EFORWOOD
Tools for Sustainability Impact Assessment

Report on Review of Existing Tools

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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

Project no. 518128

EFORWOOD

Tools for Sustainability Impact Assessment

Instrument: IP

Thematic Priority: 6.3 Global Change and Ecosystems

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Report on Review of Existing Tools

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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)	

Project no. 518128-2

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Executive Summary

This Report is Deliverable D4.2.2 of the EFORWOOD Project. It's main objectives are to:

- Review the existing tools for the assessment of different sustainability criteria
- Gather tools from different regions and sources to facilitate a better understanding of Sustainable Development assessment.

This report outlines existing sustainability assessment tools relevant to the Forestry Wood Chain (FWC) manufacturing stages. These tools are based on, Ecological Footprint Analysis (EFA), Life Cycle Analysis (LCA), Multi Criteria Analysis (MCA), Cost Effective Analysis (CEA), Cost Benefit Analysis (CBA) or Whole Life Costing (WLC).

This deliverable draws on previous work undertaken within EFORWOOD project (especially in Module 4) in particular work on criteria and indicators.

This report reviews FWC's sustainability appraisal tools and methodologies for all three tiers of sustainability, economic, social and environmental. All tools and methodologies have strengths and weaknesses depending on the objectives, timeline, and other criteria. What seems to be the most appropriate approach is to set objectives for each assessment and get information and results in various levels of detail. Therefore, it is advisable to employ more than one tool or methodology for more detailed analysis.

This work has shown national differences in the need for sustainability assessment linked to national requirements of relevant legislation and regulations. Individual companies often seek sustainability assessment for a particular reason and their requirements and objectives will call for a bespoke, tailored approach regardless which tool is being used.

For the FWC's sustainability, assessment is traditionally closely associated with the forestry side of business. Economic performance indicators were most frequently used in early sustainability assessments and have the longest history of being relevant to manufacturing. They are strongly correlated with inputs to woodlands, forestry and mill operations as well as the sustainable development of resources.

Environmental issues are establishing themselves more and more for the manufacturing stage of the FWC most frequently as Life Cycle Assessment (LCA).

BRE has undertaken a focused research into the tools for assessing sustainability but was not able to identify any tools/methodologies that are being in-use in Europe for social tier in FWC relevant to manufacturing stages, which is the focus of Module 4

The FWC has been scrutinised by various stakeholders to address social issues in the forestry phase. Sustainable Forest Management (SFM) provides a system of assessment (for both environmental and social elements of sustainability). SFM certification includes a wide range of social issues; it is applicable only to forestry even though it includes a number of indicators that are applicable to primary processing within FWC. SFM and CoC certification streamlines and supports the development of supply chain communication.

The major problem with social indicators or CSR indicators is that they are in their nature qualitative. They include how companies perform in relation to stakeholders including the community, to training, and equality in employment. It is possible to quantify some indicators, such as, health and safety (e.g. number of incidents), and availability of training. Manufacturing, not only in the FWC, is lagging behind in development and implementation of comprehensive social issues assessment tools or methodologies. If social criteria are measurable and reported, they are typically linked to H&S executives in each country or industry respectively. The FWC as well as other industries would benefit from more assistance in understanding what sector-relevant social issues are appropriate in the international context.

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Introduction and background

This report was undertaken for the European Commission as part of the EFORWOOD project, contract number 518128-2. Module 4 is responsible for this report, and is a partnership of European companies focusing on the manufacturing and processing ("gate to gate") stage of the Forestry Wood Chain (FWC) in Europe. This document is deliverable D4.2.2 "Report on Review of Existing Tools". This report reviews module specific performance indicators & key performance indicators (KPIs), methodologies and tools relating to sustainability impacts for processes within M4 in the FWC.

This document outlines the key methodologies and tools used to assess sustainability, incorporate existing knowledge from within the consortium, as well as looking at practises outside the consortium, for example in Universities. These tools are assessed in terms of the Strengths, Weaknesses, Opportunities and Threats (SWOT) which they present. Additionally, this document also indicates existing gaps in current practise, providing an opportunity to inform further development or fine-tuning of the Tool for Sustainability Impact Assessment ToSIA

This work is a precursor of any modification or creation of new tools relevant to M4 work in EFORWOOD may be developed for M4 specific reference cases with a priority given to the relationship and interaction with M1 (the development of EFORWOOD's final tool - ToSIA).

Models and tools included in this document are not aimed to assess impacts of policy changes or devise plausible scenarios of any future modifications. This is the function of ToSIA. However it is possible to explore partial impacts and influences on sustainability indicators by identifying the key contributors to these impacts, using methodologies such as Life Cycle Assessment (LCA), and including expert knowledge to predict the effects of changes to the system. LCA is increasingly being recognised as a effective method to quantify environmental impacts of products (e.g. external wall elements in housing, construction) or processes (e.g. manufacturing processes). On the European level LCA has been applied to evaluate forestry and forest industry products by the COST Action E9 "Life Cycle Assessment for forestry and forests products".

A number of tools, models, and databases were identified to be included in an integrated sustainability analysis of Forestry Wood Chains (FWCs). These can be grouped as:

1. Forest ecological (biodiversity/nutrient and carbon cycling) and forest dynamics models
2. Forest resource models (from individual stand to region and country scale)
3. Harvesting optimisation models (operational research) and decision support tools
4. Forest sector or market models
5. Processing efficiency tools and industry models (of particular relevance to M4)

6. Life Cycle Assessment tools[1]

Of these, only groups 5 & 6 are relevant to M4. Appendix C has a more extended summary of these tool.

Name of the model	Partner/ Model Provider
Bioenergy Production - Energy Efficiency and GHG Balance Model	VTT
BRE Environmental Profiling	BRE
Distribution of news information in scarcely populated areas	STFI- Packforsk
KCL- ECO 4.0 LCA software, EcoData inventory database	KCL -Oy Keskuslaboratorio-Centrallaboratorium Ab (& Finnish P&P Research Centre)
MPI PEMS	KCPK- Gasunie/ VNP
Pöyry Cost Competitiveness Model	Pöyry Forest Industry Consulting Oy (previously Jaakko Pöyry Consulting)
WinGems	STFI- Packforsk
WoodCIM®	VTT

Aims and Objectives

- Review and analyse existing tools and methodologies
- If necessary to develop new tools or to refine existing ones.
- Develop tools for defining industrial improvement options.

The starting point is to review the existing models, databases and tools. Work will primarily focus on existing models used by M4 partners for solid wood, pulp and paper and bio-energy[2] the models of KCPK, VTT, BRE, JPC, KCL and STFI-Packforsk. as described in Appendix B of the Description of Work (DoW) and outlined in Appendix B of this report, but crucial in this phase will be the evaluation and incorporation of other models, databases and tools from out-side the consortium[3] This deliverable will act as a bridge and synthesise partial Sustainability Impact Assessments SIAs for processing and manufacturing segment (M4) of FWCs.

The report will identify the most appropriate methods for assessing the sustainability levels of forest-based raw material manufacturing and processing. Viable and scientifically robust impact indicators for sustainability levels will support the benchmarking of process.

[1] Description of Work Page 8
[2] Description of Work Page 64
[3] Description of Work Page 62

Tools reviewed in this document are set in the background of PD 4.2.1 'Tool for the selection of key performance indicators'. This activity is very closely interlinked with the selection of Indicators and Criteria to ensure continuity (WP 4.1, 4.2 focusing towards past and present data and 4.3 focusing on future scenarios).

The key objectives are:

- To review and analyse existing tools (VTT's WoodCIM and BRE model both for solid wood, and the models of STFI, KCL, JPC, and VTT which deal with Pulp, Paper and Bio-Energy)
- To develop (if need be) new tools and to refine /adapt existing tools
- Conduct a scoping study of indicators most easily accessed at a company / regional / national / European level for the manufacturing industry
- Study the impact of process related policy changes and technologies
- Development of tool for the selection of key environmental indicators at a company / regional / national / European level. Such a tool will require a robust data set supporting the choice of key environmental indicators (input from WP 4.1) and showing how and why such indicators can predict the environmental performance of the company as a whole. Indicators will also need to be chosen to ensure the maximum scope for improvement within the industry
- Develop benchmarking indicators for companies to measure their performance in the future against their previous performance, against other companies nationally and across Europe
- Development of models and tools show how conversion variables concerning properties of wood raw materials, production parameters and product specifications will affect sustainability indicators.

Milestones, outputs and deliverables

The following milestones are relevant to this document:

- M4.2.1 Review of sustainability indicators and criteria, benchmarking methods, performance indicators for and in conjunction with M1, M3, M5 – (month 11, September 2006)
- M4.2.2 Review of existing tools, refinement of existing models or need for a new comprehensive set (month 15, January 2007)

These milestones are linked to the outputs relevant to WP4.2. namely:

- review of sustainability indicators & criteria
- review of performance indicators for and in conjunction with M0, M1, M3, M5
- review of existing tools, refinement of existing models or new comprehensive sets for environmental, economic and social impacts of processes on regional, national and European level for solid wood, pulp & paper and bio-energy.

The DoW allows for final refinement and consequent delivery to M1 of the Module's tools for use within ToSIA at a later stage to ensure fluidity and harmonisation of approach.

Purpose of this deliverable and relationship to TOSIA

§ Strength of the tools presented - robust scientific methods, used by industry, etc.

- Comprehensiveness and ability of tools to assess economic, social and environmental trends
- Links to future deliverable in EFORWOOD and in M4 in particular (response functions)
- Importance of the well established methods
- Replicability/reliability of results

Description of the project

The project will identify the most appropriate methods for assessing the sustainability levels of forest-based raw material manufacturing and processing. Work will primarily focus on existing models used by Module's partners for solid wood, pulp and paper and bio-energy (models of KCPK, VTT, BRE, JPC, KCL and STFI-Packforsk). Viable and scientifically robust impact indicators for sustainability levels will support the benchmarking of process. It is foreseen that this level of quality will contribute to 'real' enhancement of industrial processes throughout the FWCs. A comprehensive review and analysis of existing methods, tools, and datasets on regional, national and European level, will be undertaken in close co-operation with M0 and M1 to secure a functional ToSIA tool. Co-operation with M3 and M5 is necessary to ensure continuity of the reference streams (solid wood, fibre based products and bio-energy) throughout ToSIA. Expected development in applied technologies will be accounted for within the boundaries of each work-package as well within packages to address the distinctive characteristics and diversity of solid timber, pulp and paper, and bio-energy streams. The findings of this report will support the work of WP4.3 looking at potential impacts of various policy tools on the industry dynamics in the near future. However, other deliverables will be closely connected to the outcomes of this report in the next working period.

A comprehensive collection of relevant existing methodologies, in particular those used in the modelling tools to be used in future work, was undertaken.

These methodologies are presented in summary form below, which is derived from the table in Appendix B-Summary of Tools and M4 Partners as provided in the DoW (Description of Work).

Ecological Footprint Analysis (EFA)

Ecological footprint is a calculation method that estimates the demand of human activities on nature. It measures the resources consumed by a population and the balance between human demand and nature's supply. It can be calculated for varying geographic scales, and populations. The footprint considers productive land use and all necessary inputs (including energy or food) as well as emissions and outputs to determine how much land is required to absorb all of these. The result is typically presented in global hectares.

Objectives

To represent the effective load human activity places on the environment (in particular renewable resources) in terms of bio-capacity and land.

Value Concept Encapsulated

Primarily focuses on environmental impacts in terms of associated land sequestration. This land use is a clear measure of the strain systems, people and regions place on the environment.

Theoretical Basis

EFA was developed in stages, its origins lying in 'ghost acres' and similar concepts developed by Borgstrom[4] and Ehrlich[5] in the late 1960s. Rees then developed footprint analysis in its basic form in teaching planning students over the course of 20 years.

From the sustainability perspective, if a footprint for a given system exceeds the renewable bio-capacity of its boundaries, the 'natural capital' of the system is depleted and the system is unsustainable. This essentially results in degradation of the environment, often irreversibly.

Process of Implementation

EFA focuses on renewable resources ('interest' rather than 'capital' of a defined region) and is essentially an additive model.

Inputs and outputs of resources into a defined system are listed, their associated land use allocated to the relevant categories which measures the strain on the bio-productive capacity.

With the consumption categories (aa_i) defined, the associated land use per capita per category is determined.

[4] Borgstrom G. The Hungry Planet: The Modern World at the Edge of Famine, 2nd ed. New York: Macmillan; 1972.
[5] Ehrlich P. The Population Bomb. New York: Ballantine; 1968

The link between land use and consumption is made by:

$$aa_i = \frac{c_i}{p_i} \sim \frac{Annual\ consumption\ of\ an\ item}{Average\ annual\ yield} = \frac{kg / capita}{kg / ha}$$

The number of Consumption Categories varies between 4 and 10 or more categories. The per capita footprint (*ef)* is then found by summing the category impacts.

A matrix of consumption categories with associated land use is produced, which can then be processed in a spreadsheet.

This can then be compared with the available land, or 'Carrying Capacity' to reveal the sustainability of the system, for example, a city.

Existing software to facilitate this process exists, though ownership rights could be an obstacle to common use.

Transparency about how the calculations are performed, and what consumption categories are included can also cause difficulty (see Appendix A- Summary Table of Critique of Ecological Footprint Analysis for further information). However, there are free, basic footprint calculating tools available online for estimating a subject's (e.g. an individual, any small unit or a region) footprint based on lifestyle trends as opposed to raw data, for example.

The data can be observed in its differentiated form such that the strain on each category is measured, helping access which is the most important or largest contributor. The single figure is mainly to facilitate communication and simple interpretation of the analysis.

Data Needs

EFA is very much like LCA and requires extensive and detailed data for it to be effective. It is only as accurate as the data used to implement it. Data sources include the WWF (Living Planet Reports use EFA as an essential tool), BP, World Bank and other international organisations.

The wider the variety of data and the more representative it is of the system, the more refined the 'footprint' and the associated strains on each category.

Practical Issues

Data availability and accuracy have a significant influence on the effectiveness and reliability of an EFA study. The process can be very time consuming and thus certain levels of aggregation and assumptions may need to be made, but should be clearly stated.

There are several critiques of EFA[6] whereby the positive and negative aspects were explored with possible improvements to the methodology. The principal of these are summarised in Appendix A - Summary Table of Critique of Ecological Footprint Analysis.[7].

Discussion

EFA highlights several important social equity concerns. If the total Bio-capacity/ carrying capacity is divided by total population, there are about 1.8gha [8]available per capita. Wealthier parts of the world have footprints often ranging between 4.4 and 9.6 gha/ person[9] , and are net importers using the bio-capacity of other regions to fuel their economies. The primary contributor to this value is the use of fossil fuels[10], which is growing rapidly, increasing nine fold from 1961 to 2003.

Other categories of indicator are sometimes included depending on the specific methodology- such as health and sanitation, recreational facilities and other aspects of social provision. ‘Food and Forestry Products’ was subdivided into those derived from cropland, grazing land, forest and fishing grounds by the WWF for example. Footprint analysis often needs to be supplemented by the use of other measures to account for broader aspects of human welfare.

The scope can be varied from an individual, to a nation and to the global scale. Any system with defined barriers could be studied, so long as data is available for it. Footprint analysis is only as accurate as the data used to implement it. The wider the variety of data, and the more representative it is of the system, the more refined the footprint will be.

Associating land use with wastes remains a contentious issue, the land associated with fossil fuels for example, can be calculated either as the land required to produce the equivalent amount of bio fuel, being carbon lean overall- or the land area required to absorb the resulting emissions. These two methods produce quite different footprints,

[6] Notably Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM) - Council 1999, Van Kooten and Bulte 2000, Van den Bergh and Verbuggen 1999, Pearce 2000
[7] Critique by Van Kooten and Bulte (2000), responses from Mathis Wackernagel (summary table found in appendix A)
[8] WWF Living Planet Report 2006. Page 14.
[9] WWF Living Planet Report 2006. Example figures are those of Japan, and the USA. Germany, France and the United Kingdom have footprints of 4.5, 5.6 and 5.6 respectively.
[10] WWF Living Planet Report 2006.

Life Cycle Assessment

Evaluating the environmental impact of a product over its entire life is an extremely complex task. Consequently, many different approaches using different terminology developed causing confusion and devaluation of the technique. Both the International Standards Organisation (ISO, series 14040) and the Society for Environmental Toxicology and Chemistry, SETAC[11] have been working to clarify the methodology.

There have been other notable publications on the methodology development:

- the Swiss Ökopunkte ('Ecopoints') method;
- the CML method[12];
- the Nordic method (Lindfors *et al.,* 1995) [13]and
- the Danish EDIP method [14]
- Development of the methodology is an on-going process.

LCA is broken down into the following stages:

1. Goal and scope definition: this is where the purpose of the study and its intended use are set out. The product(s) to be assessed are defined, a functional basis for comparison chosen and the necessary level of detail and quality needed are set;
2. Inventory analysis: the processes involved in achieving the function described in the goal and scope stage are mapped out. Information on the energy and raw materials used, along with the emissions to air, land and water, are quantified for each of the processes involved and then combined to give an inventory table summing these for life cycle stages or for the whole life cycle;
3. Impact assessment: this stage is sub-divided into 3 parts:
    a) *classification* where the effects of resource use and emission generation are allocated to the relevant impact categories;
    b) *characterisation* where the contributions of different substances to each impact category are referenced to that of a specific substance ('*normalisation*' is an

[11] www.setac.org
[12] www.leidenuniv.nl/interfac/cml/ssp/projects/lca2/index.html
[13] Lindfors L-G, Christiansen K, Hoffman L, Virtanen Y, Juntilla V, Hanssen O-J, Rönning A, Ekvall T, Finnveden G (1995): Nordic Guidelines on Life-Cycle Assessment. Copenhagen: Nordic Council of Ministers
[14]glwww.mst.dk/publica/projects/2003/87-7972-582-1.htm

extension of this step and relates the level of impact recorded for the product in each category to the total amount of each problem occurring nationally, regionally or world-wide in one year); and

c) *valuation* where the results for each impact category are weighted to indicate their relative importance (this step is optional and is not allowed under ISO for published comparisons of products);

4. Improvement assessment: the need and opportunities for reducing the environmental impacts of the product(s) are systematically evaluated. The results of the study are then reported as informatively as possible. ISO regards this stage as an application of LCA whereas SETAC regards it as integral to the process.

LCA is iterative with each repeat looking at the system in greater detail. The initial analysis is often fairly superficial using approximate data to give a ‘screening’ assessment. In some cases this may be all that is needed but it is generally used to show where focusing attention will yield the most improvements. The intended use of the results determines the level and quality of the information needed, e.g. for an eco-labelling scheme the results need to be as complete as possible but for product design a degree of uncertainty may be acceptable.

When applying LCA to construction materials, it is necessary to develop a methodology that is appropriate for all materials, e.g. the impact categories used and the allocation methodology must be relevant to all construction materials. In the UK BRE has developed such methodologies (Howard *et al.*, 1999), which it has used to produce a range of tools to help architects, specifiers and their clients to incorporate material environmental performance in the decision making process. BRE’s tools are included in a later section looking at existing schemes for assessing the environmental impacts of construction materials and buildings.

Multi Criteria Analysis (MCA)[15]

Objectives

MCA ranks different options by means of their weighted performance against a set of criteria.

Value Concept Encapsulated

MCA can encompass any set of given values, and thus can cover the economic, social and environmental criteria of sustainable development. The indicators are given in varying units giving it more flexibility but less comparability than monetary methods.

The indicator values are aggregated together using a weighting system, or a lexicon-graphic ordering which focuses on set criteria.

There is sometimes an ambiguity and lack of transparency in the method, often resulting from the way in which the weighting scheme is applied. It can also be difficult to involve the public in the application of MCA- though stakeholders, experts, specialists and decision makers can take their views into account.

Theoretical basis

Based on modern welfare economics and social choice theory. MCA handles several functions at one time and involves the empirical construction of a social welfare function to express the relative achievements/ degradation of a system.

There are some key differences between 'Anglo-Saxon' and 'continental European' practises of MCA. The first being based on scoring and weighting systems based within a structure of options and criteria in some form of grid.

The second focuses more on iterative methods for direct comparisons between alternatives. Some of the 'continental European' outranking methods are thought of as inconsistent with rational choice theory by the 'Anglo-Saxon' schools.

Process Implementation

A typical method for practising compensatory MCA follows:

- Identify the key characteristics of the issue
- Scope the range of options available to address the issue
- Develop a set of criteria for comparison of alternatives
- Evaluate the performance of the alternatives against the set criteria
- Weight each criteria according to its relative importance or in terms of 'trade-off'/ conversion factors such that they are:

[15] Based primarily on information from: Inland Waterways - Annex NR0103, EFTEX In association with Environment Futures Limited. For the Defra. 20/3/06

1. compensatory – allow trade offs between criteria when producing the aggregated score

2. non-compensatory – do not allow trade offs and implies use of lexicographic decision rule over criteria or groups of criteria.

- Aggregate the alternatives to produce a complete assessment
- Using graphical or other methods, describe the results and what they indicate in terms of option ranking
- Sensitivity analysis – check the representitiveness of the model, and how changes to weightings, criteria assessments and functional forms impact on it.
- Review the outputs to form conclusions and recommendations.

There are many available methods, algorithms and software packages to facilitate and carry out compensatory MCA[16]

By contrast outranking models [17]do not employ additive aggregation functions, they are instead based on political science theories concerned with decision making. This results in them encouraging more interaction between the decision maker and model in finding the best solutions, consideration of minority interests and agreements of positive and negative nature.

MCA has been evolving and recent extensions to the methodology include multi-criteria mapping, stakeholder decision analysis and deliberative mapping- a combination of the prior two.

Data Needs

Generally quite extensive, comprehensive data on the potential effects of decisions on each of the major areas of sustainability is required. This is particularly so when ranking and weighting of the criteria is undertaken.

Practical Issues

Group components of MCA will need aided by a skilled facilitator, whom should also take responsibility for the technical aspects of using MCA software.

MCA can be a very time consuming process, especially so if there is a significant participatory process and deliberation, such as I Deliberative Mapping, an extension to MCA.

Discussion

MCA will produce a set of rankings and weightings for different options, a summary of the sensitivity analysis and graphical outputs. The deliberative process may also be a focus, attention being given to stakeholder decision making processes and specific ranking issues. These outputs are generally case specific, and cannot be used for other exercises.

Due to its complex nature MCA often benefits from enhanced participation, in particular with environmental applications. This participation will especially focus on the allocation of weights and ranking criteria and options, such that the process becomes more transparent and adaptive. Such participation should be

[16] Examples of compensatory models are: SMART, SMARTER, DEFINITE, HIVIEW.
[17] Examples of outranking models are: ELECTRA, PROMETHEE

carefully managed to prevent biases becoming inherent in the model, resulting from stronger assertions by some participants than others.

MCA can be used to study any natural resources. If this is done care should be taken that often complex effects are accounted for properly, and not overly aggregated, or misrepresented.

Availability of information, and limits to the amount of criteria can also impact significantly on the process. The way in which participants arrive at decisions with regards to weighting and ranking should also be a focus, as this can be as significant as the value judgement itself. As such MCA techniques greatly benefit form well facilitated deliberative processes.

The MCA methodology is very sensitive to changes in the options considered, and weightings applied. As such the final form of any model produced is not independent of the scenarios considered, and any further additions could require the process to restart entirely. This sensitivity can also be effectively tested and analysed to examine how the weights and values influence the performance of different options- making MCA fairly heuristic.

MCA Outranking methods can be more easily applied, demand less information, have a more descriptive approach and supporting a decision maker’s interaction with the model. However they are also less transparent in terms of the application of weightings and value judgements. The outputs can be very clear, but may well result from restrictive assumptions, limiting the representativeness of the method.

Cost Effective Analysis (CEA)[18]

Objectives

CEA is a method supporting decision making processes based on the assessment of the costs of different methods of producing a service or product. It can be applied in planning stages of work, or as an evaluation of completed work.

Value Concept Encapsulated

CEA is more a support framework to aid decision making rather than a valuation method. It can form part of the ranking exercise in multi-criteria approaches.

Theoretical Basis

CEA is essentially comparative, and enables the decision maker to compare the different associated costs of varying options, and the option's effectiveness relative to this cost. This relation of increased effectiveness per increased cost is the 'incremental cost effectiveness ratio'.

The effects of options can be in terms of reduced pressures (e.g. lowering CO2 emissions) or avoided impacts (e.g. lower risk of toxicity to humans)- which can be more difficult to assess.

Cost Minimisation Analysis (CMA) is a variant of CEA which compared different options, producing the same result, purely in terms of cost variation. Where it is decided that a stated goal cannot be valued simply in monetary terms, CEA can be used to assess the economic efficiency of an action.

Process Implementation

CEA is carried out in the following stages:

- Define the scope, scale and time frame of the project.
- Select the criteria being assessed for effectiveness. This stage is very much project specific.
- Identify the different options that can be taken to achieve the goals of the work. The expected outcomes of each option should then be compared. This stage is complimented by the use of other methods such as Environmental Impact Assessment (EIA) or Health Impact Assessment (HIA)
- Cost estimation of the different options and processes- defined as 'the sum of the opportunity costs incurred by society as a result of an action, of which there are five basic components:
    1. real- resource compliance costs
    2. government regulatory costs
    3. social welfare losses

[18] Based primarily on information from:
Inland Waterways – 02157 – 113127, Norfolk Broads, - Annex NR0103
EFTEX In association with Environment Futures Limited. For the Department for Environment, Food and Rural Affairs. 20/3/06

4. transitional costs

5. indirect costs (i.e. reductions in productivity or innovation)

- Calculate the aforementioned incremental cost effectiveness ratio.
- Conduct sensitivity analysis. This stage is very important in understanding how the impact of given weights and assumptions influence the ranking of the considered options.

Identifying alternative options, which are mutually exclusive from one another is an essential phase in ensuring that the CEA is effective. If the options produce varying outputs, then a normalising procedure should be used.

Practical Issues

The availability of data to conduct this process will have a great influence on the time which it takes. This can often take between 6 months and a year to complete. Producing a cost database can aid in the data collection stages, whereby simpler data can be gathered initially, allowing for update and improvement at later stages.

It is important that CEA is complimented with other forms of analysis, such as EIA or HIA, and that the expert engineering and technical assessments are considered carefully when looking at the different options. It can also come to form a useful component of MCA studies.

Discussion

The main output from a CEA will be a comparative presentation of the different options, with a ‘least cost’ option being the most desirable. A compilation of the associated assumptions, uncertainties and sensitivity should also accompany the report. The outputs are project and context specific.

It is important to take care defining the scope of the costs for a CEA. There are many different kinds of associated costs, which fall burden different areas of the economy.

Cost discounting with regards to the treatment of effectiveness can be an ambiguous area. The time frame which options are considered over, and the payment rate will influence which option is preferable. It is not always suitable to use discounting on effectiveness, the US EPA (200) guidance on economic [19]analysis identifies where discounting is and is not appropriate. HM Treasury’s Green Book[20] also provides guidance, and specifies a 3.5% discount rate for costs and benefits.

There should also be a clear distinction between the pressures and outcomes being considered when ranking the different options, ie one can measure the associated carbon emissions, or the avoided damage/ improvements to the quality of the environment. In practise it would be easier to quantify the prior.

CEA does not explicitly include distributional concerns. Two apparently similar options could have an impact over very different spatial areas, and impact on greatly varied populations. Thus some form of Distributional Analysis should be undertaken to account for this.

[19] www.epa.gov
[20] www.hm-treasury.gov.uk

If the objectives of a CEA are clearly defined, it will not be required to assess the monetary benefits of reaching said objectives. If the outcomes of different options can be observed and studies, it would allow for the aversion of hypothesising the complex causality relating to each option.

The main disadvantage of CEA is that it only allows cost comparison of different options to produce a single outcome (of varying quality), which is often insufficient. MCA or Cost Benefit Analysis (CBA) may be required for more complete comparisons.

Whole Life Costing (WLC)

Whole life costing (WLC) is a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. In particular, it is an economic assessment considering all projected relevant cost flows over a period of analysis expressed in monetary value. It can be defined as the present value of the total cost of an asset over the period of analysis.

In short, WLC is the total cost of a product or its parts throughout its life, including the cost of planning, design, acquisition, operations, maintenance and disposal, less any residual value.

(Note: Life Cycle Cost is a term used to describe the same process as Whole Life Costing (WLC). The difference between the two is often taken to be that LCC is a sub-set of WLC and represents the period of interest that the cost analysis is aimed at. The expression “WLC” is more commonly used in UK, and essentially used to describe the Life Cycle of a product (ie building). LCC is used in UK more for the Life Cycle for a material. Internationally LCC is commonly used for both).

The integration of Whole Life Costing (WLC) and Life Cycle Assessment (LCA) presents a powerful route to improving the sustainability of the built environment, as well as other product markets. Combining economic and environmental assessment tools to obtain "best value" solutions in both financial and environmental terms has the potential to make a significant contribution to achieving sustainable development.

WLC forms a major aspect of LCA.[21]

[21] Embodied Energy Framework Scoping Project, BRE Client report number: 216-144

Findings

Bellow are presented tools relevant to Module 4 presented by partners in a standard template.

VTT Bioenergy Production Evaluation Model

Name

Bioenergy Production - Energy Efficiency and GHG Balance Model

Owner/creator

VTT

Age, update frequency, data ownership (availability)

The model development was started in the 1990's to make simple analyses of energy and GHG balances of bioenergy production chains. The model is still being developed - the most recent application was a study on the production of biomass derived transportation fuel. All information is collected from publicly available sources and the aim has been to make the calculations and the output very user friendly. The present model is only available for internal use (research/VTT and The University of Jyväskylä).

Scope - input data/parameters

The production chain is divided into sub-processes similar to what is used in LCA-analysis – also the input data needed is similar but much more restricted as the model only focus on energy and GHG emissions. Furthermore the scope is not to produce very exact data but to calculate the magnitude of wanted data and to define sub-processes/production steps having big influence on the result.

Keeping the calculations simple have made it possible to introduce and analyse new sub-processes that might affect the results. One such new process is storage of biomass, another is related to the forest site: changes in carbon balance in forest soil due to outtake of residues.

Methodology

The energy efficiency and greenhouse gas (GHG) balance model estimates the magnitude of the energy that is needed for producing a certain amount of (bio)fuel. The production chain is divided into sub-processes similar to what is used in LCA-analysis and the energy input and the emissions are compared with the produced amount of fuel (energy: MWh_{input}/MWh_{output} or %, emissions: CO_2eq/MWh_{fuel}. As the energy content and moisture of biomass as well as the amount of material (dry mass) vary along the production chain, the carbon (C) content of the biomass has mostly been used as base parameter in the analysis. Different qualities of energy input (diesel, electricity, bio-oil etc) can be analysed separately. For more information on the methodology, see (Wihersaari 2005a).

Quality of data

The data used for the model has been collected by trained energy and environmental experts from publicly available sources, public and confidential research project as well as given by experts in companies. As the input data needed is rather restricted the variations in quality is easier to handle than in traditional LCA-analyses.

Representativeness

Most of the calculations have been made for Finnish circumstances. Local and/or state specific data should be used when available.

Use, limitations, applications

The philosophy used in the model may be used without any limitations. Input data is documented but not systematically collected to any database.

The model has been or is being used for studying the following kind of fuel production:

- Wood chip (forest residue, 5 different production methodologies)
- Pellet production (wet and dry saw dust based production)
- Agrobiomass fuel (reed canary grass, straw)
- Transportation fuel
- Biomass derived syngas
- Biogas production (biowaste, agrobiomass)
- Fuel derived from source separated waste
- Fossil fuel production

Review

The reliability of the basic data and the calculations is ensured by keeping the data and calculations simple as well as by reporting the input data together with the results. The model as well as the results has been reviewed in scientific papers. The model has been developed in research projects financed by TEKES, The Academy of Finland, VTT as well as of stakeholders representing industry.

BRE Environmental Profiling (LCA for construction products)[22]

Name

BRE Methodology for Environmental Profiles of construction materials, components and buildings, Howard N, Edwards S and Anderson J, BRE Report 370, BRE, Garston 1999.

Owner/creator

Building Research Establishment

Age, update frequency, data ownership (availability)

1998; Update on a regular basis, data ownership by BRE, aggregated level publicly available

Data quality

Data in Environmental Profiles is accompanied by descriptors relating to sources and collection methods.

Various sources

1. Detailed process information obtained directly from a reasonable sample of manufacturers of UK building materials, products and components.

2. Industry-generated average figures without data separately identified from individual companies. Where industries supply data collected as part of a previous LCA study, full details of the rules and conventions used in the study have been sought and the BRE methodology applied.

For substances and products which have a significant input to a process but for which data cannot be readily obtained from the suppliers, data has been obtained from existing commercial databases.

[22] This methodology is currently under review and will be published in April 2007. It is foreseen that changes will be issued separately as an addendum to this report.

Scope - input data/parameters

The BRE scope for LCA is generally 'cradle to grave', and looks at the total impacts of a product from sourcing to disposal. The product focus is typically construction elements. The following indicators are studies:

Climate change (from EE)	Pollution to air: Human toxicity
Acid deposition	Pollution to air: Low level ozone depletion
Ozone depletion	Pollution to water: Human toxicity
Fossil fuel depletion and extraction	Pollution to water: Ecotoxicity
Minerals extraction	Pollution to water: Eutrophication
Water extraction	Waste disposal

Recyclibility and recycled input are both included in presentation as well as guidance on whole life cost and maintenance issues.

Creating the generic Profile

Where data is available from a number of sites for a product group, the generic product for the UK is arrived at by applying an average based on the proportional contribution of each site by mass to the total UK mix of the sites supplied, where known. In a small number of cases the generic figure is derived from one site.

It has already been noted that upstream data, i.e. data about inputs into a process, has been obtained from within the Certified (i.e. individual manufacturers) Profiles project . If any gaps occur other robust, internationally accepted sources are used. These are primarily IVAM, Pré, BUWAL, ETH and SBI data, etc..

Methodology

The UK methodology was developed to be applicable for all product sectors in the UK through a joint initiative between BRE and construction product manufacturing representatives to create a common basis for life cycle assessment.

The reason for producing the agreed methodology was to ensure "level playing field" assessment of different types of building materials, elements and whole buildings and to help the user by reducing the number of confusing claims about the environmental properties of alternative building products.

The methodology ensures transparency of the method applied to create the data in the Environmental Profiles Database. It records the rationale and methodological rules that have been adopted by BRE to apply LCA to construction products and components. There is no single "right" answer for applying LCA but it is has been agreed by the majority of the building materials producers representatives in the project that this methodology represents a suitable approach to deal with all building materials.

This methodology is based on the LCA principle and conforms with ISO 14040-14043 and with ISO/TR 14025. In also have further, additional, building-specific and other methodological requirements.

The goal is to provide information on environmental performance to various actors in the supply chain, product comparison or providing input data for building calculations. This information is necessary with regard to the applicability of the schemes.

To gather and assess comprehensive and reliable information regarding the positive and negative environmental impacts of construction materials used in defined applications, which are generated over a defined lifetime.

The BRE Methodology allows Environmental Profiles to be created for different stages of the life cycle, see Table below. BRE do this to allow manufacturers and specifiers the greatest amount of flexibility from the data available to them.

Table: Life cycle stages

Assessment	Life Cycle Stages considered
One tonne of product	"Cradle to gate" - Raw material extraction and manufacture through to the point the product leaves the factory gate
One square metre of a building element	"Cradle to site" - Raw material extraction and manufacture through to installation at the construction site, including transport to the site. (Theoretically, impacts of construction would also be included here, but in practice are excluded due to their relatively small size.)
One square metre of a building element	"Cradle to grave" - Raw material extraction, manufacture, installation and use in a building for a 60 year life[23] including any associated maintenance and replacement, through to the point of removal for reuse, recycling or disposal.

Functional unit

Functional unit is relevant for the applicability in relation to the Construction Product Directive, where harmonised standards are always on product level. This can either be a functional unit on product function level or on product level. The BRE's methodology can deal with both product and product function as functional unit.

Allocation rules

A precise allocation rules are in place as these are important for comparability of results between different schemes and the use of these data in a transparent way.

Impact Assessment

[23] The BRE Environmental Profiles methodology has been devised particularly for the use of construction products in commercial buildings, hence choice of 60 years. It may also be applied to domestic buildings, infrastructure and other applications, where appropriate design lives may be applied.

Quantification of the importance of the different inputs and outputs found. Aggregation of data into indicator categories, sometimes as few as one. This assessment is carried out in 5 stages:

a. Classification- allocating data to indicators

b. Characterisation- combining the data and forming values for Category Indicators which are measures of the contributions towards environmental problems.

c. Normalisation- calculation of the magnitude of the indicators relative to the reference information, often set to value per unit reference. (e.g. CO_2 kg/KWh)

d. Grouping- allocating indicators of similar impacts into ranking categories.

e. Weighting- scales the indicators according to relative importance with regard to the environmental impact they cause. This aids in evaluation of which product/ method is more suitable. There are many different weighting systems, each is relatively subjective: distance-to-target techniques, environmental control costs, economic damage approaches, scoring techniques. BRE weightings were decided in consultation with government, lobbyists, and policy makers.

Interpretation

Study of the identified impacts and application of these in decision making processes.

An Ecopoints score is allocated to the product or service which aids in comparison and facilitates decision making.

Quality of data

LCA databases and software exists to facilitate this need to some extent. Confidentiality of up to date data can cause difficulty.

Data can be obtained from elements of the supply chain, NGOs and state departments.

Data in Environmental Profiles is accompanied by descriptors relating to sources and collection methods.

Representativeness

- Individual company level
- Typical practice in the UK
- Also representativeness for individual company i.e. whole year data or part and if so- is that representative of whole year.
- Is data for whole of firm or only one particular site? – what are the differences.

Use, limitations, applications

A high level of expertise and a large amount of time is required to conduct LCA. This varies depending on the process complexity, and data availability. The assumptions made during a study can be critical to the outputs- these should be stated clearly, and quantified where ever possible. The level of aggregation in the data is also key. Lack of transparency and the complexity of the process can lower confidence in it.

LCA generally only needs to be carried out once for each specific system, and changes in the scope of the study, or the system will require a new LCA.

Company specific data – Certified Environmental Profile – Environmental Product Declaration (if certified by BRE Certification – 3rd party)

Typical practice data - Used in selection of specifications at a design stage in Green Guides

- Anderson and Howard, (2000)*The Green Guide to Housing Specification* , CRC. Watford.
- Anderson, Shiers and Sinclair (2002) *Green Guide to Specification,* Blackwells

The target audience for this tool are designers, specifiers and their clients and those involved in the production of LCAs for buildings.

This tool is also used in conjunction with other tools, for example, BREEAM, Envest, Sustainability checklist, or Smartwaste

Review

Widely used and accepted method. ISO defined. Due to some varieties in its application, different methods may be more suitable to some stake holders than others.
BRE uses LCA in Ecohomes, BREAM and other certification programs which are widely used and accepted to the extent that they are a benchmark within the UK construction and materials industries

Distribution of news information in scarcely populated areas

Name:

Distribution of news information in scarcely populated areas

Owner/Creator:

STFI-Packforsk

Age, update frequency, data ownership (availability)

Updated 2002

Scope- input data/parameters

The program is used to evaluate number of new possible scenarios for newspaper distribution, where the reader receives the information on paper, electronically or a combination of both. See figure below.

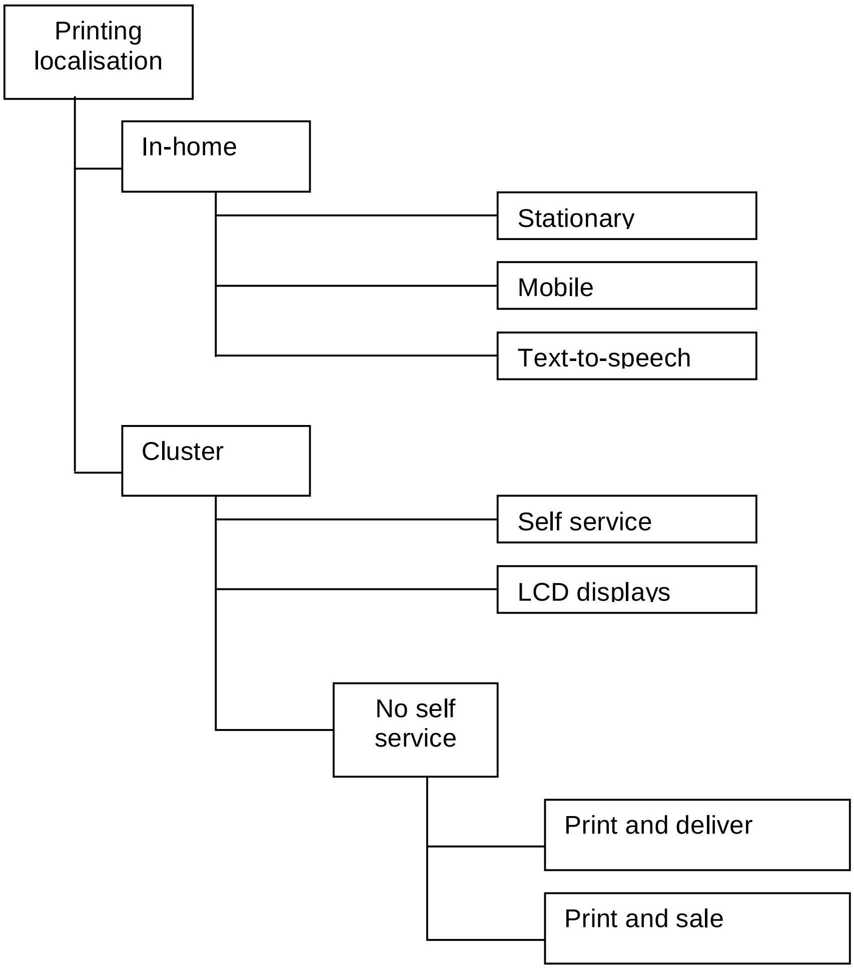

Figure: *Printing localisation criteria with identified solutions.*

The output of the model is data on the indicators described in table below.

No	Area	Group	Indicator	Measure	Explanation
1.	**Technique**				
	1.1	**Technical demands**			
		1.1.1	Performance	MB	Total in the flow newspaper - reader
		1.1.2	Automation	No.	Number of "activities" in the production-distribution chain
		1.1.3	Complexity	days	Number of education days to be able to receive the information
		1.1.4	Maintenance	-	Not included in the model
		1.1.5	Lifecycle	Years	For the total scenario measured for the equipment with the shortest expected life time
	1.2	**Availability**		**Yes/No**	
		1.2.1	On the market	Yes/No	Available or not
		1.2.2	Geographic	Yes/No	Available or not
		1.2.3	Spare parts	Yes/No	Available or not
		1.2.4	Guarantees	Yes/No	Available or not
2.	**Time**			**min/MB**	
	2.1	**Time for the reader**		**min/MB**	
		2.1.1	Searching news	min/MB	
		2.1.2	Downloading news	min/MB	
		2.1.3	Printing	min/MB	
	2.2	**Time for the newspaper**		**min/MB**	
		2.2.1	Editorial	min/MB	Can be excluded as this should not vary between the different scenarios
		2.2.2	Production	min/MB	
		2.2.3	Distribution	min/MB	
3.	**Economy**			**SEK/MB**	
	3.1	**Reader**		**SEK/MB**	
		3.1.1 3.1.2	Investment cost Running cost	SEK/MB SEK/MB	
	3.2	**Newspaper**		**SEK/MB**	
		3.2.1	Incomes	-	Not included in the model
		3.2.2	*Sum costs*	*SEK/MB*	
		3.2.2	Investment cost	SEK/MB	

No	Area	Group	Indicator	Measure	Explanation
		a			
		3.2.2 b	Running cost	SEK/MB	
		3.2.2 c	Distribution cost	SEK/MB	
4.	**Infrastructure**				
	4.1	**Physical demands**		**Text**	
		4.1.1	Material	Text	Component list
		4.1.2	Technical solutions	Text	Component list
		4.1.3	Suppliers	-	
	4.2	**Availability**		**Yes/No**	
		4.2.1	In homes	Yes/No	Available or not
		4.2.2	At newspaper	Yes/No	Available or not
		4.2.3	Geographic	-	Not included in the model
		4.2.4	Service/guarantees	Yes/No	Available or not
	4.3	**Legislation**		**SEK**	
		4.3.1	Cost	SEK	Initial cost for possible fees or apply cost to authorities
5.	**Organisation**				
	5.1	**Structure**			
		5.1.1	Lead times	min	Difference between total and productive time from editorial office to reader
		5.1.2	Competence	min/MB	Time for education at the newspaper to be able to distribute information in the new media
		5.1.3	Management	-	Can be excluded as this should not vary between the different scenarios
6.	**Quality**				
	6.1	**Technical quality**		**Contrast**	Readability / audibility to assimilate a certain amount of information
	6.2	**Demands from readers**			
		6.2.1 a	Content	MB	Available
		6.2.1 b	Content	MB	Quantity chosen not to be distributed
		6.2.2	Layout	-	
		6.2.3	Distribution	%	Percentage late or incorrect distribution
	6.3	**Added value**		**min**	**Text**

No	Area	Group	Indicator	Measure	Explanation
		6.3.1	Updating	min	Time between updating possibilities
7.	**Environment**			**EPS**	
				kg/CO_2	
	7.1	**Use of resources**		year-1	Recourse Depletion, Reserve to use
	7.2	**Acidification potential**		g SO_2-eq./g	Acidification Potential
	7.3	**Eutrophication**		g PO_4^{3-}-eq./g	Eutrophication potential
	7.4	**Climate change**		g CO_2-eq./g	Global Warming Potential, 100 years
	7.5	**Ozone creation**		g ethylene –eq./g	Photochemical Ozone Creation, 0-4 days, high background concentration of NO_x

Table: *Description of indicators and measured properties*.

In all areas a number of factors have been identified. To be able to compare the different scenarios measurable indicators have been chosen for each factor. When choosing these indicators the goal was to find numerical values that can be added to give a total indicator for the whole area.

Methodology:

The model for calculations has been developed in the software MS Excel.

When developing the model tree types of input were identified:

- Properties of the newspaper examined, e.g. number of pages, MB, editions/year.
- Choices made by the newspaper company, e.g. Internet access used by the newspaper company and the reader, type of equipment used by the reader.
- Constants, e.g. properties of the chosen equipment and environmental properties of the chosen paper.

The constants used in the model can be categorised into five different groups

1. Properties that are constant for a scenario
2. Properties of the equipment used
3. Properties of the material used
4. Environmental properties of equipment and material
5. Other constants

The data in the model is based on data from newspaper production and distribution in Sweden, and BAT technology for digital printing and ITC. Even though these properties are constant in the calculation of the model they can of course be changed if better assumptions are available or if new equipment are added to the model.

Quality of data

The data in the model is based on actual data from newspaper production and distribution in Sweden, and BAT technology for digital printing and ITC.

Representativness

Current state of art Europe (based on Swedish data) 2002.

Use, limitations, applications

The prototype model that has been developed should be seen as a tool to roughly estimate the properties of future scenarios for distribution of newspapers. To be able to calculate all the indicators in the developed model, a large number of data has to be put into the model. The outcome of the model will be of no better than the input. It is therefore important to use the model with caution and take into account the estimations made in the featured constants and the data considering the investigated newspaper's properties.

The model developed provides one of the pieces needed when looking at alternative distribution forms and how these influencers the paper qualities needed.

Review

The model has primarily been used as an internal toll at STFI-Packforsk.

KCL-ECO 4.0 life-cycle assessment software and KCL EcoData inventory database

Name

KCL-ECO 4.0 life-cycle assessment software and KCL EcoData inventory database

Owner/creator

KCL (Oy Keskuslaboratorio-Centrallaboratorium Ab), the Finnish Pulp and Paper Research Institute, Finland

Age, update frequency, data ownership (availability)

KCL-ECO 1.0 1993, database 1995. Data continuously updated as project work together with the Finnish pulp and paper industry. Owner of the tools: KCL. Availability of the tools: public. KCL-ECO 4.0 was released in autumn 2004. New version KCL-ECO 4.1 with continent/country specific impact assessment factors will be implemented in 2007.

Scope - input data/parameters

The tool helps us to identify the resources, emissions and environmental impacts of a chosen life cycle. Data covers the most common input and output parameters in paper product's life-cycle. Input data includes resources, energy, pigments, chemicals, materials, fuels. Output data covers emissions to air, water, co-products and solid waste (to the landfill, reuse or recycling). Data calculated per 1000 kg oven dry product. Transport data calculated per tonne*km. Energy production data calculated per MWh or GJ of electricity or heat.

Methodology

LCA-calculation based on Linear equations. Also closed loops can be handled (recycling). Results are per chosen functional unit (e.g. /ton of paper). Results are presented in several ways depending on the scope of the study. For example the impacts of transports only can be studied separately. With KCL-ECO you can easily handle very large systems with fully graphical user interface. KCL-ECO 4.0 has many new features including

- ability to import Ecoinvent-database into KCL-ECO
- COMPARISON OF DIFFERENT CALCULATION RESULTS: Different calculation results can be compared in two different chart-windows. Useful for example when comparing different process conditions.

- FILTERING OF MODULES: User can filter a certain amount (%) of a parameter. By filtering the user can cut the modules and flows that have small effect on the filtered parameter. A useful function when considering very large flowsheets.
- MARKING THE QUALITY AND ORIGIN OF THE DATA INTO THE MODULES
- HIDING OF MODULES: User can hide certain modules for exampel in a case if the flowsheet is sent to a user, who is not wantened to have access to all of the modules.

Quality of data

Database is continuously updated and cross-checked together with KCL research experts and pulp, paper and board experts from the forest industry or from the manufacturers. Data is of high quality and represents a unique information on typical pulping and papermaking processes for several different paper grades, forestry data, chemical manufacturing, industry specific transport data and fuel specific energy production data.

Representativness

Most of the date represents typical processes in Nordic countries or European level. Forestry data is an exception and represents Finnish technology.

Review

Internal, external, stakeholders' acceptance

Industrial processes: Finnish forest industry, KCL internal review

Transport data: industry's suppliers, VTT co-operation (LIPASTO transport database)

Chemical and pigment data: from the manufacturers/calculated data

Energy production data: Finnish energy production companies, forest industry

Forestry data: Finnish statistics from Metsateho.

MPI PEMS

Name

MPI PEMS

Ownership

Gasunie/VNP

Age

1998; Regularly updated

Scope

Input Parameters: production figures, working hours, broke and broke hours, raw material input, production output, energy bought, energy sold, energy conversion

Output data/indicators: energy use per process, energy efficiency, CO_2 emissions

Methodology

Gasunie

Summary description

Custom-made (per location) technical service programme after extensive analysis of energy flows and material flows in the mill. Energy consumption figures are calculated for every specific (sub)process and compared with measurements.

Quality of data

Data input/output has very high quality as it is produced by the individual mills using the custom-made programme, specifically designed for that location

Representativeness

- Individual company level

- Aggregation towards National (Dutch) level possible since ALL Dutch paper and board mills are using this model (100%)

Use

The model is used by mills to calculate their energy consumption. The high level of detail allows the user to analyse the specific energy consumption of sub-processes. The effect of energy improvement options and changing product portfolios can be calculated. Aggregation of results of are used in national and international benchmark studies.

Limitations

- Custom-made
- Confidentiality of individual mill data

The results of this model can (and will) be used to develop an energy model that will be able to make a reasonable assumption of energy consumption at product level, for the non-integrated virgin fiber based P&B production and recycled fiber based P&B production in the paper and board value chain. The model will also work as a decision support tool that will be able to estimate the effects of:

- different types of energy conversion
- different types of fuels
- different energy management systems
- different types or ranges of input material (recycled fiber vs. virgin fiber)
- different design of the process chain
- energy recovery from test streams (non-paper fraction, bio-gas, heat recovery from process heat etc.).

On energy consumption/energy efficiency, CO_2-emissions and related costs.

The model will therefore on the one hand, be able to compare current practices with best practices on mill level and on the other hand, it will be possible to estimate the effect of future and autonomous developments (i.e. rising energy prices, subsidy changes, CO_2-trading) on the energy efficiency, CO2 emissions and energy costs in the paper and board industry in general

Review

MPI PEMS is currently in use by 100% of the Dutch Paper and Board mills. Some mills use it only once a year to provide input towards the yearly energy-efficiency benchmark (“Convenant Benchmarking energie-efficiency”) of the Dutch Government. Many others, however, use it on a more regular base in monitoring and steering their energy consumption and production.

Pöyry Cost Competitiveness Model

Name

Pöyry Cost Competitiveness Model

Owner/creator

Pöyry Forest Industry Consulting Oy (previously Jaakko Pöyry Consulting)

Age, update frequency, data ownership (availability)

Data collection and model development were started in the 1970's. The model is updated quarterly by Pöyry. All information is collected from publicly available sources.

Scope - input data/parameters

The cost estimation model estimates paper machine and pulp mill specific production costs based on machine/mill structural differences such as:

- machine parameters: capacity and technical age of paper machines and fibre lines, furnish, product mix
- mill parameters: mill scale, integration with fibre lines, energy balance, manning
- regional factors: labour productivity, average unit prices and exchange rates, location relative to target market.

Methodology

Pöyry's cost estimation model is based on the technical analysis of the mill and on the economic analysis of the region in which the mill is situated. The costs are divided into variable and fixed manufacturing costs and distribution costs and capital charges. Rebuilds can significantly change the technical condition and consumption figures of a machine. A theoretical parameter, "technical age", has therefore been defined.

This parameter reflects the timing and nature of rebuilds. Several consumption figures are assumed to be functions of technical age. Material flows and energy balances as well as personnel requirement are estimated based on the technical analysis. Manufacturing costs are then calculated using regional average unit prices. Transport costs consist of inland and sea freights, handling costs and insurances. In addition, a sales commission of 2.5 - 3% is added.

Quality of data

All information is collected from publicly available sources by trained pulp and paper experts.

Representativeness

Local and/or state specific prices are used.

Use, limitations, applications

The analysis results of the cost Competitiveness Model can be used e.g. in the following situations: Annual business planning, Positioning of paper machines in various markets and competitive environments, Assessing competitiveness of new and hypothetical PMs and pulp lines, Optimisation and production cost reduction analyses, Evaluation of rebuild alternatives, Evaluation of new investment options, Evaluation of acquisitions or divestments, and Marginal producer analysis.

Review

The reliability of the basic data is ensured by using several sources and experts at Pöyry's overseas offices. The modelled cost analysis results are continuously compared with actual production costs at mills.

WinGems[24]

Name

STFI-Packforsk are using the commercial simulation tool, WinGems. Using this simulation program STFI-Packforsk has built up Reference and Type Mills. The “Type Mill” is defined as a mill which is a theoretical, generic mill using the most recent and commercially available technology in operation in pulp mills in Scandinavia. The ”Reference Mill” has a very high technical and environmental standard and represents a development potential for existing pulp mills. The Reference Mill is hypothetical and does not in reality exist in its entirely. However, all the unit processes and the conditions employed are in operation in pulp mills in Scandinavia. The Reference Mill has then served as a starting-point to define conditions for different processes and as a platform for developing a calculation model for the study of chemical and energy balances and other important factors. The Reference Mill is also used as a benchmark against which the “Model Mills” have been compared. Process alternatives which are under development and were assessed to have realistic potential for future implementation were chosen for further evaluation. These process alternatives were integrated into the Reference Mill, yielding “Model Mills”, in which at least one not yet commercially available sub-process has been included. The “Type Mill”, representing an average Mill in Scandinavia, can be used as a starting-point when problems in existing mills are to be solved. Modifications can be performed so that the process looks like certain process in reality and the process can be simulated.

Type and Reference mills have been built up in WinGems for production of Bleached market pulp, Integrated fine paper, Kraft liner and Magazine paper.

Owner/Creator

STFI-Packforsk

Age, update frequency, data ownership (availability)

Updated 2003

Scope –input data/parameters

Environmental parameters such as Emissions, effluents, yield, energy etc

Methodology

Based on real industrial processes

[24] Provided by Martin Johansson (2006-09-21)

Quality of data

The data are given to us from our industrial partners so they are found in the real processes.

Representativness

See description of Reference Mill, Type Mill and Model Mill above

Use, limitations, applications

The models can be used for industry to identify problems in the process, such as high water consumption, energy balance, high Cl concentration etc. The models can also be used to look at effects on the energy and mass balances of new technologies.

Review

The acceptance of the models by industry is good.

WoodCIM®

Name

WoodCIM® is a model and software system describing the whole conversion chain from the forest to the end products.

Owner/creator

VTT

Age, update frequency, data ownership (availability)

The first program module (simulation programme) was made in 1970´s and the newest 2000´s, the modules are updated regularly, data ownership by VTT and after delivery confidential input data by the user companies.

Scope

WoodCIM®, the software system for optimal allocation of wood raw material throughout primary and secondary conversion processes in order to maximize /minimize pre-set criteria e.g. profit. The system is based on simulations of individual processes producing input data for a model based on linear programming linking together wood raw materials, different production processes and final products. The software system can be used in scientific research as well as short and long-term industrial planning processes. The model has been implemented at industrial environment for channelling spruce raw material between sawmills and plywood mills. The system can be used also for analyzing impacts of different policies i.e. what is the optimal industrial structure for a forest region.

In WoodCIM® the conversion chain from forest to end products is considered in its entirety. The models virtually convert wood raw material (stems and pulp wood) in various processes into wood products, i.e. sawn timber, building and furniture components, veneer, plywood, chips, chemical and mechanical pulp and paper products maximising predetermined criteria.

Methodology

WoodCIM® consists of a number of software tools of both simulation programmes of the various wood conversion processes and optimization models based on linear programming and dynamic programming. The software modules are briefly described below:

1. Simulation program for predicting the value yield in sawmilling

The simulation model mathematically "saws" a log or a log class into sawn timber pieces by grades according to the end-users' specific needs in such a way that the estimated result closely resembles that achieved in real sawing. The best sawing set-ups for each log class are determined by simulations.

2. Program for optimizing the limits of sawlog classes

The optimization of log sorting requires as input data the volume and value yield figures produced by sawing simulations. The sawn timber marketing factors as well as the end-users' requirements should be known. The model output data presents a number of best sorting alternatives.

3. Sawing model based on linear programming

The optimal sawing strategy for certain time period(s) can be drawn up using the optimization model based on linear programming. Software combines optimally the end-users' requirements and orders, the raw material supply and the sawing possibilities. The goal is to achieve the best profitability for sawing periods.

4. Integrated optimizing model “from stump to final product”

The optimizing model is addressed to manage raw material procurements: selecting forest stands and trees; generating instructions for optimized cross cutting of an individual stem or a group stems. The model comprises also the description of the production processes and the description of orders and products demanded by the customers.

5. Flow model for sawmill

The flow model creates a plan for scheduling operations in the wood conversion chain. Timing of procedures for sawing, stacking, drying, grading and packaging are determined. The model emphasis accurate description of capacity factors in different conversion processes.

6. Simulation model InnoSim

an analysis tool for wood conversion chain operation research studies, is based on a real log/stem model. InnoSim was developed to investigate the potential of value yield improvement as logs are cut into dimension lumber or user-defined wood components. Input logs for the simulator were either built with a log reconstruction model where log external envelope, geometrical shape of log internal heartwood core and internal knots are the main features of the numerical logs. As outputs of the sawing simulation, the software presents sawing results as dimension, length, grade of dimension lumber or user defined wood components for a simulated sawing pattern under the condition of input sawing parameters. Sawing simulation with InnoSim can be started directly with reconstructed logs or alternatively with reconstructed tree stems. In the latter case, logs are firstly cut from a stem, and the resulting logs are "sawn" with the simulator.

Quality of data

The input data of WoodCIM® include data description of the log and log classes, sawing process, factors affecting the value yield and potential sawn timber products. Description of the log class involves the determination of individual logs as objects of calculation. The mathematical description of each log can be divided into two components: description of the log shape and internal features. Input data on raw material quality can be provided with sawmill statistics, through trial sawing or automatically by the scanning of the internal features of logs using i.e. X-ray systems depending on purposes of using the software system. Using the trial sawing method combined with statistics allows the creation of mathematical quality distribution functions capable of predicting the probable quality distribution percentages of lumber pieces cut from a certain segment of the log.

The input data for the simulator includes details of sawlog properties, nominal and green dimensions of sawn goods, sawkerfs, and prices of sawn timber by dimensions and grade, grade distributions of heartwood sawn timber and side boards allowed in sawing. The input data are based on information obtained from research on wood raw material, sawing processes and products and of the statistics from sawmills. The prices used in the simulation are usually based on existing sales prices.

Input data contains details of log supply (available logs), yield factors produced by set-up simulation, orders and sales potential, product prices and capacities of production lines during the time period to be planned. The software estimates the profit for the time period, the number of sawlogs to be sawn using a certain set-up, the number of sawlogs to be left in storage and the product assortment (dimensions, lengths and grades) to be manufactured. Shadow Price-analysis results in valuable information to management.

Input data for optimal allocation module for the LP-matrix is generated by the simulation software tools describing accurately the actual conversion lines and procedures. The constraints of the LP-model show the volume of raw material available, capacity limits and sales potential.

The following list presents examples of input-data needed simulations and optimization:

1. properties and number or volume of saw / veneer log and pulpwood stems
2. number of saw logs and veneer logs by log classes
3. sawing yield and veneer yield (primary conversion) by dimensions and qualities in different set-up/log class combinations
4. structure and properties of the products received from primary and secondary conversion
5. capacities of primary and secondary conversion lines by manufacturing phases
6. costs of primary and secondary conversion
7. prices of the logs and products
8. orders and sales potential for different type of products.

More detailed description of input data for InnoSIM software module is given below.

- Stem/Sawlog model: detailed input data of stems/sawlogs are required for InnoSIM sawing simulator. The stem/log data is based on a stem/sawlog model defined with an external envelope, an internal knots structure, and a heartwood core envelope. The sawlogs can be reconstructed with either the so called flitch method, or the automatic method using scanning and measurement data of sawlogs developed at VTT.
- Wood components: By wood components, we mean user-defined special sawn goods usually with special dimension and shorter length as compared with dimension lumber, but with strictly quality specifications concerning knots, wane and other quality properties like grain angle, resin pockets, checks, pith and annual ring width etc. The quality requirements can be specific for each face and each edge of a component. Wood components are normally produced for making furniture, joinery parts or finger-jointed wood products.

- Lumber and side products: Traditionally dimension lumber products have well defined dimension series and widely accepted grading rules in
- Heartwood content based classification rules, which are defined according to customers' requirements, are used to evaluate heartwood content class of lumbers. In InnoSIM sawing simulator, Heartwood lumber classification is done by checking "heartwood wanes" of both faces and the edge with more "heartwood wane".
- Lumber grading rules with respect of knots and allowed wane rates for each grade and lumber dimension.

Representativness – data for particular company/companies or 'typical' practice in the country/region

The capacity of Finnish sawmills, which have bought WoodCIM® system, is about 65 % of total capacity.

The WoodCIM® system can be used by different sized sawmills with various business dimensions. Some of the world's biggest sawmills, in addition to very small companies servicing local needs, have implemented the software. The different modules can be tailored to match the individual needs of the customers, which are identified during the business analysis by the implementation process. It is also very important to take into account specific market conditions. Some WoodCIM® modules are also prepared to simulate and predict value yield in the sawing of components for the secondary conversion industrial unities.

The WoodCIM® system has been implemented by manufacturers of sawmilling machinery in order to support planning of new machines and production lines. Software modules can also be a part of process control system, i.e. determining the best possible blade setting for a log. Consulting companies can also benefit from using the software when making economical calculations for their customers. Universities, schools and training organisations are using WoodCIM® for demonstration purposes, i.e. education about factors affecting the profitability of the conversion.

WoodCim® is a system supporting decision making to produce information for operative and strategic planning in forest industry, especially in the allocation of wood resource, sawmilling companies. The information gained from the system can be used to optimise and support procurement of wood raw material, production, further conversion and marketing.

Integrated model consists of software tools to simulate and estimate output from different processes as well as to generate a set of potential processing alternatives to be used in the optimisation model based on linear programming. The optimisation software links together the log supply, production and sales possibilities for maximising or minimising criteria, i.e. profit, value or volume yield. Optimisation always concerns time period(s) to be planned taking into account business constrains like availability of wood raw material, production capacities, orders and sales opportunities. In the optimisation models the activities are described in terms of linear and nonlinear equations. The model also contains an objective function for comparing operation options and variables in terms of their benefits. The role of simulation software is to produce operating alternatives and corresponding yield factors to be used in the optimisation models.

Use, limitations, applications

The model system can be used in scientific research as well as short and long-term industrial planning processes. The model has been implemented at industrial environment for channelling spruce raw material between sawmills and plywood mills. System can be used also for analyzing impacts of different policies i.e. what is optimal industrial structure for a forest region.

WoodCim® model system consists of software tools to simulate and estimate output from different processes as well as to generate a set of potential processing alternatives to be used in the optimisation models based on linear programming. WoodCIM® covers the whole conversion chain from the forest to the end products.

WoodCIM® is used in advanced planning at many Finnish sawmills. Computer aided planning of sawmilling activities has yielded good results. It has been possible to increase the sales value of the production considerable compared to less sophisticated planning methods. Using the integrated and optimising approach provided by WoodCIM® allows its industrial users to increase value recovery by taking a competitive advantage in:

- active management and control of procurement of wood raw material
- optimally combining the available wood raw material to market demands and orders of wood products
- dynamic promotion of lumber sales and marketing
- management and control of production chains - processes as a whole in order to achieve the best possible value yield, minimum through put times and minimum inventories in the chain,
- improvement of the added value of the products.

By using WoodCIM® software in the planning operations, sawmills can dynamically manage and control all of the conversion related procedures. By comparing the realised output with the plans, a user can create fast new plans and start the corrective actions immediately, if necessary. Need for changing the plans is usually based on changes in the lumber market and orders or changes in the quality or size of wood raw material. In computerised planning and control, the computer quickly calculates new plans, providing the management and designers relevant information to make the right decisions. By comparing different plans and alternatives, it is possible find the way towards improved profitability. Computer-aided planning can produce fast new solutions, however the final decisions are always are made by people.

Concerning the new module InnoSim, the sawing simulator has served as a conversion tool in investigating the benefits of optimization of log sawing while more log properties are available for making sawing decisions. Heartwood content based log and product features, together with internal knottiness and log geometrical shape information, has made it possible for the sawing simulator to do near live simulation of log sawing. With possibility of producing both dimension lumber and user defined component products, logs can be "sawn" with the simulator to evaluate the potential of fully extracting log raw material values under prevailing market conditions. As shown in the test simulation case, valuation of lumber products can now be assessed from different end-user perspectives, consequently sawmills now have a good chance to achieve the highest values from their sawlogs. The simulator can be used as tools for research as well as for operational planning in sawmill industry.

Review

The basic input data is received from companies. WoodCIM® results are compared to actual results from sawmilling.

VTT has sold about 80 program modules mainly to Finnish sawmilling industry. The capacity of Finnish sawmills, which have bought WoodCIM® system, is about 65 % of total capacity.

Conclusion

This report aims are to outline existing sustainability assessment tools relevant to the Forestry Wood Chain (FWC) manufacturing stages. This deliverable corresponds with previous work undertaken within EFORWOOD project (especially Module 4). In particular work on criteria and indicators (summary of social criteria for M4 are presented in Appendix D and Appendix E outlines social Lead Plus criteria for the entire EFORWOOD module structure) that has already been undertaken and delivered is considered in this report. Additionally, subsequent work that is linked to this deliverable, such as WP's 4.3.focus is also taken into consideration.

This report investigates the reality of FWC's sustainability appraisal tools and methodologies for all three tiers of sustainability; that is economic, environmental and social tiers. However, it is not the objective of this report to compare or contrast these tools. A number of tools are presented in the general section and a selected few, relevant to the work of module 4 – manufacturing and processing – are presented in detail. All tools and methodologies have, undoubtedly, strengths and weaknesses depending on the objectives, timeline, and similar criteria. What seems to be the most appropriate approach is to set objectives for each assessment and get information and results in various levels of detail. In other words, depending on the requirement, it is advisable to employ more than one tool or methodology for more detailed analysis. It is one of the conclusions of this work that there persistent national differences in the need for sustainability assessment linked to national requirements of relevant legislation and regulations. Additionally, companies often seek sustainability assessment for a particular reason and their requirements and objectives will call for a bespoke, tailored approach regardless which tool is being used.

For the FWC's sustainability, assessment is traditionally closely associated with the forestry side of business. Traditionally, economic performance indicators were the most frequently used from the beginning of sustainability assessments. These indicators are strongly correlated with inputs to woodlands, forestry and mill operations as well as the sustainable development of resources. Environmental performance as a function of forest management regulations, risk management and due diligence has for some time now penetrated the field of processing and manufacturing within the FWC of the business, most frequently as Life Cycle Assessment (LCA).

For the manufacturing side of the FWC economic indicators have the longest history of being relevant, however, environmental issues are establishing themselves more and more for this stage of the FWC.

Social performance is a focus of special interest groups and stakeholders as well other issues related to Corporate Social Responsibility (CSR). This group of indicators is still very much linked with forestry side of

FWC business. It is unfortunate that CSR often includes many environmental issue elements which makes clarification and comparisons difficult The likelihood of double counting both social and environmental tiers is contributing to a certain amount of inertia in developing social tier indicators or criteria. The Social tier of sustainability was and remains the most difficult area to assess in qualitative terms. Accordingly, it was not possible to find any accepted and widely used tools that assess social side of manufacturing business in FWC across streams (e.g. pulp & paper, biomass, wood based product).

Nevertheless, FWC is the only industrial sector that has been already under the scrutiny of various stakeholders to address social issues in the forestry phase. This unique system of assessment (for both environmental and social elements of sustainability) is called Sustainable Forest Management (SFM) and Chain of Custody (CoC) Certification. SFM certification includes a wide range of social issues; it is applicable only to forestry even though it includes a number of indicators that are applicable to primary processing within FWC. CoC certification for responsible sourcing guarantees the origins of raw material (wood) in any wood products. Therefore, this system is streamlining and supporting the development of supply chain communication.

The social issues within CSR arena that were identified as relevant to manufacturing often include the following groups of principles that are mostly reported as ‘yes’ or ‘no’ answer on reporting templates:

A - Stakeholders

- How companies perform in relation to key stakeholders, including employees, customers, suppliers and the community. These are usually linked to regional or national systems in place, for example, in the UK the scheme *Investors in People.*
- Training and development often isn’t appropriate to low-degree of specialisation fields (e.g. sawmilling). However, these issues which are relevant to manufacturing would be noted through SFM.
- Employment equity often relates to the nature of the industry in question and may disadvantage some industries that are culturally linked to one or the other gender (e.g. mining and male employment, forest nurseries and female employment)
- Trade unions and their representation will frequently follow a national regulation and International Labour Organisation agreements.

B – Human rights

- How companies deal with challenges of operating in countries where human right are most at risk. With respect to FWC these issues are already covered and traced through SFM principles.

C – Sourcing

- How companies ensure that core labour rights apply within their supply chain. In particular policies and systems of companies with global supply chains.
- Other social criteria that are applicable to a manufacturer and the ‘chain’ these can be applied with the entire supply chain.

We conclude that there is not an agreed and widely used set of criteria and therefore widely accepted tools across all industries. Individual industries have their respective sets, but these are not comparable. The Global Reporting Initiative[25] provides sector supplements based on their research work. At the time of this report guidance was only available for, financial services, logistics & transportation, mining and metals, public agency, tour operators, telecommunications, and automotive industries.

In 2002, the EC presented a paper on CSR[26] based on its Green Paper consultation the previous year. The main challenges for CSR diffusion were identified as being linked to insufficient:

- knowledge about the relationship between CSR and business performance (the 'business case');
- consensus between the various parties involved on an adequate concept taking account of the global dimension of CSR, in particular the diversity in domestic policy frameworks in the world;
- teaching and training about the role of CSR, especially in commercial and management schools;
- awareness and resources among SMEs;
- transparency, which stems from the lack of generally accepted instruments to design, manage and communicate CSR policies;
- consumers' and investors' recognition and endorsement of CSR behaviours;
- coherence in public policies.

It has also been also noted that the fragmented work on CSR and the confusion this brings to understanding social issues makes a development of a comprehensive set of agreed methodologies, indicators and tools for addressing social issues of sustainability especially difficult. In particular, CSR makes frequent links with environmental considerations such as eco-labelling.

An EC Green paper[27] from last year on 'Implementing The Partnership For Growth And Jobs: Making Europe a Pole of excellence on Corporate social responsibility' outlines the level of commitment to give greater political visibility to CSR by launching a European Alliance on CSR. Again, this paper includes elements of environmental sustainability, such as …*'a more rational use of natural resources and reduced levels of pollution*….'. On the other hand, this is a very positive and motivating step that indicates a more transparent and committed approach to this field of research. In the conclusion section of this paper this commitment is more unequivocal:

…'The Commission will reassess the evolution of CSR in Europe in a year's time following the discussion within the Multi-stakeholder Forum….'[28].

[25] www.globalreporting.org
[26] COM (2002) 347 final, Brussels, 2.7.2002
[27] COM (2006) 136 final, Brussels, 22.3.2006
[28] COM (2006) 136 final, Brussels, 22.3.2006

BRE has undertaken focused research into the tools for assessing sustainability but was not able to identify any tools/methodologies that are in-use in Europe for social tier in FWC relevant to manufacturing stages, which is the focus of Module 4.

The major problem with social indicators or CSR indicators is that they are in their nature qualitative. For example, non-discrimination indicator is often (in the EU area) covered by stringent national legislation. FWC is characteristic for being an international industry but only in SFM are social issues included in a qualitative way focusing on forest governance and stakeholder's consultation or diversity and equal opportunity. At the production and distribution stage, it is possible to quantify some indicators, such as, health and safety (e.g. number of incidents), and availability of training. BRE's conclusion is that various companies have their CSR strategies and occasionally they report on these. There is, therefore, a clear distinction between practice and communication of social issues (as well as CSR). Investment and financial institutions have developed their own checklists. However, manufacturing, not only FWC, is lagging behind in development and implementation of comprehensive social issues assessment tools or methodologies. If social criteria are measurable and reported, they are typically linked to H&S executives in each country or industry respectively. As a final point, it appears that FWC as well as other industries would benefit from more assistance in understanding what sector-relevant social issues are appropriate in the international context.

Currently there are a couple of project within the EU community that are exploring and aiming at developing and providing methodologies and tools for sustainability assessment. One project is EFORWOOD itself. The aim of the project is to provide methodologies and tools that will, for the first time, integrate Sustainability Impact Assessment of the whole European Forestry-Wood Chain (FWC), by quantifying performance of the FWC. Secondly, SENSOR is a project that aims to deliver Sustainability Impact Assessment Tools (SIAT) for use primarily by European policymakers to support decision making on new policies likely to have a significant impact on land use at the regional level throughout Europe.

These two projects are therefore mentioned in this report to indicate that some of the shortcomings discussed in this report may be addressed in the near future by deliverables of current research projects.

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Appendix A – Summary Table of Critique of Ecological Footprint Analysis

Criticism	Response
Footprint accounts are incomplete	Progress is being made towards more holistic EFA which incorporates neglected areas more comprehensively, such as water use and waste management. Although it is difficult to quantify the land required to process certain pollutants due to their complex impacts on ecosystems and biospheres. With non-renewable materials, and heavy metals etc it is implicitly assumed that their use should be limited, eradicated or managed within closed loops.
Applying Carrying Capacity concepts to human populations is flawed. Evidence has shown that (a) humans, unlike other animals, can and do increase the carrying capacity of their environment to meet their needs and (b) certain regions and communities seem to be living beyond their local carrying capacity now with few ill effects.	(a) The study is intended to be a 'snap shot' relative to the time, and is not intended to be used as static analysis for future projections. (b)This is either at the expense of another regions EF or at the cost of 'natural capital' and will result in progressively smaller yields. System boundaries should be set carefully, as any closed system cannot exceed its capacity or it will become unstable and fail (e.g. Rapa Nui- Easter Island).
The very process of aggregating land types to calculate a footprint assumes substitution - yet this is not possible.	Aggregating information does not necessarily imply that the elements being measured are interchangeable. MTOEs (Million Tonnes of Oil Equivalent) is a common unit used for aggregating the energy content of different fuel types. The fuels are not interchangeable - natural gas cannot substitute for diesel, for example.
Carrying capacity is irrelevant since resource yields can be increased in the case of renewable resources, and depletion profiles can be extended by technology in the case of non-renewable resources.	An undertaking of EFA is always relative to the reference year. Bio-capacity can change over time for better and worse. The footprint produced at one time can still be compared with the capacity of another. Technology increasing resource efficiency is a favoured approach in reducing footprints, but only works on the assumption that efficiency gains are not outweighed by consumption increases.
Carrying capacity calculations have limited relevance when trade is possible since the scarce resource can be imported in exchange for another asset in which the exporting nation has a comparative advantage.	Trade is not discouraged. EFA highlights (ecological) trade balance issues, such as not all countries being able to be net importers. Overall equilibrium within a system must be maintained in terms of this balance.
Certain economies that are highly urbanized (Netherlands, Singapore, Hong Kong) can never be sustainable since they can never meet their	Urbanised economies by definition need to import resources however this does not prevent them from achieving sustainability; it means they will have a more dispersed footprint with a

ecological demands from their own land.	transportation ‘overhead’.
Footprinting is a survivability concept not a sustainability concept. Survivability is about maximizing the time available on Earth for human species, independently of the quality of that existence.	EFA estimates are based on the minimal requirement for sustainability. To live within global carrying capacity is a requirement for, but not sufficient alone in terms of sustainability.
Calculating the fossil fuel footprints in terms of area needed to absorb the corresponding CO2 is inadequate according to some critics.	Other methods exist, such as biological area required to produce substitute fuel. This generally results in far larger footprints.
There are substantial uncertainties about how to calculate the land areas required to offset waste flows.	Generally EFA omits these and as a result underestimates the footprint of a given system. Some studies are being undertaken to incorporate these but generally there is little consensus on method or the science behind it.
Footprint accounts make no distinction between land uses that are sustainable and those that are not.	This is reflected by the bio-capacity as it changes year by year. If the carrying capacity is exceeded one year it is likely to be reduced proportionate to the overshoot, the following year.

Critique by Van Kooten and Bulte (2000), responses from Mathis Wackernagel.

Appendix B – Summary of Tools and M4 Partners as provided in Description of Work

Name of the model	Purpose	Modelling techniques used	Input data and source	Output	Status New / modified	Work Package
SIA-CBA	Assess the sustainability through overall integrated indicators	Cost-Benefit Analysis	Economic, social and environmental costs and benefits	Integrated sustainability assessment of indicators	New software tools developed using existing evaluation methods	1.5
SIA-MC	Assess the sustainability through overall integrated indicators, evaluation according to different stakeholders	Multi-criteria Analysis	ToSIA-FWC indicators, stakeholder preferences, stakeholder goals	Integrated sustainability assessment of indicators	New software tools developed using existing evaluation methods	1.5
WoodCIM®	Optimize allocation of wood raw-material into products. Simulate and analyse key figures in production. Planning of production, harvesting and sales. Verification of ToSIA.	Model based on simulation techniques and linear programming, Optimisation of wood raw-material flow from forest into products.	Volumes and qualities of raw-materials, description of processes, product specification and prices, key economic factors	Max. profit and output, min. costs in the FWC, SI values related to economics, waste, energy consumption etc.	Modified from WoodCIM®	1.4 and 4.2
MPI P&P	Benchmark paper and board production processes and best energy recovery options for recovered paper related solid wastes	Process models Statistic and mechanistic (math) models Economic indices	Energy and costing profiles for all mills in the Dutch P&P industry	Energy-efficiency optimisation, production costs values and best energy recovery options for solid waste	Modified/adjusted	4.1, 4.2, 4.3
KCL-ECO	Internal eco-balance assessment of processes or evaluation of the value chain	Linear equations	Any process data or KCL-ECODATA database. Material, energy & emissions flows or cost flows can be handled	Units of various flows in the value chain	Operational, further development for SIA	4.1, 4.2

Name of the model	Purpose	Modelling techniques used	Input data and source	Output	Status New / modified	Work Package
BRE Environmental Profiling	Assess environmental impact and best value options in construction specifications	LCA & WLC	Environmental and costing profiles form the industry, BRE ownership/guardianship/custo-dianship	Environmental impacts & life costs values	Modified/adjusted	4.1. & 4.2
Value chain analysis	Assess economic viability/sustainability of processing industries	Economic value chain/ value added analysis	Processing cases/models defined in WP4, product price and cost data from statistics and JPC databases	Economic viability of processing options (test/current/ future cases) by product and location	Modified/ adjusted	4.1 and 4.3

Appendix C – Summary of Tools Reviewed

Following is a table summarising the tools which are reviewed, their origins and basic information regarding their methodology.

Name of the model	Partner/ Model Provider	Description
Bioenergy Production - Energy Efficiency and GHG Balance Model	VTT	A tool analysis energy and Green House (emissions for biomass production
BRE Environmental Profiling	BRE	A Life Cycle Assessment tool for Construction (Wood products and biomass)
Distribution of news information in scarcely populated areas	STFI- Packforsk	The tool is used to evaluate a number of n possible scenarios for newspaper distribut
KCL- ECO 4.0 LCA software, EcoData inventory database	KCL -Oy Keskuslaboratorio-Centrallaboratorium Ab (& Finnish P&P Research Centre)	A Life Cycle Assessment tool for pulp and
MPI PEMS	KCPK- Gasunie/ VNP	A Life Cycle Assessment tool for pulp and mills
Pöyry Cost Competitiveness Model	Pöyry Forest Industry Consulting Oy (previously Jaakko Pöyry Consulting)	A tool for analysis of production costs in m
WinGems	STFI- Packforsk	A tool for comparison of environmental eff different levels of technology in pulp and p mils
WoodCIM®	VTT	A tool for optimisation of yield when converting logs into end products

Appendix D – Report with defined selected criteria and indicators for manufacturing

The below sections of tables are presented in order to indicate those indicators and criteria that were selected at the earlier stages of EFORWOOD project (EFORWOOD Deliverable D 4.1.1), due date 1st May 2006).

Module 4 selected indicators for pulp and paper production – social only

SOCIAL
Employment [a]
Community support and involvement
Health and safety (internal and external)
Level of accidents
Male/ female ratio *
Training and education
Amount of training *
Level of training *
Scientific and technical research capabilities within industry and external *
ILO standards
Recreational use of forests [c]

[a] Employment is considered twice (as an economic and social indicator), a clear decision should be made about how to define it in both sustainability pillars.
[c] On special request from one or several partners

Module 4 selected indicators for wood products production – social only

SOCIAL
Employment
Policies with impact on communities
Community support and involvement *
Health and safety (internal and external)
Level of accidents
Training and education
Amount of training
Level of training
Scientific and technical research capabilities within industry and external

Module 4 selected indicators for bio-energy production – social only

SOCIAL
Employment
Community support and involvement *
Health and safety (internal and external)
Level of accidents
Training and education*
Amount of training *
Level of training *
Scientific and technical research capabilities within industry and external

Appendix E – Social EFORWOOD Indicators – Social Lead + Indicators

A selection of social indicators in FWC Indicator *Draft* Set 5, Actual draft date: 09 November 2006.

1 - Employment

Full name of indicator (including subclasses):	***Number of persons employed classified by gender, age class and education***
General FWC sustainability indicator subclasses:	9.1. Persons employed in total FWC and by sub-sector classified by: a) gender categories i. male ii. female b) age classes i. <20 yr. ii. 20-50 yr. iii. >50 yr. c) educational categories (see European Social Survey) i. education up to 16 yr ii. education 17 – 19 yr iii. education still studying
Measurement units:	9.1.a – 9.1.c) absolute number (in full-time equivalents) per reference unit (t.b.d.)
Potential future data provider (international):	Eurostat - Social Statistics - Community Labour Force Survey United Nations Industrial Development Organization (UNIDO) - for data for ISIC 20 and 21 (classification see annex)
Potential future data provider (national):	National Statistics Office;
Comment	Values of subclasses will be calculated / aggregated; no data collection is planned at this stage
EFORWOOD ToSIA data collection:	*LI10a. Employment male* *LI10b Employment female*

Proposed version 1: September 2006	*LI10c Employment rural* *LI10d Employment urban*
Proposed ToSIA version 2: has been modified because of consistency reasons with set above November 2006:	9. 1. Persons employed by processes within each Module (M2-M5) classified by gender categories i. male **(see LI 10a)** ii. female **(see LI 10b)**
Measurement units:	9.1.) persons in a specific year (in full-time equivalents)
Data provider (regional – case studies):	Data needs to be provided by each Module for each process defined for the three test-chains
Comments:	No separation according to age classes is being done;
Comments by EFORWOOD experts to Indicator draft Set4	M3: ad ToSIA LI10b: Difficult to find gender data in each process

2 - Wages and salaries

Full name of indicator (including subclasses):	***Wages and salaries (gross earnings) classified by gender and type of employment***
General FWC sustainability indicator subclasses:	10.1. Wages and salaries in total FWC and by sub-sector classified by: a) gender categories i. male ii. female b) type of employment i. full-time employment ii. part-time employment
Measurement units:	10.1.a – 10.1.b) Euro (in millon) per reference unit (t.b.d.)
Potential future data provider (international):	Eurostat (see Population and Social Conditions)
Potential future data provider (national)	National Statistics Office
Comment	Values of subclasses will be calculated / aggregated; no data collection is planned at this stage
EFORWOOD ToSIA data collection: ***Proposed version 1: September 2006***	*LI11a Wages and salaries male* *LI11b Wages and salaries female*
Proposed ToSIA version 2:	10.1. Wages and salaries by processes within each Module (M2-M5)

has been modified because of consistency reasons with set above November 2006:	classified by gender category i. male **(see LI 11a)** ii. female **(see LI 11b)**
Measurement units:	10.1.a – 11.1.b) Euro (million)
Data provider (regional – case studies):	Data needs to be provided by each Module for each process defined for the three test-chains
Comments:	For the category "type of employment" that is still rather unclear, is currently being left out for the data collection for the prototype of ToSIA
Comments by EFORWOOD experts to Indicator draft Set4	M5 ad 11.1 (b) type of employment: Hard to find data. What does it add? M3 ad TOSIA 2: 11.1. classified by gender category: Difficult to find data about gender in each process

Key definitions:
Employees are all persons who a have a direct employment contract with the enterprise or local unit and receive remuneration, irrespective of the type of work performed or the number of hours worked. (Eurostat, http://europa.eu.int/estatref/info/sdds/en/earn/earn_ses_sm.htm)
Gross earnings cover remuneration in cash paid directly by the employer, before deductions of tax and social security contributions. (Eurostat, http://europa.eu.int/estatref/info/sdds/en/earn/earn_ses_sm.htm)
Full-time/part-time: This variable refers to the main job. The distinction between full-time and part-time work is based on a spontaneous response by the respondent (except in the Netherlands, Iceland and Norway were part-time is determined if the usual hours are fewer than 35 hours and full-time if the usual hours are 35 hours or more, and in Sweden where this criterion is applied to the self-employed. It is impossible to establish a more precise distinction between full-time and part-time employment, since working hours differ from one Member State to the next and from one branch of activity to the next. (Eurostat)
Gender pay gap is given as the difference between average gross hourly earnings of male paid employees and of female paid employees as a percentage of average gross hourly earnings of male paid employees. The population consists of all paid employees aged 16-64 that are 'at work 15+ hours per week'. (Eurostat definition)

3 - Occupational safety and health

Full name of indicator (including subclasses):	***Frequency of occupational accidents and occupational diseases***
General FWC sustainability indicator subclasses:	11.1. Occupational accidents in total FWC and by sub-sector classified by: a) non-fatal occupational accidents (= absence of work of more than 3 working days) b) fatal occupational accidents 11.2. Occupational diseases in total FWC and by sub-sector
Measurement units:	11.1.a) absolute numbers and in % per 1000 employees per reference unit (t.b.d.) 11.1.b) absolute numbers by 100 employees per reference unit (t.b.d.)

	11.2.) frequency of cases per number of persons exposed multiplied by number of years of exposure and in % per 1000 employees per reference unit (t.b.d.)
Potential future data provider (international):	Eurostat - European Statistics on Accidents at Work (ESAW) - European Occupational Diseases Statistics (EODS) International Labour Organisation (ILO)
Potential future data provider (national):	National Statistics Office
Comment	Values of subclasses will be calculated / aggregated; no data collection is planned at this stage
EFORWOOD ToSIA data collection: ***Proposed version 1: September 2006***	*LI12a occupational accidents (non-fatal)* *LI12b Occupational accidents (fatal)* *LI12c Occupational diseases*
Proposed ToSIA version 2: has been modified because of consistency reasons with set above November 2006:	11. 1. Occupational accidents by processes within each Module (M2-M5) classified by: a) non-fatal occupational accidents **(see LI 12a)** b) fatal occupational accidents **(see LI 12b)** 11.2. Occupational diseases by processes within each Module (M2-M5) **(see LI 12c)**
Measurement units:	11.1.a) absolute numbers and in % per 1000 employees per reference unit (t.b.d.) 11.1.b) absolute numbers by 100 employees per reference unit (t.b.d.) 11.2.) frequency of cases per number of persons exposed multiplied by number of years of exposure and in % per 1000 employees per reference unit (t.b.d.)
Data provider (regional – case studies):	Data needs to be provided by each Module for each process defined for the three test-chains
Comments by EFORWOOD experts to Indicator draft Set4	M5 ad measurement units: Strange mix of % per 1000 and per 100 *WP1.1. statistically used measurement units* M5 ad TOSIA data collection version 2: in 11.1 wants to delete "and diseases" *WP1.1. ok* M5 ad TOSIA 2 LI11a "-fatal": measurement units wants to delete in 12.1.a "and in % of 1000 employees" and in 11.1.b "100 employees" M3 ad ToSIA1: Statistcs is usually organised after terms like "forestry", or "large scale forestry"…. rather than processes e.g forwarding, harvesting etc…

Key definitions:

Absence from work of more than 3 working days: ESAW considers only full working days of absence from work of the victim excluding the day of the accident. Consequently more than 2 days, means at least 4 days which implies only accidents with a resumption of work not before the fifth day after the day or the accident or later. (see http://ec.europa.eu/employment_social/publications/2002/ke4202569_en.pdf9)
Fatal accident at work: accidents at work leading to the death of the victim within a year (after the day) of the accident. (see: http://ec.europa.eu/employment_social/publications/2002/ke4202569_en.pdf)
Occupational disease is a case of disease recognised by the national authorities as being caused by a factor at work. (The EODS data collection covers two types of occupational diseases: a) An incident occupational disease is an occupational disease recognised for the first time as an occupational disease during the reference year. This excludes occupational diseases which had been recognised already earlier even if they became more severe during the reference year and were consequently recognised for a higher level of disability. B) A fatal occupational disease is a death recognised by the national authorities as due to an occupational disease during the reference year regardless of when the occupational disease had been recognised for the first time.) (see: European Occupational Diseases Statistics (EODS)

4 - Education and Training

Full name of indicator (including subclasses):	***Education time and training expenditure per employee as % of turnover classified by gender***
General FWC sustainability indicator subclasses:	12.1. Education time in total FWC, by sub-sector and by gender (male, female) 12.2. Training expenditure as % of turnover in total FWC, by sub-sector and by gender (male, female)
Measurement units:	12.1) years per person per reference unit (t.b.d.) 12.2) in % of turnover per reference unit (t.b.d.) 12.1 – 12.2) in Euro per person per reference unit (t.b.d.)
Potential future data provider (international):	Eurostat (European Social Survey) Nations Education, Scientific and Cultural Organisation (UNESCO-UIS) Organisation for Economic Co-operation and Development (OECD)
Potential future data provider (national):	National Statistics Office;
Comment	Values of subclasses will be calculated / aggregated; no data collection is planned at this stage
EFORWOOD ToSIA data collection: ***Proposed version 1: September 2006***	*LI13a Education time per person-year working time in the process* *LI 13b Education expenditure per person-year working time in the process*
Proposed ToSIA version 2: has been modified because of consistency reasons with set above November 2006:	12. 1. Education time by processes within each Module (M2-M5) **(see LI 13a)** 12.2. Training expenditure by processes within each Module (M2-

	M5) **(see LI 13b)**
Measurement units:	12.1.) per person-year working time per reference unit (t.b.d.) 12.2.) in Euro per person-year working time per reference unit (t.b.d.)
Data provider (regional – case studies):	Data needs to be provided by each Module for each process defined for the three test-chains
Comments:	Sub-classes for the two categories are not so important for the prototype of ToSIA and therefore no data will be collected at this stage
Comments by EFORWOOD experts to Indicator draft Set4	M5: data for education and training very hard to find; M5 ad measurement unit 12.1. average or what? ; 12.1.-12.2. wants to delete “(in million)”. *WP1.1. ok*

Key description:

Turnover comprises the totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods or services supplied to third parties. Turnover includes all duties and taxes on the goods or services invoiced by the unit with the exception of the VAT invoiced by the unit vis-à-vis its customer and other similar deductible taxes directly linked to turnover. It also includes all other charges (transport, packaging, etc.) passed on to the customer, even if these charges are listed separately in the invoice. Reduction in prices rebates and discounts as well as the value of returned packing must be deducted. Income classified as other operating income, financial income and extra-ordinary income in company accounts is excluded from turnover. Operating subsidies received from public authorities or the institutions of the European Union are also excluded. (Eurostat definition)