social trends.

Reference futures (a baseline) and policy scenarios should be separated. Reference futures are ‘benchmark’ scenarios with dynamics, but without major policy interventions. Subsequent comparison with policy scenarios then enables the assessment of the effect certain policies will have.

Because driving forces can take different directions, it is better to develop multiple baseline scenarios. It is not recommended to use three alternatives because practice shows that policy makers then tend to focus on the middle scenario, which is believed to be the most realistic (Alcamo 2001). This should be avoided. For scenarios with a long time horizon four baselines are recommended because differences among the scenarios tend to diverge more over longer time periods (Alcamo 2001). For shorter time horizons two baselines are probably sufficient (Alcamo 2001). In EFORWOOD it was therefore decided to focus on two baseline scenarios. We call these the reference futures.

In 1996 the IPCC decided to develop a new set of emission scenarios that are described in the Special Report on Emission Scenarios (SRES). This set of scenarios is now known as the SRES scenarios, which were used by the IPCC for their third and fourth assessments. The scenarios are mostly developed for energy system parameters and related emissions. The underlying 4 reference futures, however, provide consistent storylines on the development of drivers like population growth and economic development in the future. Of the set of four

SRES reference futures only the two contrasting A1 and B2 storylines will be used within EFORWOOD.

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. 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 2000)

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 2000)

1.2 Aim of this document

The aim of this document is to further define, quantify and downscale the reference futures A1 and B2 to the European FWC and to set up and specify three actual scenarios. This quantified material will serve as consistent input to the model runs in the Modules. Most of the material is on the Eforwood portal at www.eforwood.org under Partners only, EFORWOOD Scenarios.

Chapter 2 interprets the A1 and B2 story lines for the European FWC. Chapter 3 and further then identify the market, technologies and policies scenarios as identified by the Eforwood modules.

1.3 Methods

Literature review forms the basis of the current report. Based on this review first outlines of reference futures were drawn up, and specified to the EU FWC. These reference futures were discussed in several Eforwood meetings and specific workshop. Also stakeholders were consulted in this process. A consistent set of input for the Modules to be used in order to quantify indicators under the reference futures was produced by models as IMAGE (Van Vuuren 2007, Bouwman et al. 2006), EFI-GTM (Moiseev 2006) and EFISCEN (Nabuurs et al. 2006, Schelhaas et al. 2007).

Through brainstorming sessions the first ideas were formed on the actual technology and policy scenarios to be studied. The various project modules further elaborated these ideas for either their regional cases or the EU level case (still included in this document). Then again the EFI-GTM and the EFISCEN models were run for these scenarios and their input were provided to the modules. The process of data flow is given in Figure 1.

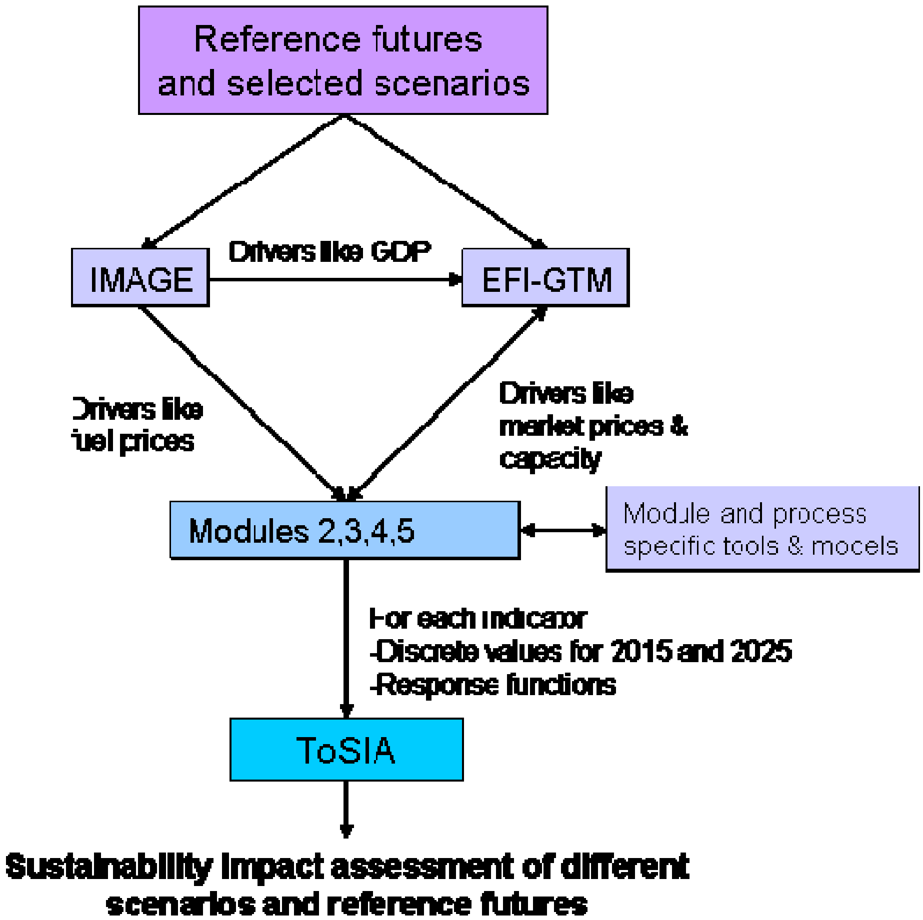

Figure 1. Process of data flow in Eforwood.

2 Interpreting the SRES A1 and B2 global reference futures

2.1. Interpreting the A1 global reference future to the European FWC in 2030

The A1 future world can be characterised as consumer oriented with diluted national governance and highly developed global trading systems. World economic growth is high and globalisation is rapidly accelerated, with China, India and Russia (amongst others) now fully-fledged economic powerhouses, competing head-to-head with the US and Europe on all fronts. International best practice in technology and management is adopted quickly and global standards emerge for many products and services. Social values are materialist. There are high levels of consumption, expectation, entitlement and mobility. Because of low fertility rates that are driven by rapid income development, population growth is relatively low resulting in an aging society, in which families become smaller. Subsequently labour participation of women will increase.

An important characteristic of this A1 world is the availability of relatively low cost energy[1] and material resources to underpin strong economic performance. There is little room for environmental concerns and fossil fuels still dominate.

Social, environmental and economic developments

In Europe, large (global) multinationals dominate the market, and GDP growth is high with 2.6% a^{-1}. Energy prices increase, e.g. with 20% for heavy oil in 2025 compared to 2000. This is slightly lower than in the B2 future. CEE countries develop rapidly and converge to Western European levels. Russia and China become important trading partners, and the Global North-South difference in general becomes smaller, but remains the same for the poorer African countries. Growth in the service and knowledge based economy dominates this high innovation, rapidly changing world. Consumers prefer high quality goods and cheap consumables (so demand for paper and packaging is relatively high). A more mobile labour force increases migration to economic hot spots, and from outside Europe into Europe.

The energy decisions are driven by availability and price of different energy options. The high economic growth requires a lot of energy, and part of that is supplied by renewable energy sources and bio-energy. Because of the lack of new ways to produce bio-energy, it is hardly competitive with fossil fuel energy Because of a lack of environmental awareness and absence of direct economic advantage the fraction of energy from renewables (solar, wind, biomass) in total energy increases from 6% in 2000 to 11% in 2025.

[1] Energy prices will be high under an A1 ref future, but because the income and GDP development is high as well, the energy prices are relatively modest.

Traditional manufacturing (heavy industry), but also some service sector jobs move to regions with lower labour costs such as Russia and the developing world (now principally Africa) following rapidly expanding markets and cheaper labour. However, in Western Europe some niche sectors producing high value added products thrive as their international export market widens.

Whilst people can afford and choose to live in smaller households – the physical dimensions of dwellings (urbanisation) are increasing and there are knock on impacts in terms of the energy used. In absolute terms, the standard of living of most people is improving.
Because of relatively low energy costs (high price combined with high economic growth), there is little pressure to develop more sustainable and energy efficient homes. People do not really care how products are manufactured, nor do they care how to dispose of them (i.e. recycling rates do not increase and waste is exported to poorer countries).

A high level of economic growth, free trade and limited environmental concern causes road transport to grow rapidly. Air travel growth is strong and tourism grows in Atlantic and boreal Europe. Wilderness areas are a major attraction in a crowded and industrialised world with high CO_2 emissions and high N-deposition. In this A1 reference future, direct impacts of climate change on the forest resource are not taken into account.

Forestry Sector developments

Forest functions are clearly spatially separated. Tourism is still much in demand, and this is changing the focus of owners from timber production to facility management and visitor cash generation.
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, although consumption of forest products as a whole is highest in the A1 (see fig). Since agriculture is out-competed in a free trade world, land abandonment takes place at a large scale throughout Europe. Often these abandoned lands are planted with trees and/or are naturally colonised by tree regeneration and are converted to forest. Forest area increases by some 18 million ha between 2000 and 2030, and 30 million by 2050.

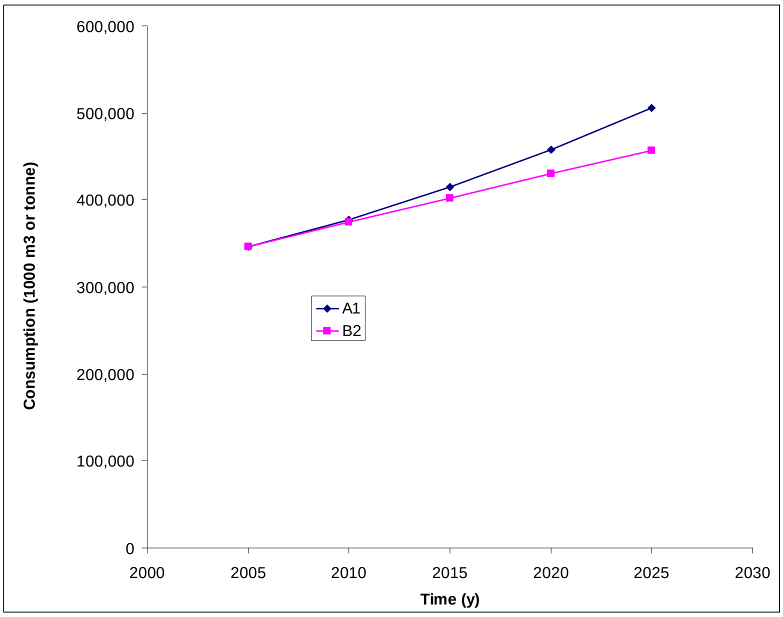

Fig 2. Consumption of forest products in the EU27 until 2025 (EFI-GTM, Moiseev).

Steel, concrete and brick are the main materials used in construction, driven by their powerful lobbies and there is increased competition from wood plastic composites. Since there is less focus on environmental issues and less pressure on wood prices, the recycling rate of paper products is not increasing above current levels.

Forest resource and forestry to industry

In the A1 world, the EU forest owners remain in a difficult financial position with reduced markets dominated by imports. The forest owner sees cheap woody raw material being imported from plantations in tropical countries, Russia, etc (see Fig 3,where the millgate prices are lower in the A1) because labour costs and transport are cheap. This leads to little investment in forest management and low harvesting levels in Europe (Fig 4). However, the hardwood sector is doing relatively well because specific high quality assortments are very expensive (wealthy urbanised societies like exclusive wooden furniture) and because high quality tropical hardwood resources are getting depleted. This hardwood sector is able to compete on the Chinese and Indian markets.

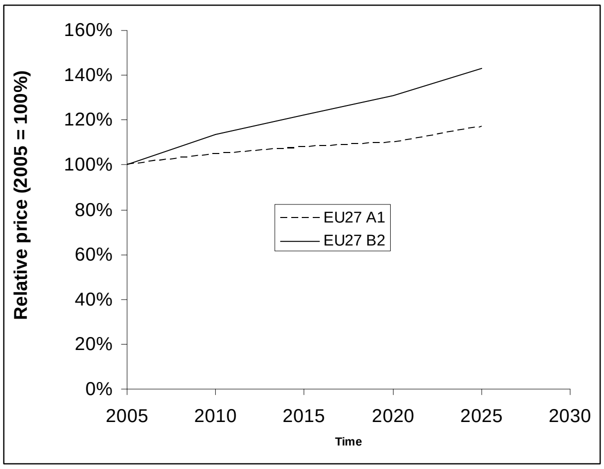

Fig 3. Mill gate prices of coniferous industrial roundwood (EFI-GTM, Moiseev)

Any harvesting is economically optimised and based on clear felling regimes with single coupes being large, and intense. Forest management is practised in those regions where production is competitive with imported materials. Thus growing stocks increase overall, leading to old forests, with more natural dynamics. These "more natural" forest areas are appreciated by the urbanised societies.

Improved logistics scheduling has removed costs from the transport sector. Where possible road transport is preferred above boat and train, except in remote areas in Scandinavia. There is little investment in infrastructure that would facilitate transport by boat and train. Because increased imports of wood and reduced timber production in Europe, the focus of transport will shift from forest to industry to from harbour to industry.

Processing and manufacturing

As the prices of raw material are low and consumption is high the processing and manufacturing industry will be able to make high profits, but only because they have moved their factories out of Western Europe. 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. Production costs are relatively low (16% higher for market pulp in 2025 compared to 2000 in the A1).

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. The availability of cheap raw materials mitigates the economic effect of decreased input from recycled paper.

Industry to consumer

As the standard of living is high, so is the demand for quality products and luxury goods. The high educated, demanding consumer asks for niche products and increases the demand for flexible distribution chains as products need to be available any time, any place.

The paper industry has done a lot to address or understand customers and consumers particular needs and demands. Industries meet consumers' needs regarding type and quality of paper and size of product. The performance requirements of the printing technology have increased. Increasing education standards in the Southern hemisphere will cause a growth in paper consumption 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. The packaging industry meets the customers' specific and costly requirements regarding functionality, variability in size of product, security and marketing and communication functions. Increased globalisation and the shift of manufacturing industries from West to East results in a shift of the packaging industries in the same direction. India, China and South-East Asia become leaders in fresh and processed fruit production and export and consequently develop packaging industries. The total packaging quality is equal all over the world since "international best practice in technology and management is adopted and global standards have emerged".

2.1. Interpreting the B2 global reference future to the European FWC in 2030

Global context

This is a world in which more emphasis is given to social cohesion and to maintaining environmental integrity. In the B2 world the greater effectiveness of global institutions is manifested through stronger collective (EU) action. Characteristic for this storyline is that solutions are found locally; i.e. within Europe. Because of this, and because of slower economic growth, the global North-South difference remains relatively large.

The global population grows faster and higher than in the A1 (8 billion in 2025, compared to 7.5 billion in A1). Markets are less open than in A1 (China and Brazil rise, but do not impact Europe so much). Energy prices increase, e.g. with 24% for heavy oil in 2025 compared to 2000. This leads to slightly higher priority being given to energy efficiency improvements and the development and deployment of renewable energy sources. This enables everybody to afford bio-based power and heating, which is now the cheapest option. Both households and industrial consumers reduce their energy consumption, but with an increasing share of bio-energy.

The 3P principle – people, planet, profit is fully embraced. People care about the way products have been produced, and the way they are disposed of. They have a preference for renewable and recyclable products, and use e-communication more. As a result of market processes (people ask for it) corporate social responsibility principles are fully incorporated in most enterprises. This is a well-informed world with high labour market mobility within Europe. The lower wealth leads to a large demand for cheaper but eco-friendly products.

Social and economic developments

In Europe, intermediate levels of economic development sustain (e.g. GDP growth of 1.8% a^{-1}), and less rapid, but more diverse technological change takes place. Level of globalisation of firms is less strong. The slower economic growth is also reflected on CEE countries, and the difference with former EU15 countries remains relatively large. As a result of high levels of corporate social responsibility there is a large investment in projects with long-term benefits to the economy, environment and society. The 'greening' of business is demonstrated by the routine adoption of the best environmental practices and technologies. The knowledge based economy expands.

Urbanisation is less strong, and the rural areas continue to host a significant share of the population. This runs parallel to a profitable agriculture, and thus rural employment, and less abandonment of agricultural lands. As more people tend to work from home, or choose to live closer to where they work (rural areas staying populated), the annual car utilisation rate falls slightly.
Europe looses some of its heavy industry, but not as much as in A1. Because of the high environmental concern many producers have invested in clean production and the fraction of energy from renewables (solar, wind, biomass) in total energy increases from 6% in 2000 to 13% in 2025.
Tourism grows, but is more local, i.e. within Europe. Environmental tourism becomes increasingly common and is more local. In this B2 reference future, direct impacts of climate change on the forest resource are not taken into account.

Forestry Sector developments

The slower economic growth leads to low overall consumption levels. The declining trade between continents results in high raw material prices and a high demand for European round wood. The industry commits to deliver both conventional commodities and social and environmental benefits to society with a lot of emphasis on full chain sustainability.
There is strong support for low carbon footprint homes, which benefits the forest industry. New standards of construction have been introduced for greater energy conservation and acoustic levels.

The expanding knowledge based economy has slower but more diverse technological changes, is very innovative, and is an ultimate place for cross-sectoral developments (like combination with biosciences and nanotechnology).

Forest resource and forestry to industry

Reduced wood imports in combination with the high demand for wood products for building increases the demand for European wood raw material (Fig 4) (e.g. increase in fellings of 1.5% a^{-1}), although the overall consumption of wood products is lower in this B2 (Fig 2). This is favourable for the forest owner who makes high profits from harvesting (see Fig 3, with higher mill gate prices in the B2) and who invests in his estate. Overall sawlog and pulplog harvest in EU EFTA rises to 451 million m^3 in 2025 under B2, compared to 411 in the A1.

As a result owners are able to combine forest functions locally. Management aims at small scale harvesting, the development of mixed forests and the intensity of management is broadly similar throughout Europe. In all regions in Europe locally tourism, biodiversity and wood production are combined. Forest area increases in A1 with 19 million ha between 2000 and 2030.

The Mediterranean also becomes an important wood production region (because climate change is limited). New plantations of genetically improved tree species are coming on stream with timber of higher density and better form.

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. Improved logistics scheduling has reduced costs from the transport sector, making more plantations economically viable to harvest. Rail and sea transport is strong, and new industrial developments are located in close proximity to these services. The forest industry takes advantage of new multi-modal forms of transport to minimise its costs within this framework.

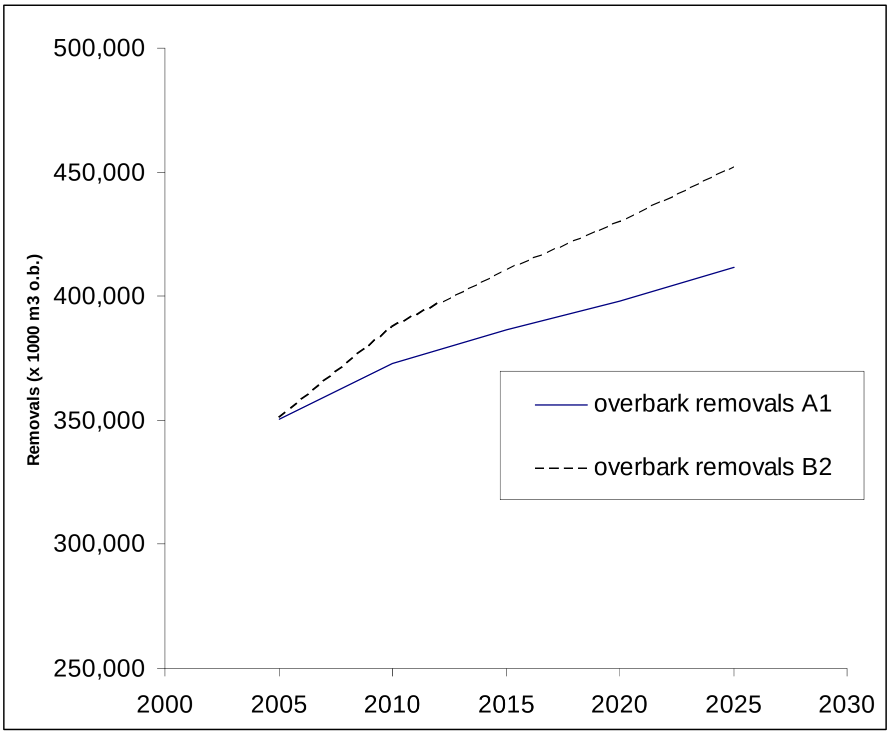

Fig 4. Removals (coniferous and deciduous together o.b.) in EU forests in the two reference futures.

Processing and manufacturing

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.

Because of high raw material prices together with high energy costs the paper industry is faced with high production costs (40% higher for market pulp in 2025 compared to 2000 in the B2). New product development, involving wood modification and engineered wood products, leads to greater linkages between saw-millers and construction companies (panel industry) to maximise returns through tying-in markets for sawn material to high value-added end uses. This is where the paper, board and packaging industry also finds many new niches. Innovation is high. Under the slower economic growth, the labour costs had to stabilise. Production remains within Europe, but labour is coming more and more from increased immigration from skilled workers from CEE countries.

Industry to consumer

The overall per capita consumption levels increases modestly and there is more demand for cheaper and lower quality goods. The educated and environmental conscious customers care about the sustainability impact of goods (during production, use as well as disposal). 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 leading to more tailored packages (e.g. juice packages which are unattractive but strong and safe for hospitals, large industrial packages for restaurants and design packages for (mini-)bars).

2.2. Overview of drivers

The identified drivers of changes in the baseline scenarios can be divided in primary drivers that are mainly outside the forestry sector like GDP, population, oil price, etc. Secondary drivers will largely depend on the developments of the primary drivers and as such are more a result of the primary drivers. These identified secondary drivers are more or less linked to the forestry sector. Depending on the needs for additional drivers, the modules can further expand this list. Directions of the secondary drivers should, however, be consistent with those of the primary drivers.

Table 1. Semi quantitative description of drivers as outlined in the A1 and B2 storylines

		A1	B2
Nr	***Primary drivers***		
1	GDP		
2	population		
3	Oil price		
4	General tax level		
5	Technological development in industry		
6	Knowledge society (as the degree of average education		
7	Technological development i.r.t. environmental issues		
8	Government regulation expressed as a degree of government interference in the free market		
9	Global trade intensity		
10	Trade intensity within EU27		
11	Consumption level		
12	Share of renewables in energy supply		
13	Overall demand for global wood products (incl bio energy)		
14	Overall demand for EU wood raw material (incl bio energy)		
15	Occurrence of natural disturbances in the forest		

Table 1. continued

	Secondary drivers		
16	Urbanisation (share of the total population living in cities)	↗	→
17	Size of single mills	↗	↗
18	Share of total transport carried out as road transport	↗	→
19	Number of mills within EU	↘	→
20	Multi-functionality in forestry implemented locally	→	↗
21	Share of wood in construction of buildings	→	↗
22	Environmental awareness (general public attitude)	→	↗
23	Size of single harvesting event (in terms of area or volume)	↗	→
24	Deliberate nature orientation in forest management (incl networks of reserves)	→	↗
25	Profitability of wood based industries (internal rate of return)	↗	→
26	Profitability of forest owners (sometimes expressed as land expectation value)	→	↗
27	Conversion of agricultural land in Europe to forest	↗	→
28	Large distance, large scale tourism	↗	→
29	Employment in country side	→	→

3. The actual scenarios

Three scenario areas are decided within EFORWOOD, each for one regional case. In addition one scenario is chosen for the EU scale case.

Following scenarios were adopted:

- Forest conservation scenario to be applied to the whole of the EU (ch 4)
- Bio-energy scenario to be applied to the Baden Württemberg, Germany case (ch 5);
- Technology change scenario to be applied to Vasterbotten, North Sweden (ch 6);
- Consumption change scenario to be applied to the Iberian peninsula (ch 7);

Table 2 indicates for each case how many scenarios levels will be produced, and compared to which reference future.

Table 2. For each case study the combinations of reference futures, scenarios and years that need to be quantified and for which data need to be collected.

Scenarios	Year	Case			
		Vasterbotten	Iberia	B-W	EU-FWC
Ref future A1	2015	X	X	X	X
Ref future A1	2025	X	X	X	X
Ref future B2	2015			X	X
Ref future B2	2025			X	X
Scenario+A1 level 1	2015	X	X	X	X
Scenario+A1 level 1	2025	X	X	X	X
Scenario+A1 level 2	2015	X	X		X
Scenario+A1 level 2	2025	X	X		X
Scenario+A1 level 3	2015				X
Scenario+A1 level 3	2025				X
Scenario+B2 level 1	2015			X	X
Scenario+B2 level 1	2025			X	X

Scenario+B2 level 2	2015				X
Scenario+B2 level 2	2025				X
Scenario+B2 level 3	2015				X
Scenario+B2 level 3	2025				X

4 Forest conservation scenario at the EU level

Forest management in Europe is changing towards a more multifunctional orientation. Current percentages of forest in each EU country managed with the protection of biodiversity as a prime objective are given in Figure 5. The policy further implementing this demand from society under the Habitats Directive from 1992 is Natura 2000. It aims to establish a European network for conservation of biodiversity and to promote sustainable activities. It is intended that the network will eventually grow to cover 15% of EU territory. thus further integrating multi-functional forest management (ecological, economic, protective and social functions) into the EU forestry strategy.

Table 3. Minimum percentage of EU forests under forest conservation scenario designation in Levels 0-3.

Level	A1 2015	A1 2025	B2 2015	B2 2025
0	7	7	7	7
1	8	10	8	10
2	10	15	10	15
3	15	25	15	25

Detailed in Table 3, are estimates of percentages of EU forests to be designated under the forest conservation scenario. Level 0 is an estimate of the current forest area (averaged across all countries) covered by Natura 2000 designation status, while level 2 assumes the documented expectations of Natura 2000 coverage is achieved by 2025. Levels 1 and 3 are variations in coverage shares that respectively highlight the possibility of not meeting or surpassing targets.

The A1 storyline describes a future of intensive globalisation both economically and technologically, with a mid-century peak and subsequent decline in world population. These advances in technology coupled with an increase in consumer and commercial demands will lead to a rapid increase in the competition from international timber supplies within the EU domestic market. The EU timber industry then will be severely challenged by this volume of foreign imports making timber production from Natura 2000 sites uneconomic. With lower investments in forest management and decreasing harvesting levels in Europe, such areas effectively will be removed from production.

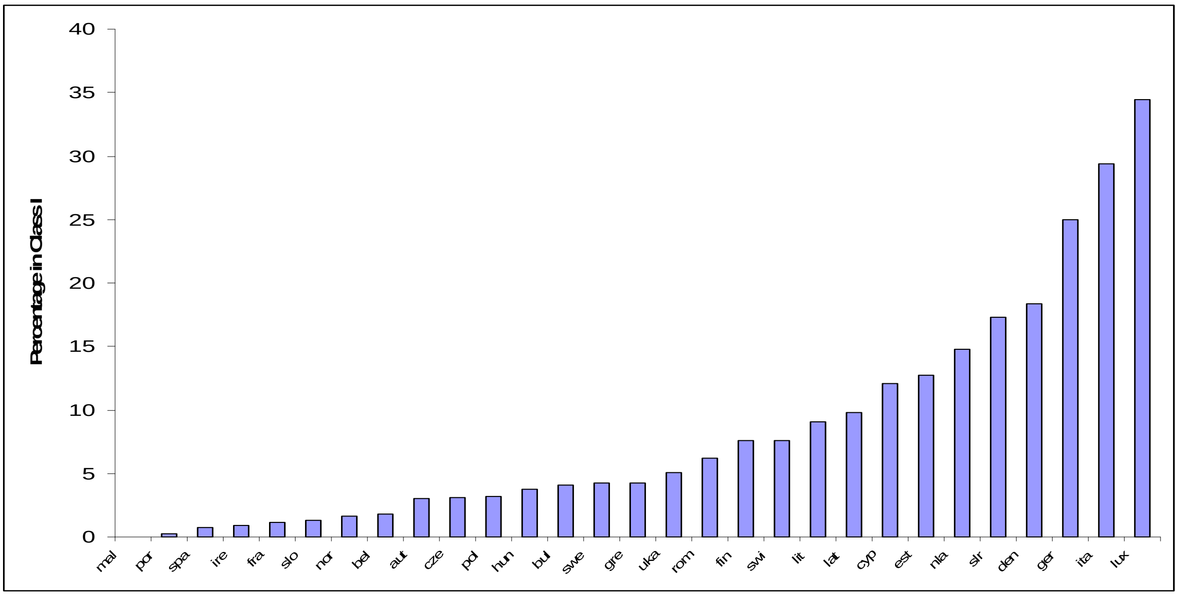

Fig 5. Percentage of the national forest with biological protection as primary objective in 2005 (classes 1.1. to 1.3 according to MCPFE) (MCPFE 2007).

The B2 storyline describes a future where social, environmental and economic sustainability is addressed at a local level with local solutions. Even though global populations would be steadily rising, the economic and technological development occur on a less rapid and diverse scale. There is a higher demand for high grade timber and an increase in demand for biofuel while there would be less competition from wood imports and more competition from agricultural development. Interpreting the impact on Natura 2000 designated forests is uncertain but it seems likely that there would be a combination of strict set aside in areas of highest biodiversity value and sensitive management in the remainder, probably under a form of 'close-to-nature' (ProSilva) type management (EC, 2003). This would presumably result in longer rotations, more thinnings and less clear felling, a change to mixed species in plantations and an overall decrease in yields (perhaps by 20-30% on a per hectare basis compared with conventional management).

So we therefore proceed as follows.

We use the MCPFE statistics to provide a country by country estimate of protected forest areas in 2005 under Natura 2000 (Fig 5). If the country already has a protected forest area exceeding that required by the Table 3 and appropriate level 0-3, then no changes will be made in the set up of EFISCEN which covers forest area available for wood supply only. So, strict reserves are anyway out of EFISCEN simulations.

However, if the area of figure 5 is below that suggested in the Table 3, then the protected areas are increased to meet the Table. This can be done by removing part of the forest estate from the simulation, and still trying to achieve the same total national demand for wood. Under the A1 storyline, these changes amount to withdrawing all these protected forest areas from timber production. Any reduced fellings (compared to ref future) are reported to Alex as a reduction in available wood.

Under the B2 storyline, we assume that the area in MCPFE classes 1.1 and 1.2 are not available for production. However, for class 1.3, we assume timber production is possible following 'Pro-Silva' principles, which accords with the Natura 2000 document. In classes 1.1 and 1.2 we do the same as sketched above, but for class 1.3 forests we apply a mixture of measures. We reduce the final felling chances, so as to prolong the rotations, we set some final felling chances at '0' for old deciduous forests, and we regenerate part of the coniferous forests with deciduous forest. This represents a shift along the FMA's as set up in wp2.1.

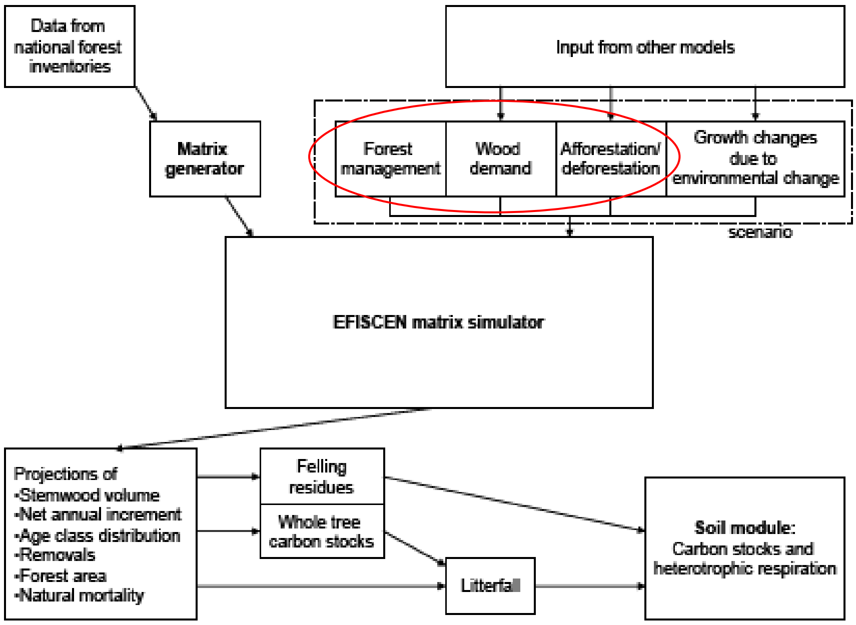

Figure 6. Outline of the structure of EFISCEN with the scenario options indicated in the circle.

5 Bio-energy scenario within the Baden Wurttemberg regional case study

Within the case study Baden-Württemberg the Bio-energy scenario is modelled in two directions: on top of a world within the framework of A1 reference future and on top of a world within the framework of B2 reference future, in both cases as a high-impact scenario.

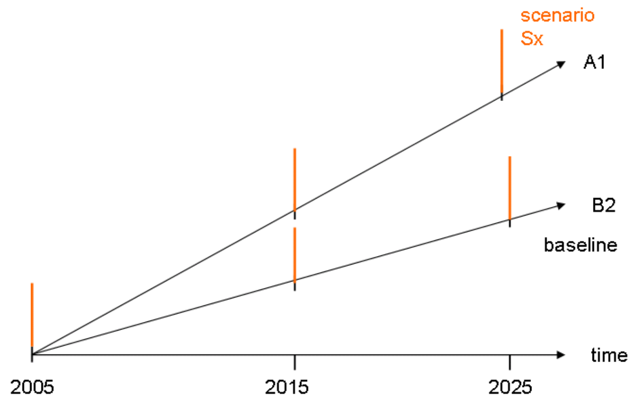

Figure 7: Data collection points for case studies: base line (2005), reference future A1 (2015, 2015), reference future B2 (2015, 2015), high scenario bio-energy A1 (2015, 2015), high scenario bio-energy B2 (2015, 2015)

The bio-energy scenario only deals with the increased use of bio-energy with consequences for production. On the production side, biomass from the forest (e.g. harvest residues, stumps, industrial wood) and from the industry (sawdust, chips, bark, black liquor, rejects and downgraded assortments) are covered.

The reference futures serve as a basis on top of which the following bio-energy scenario will be placed and described within the boundaries of M3 as follows:

- More roundwood will be allocated to bio-energy. This will be 10% of the total harvested roundwood volume in 2015 and 20% in 2025. As of 2005 there is a large potential of beech, especially in older forests, already in the reference futures of A1 and B2 for 2015 and 2025 the share of cuttings in beech will increase more than in spruce[2]. This has an effect on roundwood which goes into bio-energy. As due to its high density and thus related higher energy potential, as well as its tendency to crookedness and discolourations, more beech roundwood will go into bioenergy than

[2] There will be an increase which results in plus 20% of the total volume in beech and plus 5% of total volume in spruce (compared to 2005). In 2025 plus 40% of total volume in beech and plus 10% of total volume in spruce will be cut (compared to 2005). The total cutting volume as defined by reference futures A1 and B2 remains unchanged.

spruce roundwood. These allocations will be specified based on local availability in the forest resource.

- The use of harvest residues will increase. This applies for softwood branches with needles and to hardwood branches without leaves (winter harvesting). In 2015 this will be 50% of all harvest residues and in 2025 70% of all harvest residues.
- Stumps harvesting: As hazards like storms increase, there will be increased storm throw-volume. Of 10% of this storm-thrown volume, 50% go into stump harvesting in 2015 and in 2025 (that means 5% of total storm-thrown volume).
- Energy plantations will also be established on agricultural land and provide woody biomass from the agricultural sector. This “import” from agriculture into the forest-wood sector will be modelled as an import from outside Europe so that it does not alter the area and volumes of forest and wood at the M2-M3 boundary. The total available area for those energy plantations in Baden-Württemberg would be 40.000ha; we assume 75% of those (=30.000ha) as production area in 2015 and 2025.
- Transport: The share of the wood which is transported from the forest to the mill by truck is 80%, 15% by rail and 5% by water in 2005. In 2015 and 2025 a slight reduction of road transport to 75% is assumed. This is due to the fact that the long-distance trade and exchange of material will increase. Consequently rail transport will be 10% and ship transport will be 15%, which means both in 2015 and 2025, an increase compared to 2005.

Consequences of this M3 bio-energy scenario storyline for M4/M5:

In M4, Chemical pulp mills are already self-sufficient in terms of heat and steam, in many cases even electricity. The electricity self-sufficiency is likely to increase due to technological development. Pulp mills can also contribute more to the local electricity supply to households. Paper mills can increase the self-sufficiency in heat and electricity by having their own CHP plants and purchasing dendro-biomass instead of refined forms of energy, i.e. electricity and heat. Combined chemical pulp and paper mills may, and probably will, increase their self-sufficiency both in terms of fuels and purchased electricity. This is due to the development of energy efficiency at paper mills and improved fuel efficiency at the pulp mill.

There will be more combined heat and power (CHP) plants and power plants to use the increased amount of energy wood in both reference futures. Depending on the increase, the relative share of power plants may grow due to limited need of heat. Small-scale use of wood for heating also increases along the availability of wood for energy. The bio-energy scenario as it will be applied in BW against an A1 and a B2 background takes into account increased production of bio-energy from dendro-biomass.

In the scenario under the A1 and B2 reference future the volume produced from the forest will not change, but a greater part of the harvested volume of small round wood will be reallocated to bio-energy, and by this shift increase the competition for raw material with pulp and paper industries. Additionally harvest residues will be utilised for bio-energy production and agricultural land is converted to short rotation plantations that will be used for dendro-bio-energy production.

The detailed assumptions for M3 are stated in the table below (see Table 1) for the reference futures A1 and B2 as “high bio-energy level scenario”. All relative values are based on those of the case study Baden-Württemberg in 2005.

Table 4: Overview of M3 assumptions for the bio-energy scenario for A1 and B2.

Bio-energy Scenario in BW (Status Quo= 2005) absolute figures come from M2 and M1 calculations for reference futures A1 and B2. Stated relative amounts (here) refer to those.	**Scenario** **high level for A1 and B2**
A larger share of the existing roundwood harvest allocated to bioenergy	2015: 10% of harvested volume, thereof beech and spruce allocation to be specified based on local availability in the forest resource 2025: 20% of harvested volume, thereof beech and spruce allocation to be specified based on local availability in the forest resource
Increased use of harvest residues for bioenergy Softwood: including needles [%] Hardwood: including leaves (Winter)	All harvestings: 2015: 50% of residues thereof beech and spruce allocation to be specified based on local availability in the forest resource 2025: 70% of residues thereof beech and spruce allocation to be specified based on local availability in the forest resource
Stumps harvesting	10% of the storm-throw-volume 2015: 50% stump harvesting (all species) 2025: 50% stump harvesting (all species)
Short rotation woody bio-energy plantations on agricultural land (modelled in ToSIA: import of energy; chipping and heating) available area: 40.000ha	2015: 75% (¾=30.000ha) 2025: 75% (¾=30.000ha)

6 Technology change scenario within the Northern Sweden regional case study

The technology scenario will be implemented in the Scandinavian Case. The scenario comprises a set of new technologies in the wood products value chain that will increase the efficiency of using of raw materials and/or at the same time increase the quality of end products, including the production of more value added wood components and the upgrading of sawn timber.

The "Scandinavian regional case" was appointed a forest-defined case, in comparison to the Iberian and the Baden-Württemberg, which are consumption defined and region-defined, respectively. This means that the case deals with the whole forest chain from the production and harvesting of the trees to the end-user of the forest product produced with the origin of the wood from Västerbotten. In M2 the status of forest area is described and divided in five management regimes including close to nature forestry (pine and spruce), combined objective forestry (birch and mixed), and intensive even-aged forestry (mixed). The sustainability of these different management regimes is explored in the project. In M3 the transport of the annually cut trees from the woods to the industries (saw mills, kraft mills and fine paper mills) are described. The further processing of the cut volumes are defined and presented in M4. The wood chain in the Scandinavian case ends with the processes dealt with in M5, i.e. the producer-consumer interaction, which are divided into the three groups; distribution of the finished product from the producer to the end user, use of the wooden products, and recovery and the end of life routes for the wooden products. The end products defined by M4 are e.g. wooden houses, glulam, windows, furniture, planed goods, particleboards, plywood, sawn wood, pellets, kraftliner, fine paper and bio energy (see Fig 8).

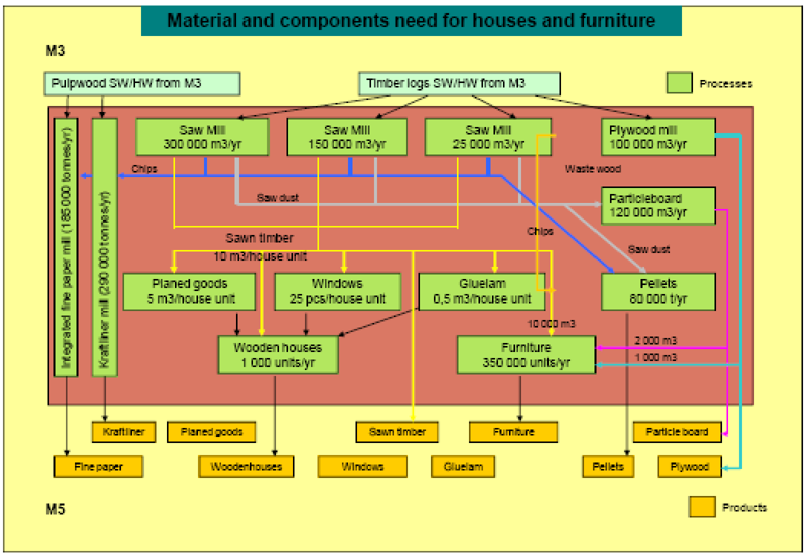

Figure 8. Overview of material flows related to wood products processing (M3, M4 and M5) in the Scandinavian Case (source: PD 2.0.5)

Overview of technologies

Under the technology scenario, several new or improved technologies are combined to increase the use efficiency of raw material and produce higher quality products that are tailored to the needs of consumers, which results in less use of raw material and/or an increased value added of the products. In fact, we study the combined effect of 4 different types of new technologies. The technologies are described individually and in detail in Appendix A. In short we characterise the different technologies below. In Figure 9, we also indicate the position of the technologies in the Scandinavian Chain:

1) Scanning of internal properties of stems and logs for optimizing sawing operations
2) Measuring systems for characterization and grading of sawn timber as well as supporting secondary conversion.
3) Information system and intelligent material flow control → not impacting the chain as such. It will be possible to track origin of wood however and it ensures the linkage of information between (1) an (2)
4) Value added components and upgrading of sawn timber into components with flexible and adaptive manufacturing systems for sawmills. Could be simplified and modelled as increased added value (and/or demand) in existing product groups (see figure 9)

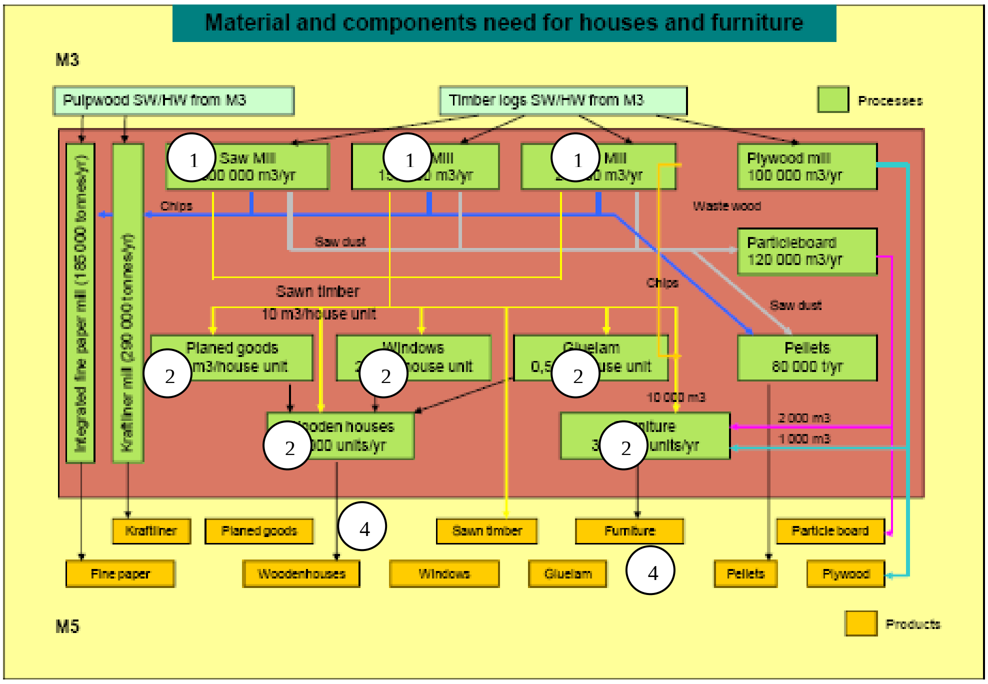

Figure 9. Overview of material flows and position of technologies in the wood products processing (M3, M4 and M5) in the Scandinavian Case (source: PD 2.0.5)

Given the scenario description, the summarized impact of the scenario could be as follows:

- The combination of the 4 technologies makes it possible to create more homogenous products with better defined properties. This might result in:
  - Increased value added of existing wood products

- Production of new types of wood products with high value added[3]
- Increased demand of wood products due to increased competitiveness against other products

- Due to better matching of wood characteristics with sawing operations (1),
  - The amount of sawn wood per tree increases.
- Due to better matching of wood characteristics with sawing operations (technology 1),
  - The amount of sawmilling by products per tree, i.e. sawdust and chips decreases.
- Because of better quality of wood products (2),
  - Wood product prices go up
- Because of new technologies (1), (2) (3),
  - Investment costs go up
  - Raw material costs for wood products go down
  - Labour costs go down
- Because of smaller batches and costumer orientation,
  - Transportation costs increase
- Because of better products,
  - Recycling and reuse of sawn timber increases

However, since we implement two levels of the technology scenario, not all impacts will be visible in both levels. We now will introduce the two scenario levels:

Two levels of the technology scenario will be explored.

Level 1:
In the first level we assume that, although the new technologies provide better products with increased added value, the demand for wood products remains unchanged compared to the reference future A1. This means that the material flows to M5 remains unchanged compared to reference future A1. The increased material efficiency, however, ensures that this demand can be met with a reduced amount of sawn timber, meaning that less timber logs will be needed from M3. Due to the decreased amount of timber logs and the decreased amount of sawmilling by-products (sawdust, bio-energy) from sawing, the pellet-, particle board, and pulp mills will receive less raw material from this source. These mills will need to look for other sources of raw material to meet demands of pulp and paper and pellet products.

Level 2:
In the second level, the increased quality of products enhances an increased demand in (high value added) wood products. This means that the wood product flow in M5 increases as compared to reference future A1. M4 needs to produce more timber products. Because there is also and increased material efficiency, the increased demand can be met with less volumes of sawn timber as if compared to a similar increased demand under the reference situation. Calculations within M4 should show how much timber logs are exactly needed from M3. After that, M4 can calculate how much by-products will be left after sawing. It can then be calculated how much raw material is available for pellets and pulp mills, and if these mills should look for other sources of raw material to meet their demands.

[3] not explored in EFORWOOD due to model constraints

In Figure 10, a schematic overview of the main material flows in the technology scenario is shown. The different flows have different colours, which we use to explain the two levels once more.

In level 1, the *yellow*, *red* and *black* streams remain unchanged (as demand remains unchanged). Due to increased efficiency in sawing, the *orange* stream of timber logs is reduced (M4 calculation). This means that there will be less *blue* by-products for pulp en pellets (M4 calculation). As demand for paper products and pellets (*red* and *black*) is the same, other sources of raw material (e.g .increased pulpwood (*pink*)) are needed to meet demands.

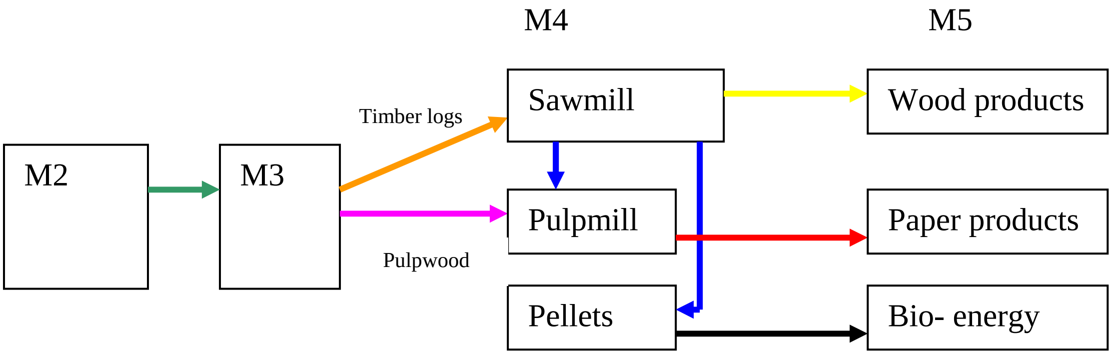

Figure 10: Schematic overview of main material flows in the technology scenario

In level 2, the wood products demand is increased. Therefore, the *yellow* wood products supply to M5 is increased. The *red* paper and *black* bio-energy streams remain unchanged. With help of M4 calculations, the amount of *orange* timber logs needed to produce the *yellow* wood products (taking into account the scenario's high sawing efficiency) is determined. The amount of *blue* by-products available for pulp and pellets can be calculated from the amount of *orange* timber logs (taking into account the scenario's low amount of by-products). The demand for paper products and pellets (*red* and *black*) remained unchanged and it is depending on the calculated amount of available *blue* by-products if other sources of raw material (e.g .increased pulpwood (*pink*)) are needed to meet demands.

7 Consumption change scenario within the regional case study Iberia

The aim of this chapter is to outline the consumption scenario with regard to newspaper consumption in Iberia case study.

Presumptions:

- Scenario description based on A1 reference futures drivers
- Time scale 2015-2025
- World economic growth (GDP) is high
- Population growth is moderate
- Global trade is increased
- Iberia peninsula region – region of interest

Year 2015

Declining consumption scenario

World economic growth on a high level guarantees wealth for households and individuals. Laptops are sold at low prices and are thus available for many people. Internet access is well developed as well as wireless in combination with digital tools to read virtual newspapers. Those facts combined with *moderate population growth* and already detected trend towards personalised products can cause following results:

1. The industry switches from being a producer of bulk commodities towards manufacturing specialised products and appears to have done a lot to address or understand customers and consumers particular needs and demands. Consequences appear in production process, transportation and logistic field.
2. Industries meet customers and consumers needs regarding the type and quality of paper and size of product. Consequences appear in production process, internal logistic, information flow, material flow.
3. A **25 %** decrease of A1 newspaper consumption level is foreseen.
4. The performance requirements of the printing technology have increased, the total printing products quality is equal all over the world since "international best practice in technology and management is adopted and global standards emerged". Consequences appear in production process, management, labour competence, and wages.
5. People can afford to purchase personalised products = high prices are accepted. Consequences appear in sales, turnover, wages and economics.
6. Less total waste of material is achieved. Consequences appear in waste management costs and transportation.

Increasing consumption scenario

High world *economic growth* together with well developed *global trade*, as well as adopted global standards enables access to cheap raw material for high quality mass production of newspapers. It is assumed that the traditional newspaper remains competitive to the digital virtual tools. More people are interested in “traditional” products.
This will cause:

1. A **25%** increase of the A1 level of paper consumption in order to secure access to paper needed for newsprint purpose.
2. Digital printing technology enables responding to the needs of people. Consequences appear in production process, information and material flow.
3. Increase of efficiency in transportation and long-distance logistics. Consequences appear in resources consumption, fuel consumption.
4. Improvement of the efficiency in paper use will reduce paper waste. Consequences appear in production process and resources consumption, reducing waste management costs.

Year 2025
Declining consumption scenario

1. The same trends continue as mentioned above under the declining consumption scenario. This leads to a decrease of newspaper consumption with 50% compared to the A1 level.

Increasing consumption scenario

2. The same trends continue as mentioned above under the increasing consumption scenario. This leads to an increase of newspaper consumption with 50% compared to the A1 level.

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EFORWOOD
Sustainability Impact Assessment of the Forestry - Wood Chain

Annex 1. Quantifying drivers for reference futures A1 and B2

A full listing with all quantifications was placed on the Eforwood portal.

This file includes values of those drivers that need to be quantified to be able to define the indicator values for the reference futures (A1b and B2) under the EFORWOOD project.

Driver	Source	Unit	Estimated values for reference futures 2005	A1b 2015	A1b 2025	B2 2015	B2 2025
Primary drivers							
Gross Domestic Product (GDP) - Eastern Europe	M1/IMAGE	1995US$/capita	4448.45	6577.63	9883.49	6185.28	8290.21
Gross Domestic Product (GDP) - OECD Europe	M1/IMAGE	1995 US$/capita	25873.78	34378.27	44440.58	31531.94	37846.94
Population - OECD Europe	M1/IMAGE	10^6 people	391.17	395.31	403.39	394.87	392.08
Population - Eastern Europe	M1/IMAGE	10^6 people	121.8	120.72	118.55	123.34	122.56
Population - Global	M1/IMAGE	10^6 people	6493.95	7074.5	7560.6	7311.7	8063.8
Population in rural area	M1						
Oil price (crude energy price)	M1/IMAGE	1995 US$/GJ	6.712	6.739	5.773	6.835	5.794
Oil price (crude energy price)	M1/IMAGE	1995 US$/bar	41.08	41.24	35.33	41.83	35.46
General tax level	M1/IMAGE		*Will be delivered by PBL shortly*				
Share of renewables in energy supply	M1/IMAGE		*Will be delivered by PBL shortly*				
Overall wood demand in EU	M1/EFI-GTM			See sheet	See sheet	*Will follow shortly*	
Occurence of hazards	M1/M2						
Development of inflation	OECD 2008 - Factbook 2008	% (annual gro	2	2	2	2	2
Other drivers							
Wood price from forest	M1/EFI-GTM		*Will be delivered by EFI shortly*				
Wood price from mill	M1/EFI-GTM		*Will be delivered by EFI shortly*				
Wages in forest industry	M1/EFI-GTM		*Will be delivered by EFI shortly*				
Global wages level	M1	US$/yr	38397.6	56776.002	85311.13	53389.362	71558.446
Average hours worked	M1	hrs/year	1627	1627	1627	1627	1627
Wages increase (OECD)	M1	% per year		3.99	8.31	3.35	6.42
Average country wages	M1	US dollars calculated using PPPs	See sheet Labour Compensation				
average hourly labour costs	M1/based on	Euro/hr	Value for 2008				
Labour productivity	OECD 2008 - Factbook 2008	% (annual gro	1.06				
Interest rate	M1	%	10.00	10.00	10.00	10.00	10.00
Amount of available work force	M1/ OECD 2008 - Labour Force Statistics 1986-2006, 2007 Edition	% of total pop	47.60	46.20	43.00	46.20	43.00
Amount of labour force in OECD Europe	M1	10^6 people	186.20	182.63	173.46	182.43	168.59
Employment rate female	M1/ OECD 2008 - Labour Force Statistics 1986-2006, 2007 Edition	% of total female working age (15-64 yrs) population	58				
Employment rate male	M1/ OECD 2008 - Labour Force Statistics 1986-2006, 2007 Edition	% of total male working age (15-64 yrs) population	72.3				
Female employment	M1/ OECD 2008 - Labour Force Statistics 1986-2006, 2007 Edition	% of total employment	44.5	Here we could assume that female employment f			
Male employment	M1/ OECD 2008 - Labour Force Statistics 1986-2006, 2007 Edition	% of total employment	55.5	Here we could assume that female employment f			
Purchasing power parity per country	M1/IMAGE	*Will be delivered by PBL shortly; persons requesting/using this PPP will nee*					
Share of fossils in energy supply	M1 and others	*Is similar to share of renewables in energy supply? Will be delivered by PBL*					
Prices of competing products							
Raw material supply				See sheet	See sheet	*Will follow shortly*	
Energy prices (light oil/gasolene), transport sector	M1/IMAGE	1995 US$/GJ	23.727075	23.51	21.70	24.98	24.00
Energy prices (light oil/gasolene), industry	M1/IMAGE	1995 US$/GJ	4.55113	6.03	5.77	6.39	6.16
Energy prices (heavy oil/diesel), transport sector	M1/IMAGE	1995 US$/GJ	25.599365	27.22	23.97	28.23	25.53
Energy prices (heavy oil/diesel), industry	M1/IMAGE	1995 US$/GJ	7.7011475	9.66	8.12	9.81	8.25
Energy prices other	M1/IMAGE	1995 US$/GJ		See sheet	See sheet	See sheet	See sheet
Energy prices (electricity)	M1/IMAGE	1995 US$/GJ	5.21	7.80	6.61	7.90	6.66