



**EFORWOOD**

Sustainability Impact Assessment  
of the Forestry - Wood Chain



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EFORWOOD

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## Summary

This report is a project deliverable PD 4.2.6.”*Conceptual outline of response functions and draft response functions for case studies*” of the EFORWOOD project.

The purpose of this report is to give information to other Module 4 partners on response functions and show why and how they can be created and applied in the EFORWOOD project. In addition, this report welcomes the other Modules to study the Module 4 approach.

The first chapters of the report describe theory of response functions. In addition, also generally used prioritisation and screening methods are presented. The final chapters, Chapters 3-4, show in a very “hands on way” how these methods could to be used in Module 4 work and give also some draft response functions for the case studies.

The author of this report is Pöyry Forest Industry Consulting. For this report, Pöyry has followed the work of EFORWOOD’s “Scenario”-group and organised meetings with EFI, who is responsible for the “ToSIA” tool and runs the “EFI-GTM”-model. In addition, together with the other Module 4 partners, Pöyry has participated in the case-study work.

## 1 INTRODUCTION

This report belongs to European Commission's EFORWOOD project, contract number 518128-2. Module 4, who is responsible for this report, is a partnership of European companies, universities and research institutions focusing on the manufacturing and processing ("gate to gate") stage of the Forestry Wood Chain (FWC) in Europe. This document is a project deliverable PD 4.2.6." *Conceptual outline of response functions and draft response functions for case studies*". Response functions express the impact of a driver on an indicator and/or on material flows in the FWC

The purpose of this report is to give information to Module 4 and other Eforwood partners on the nature and use of response functions and show in a very hands-on level how to apply them in Eforwood Module 4.

Information from other Module 4, work package 4.2. reports and the case study work have been used as an input to this report. In addition, the current work of EFORWOOD's "Scenario"-group and the "ToSIA" tool has been kept in mind while compiling this report.

This report will be strongly linked to PD 4.3.8. "*Draft description of response function framework and examples*". The information from reports *PDs 4.3.2., 4.3.3 and 4.3.4.*, which deal with the comprehensive picture of the industry dynamics, is also essential for the work on response functions. The different dynamics between forestry-wood value chain actors, e.g. between forest and paper industry, should be kept in mind in the development and interpretation of ToSIA.

The author of this report is Pöyry Forest Industry Consulting.

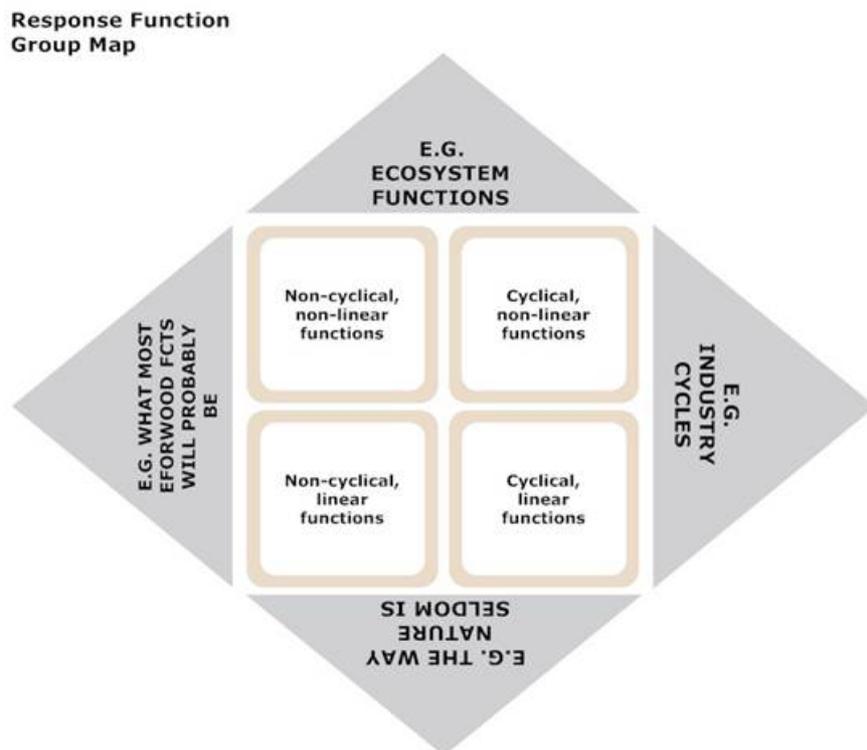
## 2 THEORY ON RESPONSE FUNCTIONS

Response functions are used for mathematically describing the impact of a parameter change to a system. In this section we provide some theoretical and practical examples as well as introduce a methodology for constructing meaningful response functions for the purposes of Eforwood. The experts of various modules will be responsible for describing the impact of a reference future and scenario on their most crucial parameters and for constructing a meaningful response function.

### 2.1 Introduction to Function Types with Illustrative Examples

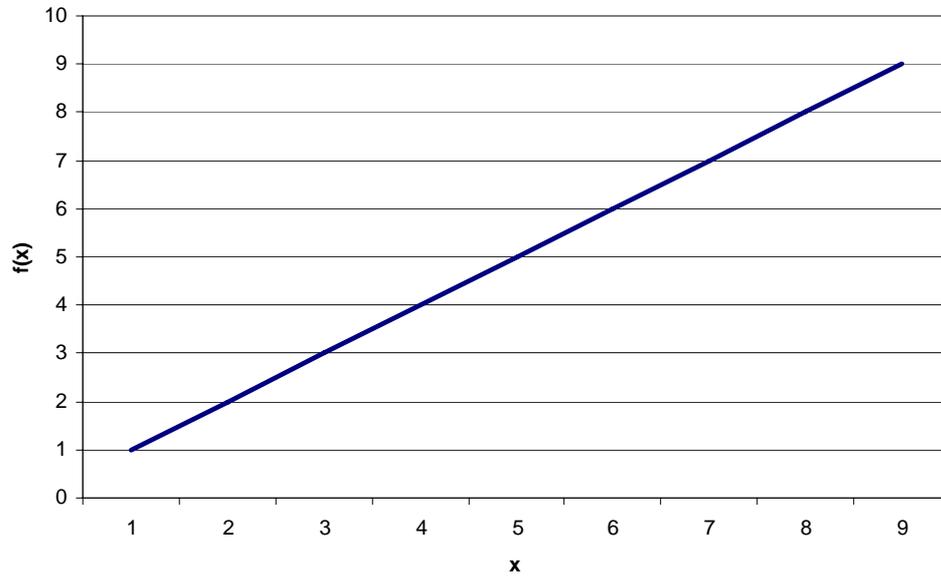
Response functions may take various shapes depending on the nature of the system analysed. Functions can be grouped based on e.g. linearity and cyclicity. In Figure 2-1 these properties have been linked with likely uses of functions.

**Figure 2-1**  
**Illustration of Potential Response Function Types**



Response functions are likely upward or downward sloping linear or nonlinear functions. Linear implies that the change to the system causes a constant increase/decrease in the key parameters. One common representation of a non-linear function, in e.g. ecosystem modelling or economics, is the exponential function. We introduce an example of each of the function types with a forest sector related real life example.

**Figure 2-2**  
**Basic Linear Function: A Linear, Non-cyclical Function**

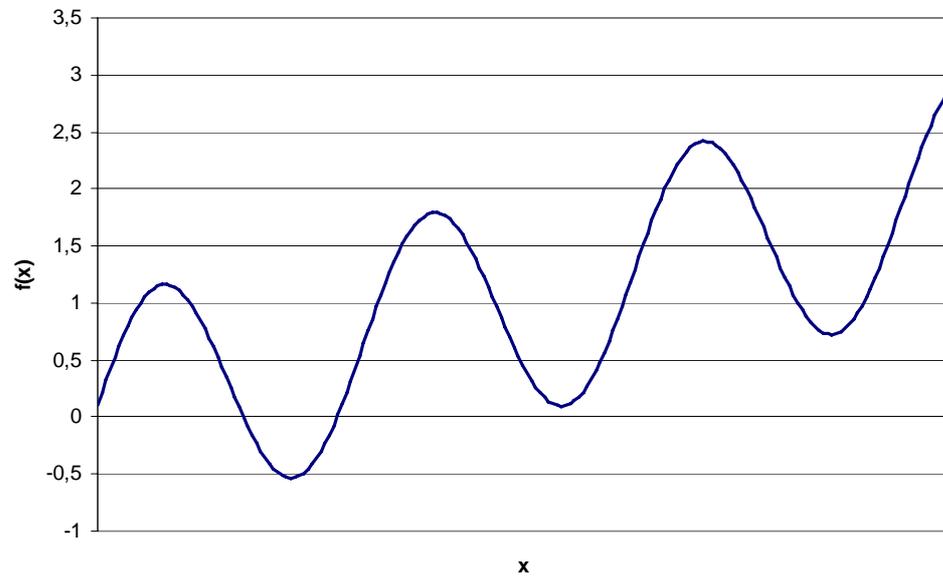


The linear function is described by the formulae  $y = f(x) = ax + b$  in which  $x$  is the independent variable that changes *independent of* the system analysed. The slope of the line is determined by the coefficient  $a$ , and the coefficient  $b$  denotes the y-intercept of it (the value of  $y$  when  $x$  equals 0).

In this case the resulting line is upward sloping ( $a > 0$ ), but it may as well be downward sloping ( $a < 0$ ).

Application example: Constant increase in labour costs would increase all other things equal production costs in this way (in other words, labour cost vs. total production cost).

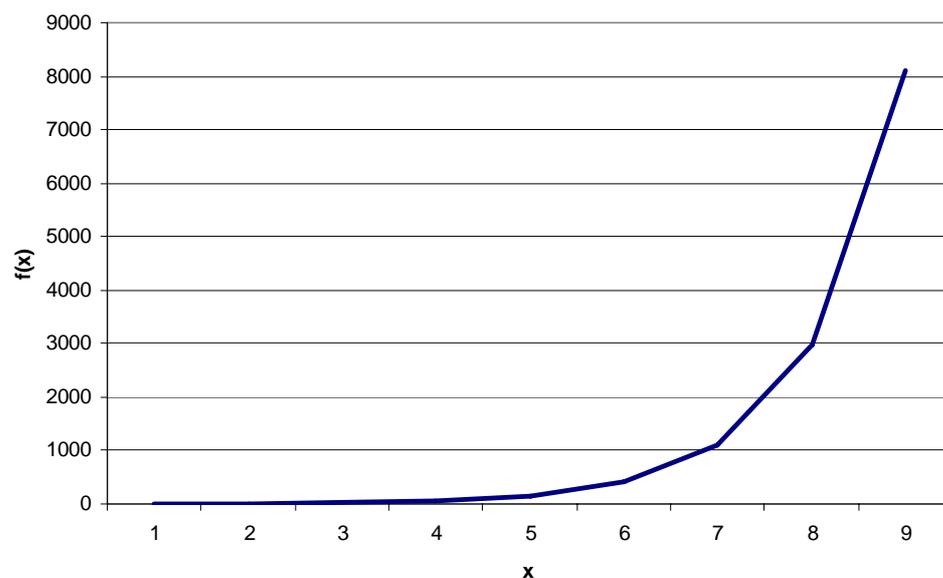
**Figure 2-3**  
**Cyclical Function: A Linear, Cyclical Function**



The cyclical, linear function of our example is described by the formulae  $y = f(x) = \sin(x) + cx$ . The sin function is cyclical around the slope of the line.

Application example: In the past, time versus paper industry business cycles followed linear, cyclical functions.

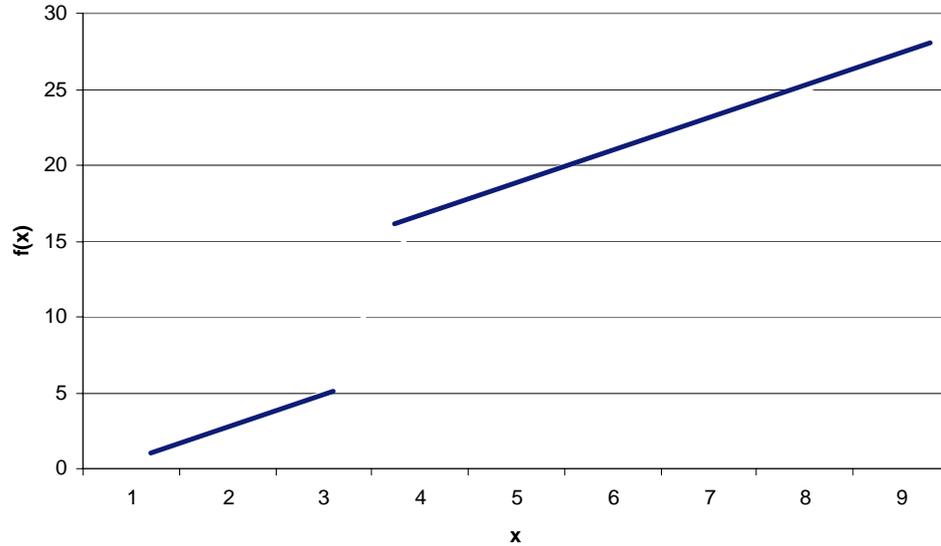
**Figure 2-4**  
**Exponential Function: An Example of a Non-linear, Non-cyclical Function**



The formulae for the exponential function is the following:  $y = f(x) = e^x = \exp(x)$ . Note: The logarithm of the exponential function is a linear function.

Application example: Change in fuel prices towards the point in time when oil reserves are depleted and when substitution is limited.

**Figure 2-5**  
**Special Case: A Discontinuous Linear Function**



In this type of a function the development is smooth to a certain point at which there is a “jump” to a higher (or lower) level. Beyond this point the trend may continue as before as shown in this picture. The point of discontinuity may also imply a change in, for instance, the slope of the linear graph (i.e. factor  $a$  in the formulae for linear function).

Application example: Productivity increase in a facility that is closed for rebuild between 3 and 4, and reopened after major technological upgrades.

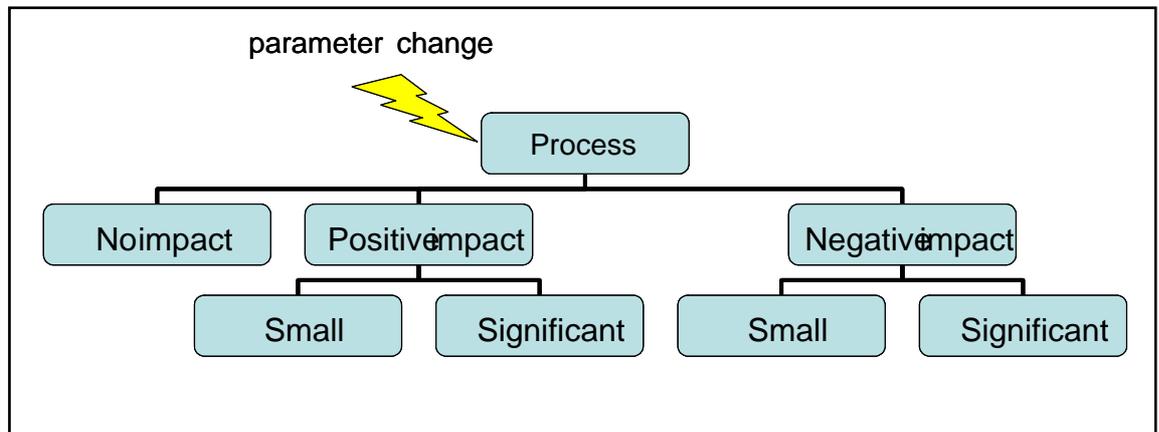
**Note:** In the examples above, we have used “time” as one of the variables. However, most of the Eforwood scenario response functions, will be of format “indicator” versus “some scenario specific variable”, not time.

## 2.2 How to Derive Response Functions and Select Key Parameters

The shape and slope of the response function depends on the nature of the system. The aim of a model is to present reality in a simplified way. Needless to say, the task is challenging.

When a parameter not defined in the system (exogenous) changes, the resulting impact may be any of the following:

**Figure 2-6**  
**Impact Map of Change in a Parameter External to System**



Because the number of indicators for each process is vast, there is a need to identify the most important ones. An expert often has an idea of the direction and magnitude of the way a particular system will respond to a change in an external factor. This approach allows for selection of the most relevant form of response function. Simply determine using expert opinion/ system modelling whether the impact; positive or negative; is major i.e. large enough to impact the chain *significantly*. Considering the range of processes and impacts on economic/environmental/social indicators in FWC, a universal rule of importance is not applicable. Change must be considered relative to the business-as-usual values.

Methodological frameworks for modelling external shocks are available. We will briefly introduce some of them.

### 2.2.1 SWOT Analysis

SWOT analysis is aimed at listing all relevant internal and external factors of a system (of any level). Internal factors are divided into strengths and weaknesses, and external factors to opportunities and threats. The results are usually displayed in a table like the one in Figure 2-7.

**Figure 2-7**  
**SWOT Matrix**

	Helpful	Harmful
Internal	<b>S</b> trengths	<b>W</b> eaknesses
External	<b>O</b> pportunities	<b>T</b> hreats

### 2.2.2 Cross-Impact Matrix

Another method that can be used for plotting the system and its complexities is the construction of cross-impact matrices. In a cross-impact matrix key variables are compared against each other. The resulting matrix can be used qualitatively for showing the connection between factors or quantitatively to show the numerical impact under a specific impact, including the direction of change.

**Figure 2-8**  
**Illustrative Cross-Impact Matrix**

	A	B	C	D	E
A	X	++	+	--	0
B	+	X	0	+	-
C	+	0	X	+	--
D	--	++	++	X	+
E	0	-	--	+	X

The cross-impact matrix displays the impact of the top row variable on the first column variable. Positive impacts are denoted with plusses (+, ++) and negative impacts with minuses (-, --), zeros (0) mean no impact and the diagonal (variable impact on itself) of the matrix is marked with X, not relevant. The impact may, depending on the variable, be symmetric (impact of E on D same as D on E) or unsymmetrical (impact of A on B more positive than B on A).

Cross-impact matrices have developed from Delphi-methods towards its own method. First attempts to use computer-based cross-impact matrix analysis were done in late 1960's. A key issue with these models is to identify and utilise the interrelations of the variables, namely to analyse when the occurrence of an impact between two variables may change the probability of events that happen between other variables. The quantitative analysis of cross-impact matrices is fairly complex mathematically.

### 2.2.3 System dynamics

System dynamics is a method for modelling multi-faceted problems *quantitatively*. The aim is to model the system in a way that allows for testing the implications of changes in key variables. The crucial issue is the existence and impact channel nature of inter-linkages. The approach was popularised with "*Limits of growth*" and is particularly useful for long-term forecasting.

Approach briefly:

1. identify a problem
2. draw all major patterns of influence, then construct negative and positive feedback loops based on this, determine levels and rates of contributing factors
3. model to enable testing the impact of events outside the system (external), simulate to validate the functioning of the model

A challenge with use of system dynamics approach is that it requires considerable ability in modelling and computing. The basic computer model for system analysis employs a set of first order, non-linear differential equations to reflect changes over time, with the chosen time interval small enough so that system behaviour appears continuous.

#### 2.2.4 Trend Fitting

When some reference data exist, it is possible to look for future values by extrapolating from existing data onwards. In short-term forecasts the most commonly applied curves are linear or exponential. In the long term there may be sources of discontinuity due to limits to growth or a jump to an altogether different level of impact due to e.g. innovation or a threshold value in raw material costs that start to cause close-downs of manufacturing units. One trend curve sometimes applied for the long-term forecasts is the s-shaped logistic curve, which shows at first exponential change but then smooths out. It has been used for describing impacts of innovation with respect to time.

One should remember that the proper time scale depends greatly on the nature of activities (e.g. industry depending on the end product, technology, required investments etc.).

Some key questions that an expert should ask themselves when doing trend extrapolation:

1. Does the data really display a trend? How reliable is the data?
2. What do we know about the factors causing the trend? Is there reason to believe that the trend will continue unchanged to the foreseeable future or could it instead be even reversed?
3. At what point could a ceiling or turning point be reached?
4. What is the relationship between quantitative and qualitative changes? (e.g. diffusion of new technology: not only more of a product but also *different* products.)

### 2.3 Summary and Evaluation

This chapter outlines the examples of main response function types and identifies some of the methodological questions involved. Linear representation is often useful when the change is constant over time or *approximately* constant. The methods presented are useful for different purposes in the process of defining response function in Eforwood. (*However, there are also other methods available. The method to be used should be selected according to the case and process to be analysed, and need not to be limited to the ones presented in this chapter.*) SWOT and Cross-Impact matrices are primarily a tool for looking at the interdependencies between the reference future realities and a selected process/ process driver. System dynamics is not directly useful on process level but a “light version” of the idea could be useful when thinking at the interdependencies and impact routes between processes. Outlining of impact could be beneficial in discussing the module internal and chain-specific interlinkages with Eforwood colleagues. Trend fitting exercise is a way to approach the formulation of response function.

The main challenge is to identify a reasonably reliable way to describe the interrelationship between variables. It should be kept in mind that models are never exact descriptions of reality but rather an attempt to simplify in a meaningful way.

### 3 RESPONSE FUNCTIONS IN EFORWOOD M4

#### 3.1 Background – Eforwood

It has been agreed, that in addition to the base year 2005 information, ToSIA could be used for running:

- two “reference future” cases, called A1 and B2 for years 2015 and 2025 (for more information, please see EFORWOOD PD 1.4.7)
- a set of scenarios which deal with changes in legislation/policies, bioenergy use, technology and consumption patterns.

A response function for an indicator depicts quantitatively how the indicator value changes when some factors of references futures are being altered (= scenarios). The following text is quoted from a presentation held by Marcus Lindner during the Eforwood week in Zvolen 2007:

There are two types of scenario applications in ToSIA. “Type 1” is for comparing modified FWCs with a reference case. In “Type 1”, sustainability indicators will be collected for alternative FWCs and an evaluation method may be applied to compare alternatives, for example waste management methods in M5. Response functions are needed in “Type 2” scenario applications in ToSIA, meaning scenarios of changing policies and/or global trends. Partial chain or process-specific models will be applied to derive response functions to project indicator changes for ToSIA. Response functions express the impact of a driver on an indicator and/or on material flows in the FWC. Indicator response functions are developed at the process level by each module based on existing data or model predictions, in other words module specific models and tools.

**Note:** Based on the current information, no “Type 2” scenarios are applied in ToSIA. This means that we are not going to fill in any “functions” in to ToSIA data client, but only “data points”. However, response functions can be used, and in most cases should be used, to compile these “data points”.

Table 3-1 below shows for which case studies the reference futures and scenarios are analysed.

**Table 3-1**

Case study	Reference futures	Scenario
Scandinavian	A1	Technology 2 alternatives.
Iberian	A1	Consumer 2 alternatives.
Baden-Württemberg	A1 and B2	Bioenergy 2 alternatives.
EU-FWC	A1 and B2	Environmental protection, 3 alternatives.

## **3.2 Module 4**

Module 4 partners need to provide indicator values for the reference futures and scenarios. For this, we suggest the following approaches:

### **3.2.1 Data points for the reference futures**

We start the work with reference futures A1 and B2. We need to calculate values for processes and indicators for A1 for the years 2015 and 2025 and for B2 for the years 2015 and 2025, according to Table 3-1.

In M4 we have used the term “autonomous trend factor / autonomous development” to describe the “projections of indicator values into future”. The autonomous trend factor takes into account several key assumptions about changes in the process drivers in the reference future storylines, but not accounts for differences in A1 and B2.

Here, *we do not need to construe continuous response functions for ToSIA*. What we need for the two reference futures are two discrete values, i.e. “data points” for the indicators for 2015 and 2025. Thus, Module 4 partners should estimate the needed values for the indicators with their tools and models, whichever combination best fits the task. The Scenario Group, EFI-GTM and ToSIA experts will provide some background information on general drivers, and this information can be used in the compilation of the indicator projections. The list below, adapted from PD 1.4.7, shows the general drivers that are supposed to be used in this work and their sources:

***Main drivers:***

- GDP percentage growth rate per country, per year until 2030 (from international outlooks, under IPCC scenarios)
- Population by country until 2030 (from international outlooks, under IPCC scenarios)
- Oil price (\$/barrel) until 2030 (from international outlooks, under IPCC scenarios)
- Tax level (% of the gross income)
- Technological development (expressed as investment % ,or R&D spending, from EFI-GTM)
- Government regulation (expressed as relative rate)
- Global trade barriers/ trade intensity (from EFI-GTM, as ref future assumption)
- Consumption/demand (million units/y) (from EFI-GTM)
- Share renewables (%) (from international outlooks, under IPCC scenarios)
- Hazards (%losses per year) (from international outlooks, under IPCC scenarios)

***Secondary drivers***

- Currency exchange rate (%) (from EFI-GTM, as ref future assumption)
- Production costs per unit commodity (€/unit) (from EFI-GTM, in iterative way with module expert)
- Transport cost (€/unit/km) (from EFI-GTM, in iterative way with module expert)
- Average size of mills (avg capacity)(from EFI-GTM, in iterative way with module expert)
- Interest rate % (from EFI-GTM, as ref future assumption)
- Forest area (kha per country per 5 years (in iterative way with module 2 expert)
- Area of reserves (kha per country per 5 years (in iterative way with module 2 expert)
- Total national fellings, m<sup>3</sup> per country per spp group per 5 years (in iterative way between EFI GTM and with module 2 expert)

As mentioned above, there are several ways to get the data points for years 2015 and 2025. *One way to develop “indicator projections” could be as follows:*

1. defining crucial issues that influence a process (e.g. fine paper production), based on the reference future descriptions
2. selecting and quantifying those of the issues that change in the reference futures -> process drivers (done partly by M1, please see the list above)

3. developing a projection for each indicator of a process
  - a) taking an indicator
  - b) selecting the process drivers that have an impact on this indicator
  - c) finding the interdependencies between the indicator value and the selected drivers
  - d) generating the indicator value

**Note:** In point 2. the methods presented in Chapter 2 of this report (or some other suitable method) should be used. Points 3b)-3d) should be done using module and/or process specific tools, models and expertise.

### 3.2.2 Response functions for scenarios

Initially, when we thought that also “Type 2” scenarios were to be analysed in this work, we planned to follow the procedure described below. However, now when the scenario definition work is almost ready, we notice that no “Type 2” scenarios are to be analysed. However, in order to get reliable and consistent “Type 1” scenarios, we still need to have the following criteria fulfilled:

- First, the scenarios must be defined clearly and concisely, so that there are only a moderate number of assumptions in a scenario. These assumptions must be declared unambiguously
- Assumptions behind a scenario are inserted into EFI-GTM or other commonly in the Eforwood work used tool/ data source, which produces the common drivers used in module specific modelling and compilation of the new indicator values

*Initial procedure - has been left out:*

In addition to the indicator values for reference futures, we calculate a set of values and study the form of the response functions for the set of processes and indicators our expert panel has selected for scenarios:

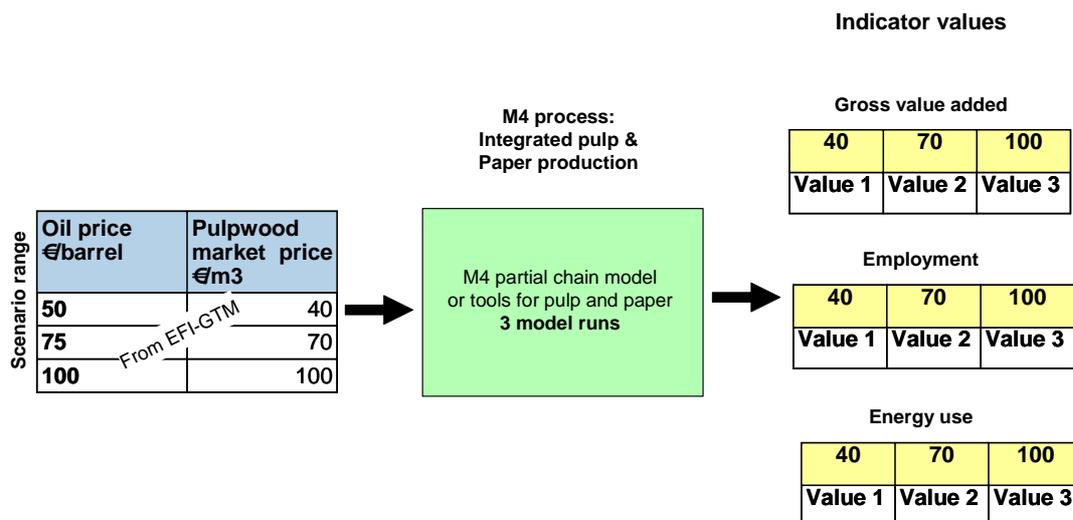
1. Module 4 experts form an expert panel which chooses the most relevant Module 4 indicators for these processes. The selection process and prioritisation must be well documented. In the process, we take into account e.g.:
  - a. the descriptions of the scenarios
  - b. previous screening and mapping done in Module 4
  - c. tools, models and expertise of the Module 4 partners

The reference futures and scenarios affect processes in different ways. Thus, the selected indicators can vary between the processes, or in other words, different processes and chains can have different sets of indicators that will be studied further.

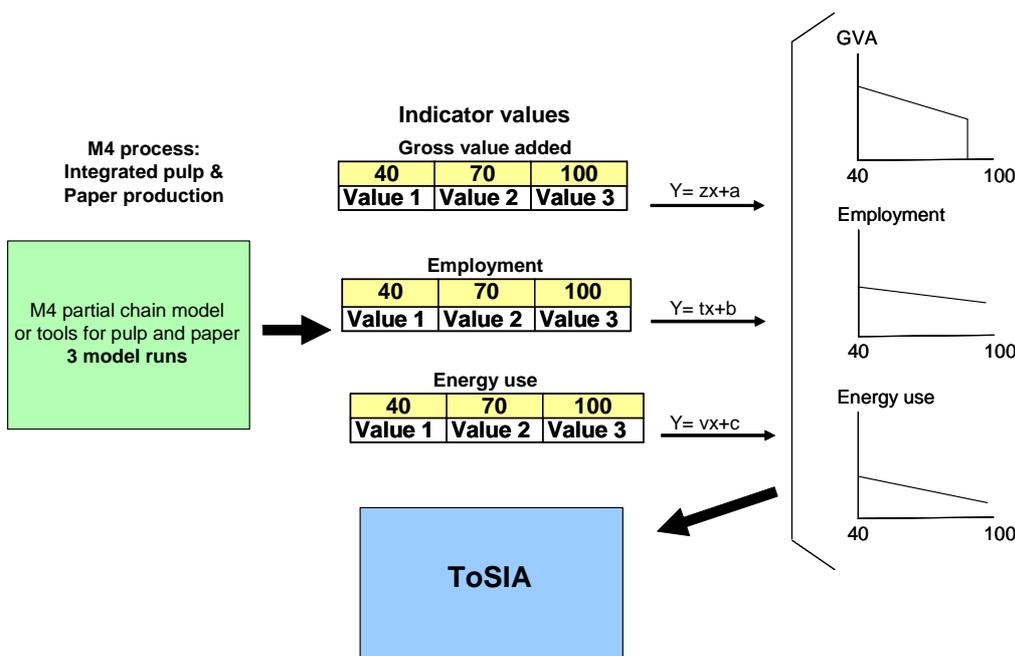
2. A separate group of experts reviews the process and the selection

- Module 4 partners compile the needed values for the selected set of processes and indicators with their tools and models and study which type of response functions would best suit their processes (e.g. linear, step curve, exponential). The Scenario Group, EFI-GTM and ToSIA experts will provide information on drivers and scenario specifications that are needed for the calculation of the range of values. The information can be in form of “something changes X%, Y% and Z%” and we need to calculate corresponding indicator values for these changes. The two pictures below shows the process described in this paragraph.

**Figure 3-1**  
**Calculation of Response Functions 1/2 (Adapted from Lindner/Zvonen 2007)**



**Figure 3-2**  
**Calculation of Response Functions 2/2 (Adapted from Lindner/Zvonen 2007)**



After that, the response function should be developed as follows (steps 1-3 of the “*initial process*”):

- a) looking at one process
- b) selecting which of the scenario assumptions have an impact on the process -> process drivers
- c) looking at one indicator at a time (only the ones selected by the expert panel as relevant are considered)
- d) selecting the process drivers that have an impact on this indicator
- e) finding the interdependencies between an indicator value and the selected process drivers

Note: Points 3b)-3e) should be done using module and/or process specific tools, models and expertise.

**Summarising: Both the reference future indicator values and scenario indicator values can be compiled using the same methodology.**

### 3.3

#### Problems

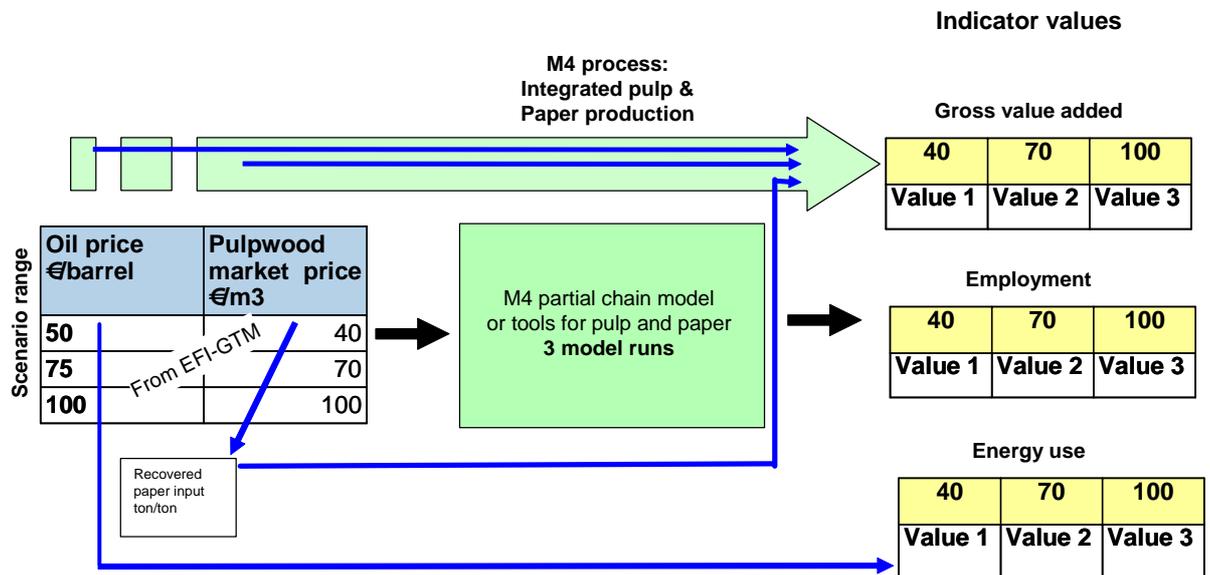
1) It is very important, that the cross-linkages between modules and indicators are taken into account in some way in ToSIA. However, this is especially challenging in the more complex analysis, e.g. in European level analysis.

If it is assumed that the scenario is very simple, for example only varying oil prices. Then it could still be imagine that this simple scenario would have an impact on more than one “driver”. For example:

- on the pulpwood market price (as was shown in the picture),
- on the energy use (directly on the indicator value),
- on the recovered paper input (driver but directly related to pulpwood price).
- but also directly on e.g. the GVA

Then again, all these drivers, on their turn, could have a (joint) impact on several indicators. For example on the GVA (blue arrows). The following, based on material from Jobien Laurijssen/KCPK illustrates the problem.

**Figure 3-3**  
**Joint Impact of Drivers (Adapted from Laurijssen 2008)**



The problem above should be handled in “scenario specific, M2-M5 wide work groups. The participation of representatives from all modules is important, because there might be not only Module specific cross linkages, but also cross linkages between for example M3 and M5.

However, despite of the current limitations, we present below examples on “indicator projections” and response functions for M4 Iberian case.

## 4 EXAMPLE RESPONSE FUNCTIONS

### 4.1 Case Example – Data Points for the Reference Futures and the Scenarios

In this example, we show how to calculate “data points” for the reference futures and scenarios. In case you are interested in compilation of response functions – which are not needed as such for ToSIA - please see Annex 1.

We have selected “Iberian case” “Fine/office paper chain” “M4 part” and reference future A1 (current description, dated September 2007) for the example case here. The example process is an Iberian integrated hardwood pulp and woodfree paper mill producing fine/office paper. In this part of the chain, there is only one M4 process, “Integrated hardwood pulp and woodfree paper production”.

In this example, we follow the method we described in Chapter 3.2.1 for “indicator projection”. The compilation of indicator values for reference future B2 and the scenarios can also follow the same procedure:

1. defining main drivers, in other words crucial issues, that influence a process (e.g. fine paper production), based on the reference future descriptions
2. selecting and quantifying those of the issues that alter in the reference futures -> process drivers
3. developing a projection for each indicator of a process
  - a) taking an indicator
  - b) selecting the process drivers that have impact on this indicator
  - c) finding the interdependencies between the indicator value and the selected drivers
  - d) generating the indicator value

#### Point 1 – Defining main drivers

Our test expert panel selected issues in reference future A1 that have a large impact on Iberian case fine paper M4 (marked with **bold text**). We took the description of the A1 as such and do not comment the content of the scenario.

**As the prices of raw material are low and consumption is high the processing and manufacturing industry will be able to make high profits, but only because they have moved their factories out of Western Europe.** Most of the heavy industries will move to Eastern Europe and the developing world where wages are still lower. However, **in Western-Europe there are high levels of technical development, innovation and education with high rates of investment. Production will focus on a wider range of products and more on high-tech value added niche markets.**

**Energy prices are higher than the current situation but lower than in the B2 future.**

The paper industry has seen mergers into fewer and larger global multinationals and profits from the availability of a cheap woody fibre resource. The bulk of the paper, however, will be produced further away outside Europe, but transport costs are relatively low. **The European paper industry focuses on innovative value added products. The availability of cheap raw materials mitigates the economic effect of decreased input from recycled paper.**

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

The paper industry has done a lot to address or understand customers and consumers particular needs and demands. Industries meet consumers' needs regarding type and quality of paper and size of product. **The basis weight of the paper used in printing, publishing as well packaging sectors is half of that of today. The performance requirements of the printing technology have increased.** Increasing education standards in the Southern hemisphere will cause a growth in paper consumption as a result of the necessary production of educational material.

## Point 2 – Selecting and quantifying process drivers

Different methods can be used in the selection and quantification of process drivers. In this example, we have used SWOT analysis, because it illustrates well the logic/ thinking behind the selection process, is user friendly and transparent.

Thus, based on the analysis of the main drivers from the reference future A1, we carry out a strength-weakness analysis for the Iberian case fine paper mill:

Strengths:

- Low cost of fibre
- Low cost of labour (immigrants from Africa due to close location to Iberia)
- Medium / moderate cost of energy
- Due to innovative technologies, the mills are able to produce both niche and (in Iberia) value added bulk products

Weaknesses:

- Unfavourable development of transport infrastructure (road vs. ships/rail)
- Niche production of value added products with low basis weight and high printability is demanding and increases web brakes

So, the process drivers found and selected by the expert panel are (note: the amount of drivers per process/case can vary, need not to be six):

1. Fibre cost
2. Labour cost
3. Energy cost
4. Technology development
5. Availability of work force
6. Transports

If we look at the list of “Eforwood common” drivers in Chapter 3.2.1 the following “Eforwood common” drivers, having some kind of link to the selected process drivers can be found. At a later stage of the project, they will also be quantified by M1.

- Oil price (link e.g. to energy cost, technology development, transports)
- Technological development (link e.g. to energy and labour cost, technology development)
- Share renewables (link e.g. to fibre costs, energy cost and technology development)
- Hazards (link e.g. to availability of work force)
- Production costs per unit commodity (link e.g. to energy and labour cost, technology development)
- Transport cost (link e.g. to transports)

These drivers are used for the calculation of the indicator projections.

### Point 3 -Indicator values

Below is the list of all Eforwood sustainability main indicators for data collection. The indicators selected for the EU case have been **bolded**. Please note that the list is different for each regional case and for the EU case, reference future and the scenarios. Not all sub-indicators are to be collected for selected main indicators. A complete list of sub-indicators can be found in a document *Indicators Tosia demonstration* dated for November 2008.

<b>Economic FWC-sustainability indicators</b>	<b>Social FWC-sustainability indicators</b>	<b>Environmental FWC-sustainability indicators</b>
<b>1. Gross value added</b>	<b>10. Employment</b>	<b>18. Energy generation and use</b>
<b>2. Production cost</b>	<b>11. Wages and salaries</b>	<b>19. Greenhouse gas emissions and carbon stock</b>
<b>3. Trade balance</b> <i>- applicable only at country level</i>	<b>12. Occupational safety and health</b>	<b>20. Transport</b>
<b>4. Resource use, incl. recycled material</b> <i>-included, but no data collection</i>	13. Education and Training <i>- not selected for demonstration in EU case</i>	21. Water <i>- not selected for demonstration in EU case</i>
5. Forest sector enterprise structure <i>- not selected for demonstration in EU case</i>	14. Corporate social responsibility <i>- not selected for demonstration in EU case</i>	<b>22. Forest Resources</b>
6. Investment and research & development <i>- not selected for demonstration in EU case</i>	15. Quality of employment <i>- not selected for demonstration in EU case</i>	23. Soil condition <i>- not selected for demonstration in EU case</i>
<b>7. Total production</b> <i>- included, but no data collection</i>	<b>16. Provision of public forest services</b>	24. Water and Air Pollution <i>- not selected for demonstration in EU case</i>
<b>8. Productivity</b> <i>-included, but no data collection</i>	17. Consumer Behaviour and Attitudes <i>- not selected for demonstration in EU case</i>	<b>25. Forest biodiversity</b>

9. Innovation - not selected for demonstration in EU case		26. Forest damage - not selected for demonstration in EU case
		<b>27. Generation of waste</b>

### 3a) taking an indicator

We use indicator 2. Production cost in our example. According to “*Manual for case study data collection*” *Background document for EFORWOOD Training - Working document for Task Force - Final 25 January 2008*, is defined in the following way (more information can be found from the report):

<b>Full name of indicator</b>	Average production cost and share of cost of wood-based materials
<b>Name of subclass</b>	2.1 Average cost by processes within each Module (M2-M5). 2.1.1. raw material from FWC 2.1.2. raw material from outside FWC 2.1.3. labour 2.1.4 energy (e.g. fuel costs in case of transportation) 2.1.5 other productive costs (maintenance, general industrial costs, administrative costs, sales expenditures, etc) 2.1.6 non-productive costs (corporate taxes, capital charges, VAT and any other taxes or charges) 2.2 Share of cost of wood-based materials
<b>Measurement units:</b>	2.1. In €per reporting unit 2.2. In % of average production cost

From here, we take indicator 2.1.4 “Energy” for a detailed analysis. The same analysis should be done for all of the indicator subclasses 2.1.1.-2.2.

### 3b) selecting the process drivers that have an impact on this indicator

Indicator 2.1.4 “Energy” is affected by the following process drivers:

1. Energy cost (medium, higher than today)
2. Technology development (both positive and negative effects on costs)

Again, they match the following “Eforwood common” drivers (which are quantified by M1):

- Oil price
- Technological development
- Production costs per unit commodity

### 3c) finding the interdependencies between the indicator value and the selected drivers

The energy cost used in this example for the Iberian fine paper mill for 2005 was 90€/ton. We suppose that the electricity and fuel prices for the mill will follow global oil price. On the other hand, niche production of value added products with low basis weight and high printability is demanding and increases web brakes. This increases energy consumption 15% in 2015 and 10% in 2025 per ton of paper compared to the base year 2005(source: Pöyry models).

Oil price is quantified in the following way in PD 1.4.7:

**Global price development for oil (\$/GJ) based on the IMAGE model for the SRES A1b and scenario. (Source: PD 1.4.7)**

Year	2000	2005	2015	2025	2050
Price	3.03	6.42	3.02	3.47	5.60
Change %		0	-53%	-45%	

### 3d) generating the indicator value

The new data points can be calculated in the following way:

2005 data point: 90 €/ton Technology & product change effect: +15% for 2015 and +10% for 2025 (compared to 2005).

2015 data point:  $90\text{€ton} \cdot (1 - 0.53) \cdot (1 + 0.15) = 49\text{ €ton}$

2025 data point:  $90\text{€ton} \cdot (1 - 0.45) \cdot (1 + 0.1) = 54\text{ €ton}$

## **5 CONCLUSIONS**

The Eforwood scenario definition process is not yet completely ready. However, based on the information we have, we suggest the systematic approach described in Chapters 3 and 4 for compilation of the indicator values for reference futures and scenarios. The systematic approach is recommended for the compilation of the “data points” - even though we are not supposed to fill in the response functions in the ToSIA data client.

## **ANNEX 1 - Hypothetic example on response functions**

Because no “Type 2” scenarios are to be analysed, we have invented a scenario case that is based on the reference future description A1 – just to demonstrate the method. In this case, we study the effect of three different levels oil price at both time points (2015 and 2025). The reasons for the three different price levels would be described in detail in the scenario description.

**Note: this is not a real scenario.**

In this example, we follow the *initial method* we described in Chapter 3.2.2 for “scenario response functions”:

1. Module 4 experts form an expert panel which chooses the most relevant Module 4 indicators for these processes. The selection process and prioritisation must be well documented.
2. A separate group of experts – probably selected from M4 partners - reviews the process and the selection

3. Module 4 partners compile the needed values for the selected set of processes and indicators with their tools and models and form the response functions:
  - a. looking at one process
  - b. selecting which of the scenario assumptions have an impact on the process -> process drivers
  - c. looking at one indicator at a time (only the ones selected by the expert panel as relevant are considered)
  - d. selecting the process drivers that have an impact on this indicator
  - e. finding the interdependencies between an indicator value and the selected process drivers
  - f. shaping the response function for the indicator

#### **Point 1 and 2– Selection of indicators**

As in the case of reference futures, our test expert panel selected issues in “scenario reference future A1” that have a large impact on Iberian case fine paper M4. Based on the drivers from the “scenario reference future A1”, we carry out a strength-weakness analysis for the Iberian case fine paper mill. (Please see point 1 in chapter 4.1, case example – reference futures)

Most strengths and weaknesses have an impact on several indicators. We have selected and presented in the table below the most crucial ones, including a brief reasoning for each. The indicators have been sorted into directly and indirectly affected ones.

Based on the SW-analysis, the influence of scenario A1 is largest in the following indicators:

<b>Strengths:</b>	<b>Affects predominantly indicator:</b>
Low cost of fibre	<p>Direct: 2. <i>Production cost (lower)</i></p> <p>Indirect: 1. <i>Gross value added (via production cost.), 4. Resource use incl. recycled material (altered composition), 7. Total production (depends on substitution capabilities), 8. Employment (changes in process or handling of raw materials?)</i></p>
Low cost of labour (immigrants from Africa due to close location to Iberia)	<p>Direct: 9. <i>Wages and salaries</i></p> <p>Indirect: 1. <i>Gross value added (via production cost), 2. Production cost (lower labour cost), 7. Total production (may change)</i></p>
Moderate cost of energy	<p>Direct: 2. <i>Production cost</i></p> <p>Indirect: 1. <i>Gross value added, 4. Resource use, incl. recycled material, 7. Total production, 8. Employment, 12. Energy generation and use, 13. Greenhouse gas emissions and carbon stock</i></p>
Due to innovative technologies, the mills are able to produce both niche and value added bulk products	<p>Direct: 1. <i>Gross value added (more rewarding product portfolio)</i></p> <p>Indirect: 2. <i>Production cost, 4. Resource use, incl. recycled material, 7. Total production, 8. Employment, 12. Energy generation and use, 13. Greenhouse gas emissions and carbon stock</i></p>
<b>Weaknesses:</b>	
Unfavourable development of transport infrastructure (road vs. ships/rail)	<p>Direct: 2. <i>Production cost (pressure from transports, possibly required changes in production)</i></p> <p>Indirect: 1. <i>Gross value added (via transport costs), 4. Resource use, incl. recycled material (may involve substitution to improve logistics), 7. Total production, 8. Employment, 12. Energy generation and use (via fuel transport), 13. Greenhouse gas emissions and carbon stock (via own energy generation,</i></p>
Niche production of value added products with low basis weight and high printability is demanding and increases web brakes	<p>Direct: 2. <i>Production cost, 12. Energy generation and use</i></p> <p>Indirect: 1. <i>Gross value added, 4. Resource use, incl. recycled material, 7. Total production, 13. Greenhouse gas emissions and carbon stock, 15. Water, 19. Generation of waste</i></p>

Indicator “hit list” shows how many times one indicator has been linked directly (D) or indirectly (ID) to the scenario.

<b>Economic FWC-sustainability indicators</b>	<b>Social FWC-sustainability indicators</b>	<b>Environmental FWC-sustainability indicators</b>
1. Gross value added <b>D: 1, ID: 5</b>	8. Employment <b>D: 0, ID: 4</b>	12. Energy generation and use <b>D: 1, ID: 3</b>
2. Production cost <b>D: 4, ID: 2</b>	9. Wages and salaries <b>D: 1, ID: 0</b>	13. Greenhouse gas emissions and carbon stock <b>D: 0, ID: 4</b>
4. Resource use, incl. recycled material <b>D: 0, ID: 5</b>	10. Occupational safety and health	14. Transport
7. Total production <b>D: 0, ID: 6</b>	11. Education and Training	15. Water <b>D: 0, ID: 1</b>
		19. Generation of waste <b>D: 0, ID: 1</b>

The results above show that the invented scenario has the most direct effect from different aspects on the indicator 2. Production cost, and also some direct effect on the indicators 1. Gross value added, 9. Wages and salaries, and 12. Energy generation and use. The indicators that are impacted indirectly from various points of view by the scenario, are 1. Gross value added, 2. Production cost, 4. Resource use, incl. recycled material, 7. Total production, 8. Employment, 12. Energy generation and use, and 13. Greenhouse gas emissions and carbon stock.

The magnitude of direct and indirect impacts is evaluated, and the most affected indicators are chosen accordingly. The next step is to show the list above to a different group of experts, and they review the prioritisation process and the selection.

After the external group of experts has approved the selection of indicators per processes, response functions are to be compiled to the selected indicators.

### **Point 3 - Response functions for the indicators**

Again, the following text is quoted from a presentation held by Marcus Lindner in Eforwood week in Zvolen 2007: Response functions express the impact of a driver on an indicator and/or on material flows in the FWC. Indicator response functions are developed at the process level by each module based on existing data or model predictions, in other words module specific models and tools.

The standard way of estimating the response functions will be to apply partial chain models or process-specific models for a predefined scenario-range.

**3a) looking at one process**

That is “Integrated hardwood pulp and woodfree paper production” in Iberia.

**3b) selecting which of the scenario assumptions have impact on the process -> process drivers**

Done in Point 1 - Selection of indicators

**3c) looking at one indicator at time (only the ones selected by the expert panel to be relevant in the scenario, are being considered)**

Again, we study indicator 2. “Production cost” and take indicator 2.1.4 “Energy” for a detailed analysis. The same analysis should be done for all of the indicator subclasses 2.1.1.-2.2.

**3d) selecting the process drivers that have impact on this indicator**

Because we use the reference future A1 also in this scenario example and study the same indicator, we have the same drivers as in the previous example.

3. Energy cost (medium level but higher than today) Note: does not match with the currently available EFI-GTM runs below.
4. Technology development (both positive and negative effects on costs)

Similarly, they match the following “Eforwood common” drivers (which will be quantified by M1 at a later stage of the project):

- Oil price
- Technological development
- Production costs per unit commodity

**3e) finding the interdependencies between an indicator value and the selected process drivers**

The energy cost used in this example for the Iberian fine paper mill for 2005 was 90€/ton. We suppose that the electricity and fuel prices for the mill will follow global oil price. On the other hand, niche production of value added products with low basis weight and high printability is demanding and increases web brakes. This increases energy consumption 15 % in 2015 and 10% in 2025 per ton of paper, compared to base year 2005 (source: Pöyry models). Oil price is quantified in the following way in PD 1.4.7: (Note: does not follow the scenario description)

**Global price development for oil (\$/GJ) based on the IMAGE model for the SRES A1b and scenario. (Source: PD 1.4.7)**

Year	2000	2005	2015	2025	2050
Price	3.03	6.42	3.02	3.47	5.60
Change %		0	-53%	-45%	

However, now in this hypothetical scenario, we study the effect of three different oil price levels both on 2015 and 2025 (the price levels would be given by M1/scenario group, in this case they are just invented). It is assumed, that the effect of value added niche production stays at 15% / 10%.

Year	2005	2015	2025
Initial price	6.42	3.02	3.47
Change %	0	-53%	-45%
Price 2	6.42	4.05	5.20
Change %		-37%	-19%
Price 3	6.42	5.55	7.03
Change %		-14%	+10%

### 3f) forming the response function for the indicator

The data points needed for the calculation of the response functions are shown in the table below:

Year	Oil price	Indicator 2.1.4. "Energy"
Initial case 2015	3.02	$= 90 \cdot (1 - 0,53) \cdot 1,15 = 49 \text{ €/ton}$
Initial case 2025	3.47	$= 90 \cdot (1 - 0,45) \cdot 1,1 = 54 \text{ €/ton}$
Case Price 2 2015	4.05	$= 90 \cdot (1 - 0,37) \cdot 1,15 = 65 \text{ €/ton}$
Case Price 2 2025	5.20	$= 90 \cdot (1 - 0,19) \cdot 1,1 = 80 \text{ €/ton}$
Case Price 3 2015	5.55	$= 90 \cdot (1 - 0,14) \cdot 1,15 = 89 \text{ €/ton}$
Case Price 3 2025	7.03	$= 90 \cdot (1 + 0,10) \cdot 1,1 = 108 \text{ /ton}$

The table above gives the co-ordinates needed for response functions.

Co-ordinates for year 2015 response function.

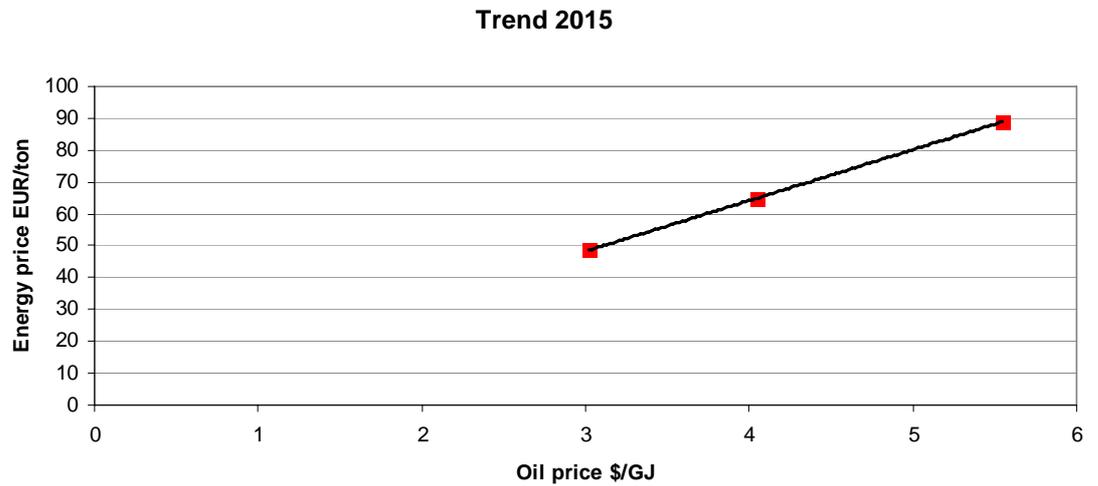
Oil price	Energy cost €/ton
3.02	49
4.05	65
5.55	89

Co-ordinates for year 2025 response function:

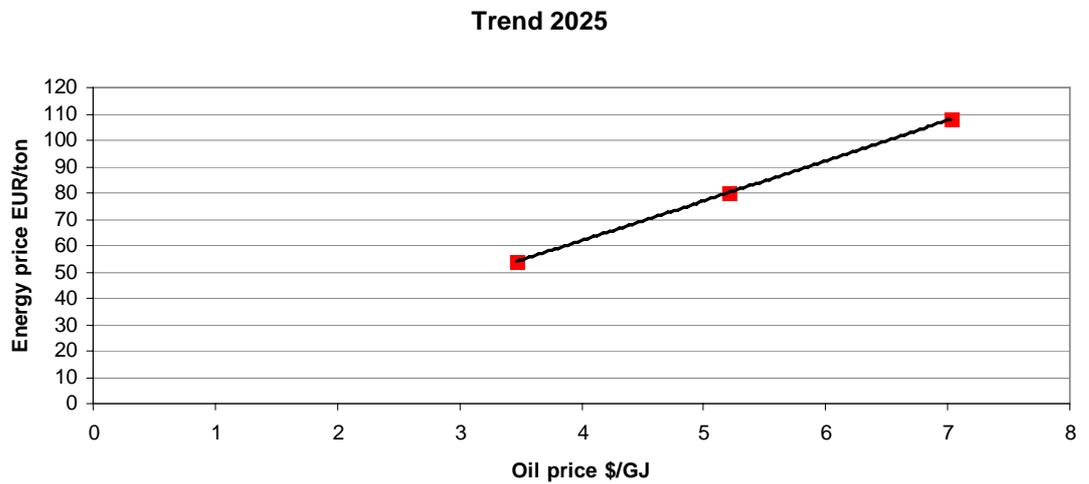
Oil price	Energy cost €/ton
3.47	54
5.20	80
7.03	108

The final format of ToSIA response functions has not yet been defined. Below, graphical representations of 2.1.4. “Energy costs” response functions for years 2015 and 2025 is shown.

**Figure**  
**Response Function Energy Cost vs. Oil Price for Year 2015**



**Figure**  
**Response Function Energy Cost vs. Oil Price for Year 2025**



The analysis described in this “Point 3- response functions for the indicators”, should be carried out for all *relevant* indicator 2. Production cost sub indicators 2.1.1-2.1.6. After that, indicator 2.1 “Production cost in €ton” will be calculated by summing up all the sub indicators for both year 2015 and 2025, per each level studied. Thus, three values are received both for 2015 and for 2025.

The analysis presented in this report has been based on looking at the reference future A1, i.e. just one of the two alternatives (A1 and B2).

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**ABBREVIATIONS**

<b>TOSIA</b>	Eforwood's Tool for Sustainability Impact Assessment
<b>FWC</b>	Forestry-wood chain
<b>EFI GTM</b>	European Forestry Institute's Global Trade Model