EFORWOOD
Tools for Sustainability Impact Assessment

Report describing the technology scenario

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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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EFORWOOD
Sustainability Impact Assessment
of the Forestry - Wood Chain

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EFORWOOD

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Report describing the technology scenario

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Final version

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Abstract

Under the technology scenario several new or improved technologies are combined to increase the use efficiency of raw materials in saw milling and to produce higher quality sawn timber 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. Two levels of the scenario will be applied on top of the A1 reference future in sawmilling processes in the Scandinavian Case. In the first level, although the new technologies provide better products with increased added value, the demand of wood products remains unchanged as compared to the reference future A1. The increased material efficiency, ensures that this demand can however be met with a reduced amount of sawn timber. In the second level, the increased quality of products enhances an increased demand in (high value added) wood 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. This report includes a complete scenario description and a proposal for scenario implementation.

0. Contents

1. Introduction

The technology scenario is 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.

This document comprises a full overview of the technology scenario, including a description of the scenario (content), the boundary conditions and the two different levels under which the scenario is studied.

Reading guide:
In chapter 2, a description of the scenario is given, including the two different levels that are applied. The boundary conditions under which the scenario will be studied are discussed and a brief overview of the technologies is given(a more detailed overview of the selected technologies is given in Appendix A).

In chapter 3, guidance is given on the process of implementing this scenario. Also a time schedule of the implementation process is shown in this chapter.

Finally, a detailed description of the technologies is given in Appendix A.

2. Scenario description

The technology scenario is 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 technology scenario will be implemented:

- only in the Scandinavian Case
- only under the Reference future A1
- on 2 different (impact) levels

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.

A schematic overview of the material flows related to the wood products processing (M3, M4 and M5) in the Scandinavian case (from PD 2.0.5) is shown in figure 1.

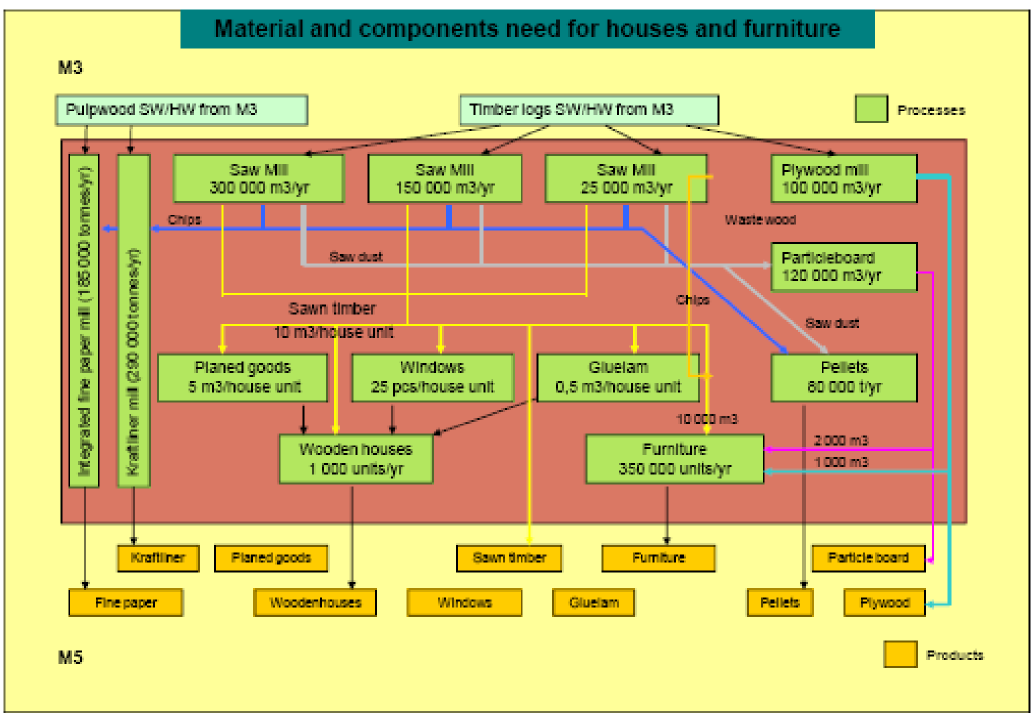

Figure 1. Overview of material flows related to wood products processing (M3, M4 and M5) in the Scandinavian Case (source: PD 2.0.5)

The reference future A1 on which the technology scenario is built, 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 SRES).

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 2, 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) and (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 2)

Two impact levels:
Two levels of the technology scenario will be explored.

Level 1:
In the first level we assume that, although the new technologies in Scandinavian saw mills provide better products with increased added value, the demand of wood products in the EU remains unchanged as compared to the reference future A1. This means that the material flows to M5 remains unchanged as 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.

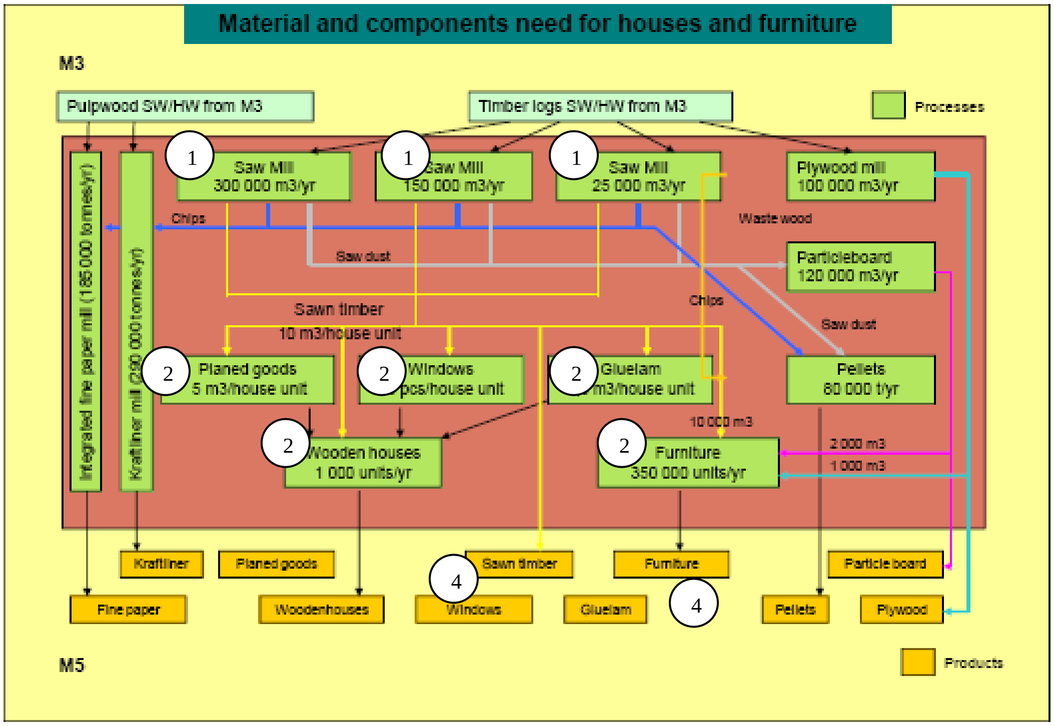

Figure 2. Overview of material flows and position of technologies in the wood products processing (M3, M4 and M5) in the Scandinavian Case (source: PD 2.0.5)

Level 2:

In the second level, apart from the new technologies with increased material efficiencies in Scandinavian saw mills (level 1), also the increased quality of products enhances a 50% increased demand in sawn wood products in the whole EU. 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.

Basic assumptions in Scandinavia that were taken into account when running EFI-GTM:
→ 2% increase in transportation costs (due to smaller batches and customer orientation)
→ 5% increase in investment costs (due to new technology) in saw mills
→ Increased share of sawn wood in output products (***OLD***: 50% sawn wood, 35% chips, 15% saw dust), (***NEW:*** 55% sawn wood, 32% chips, 13% saw dust).

→ Level 2 further assumes a 50% increased demand in sawn wood products in the EU.

3. Possible scenario effects

The effect of the scenario on e.g. harvesting levels, production volumes and costs will be modelled via EFI-GTM. Apart from EFI-GTM results we expect the following effects:

Effect on indicators (in M4):

Economic

Apart from EFI-GTM results above:

- Decrease in labour costs (less employees, but perhaps slightly higher salaries)
- Less resource use (for sawn wood)
- Recycling and reuse of sawn timber increases
- Increase in investment costs (5% for saw mills)
- Increased productivity

Basic assumptions that were taken into account when running EFI-GTM:
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Social

- Less employment (per ton of end product)
- Low costs automated systems supports business of small companies which affects positively on the employments in rural areas and improves regional employment rate.
- Wages and salaries might go up due to higher skilled employees needed for novel technology
- Increased occupational health due to improved control of activities. Manual grading causes a lot of stress. Automated grading decreases occupational health risks.
- Less accidents due to less manual handling activities
- Education level needed might be a bit higher

Environmental:

- Energy use: no big changes (apart from increased mechanisation of processes and increased transportation)
- GHG emissions: no big changes (apart form increased mechanisation of processes and increased transportation)
- Transportation costs increase
- Water use: no big changes
- Waste amount decreases

Effect on indicators (in other modules):

The effect on indicator values in other modules is to be determined by the other modules experts themselves. As a guidance, modules can use this document with descriptions of the scenario, the EFI-GTM run results and of course, most importantly, their own expertise. As additional guidance some issues are mentioned below:

Impacts from M4 to M3

Module 4 issue	**Module 3 impact**
Precisely defined products	Smaller batches of logs Demanded specifications of the log Precisely defined properties of log batch
Just on time deliveries	Accurate control of wood flow from the forest to the mills
Demanded customers product specifications Several mills in the same company Small mill making business in networks	Allocation of wood raw materials
Information systems	Transferring • data from the origin of logs • measurements carried out in the forest • information about stand characteristics • information about potential stands to be harvested and their characterisation
Increase of wood raw material need	Increase harvesting

Impacts from M4 to M5

Module 4 issue	**Module 5 impact**
Precisely defined products	Smaller batches of sawn timber or components Marketing strategies and channels Sales activities of the products
Just on time deliveries	Accurate control of product flows from the mills to the end users Positions and volumes of storages Information about delivery times
Demanded customers product specifications Several mills in the same company Small mill making business in networks	Accurate control of product flows from the mills to the end users Positions and volumes of storages
Information systems	Transferring to the customers • data from the origin of wood raw materials • data from the properties of the products for improving business processes • information about processing parameters • information about how to use the products

Scenario effects on materials flows within the Scandinavian chain:

This will be further developed as soon as the material flows in the Scandinavian chain 2005 are available. Module 4 will coordinate actions, and will contact relevant Module experts accordingly.

Summarized scenario impact:

Given the scenario description, the summarized impact of the scenario could be as follows (since we implement two levels of the technology scenario, not all impacts will be visible in both levels):

- 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[1]
  - Increased demand of wood products due to increased competitiveness against other products (modelled in level 2 only)

- 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 (in level 2 only)

- 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

[1] not explored in EFORWOOD due to model constraints

4. Scenario implementation

1) Scenario description (M4)

A description of the technology scenario should be made by Module 4. This description should include an overview of the boundary conditions and a description of the technologies, an indication of possible impacts of the scenario on the material flows in between modules and some guidance on the effect on indicator values. Moreover, it should contain a protocol for scenario implementation including necessary steps, responsible partners and timelines.

2) Quantification of some relevant parameter for EFI-GTM runs (M4)

The results of EFI-GTM runs on the technology scenario can be used in the same way as they are used for the reference futures (i.e. as a guide in estimating new indicator values). In order to run the model, some key parameters of the scenario on both impact levels need to be quantified. Module 4 will supply EFI with the necessary parameter values.

3) EFI-GTM runs (EFI)

Building on the reference future A1 assumptions and including the key parameters of the scenario as provided by Module 4, EFI will make new model runs for both impact levels of the scenario, with EFI-GTM.

4) Distribution of interpretation of output of EFI-GTM runs to all modules (M4)

The results of EFI-GTM runs on the technology scenario can be used in the same way as they are used for the reference futures (i.e. as a guide in estimating new indicator values). The results of the runs including interpretation graphs will be made available for all modules.

5) Input of new material flows (split ratios) into ToSIA (M4)

Module 4 will coordinate the implementation of these results into the dataclient and ToSIA

6) Collection of indicator data in data client (M2, M3, M4 and M5)

Knowing the new material flows, the results of EFI-GTM runs and the additional information provided in the scenario description, all modules should be able to use their expert knowledge to come up with indicator values for the technology scenario on two impact levels.

Appendix A: **Description of implementation of new technologies**
Unfortunately figures have been removed to save MBs (please contact Arto.usenius@vtt.fi for those interested in the figures)

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

X-ray scanning is a powerful tool for detecting internal differences of solid bodies. X-ray imaging is used to identify the internal density changes inside stems and logs such as knots and defects. The system consists of X-ray sources (from one up four). The voltage (energy kV) and the current (intensity mA) of the X-ray tube can be regulated to optimise the measurement for different objects. The optimisation is based on conveyor speed, timber thickness and moisture content. The log is moved by a conveyor system which can also rotate the log to any desired angle. Essential parts of the system are the detector and a controlling/data logging computer. The measurement data are logged by a computer which convert into grey-scale and saves it for later processing and analysing e.g. to reconstruct a 3D tomography image of a measurement log or to be used as 2D images. For radiation safety, the X-ray inspection system is encapsulated in a large metal cabinet with lead lining inside

Figure 1. 2D X-ray picture of a log

The purpose of X-ray inspection system is to show the accurate position of internal wood properties and defects, knots and heartwood / sapwood areas. It can also detect defects, which are not visible on any surfaces of wood. X-ray system can be used at inspecting boards, planks and logs depending on the configuration of the system. The analysis software is tailored to meet application requirements. Typical functions can include measuring of dimensions/volume, moisture content, detection of knots, rot and other defects and heartwood/sapwood ratio. Big variations in moisture content and density profiles may difficult the detection accuracy and has to be taken account for when suitable X-ray systems is to be chosen. It is not necessary easy to detect the border between living and dead parts of the knots. This needs also to be taken account when designing optimization software which uses the inside log information.

Scanners can be implemented at log sorting station, cross cutting terminals for stems and also just before sawing machines.

Figure 2. Special reconstuction software of X-ray data showing the X-ray images, a binary image (knot/clearwood) and 3D-mesh image with knots and surface modelled

Present situation

Only geometrical properties of stems and logs are measured providing data like top and large end diameters, length, taper, shape of the log. In some cases logs are graded visually into quality classes.
Information about internal quality aspects is not available

New technology implementation

Precise characterisation of logs and stems can be made by scanners based i.e. x-ray technology combined with true shape data through laser applications. Depending on the system configuration, scanners provide in different detail level information about knottiness, individual knots, density, annual ring orientation, moisture content etc. Scanners provide data for planning systems and process control for sawing optimisation

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

Multisensor 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 result. System configuration is depending on the type of wood raw material and products and the size of the mill.

Figure 3. Multisensor scanning is a powerful tool generating data of wood properties.

Figure 4. Image analyses provides 2D or 3D map of wood properties for grading and optimisation of secondary conversion options.

Present situation

Grading of sawn timber and components provides timber pieces in quality classes - classification. Grading is visually made by human graders especially at small mills. Grading errors cause big economical losses. It's difficult to learn human graders to adapt new grading rules fast. Bigger sawmills are using automated grading mainly for replacing human grading. Colour and B/W cameras are used. Limited parameters are measured. Current systems are not supporting further conversion and upgrading sawn timber into components.

New technology

Scanner based grading provides precise map of wood properties on four faces of entire piece. Grading can be based on precisely defined customers specifications. However conventional grading can be realised with high accuracy. Map of wood defects provides possibility to convert original sawn timber piece efficiency into smaller components in secondary conversion phase. Information produced by the scanners can be stored into companies database and used in management of business processes and process control systems. Special low costs systems for SME:s will be developed.

1.3. Information systems and intelligent material flow control

A new information system for an advanced control of forest - wood chain through marking pieces, reading the markings and data processing establishes a strong opportunity to make better business (Figure 5 right). Marking of pieces can be done using different techniques i.e. RF-tags, transponders and ink jet markings. The most potential and economical marking method for forest - wood chain at present seems to be colour marking, which can be done in the forest using traditional equipment existing on harvesters, however slightly modified. For marking boards an ink jet writer is capable to produce a high quality alphanumerical code. Reading of the marking or the code on logs and boards can be done by a colour camera. The core of the reading system is neural network software for decoding the code.

Figure 3. Recorded and lost information can be recovered through marking / reading pieces and advanced data processing.

Present situation

Figure 5 (left) presents in principle the volumes of information in different stages of the forest - wood chain. Measurements and observations throughout the chain produce data and information. In individual stages information is growing rapidly. This information is, however, used only locally. After the wood material has left the processing phase, almost all specific information has been lost. This happens all the way throughout the supply chain. It is not possible to link final products, raw materials and processing parameters together. The picture also shows an accumulated curve assuming that all the information from previous phases would be available in the later phases. If the lost information could be regained, much more effective business could be realised. Information "recovery" can be achieved through marking pieces, reading of the markings and storing the corresponding data in a database.

There is not information available about the origin of wood raw material. Forest –Wood chain includes a lot of data and information. Data is gathered however only locally used and then the data is lost. It is not possible to link together products, wood raw material and processing parameters, which is very important for planning operations. Information systems are isolated and not communicating.

New technology implementation

Marking - reading – information (MRI) system applications concern quality control, process control, planning procedures and customer service. Marking of pieces is also a way to show the origin of pieces and can be for instance used to ensure that the material originates from a certified source. MRI provides a quite new approach for the management of material and information flows from forest to the end products supporting customer oriented business and added value production.

Concepts for the industrial implementation of MRI systems have been created. Some concepts are based on the collective following of wood material batches producing information on how to process certain categories or classes of wood. Other concepts are more detail oriented and necessitate following individual pieces of wood raw material, semi finished products and final products. It can be estimated that radical improvements can be achieved in economics, customer orientation and environmental issues though implementations of MRI systems.

Information system is covering whole chain –from the forest to the end products. Integration of data throughout whole conversion chain can be done by marking wood raw material, logs, in the forest and storing data into information system. Marking can be i.e. 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 into the information system. The linked data and information is available for planning systems and process control ensuring precise management of business processes.

Marking pieces with visible or non-visible markings in the forest and forwarding this information to the customers and end users

1.4. Value added components and upgrading of sawn timber into components with flexible and adaptive manufacturing systems for sawmills.

Present situation

Sawmill companies are selling standard sawn timber, bulk products, with low price. Present production systems are effective, however very much volume and bulk production orientated emphasising minimising 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.
Learning and teaching is realised only by human people and is very much depending on the nature of the persons. Procedure is very sensitive. Business and production is not adaptive and self learning

New technology implementation

Sawmill process is provided with machine vision system and smart decision making system for grading and selecting sawn timber pieces into different classes. One class continue in traditional way and the final product is sawn timber. This situation concerns high quality sawn timber. Especially low quality sawn timber pieces are converted into smaller pieces – value added components with high price. Further processing may consist of cross-cutting, ribbing and edging phases. Future production systems consists of following integrated key elements. Control and optimisation of information and material flows in planning and production systems. Intelligent, flexible and self learning measuring, production and logistic systems

Integrated information systems covering entire conversion and delivery chains Creation and utilization of the feed back information in order to make business self learning. Smart and self learning measuring, production and logistic systems. Creation and utilization of the feed back information in order to make business self learning