SimaPro 7

Tutorial

product ecology consultants

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Colophon

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Written by: PRé Consultants

Mark Goedkoop, An De Schryver and Michiel Oele

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Support: phone +31 33 4555022
fax +31 33 4555024
e-mail support@pre.nl
web site www.pre.nl

Content

1 Introduction

1.1 The purpose of this tutorial

In this tutorial we aim to provide you your first experiences with SimaPro, by taking you through a series of simplified examples. The tutorial does not attempt to explain the concept of LCA and all methodological issues. This basic theory and the concepts behind LCA are described in the *Introduction to LCA with SimaPro*. Each lesson in this tutorial starts with a table that describes what you should read.

To follow the examples in the tutorial, you need to have a demo version or a registered version of SimaPro 7. The demo version is very much the same as the full version with one important limitation. You can enter, edit and save data, but the save command can only be used 16 times. This is sufficient to do all exercises, but be careful not to waste your opportunities to save data.

1.2 The Lessons

We have prepared a number of examples that allow you to get to know SimaPro. Which examples you would like to follow depends on the time you have available and the application you have in mind.

1.2.1 Lesson 1: Basic features of SimaPro

We suggest starting with example 1: *the guided tour with coffee*, as this will show you how a complete LCA is stored and analysed in SimaPro; it also explains how you should interpret the results, and how the result windows works. It does not explain how you enter data into SimaPro.

1.2.2 Lesson 2 A, B, C and D: Entering data and building life cycles

Now you can experience how to enter data and how to build up an LCA. Lesson 2 is a very comprehensive example, and will take a few hours to complete. It shows how to enter process data, and analyse results or perform a simple sensitivity analysis.

1.2.3 Lesson 3: Using the Wizard to build life cycles

After having done the hard work in lesson 2, this lesson shows how you build a life cycle in a semi automatic way. In fact you build a much more advanced life cycle in a much shorter time. You may of course wonder why we made lesson 2, but without having experienced making a life cycle “the hard way” you will find it difficult to understand what the wizard does for you and what the results mean.

1.2.4 Lesson 4: Using input output data

Input output databases open up entirely new possibilities to assess services and study consumption patterns. They are also very useful in screenings, or to assess the importance of missing data.

1.2.5 Lesson 5: Addressing the weighting problem

Weighting is a disputed issue in LCA. In many cases you will need to make trade-offs between impact categories. The weighting triangle is a way to come to communicate the weighting problem to stakeholders and come to a decision without using weighting factors.

1.2.6 Lesson 6: Assessing uncertainties with Monte Carlo

The SimaPro Analyst and Developer versions can run Monte Carlo analysis to determine the uncertainty in your results. In the demo you can use the Monte Carlo feature 4 times, to experience the clarity such an analysis can give.

Please be aware that if you have a demo version, you can only save processes 16 times. This should be enough to run the exercises in this tutorial, unless you save processes more than once. Please note that re-installing the demo will not reset the counter.

1.3 SimaPro training

With this tutorial, you can learn how to use SimaPro by yourself. If you want to develop more advanced skills, PRé and its international partners provide dedicated SimaPro trainings. Please check www.pre.nl/trainings for more information. Some trainings require you to perform some lessons in this tutorial, to ensure that all people at the course already understand the basics. In this way, the time can be used for more advanced subjects.

2 Lesson 1: General introduction, using the guided tour

Overview	
What you will learn	Get a general overview, become familiar with the most important result screens and terminology in SimaPro
Required entry level	Some basic understanding of what LCA is about. This is intended to be your first experience with SimaPro
Recommended reading	Introduction to LCA with SimaPro, chapter 1
Project needed	Introduction to SimaPro 7
Approximate time needed	15-45 minutes

2.1 The problem

Find out what guidelines should be given to designers of coffee machines. For instance, should they focus on material selection or energy efficiency in the use phase? Is the consumption of paper filters important? In example 6 below, we will also investigate if it is important to organize a take back and recycling system.

2.2 The SimaPro solution

Two coffee machines are defined, a model Sima and a model Pro, with the following specifications:

	Model Sima	Model Pro
Main material for housing	Plastic	Aluminium
System for keeping coffee warm	Thermos Jug	Hotplate

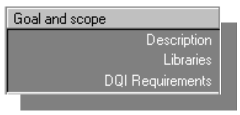
2.3 Use the predefined wizard first

Start with running the coffee machine wizard; the wizard will guide you through and give a generic overview of the capabilities of SimaPro. Take your time to read the texts on the window. This will take about 15 minutes.

2.4 Use the standard user interface

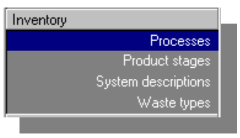
After finishing the wizard, you can also go through the example step by step, using the normal interface. This will help you to understand the basic features in the interface. This part will take another 20 minutes.

2.4.1 Step 1: Inspect goal and scope



Read the description of this fictional project under Goal and Scope in the Explorer bar, and check the DQI requirements. Under the DQI Requirements, you specify the desired data characteristics for this specific project.

2.4.2 Step 2: Inspect the processes in the database

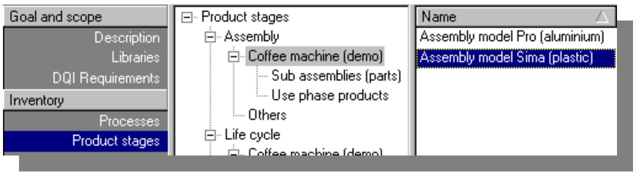


Click on processes under Inventory, and inspect the range of processes supplied in the database. Both colours in the index and

DQI specifications indicate how well the data in each process conform to the settings under the DQI requirements described in step 1. Choose a process, and double click on it. The process is opened and you can inspect how the process is defined.

2.4.3 Step 3: Analyse the environmental profile of a product

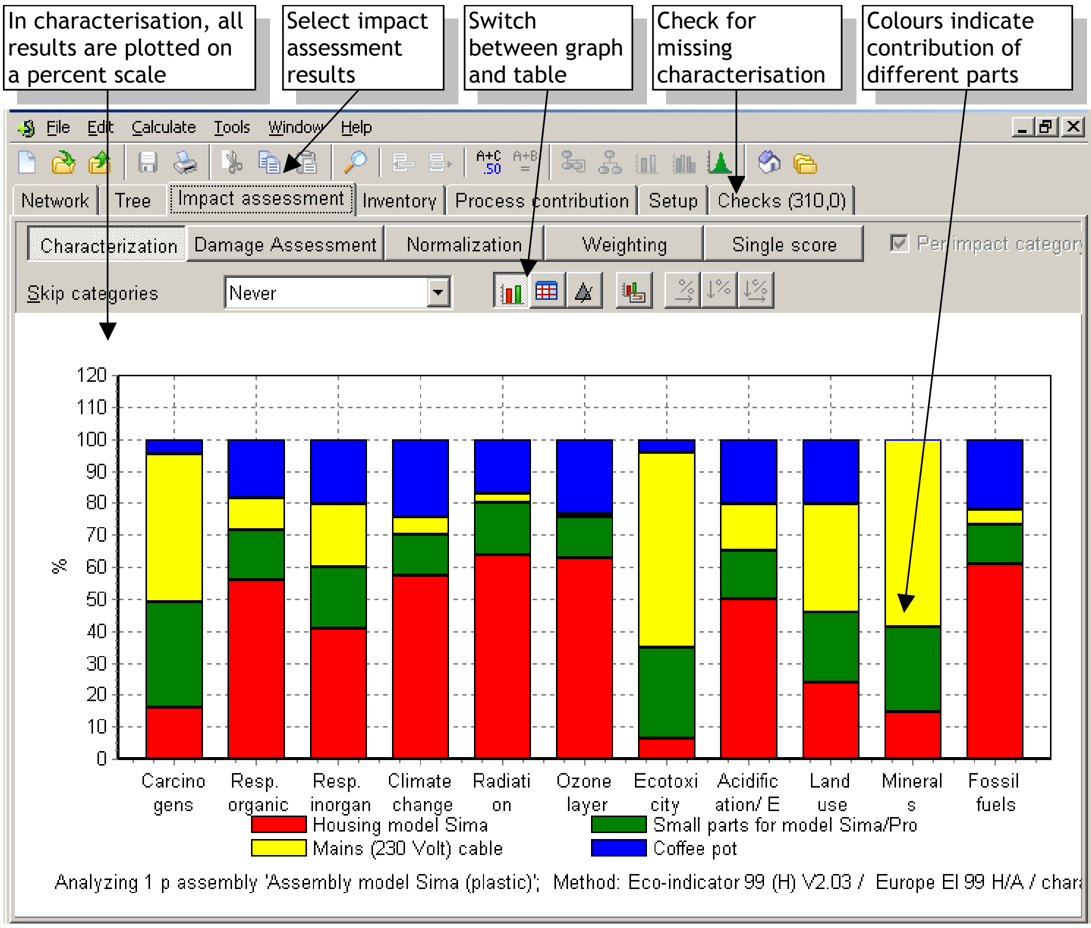
Click on Product stages; select Assembly and then Coffee machine (demo). You will see a list of assemblies. These are the product definitions.



Double click on *Assembly model Sima (plastic)*, the assembly will be opened and you can see how this assembly is defined.

Now click on the Analyse  toolbar button to see the inventory and impact assessment results, as well as the process contributions (see figure on the next page). The Eco-indicator 99 method has been selected as the default; but you can change this in the pop up window. Later, in step 10, we will see how you can select another default impact assessment method.

The window shows the characterisation results. As all impact categories have a different unit, they are plotted in a percent scale. The colours indicate the relative contribution for different parts of the product.



From the many possible uses of the results window we just mention three:

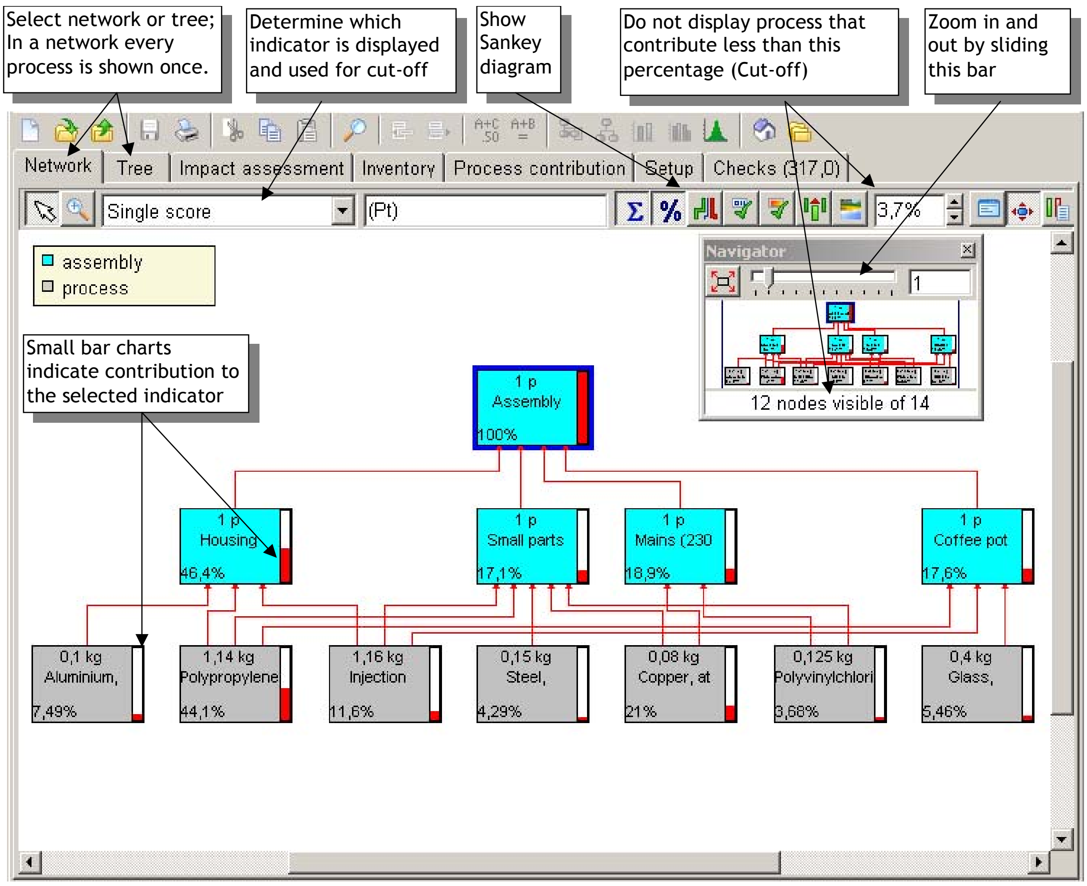
1. LCI results. The inventory result is a long list of emissions and resources. Click on the Inventory results tab.
2. With the buttons: Characterisation, Damage assessment, Normalisation and Weighting you can follow the different impact assessment steps.
3. Contribution analysis: this shows the relative contribution of each process to an impact category or to another indicator.

A special feature of this window is the possibility to double click on a graph. You will get the option to ask for a further specification.

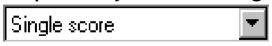
Please feel free to experiment with this important window. Click F1 if you need help or explanation.

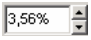
2.4.4 Step 4: Generate a process network

Click on the Network tab in the upper left-hand corner of the window. A network presentation will be generated. A warning message will tell you that the network is not completely visible; click OK. Each box represents a process; the arrows present the flows between the processes. The saw mill red bar charts (or thermometers) indicate the environmental load generated in each process and its upstream processes. This is a very useful feature, as you can distinguish between important and less important processes (identify hotspots).



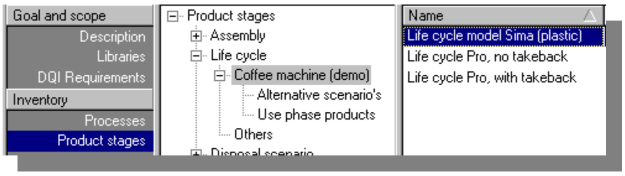
The process tree window has a wide range of options that you can experiment with. The following are especially interesting:

- With the 

selection box, you can specify which indicator or LCI result is to be represented by the saw mill “thermometers” in each process. You can choose any single impact category or inventory result. By default, the Eco-indicator 99 is shown in this demo.
- *Cut-off setting.* 

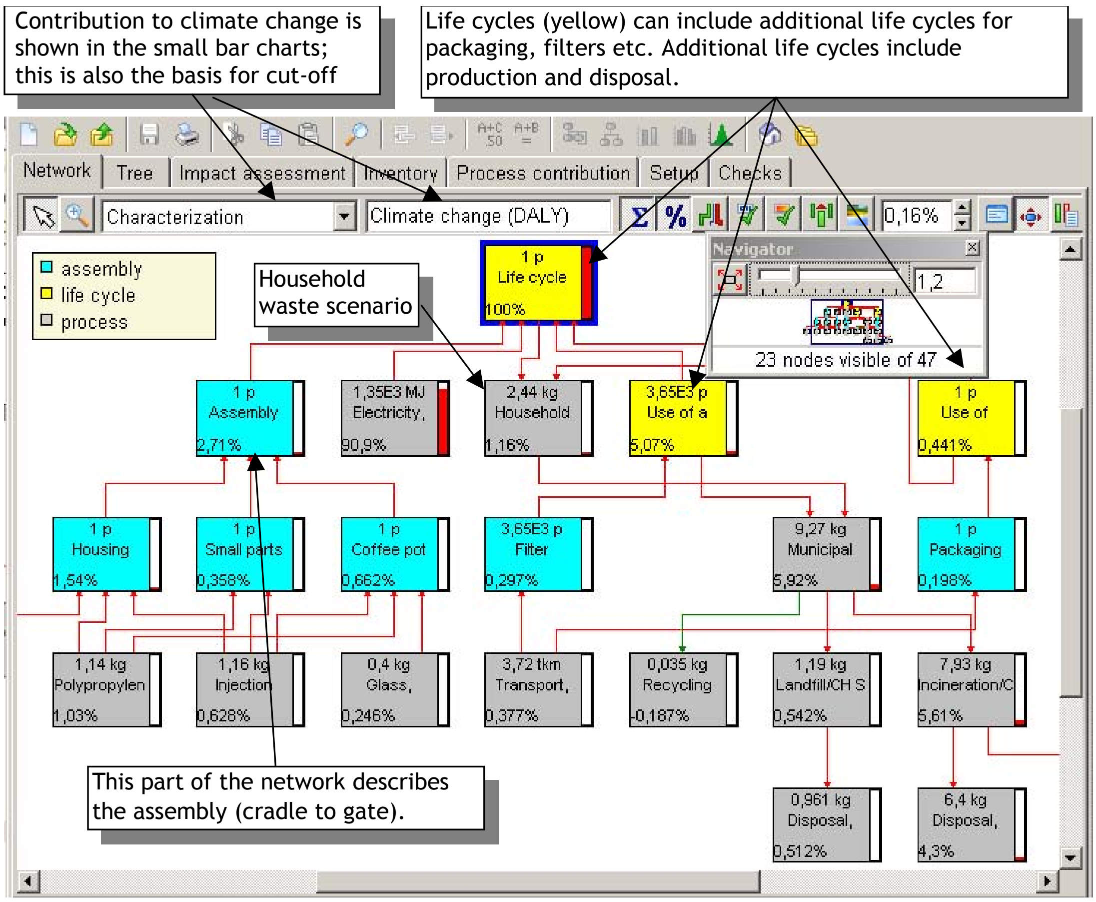
Processes that contribute less to a selected indicator, than the percentage you specify here, are not shown. By default, the single score is used (if available in the selected method), but you can also select a category indicator or even a substance.
- *The split screen*  allows you to look at the content of the process in any parts of the process tree.

2.4.5 Step 5: Analyse a full life cycle



You may want to analyse a full life cycle of the coffee machine. Close or minimise the previous window and click on product stages, select Life cycle, then select Coffee machine (demo). You will see a list of product life cycles. Double click to open *life cycle model Sima (plastic).* Read the comments to see how the functional unit has been defined.

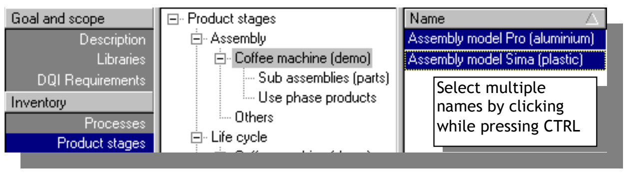
Click on the  button to get the same analysis as in step 3, but this time the analysis of the whole life cycle is shown; inspect the relative contribution of the life cycle stages. Now select the tab marked with *Network* to get a window as below. You will be able to recognise the assembly, the use processes and the disposal processes. The filter and the packaging are both defined as an additional life cycle, each with their own assembly and disposal stage.



2.4.6 Step 6: Compare two products in the production stage

Apart from model Sima, that has a plastic housing, there is also a coffee machine model Pro. This one has aluminium housing, and it uses a thermos jug to keep the coffee warm. Model Sima uses a hotplate.

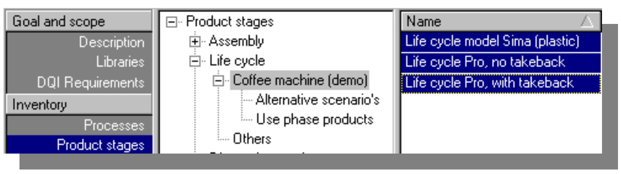
First, compare the production stages. Select model Sima, and while you hold the CTRL key, select model Pro in the list of assemblies. Both assemblies are now selected and have a blue background



Click the compare button. A window will be generated that compares both products, impact category by impact category. In this case, interpretation is easy. Model Sima has a much lower load than model Pro. If you analyse model Pro -see step 3- you will see that this is due to the use of aluminium in the housing.

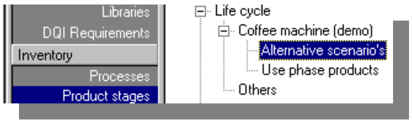
2.4.7 Step 7: Compare life cycles

Comparing life cycles can be done in the same way. Select the *Life cycle Sima (plastic)*, the *life cycle Pro, no take back* and *Life cycle Pro, with take back.* Click the compare button, and you will see a comparison of the three life cycle models. When the life cycles are compared, impact category by impact category under characterisation, it appears model Sima has a higher environmental load for all impact categories, except for



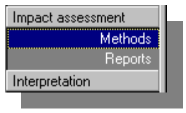
the depletion of minerals. Click the single score button to see a weighted total score for the three product life cycles. This clearly shows that model Sima has the highest total load. This is interesting, as in the production stage model Sima had the lowest environmental load; apparently the higher energy consumption in Model Sima determines the outcome. Note that according to ISO single scores may not be used for “comparisons disclosed to the public”.

2.4.8 Step 8: Perform sensitivity analysis on alternative assumptions



The assumptions regarding the use of the machine are quite uncertain and may be even speculative. There is a special subcategory under the life cycles of the coffee machine that stores life cycles based on other assumptions regarding intensity of use and life time of the product. There is also a special version of model Pro where electricity is left out; this allows you to inspect the effect of the take back system; see also example 6, where this example is used in a Monte Carlo analysis.

2.4.9 Step 10: Inspect or select a method



In the Methods section in the Explorer, you will find a list of all available impact assessment methods. In the full version of SimaPro, you can edit these methods and add new ones. In this section you also can select another method for your calculations. Click on the method name, click on an associated Normalisation and weighting set, and use the *select* button.

2.4.10 Step 11: Inspect the interpretation section

The interpretation section is used as a checklist and a framework for your LCA report. The most important interpretation issues according to ISO 14043 can be entered here. An example text is provided in this section.

3 Lesson 2a: Enter production processes

Overview	
What you will learn	Get hands on experience with SimaPro, while entering some simple data, and building a simple process network that describes the production of planks from a tree
Required entry level	Lesson 1 should be taken first
Recommended reading	Introduction to LCA with SimaPro, chapter 2 and 3 is essential reading material if you want to understand the backgrounds of issues like allocation and system boundary setting
Project needed	Tutorial with wood example
Approximate time needed	45-60 minutes

3.1 Introduction

Let us assume you want to make an LCA of a simple wooden shed, to be used in a private garden. The shed is made of just two materials: wood and some steel for the nails and other metal parts. There is no packaging. We also assume there is no wood preservation or paint, there are no windows, no doors and there is no heating or lighting. It is just a simple shed.

There are three basic parts in this modelling exercise:

1. Enter some processes that describe the environmental impact of cutting a tree and sawing planks in a saw mill. For simplicity, we do what you may never do, that is to ignore the impact of woodcutting on the biodiversity in the wood. For the steel used in the shed, we shall use some data already available.
2. Describe the end of life of the shed. For that, we will demonstrate some of the unique and advanced features in SimaPro to model waste scenarios. In this example, we will use the assumption that 40% of the wood is burned in open fireplaces at peoples home and that 60% is landfilled in a modern landfill.
3. Once we have developed the production and the end of life scenarios, we will develop the specification of the shed (the assembly) and the life cycle.

During the modelling, we will of course encounter some methodological issues. However, these will not be thoroughly analysed here. We refer to the Introduction of the LCA manual for further information. The data we use for this LCA are not the best and most representative available, and they are by no means complete. The purpose is to exercise and not to provide you with data.

3.2 Preparation for data entry

3.2.1 Starting a registered version of SimaPro

Upon start-up, SimaPro will prompt you to open a project. Select the “Tutorial with wood example” from the list, and click the open button. Please ignore the following paragraph.

3.2.2 Starting from the SimaPro demo version

As long as you do not have entered the license code provided by PRé, SimaPro will run in demo mode. In this mode, you can still run this example. SimaPro allows you to save processes 16 times. The example requires you to save 9 processes. You still have 7 spare "saves" to correct errors or to perform a sensitivity analysis. After 16 times you are still able to run the demo and view the results, but there is no way to make changes (re-installing the demo will not help).

When you start the demo, it will ask you to register or run in demo mode. Choose demo. Next, it will ask you which version of SimaPro to use. Choose the "analyst" version. After that, it will ask you to run the guided tour with the coffee machine, or the wood example. Choose the wood example and read the welcome message.

Go to the File menu and select Open project; select the "**Tutorial with wood example**" from the list and click the Open button.

3.2.3 Starting the wood example project

SimaPro organizes all the data you enter into 'projects'. This is very useful if you run more than one LCA project, as you can keep all data separate. (By the way, in the Demo version you cannot create your own projects).

A project has 4 different sections (see the menu on the left side of your screen):

1. Goal and scope. Here you describe the purpose of the project and you can set your preferred data quality standards for the project.
2. Inventory: Here you enter and edit your data, as we shall see in the next chapter.
3. Impact assessment, here you can edit, enter and select impact assessment methods.
4. Scripts: Here you define wizards like user interfaces for the less experienced users. The step-by-step menu of the 'introduction to SimaPro' and the guided tour with coffee are examples of this feature.

3.2.4 Goal and scope

The initial stage in LCA is to go through the **Goal & Scope Definition**, namely define all the practical details related to the project. It might seem a short and easy step. However, it is highly important, since aspects defined in this step appear in all stages of the LCA and are relevant to the product life cycle. In this example, in order to keep our focus on how entering data and building up new processes in a SimaPro can be executed, we have defined these parameters in advance, so that they are already filled in. Please take some time to see what is described.

3.2.4.1 Description

Under the description tab, you find information on the goal and most important choices. The text fields refer to the obligatory issues you need to describe according to ISO 14041. You can cut and paste these texts to your word processor if required. You may use the arrow keys to run through the description menu.

3.2.4.2 Libraries

In this section, you can predefine which libraries you want to use for this project. Libraries are a special type of project. They are intended to be used as a resource that you can use in all your projects and are not intended to be edited. In case you need to edit an item that is in a library, you can copy the item to your project. After that, you can edit the item. In this way, you keep your libraries untouched for other projects. In this project, we only need the Buwal250 library and the Methods library.

Keep the library selection as it is; if you select additional libraries, or deselect the BUWAL250 or Methods library, you will run into difficulties in the next chapter.

3.2.5 Data Quality Requirements

In the **Data Quality Requirements** section, you can fill in specific parameters related to the project you want to create. These requirements are namely *time*, *geography*, *type*, *allocation* and *system boundaries*, these terms refer to methodological choices that need to be made in the goal and scope of each LCA.

The purpose of these indicators is to help you to understand to what extent the data from libraries is consistent with the requirements of your own project.
Once you have set these data quality indicators (see figure 1), later you will see that each process in the library will get a field with a colour that depends on the (mis)match between the data and the desired properties. There are four colours to indicate to which extent a process matches your project requirements. *Green* colour shows that the material or process chosen is applicable to your project, yellow is quite matching, orange is less close and finally red means that although useable, the process or material is beyond your project requirements (see for example processes/material/chemicals).

In the wood example project, we have already entered the desired data quality, as indicated in the overview below. We will not go into detail about the reasons for each setting. Please refer to the 'Introduction to LCA' for some more explanation of this concept.

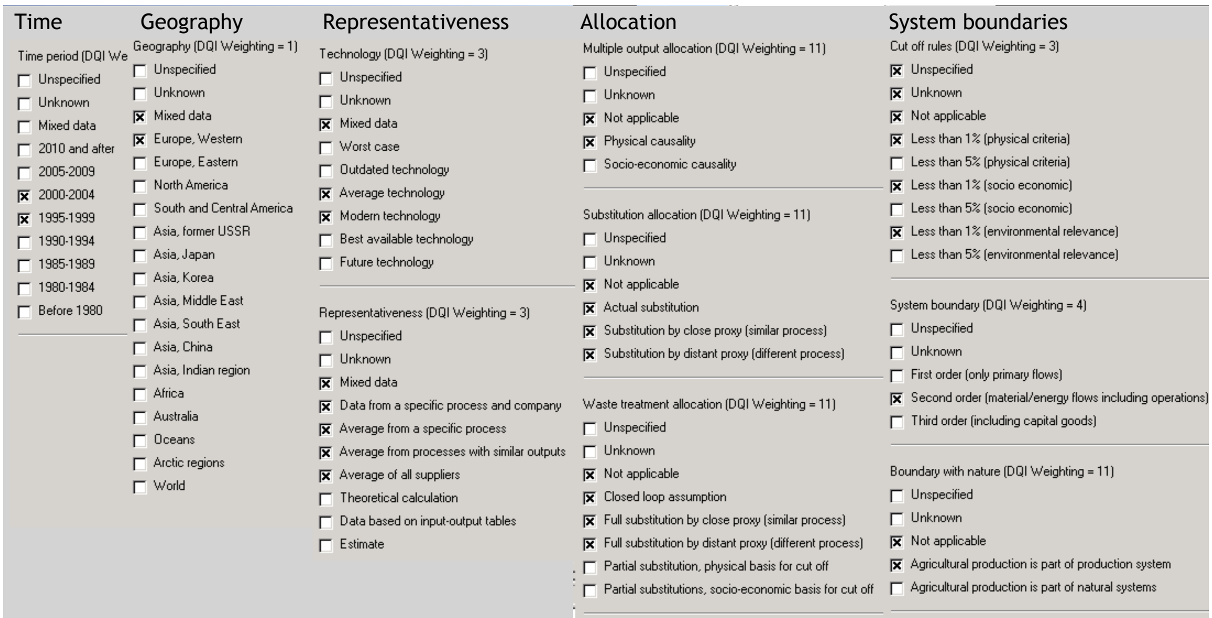


Figure 1: Overview of data quality setting used in this example

In the next chapter, we describe how you can actually enter data in the **Inventory** section of SimaPro. We will concentrate on the production of the sawn planks needed for the shed. For the steel data, we will use existing data in the SimaPro database.

3.3 Entering process 1: felling the tree

The first process describes the felling of the tree. Before we can enter the data, we will have to collect the data. In this example, we will provide you the following data:

- About 1,25 ton of wood is felled to produce a tree trunk of 1 ton, the rest (branches and tops) is left in the forest. We assume these do not cause emissions, as they are part of the natural processes in the forest. In a full LCA, this assumption should be analysed better of course.
- We use a chainsaw for felling the trees. The chain saw data provided in the example are specified as impact per hour. In this example, we use a production rate of 25 ton of wood per hour, which means that for 1,25 ton. We need 3 minutes of chainsaw input. Of course, we could also have entered the amount of fuel for the sawing energy, if this would be available.

Now follow the three steps, which are also shown in the figure below:

1. Step 1: click on Processes in the explorer window.
2. Step 2: click on the category Wood.
3. Step 3: Click new and a new and empty process record will appear.

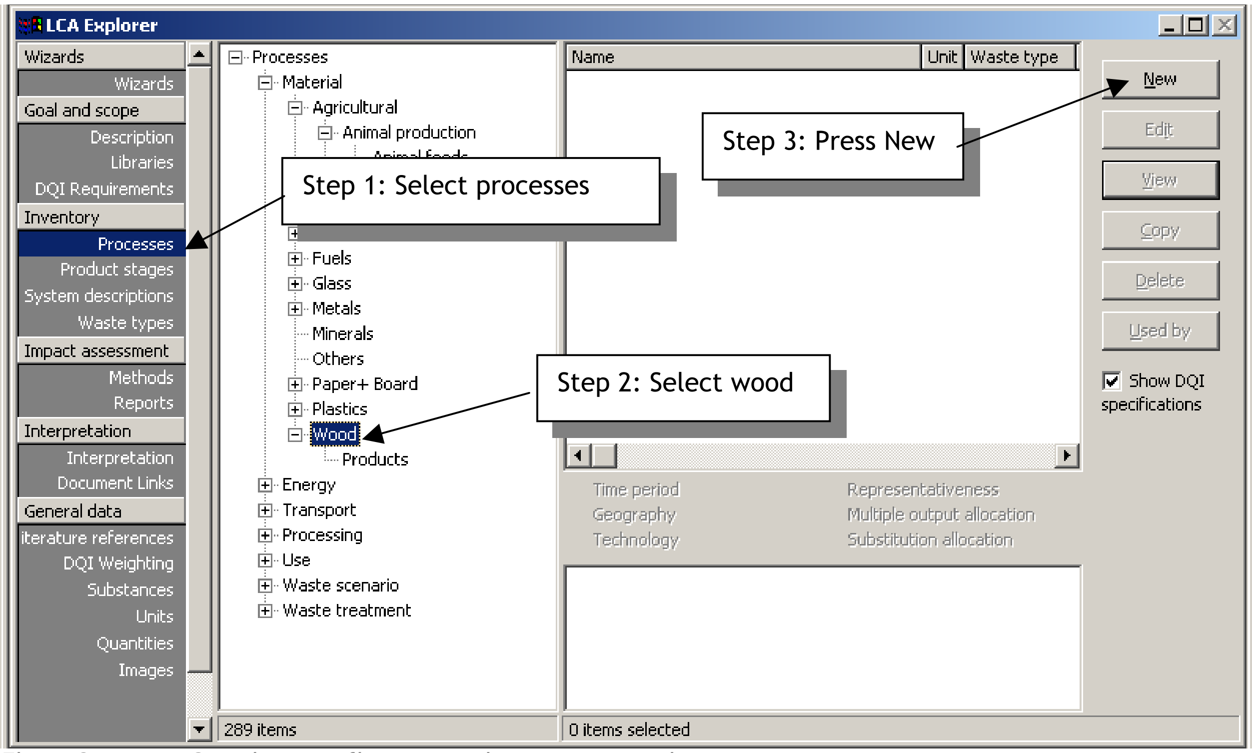


Figure 2: Creating your first new and empty process sheet

3.3.1 Entering process outputs (products)

Figure 3 (see below) shows the top section of the window that appears. At the top, there are three tabs, giving access to the three different parts of the process record. For now, use the middle tab, input/output.

Follow the four steps shown in this figure:

1. Double click on the white field under the "known outputs to techno sphere. Products and co-products" section and a new line will appear.
2. Enter the text "Felled tree" in the section under "Name". Jump to the next field by using the enter or tab key.
3. Enter the number 1 under 'Amount'.
4. Double click in the field under "unit" and choose ton by using the pull-down option. SimaPro can convert units, so it understands that you now have just entered an output of 1 ton of felled trees. If you would have liked to use cubic meters this is also possible, but in that case, you should first change the quantity from Mass to Volume.

You can ignore the high and low volume. This version of SimaPro does not use these fields yet. In the next chapter, we shall also explain the percentage under allocation and the waste type. For now, you can ignore these.

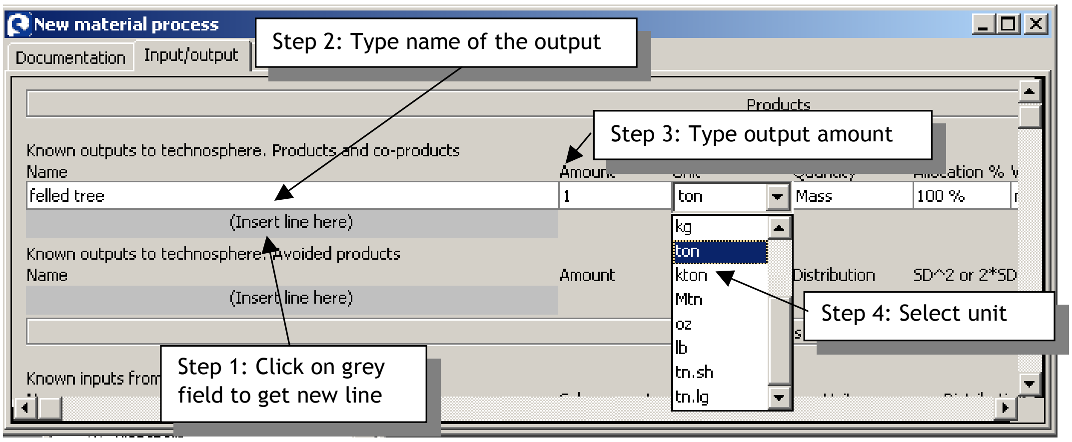


Figure 3: Entering the process output

The next product-input line "Known outputs to technosphere - avoided products" can be ignored, as there are no such products (see also paragraph 4.2, where this option will be used in the landfill process).

3.3.2 Entering inputs

The next section describes the inputs to the process (see the figure below). We will enter data about the amount of wood we will extract form the forests. Note that there are three lines in the record where you can specify inputs:

1. Known inputs from nature (resources). Here you can list the resources that are directly taken from the natural resources. In this case, the wood that is extracted from the forest. In a process that describes mining, the ore or metal input would be described here. All data you enter here will be included in the inventory result table.
2. Known inputs from technosphere (materials and fuels). Here you enter inputs that come from other industrial processes and not from nature.
3. Known inputs from technosphere (electricity and heat). This field has the same purpose. We suggest you specify all inputs with a mass unit in the field under point 2, and all others under this field. This will help you keeping track of the mass balance.

3.3.3 Input from nature resources

The sequence below is the sequence that is generally used in all fields (except for the output fields).

Step 1: create a new line by clicking under 'known inputs from nature (resources)'
Step 2: double click in the blue field; a list of predefined resources is presented
Step 3: select wood from the list; you can do this by scrolling, but also by typing "wo"; SimaPro will immediately search for the closest match. If wood would not be present in the list, you can use the 'New' button to create a new resource, however in this example we leave this button.
Step 4: when you found wood, click 'Select' (or select by double clicking)
Step 5: enter the amount as 1,25 ton (or 1250 kg); the difference between input and output will be waste from branches

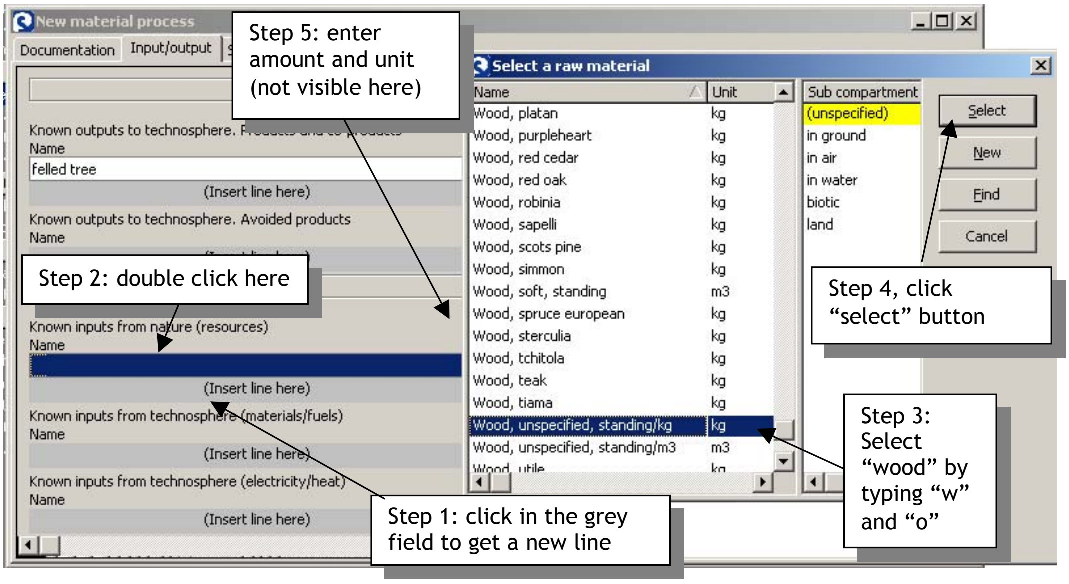


Figure 4: Entering the inputs form nature (resource depletion)

3.3.4 Inputs from technosphere (materials/fuels)

The chain saw needed to cut the tree has already been predefined in the project. We thus can enter this as an input from technosphere (see figure 5). This means that the chain saw process is linked to the process we are creating. This has the benefit that all emissions and resources needed to operate the chain saw are in that specific record and we do not have to (re)enter all emissions in the record.

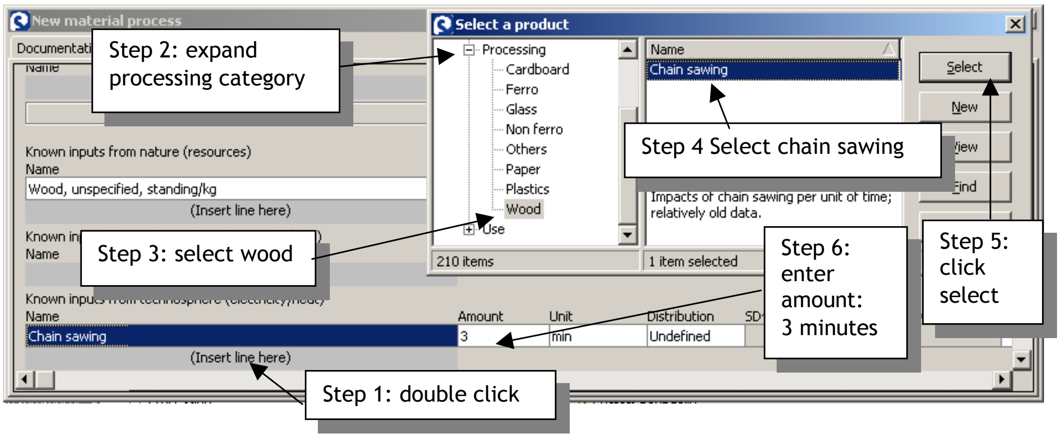


Figure 5: Entering inputs from other processes; in this case the chain saw

Here we repeat the basic procedure, by starting to double click in the last of the three input fields (electricity and heat), as the use of the chain saw will not add to the mass balance of this process. Instead of a list of predefined resources, you get a view into the list of already available process outputs. The chainsaw process has been defined in the processing section under wood. In this case there is only one process in this subcategory. (If you would not know if and where a process is in the datasets, you use the “find” button to locate the process).

In the lower part of the selection window, you can see the data quality indicators. All indicators are green, except for the period. Apparently, this process is older than we defined in the data quality profile. Later we shall see how important this deviation will be.

The process is specified with time (hours) as a unit. We need to input the average time to fell 1.25 ton of a tree. The estimate from the wood company is that this is on average 3 minutes (or 0.05 hours). Again, you can use the unit conversion and enter 3 minutes.

3.3.5 Entering emissions and other outputs

The lower part of the window is used to specify emissions and wastes. There are eight different sections:

1. Emissions to air
2. Emissions to water
3. Emissions to soil (usual to express leaching)
4. Final waste flows, or wastes in solid form, especially intended to monitor the volume or mass of waste (any leaches and emissions from the wastes should be specified in the other categories)
5. Non material emissions, like radiation, noise etcetera
6. Social issues
7. Economic issues
8. Waste and emissions from this process only to (waste) treatment

The last category is a powerful feature. You can specify emissions and wastes that are treated in some form of waste treatment or for instance flue gas purification. In this way, you can describe very precisely, how production wastes are handled.

In this example, we shall only specify the final waste flow from branches that remain in the forest. As stated, the emissions from the chain saw are already specified in the chain saw record and should not be specified here again (this would result in a double count).

The procedure to specify the waste is the same as in the case of resources. It is illustrated with the 3 steps in the figure 6. 250 kg of wood is left in the forest. In a similar way, you could add other emissions.

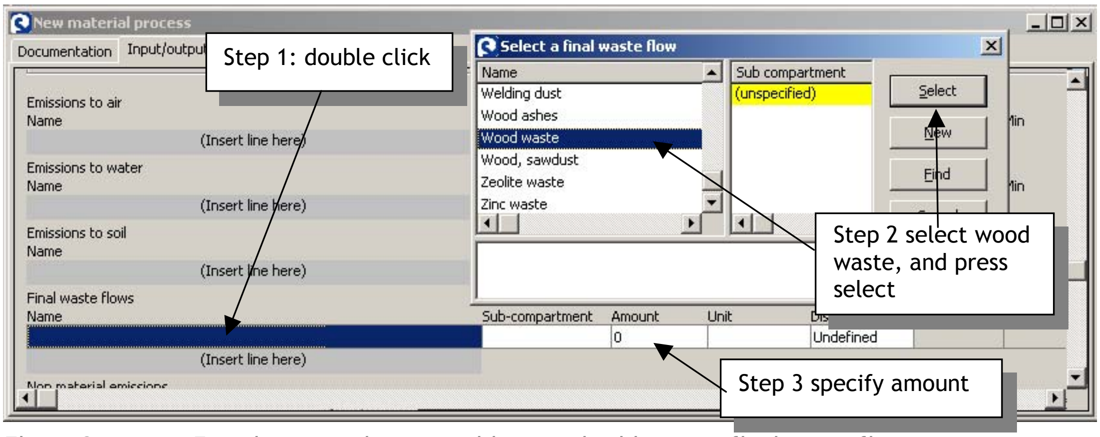


Figure 6: Entering an environmental impact, in this case a final waste flow

3.3.6 Quick feedback, inspect the tree or network.

Now we have entered the data, we can click the  button, to get a first look at the network we have created. You do not have to save the process at this time, simply click the button, while the 'felled tree' process is being edited. The window will look like the figure below.

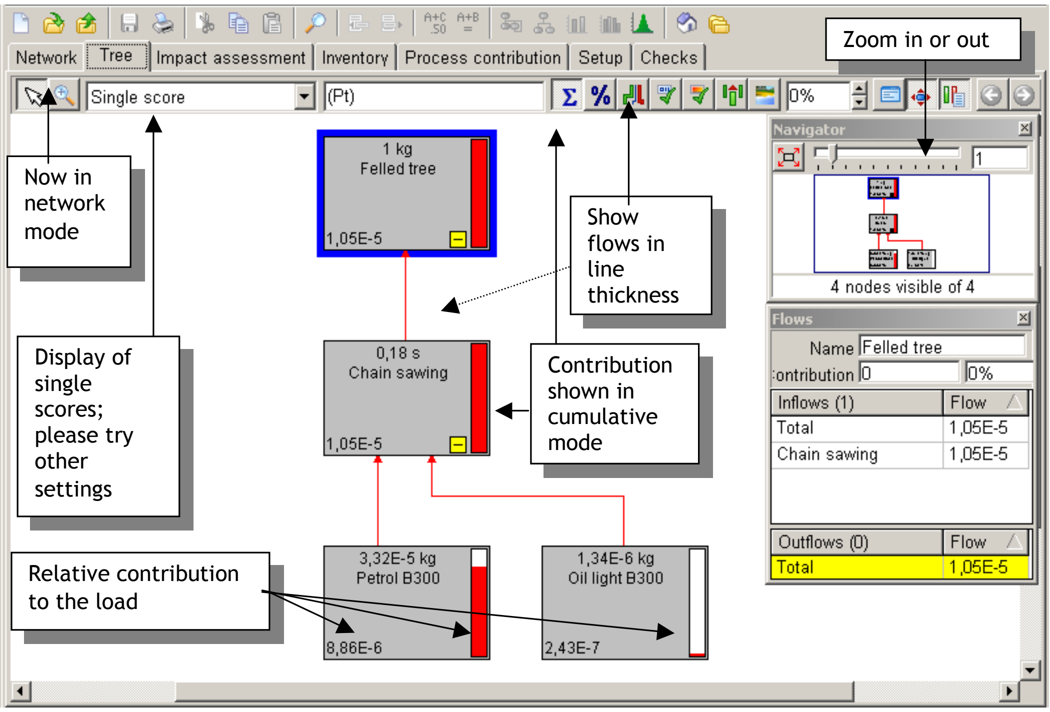


Figure 7: Inspecting the result of your modelling, the felled tree is linked to the chain saw, and the chain saw appears to be linked to fuel input

As you can see, the top process, the felled tree, gets an input from the chain sawing process we have entered. On its turn the chain saw process has an input for the fuel production and for the production of lubricants. As you can see, by entering links between processes, you can build up complete trees.

You can also play around using zooming options and other features. We will not discuss all the features of this window, but mention a few. The saw mill bar graphs in the processes and the line thickness display the contribution to the total environmental load. How this load is calculated depends on the impact assessment method that is currently selected (see bottom of the window) and on which level the method is used. In this figure, the total (weighted) Eco-indicator score is used, but you can also select alternatives, like using the climate change impact category indicator result. You can experiment with these settings as much as you want.

If you have selected another impact assessment method that does not have a single score, SimaPro will choose one of the impact categories to be displayed.
You can return to the process sheet by closing the window with the network.

3.3.7 Documenting a process

Now use the 'documentation' tab, located beside the input/output tab of the felled tree. In the documentation tab, you can specify all types of characteristics of this process record.

The figure below provides an example of how such documentation for this specific record could be entered. Please note the following characteristics:

- The Name of the process is not the name that you will find in the list with processes. SimaPro uses the outputs as you specified on the other tab as a label. In fact, the name of the process is only there for your own reference.
- Under Data Quality Indicators there are 8 fields you can use to characterize the record. SimaPro will match the information you provide here with the Data Quality indicators, set in your project goal and scope (see paragraph 3.2.5). If the match is perfect, the process will get a green label, if one or more mismatches occur, a yellow, orange or red label will be presented. In the figure below, the appropriate settings have been entered.
- The comment field in the bottom will also be shown in the listing of the processes in the explorer. It is useful to add some characteristics that help you to understand the exact contents of the record.

Please enter the data as presented below:

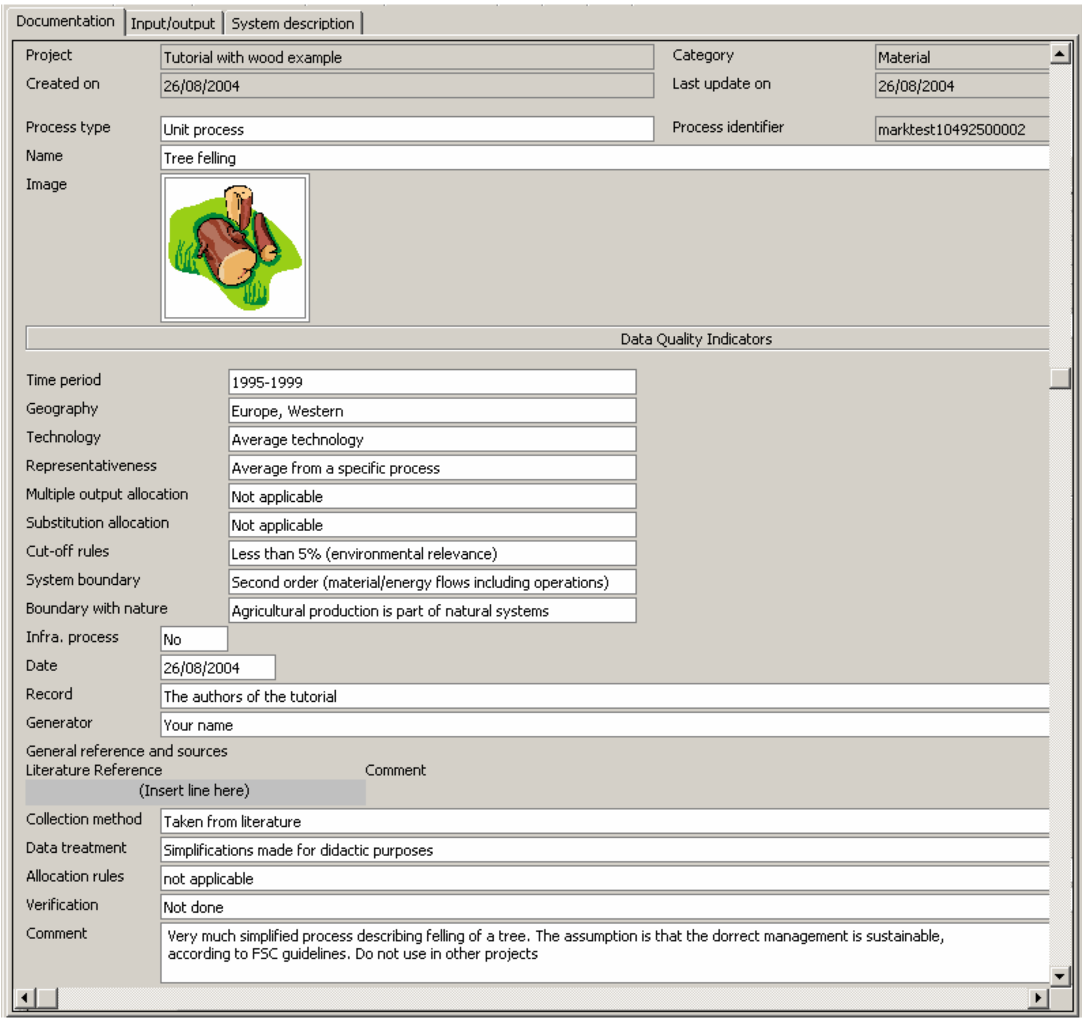


Figure 8: Documentation of the 'felled tree' process

System description

The third tab at the top of the process record is called system description. In this example, it is not used and in fact not needed. System models are used when a process record does not describe a single "Unit process", but a combination of unit process, a so-called "system". For example, the Steel processes in the Buwal database describe the complete steel production process in a single record, while in fact the steel production process contains many unit processes. By presenting this data, much of the transparency within the processes is lost. To partially compensate that, the System description provides information about the way the process was built. We suggest you inspect some of these system descriptions in the Buwal or other databases at a later stage.
Again, this information is not needed here, as we are building "unit processes".

Parameters

The last Tab is the parameter tap. We will explain in paragraph 6.3 how you can use parameters.

3.3.7.1 Saving data

Click the button with the saw mill diskette symbol to safe the data you have entered. You can now close the process record window in the normal way. You will get back to the process index, and you will see that felled tree process is now stored under Wood.

Important message for users of the SimaPro 7 demo version

In this example, you will need to create and store new processes and product stages. After installing a demo version, you can only *save* 16 changes. After this, the demo can still be used to view results, but there is no way to add or edit data in the databases

3.4 Process 2 – Saw mill ('planks')

Our next aim is to define the saw mill process, where logs are turned into planks, bark and sawdust. In order to do that, we have to create a new process. This is done in the same way as described above, so, while in materials - wood, select 'new' and again an empty process record will appear.

- This process will convert the felled trees into three products:
  1. Planks, about 50% of the output
  2. Sawdust, about 40% of the output
  3. Bark, about 10% of the output
- Some remaining wood (250 kg) is used within the saw mill process to dry the wood. This drying process will result in some emissions to air.
- Furthermore, we will enter the transport needed between the place of felling and the saw mill. Like in the case of the chainsaw, we will link a process describing the environmental load of a truck to the saw mill process.
- Finally, we shall enter the electricity use in the saw mill, also using an already predefined process record describing electricity production.

3.4.1 Describing the three outputs, waste types and allocation percentages

The fact that the saw mill has three outputs creates an allocation problem. The environmental load of the felling, the transport and the saw mill itself must be allocated over three different outputs: planks, sawdust and bark. In this example, we shall use the mass as an allocation basis. This means that 50% of the environmental load will be allocated to the planks, 40% will be allocated to the sawdust and 10% to the bark.
An alternative solution would be to use the value of the three products as an allocation basis. As wood will generate about 80% of the value, with sawdust generating about 20%, while the bark will create virtually no value, the allocation percentages would be 80% for the planks and 20% for the sawdust.

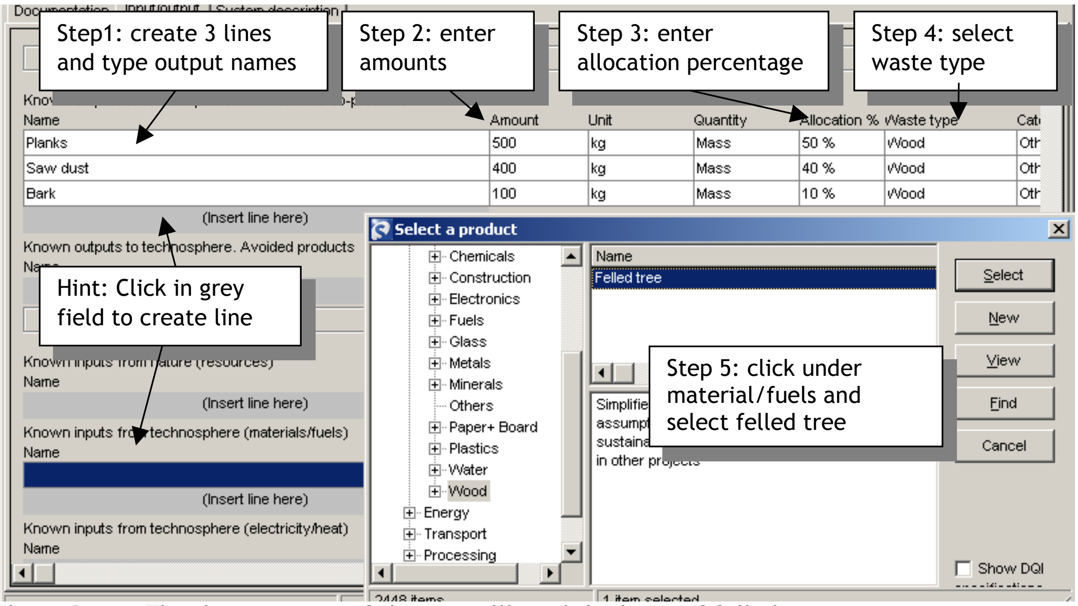


Figure 9: The three outputs of the saw mill, and the input of felled trees

The procedure is now as follows:

- Step 1: create three lines under "known outputs", by clicking three times on the "insert line here" field
- Step 2: type in the names of the three outputs
- Step 3: enter the allocation percentages, in the figure above this is done according to the mass, you can also use the economic allocation
- Step 4: click under the waste type column and select wood, below the purpose is explained
- Step 5: click under 'Materials and fuels'. A selection box will appear, from which you can select the felled tree. This is the record we made in the previous paragraphs. If you cannot find, use the 'Find' button. To produce 1 ton of products (planks, sawdust and bark) and to have enough wood to burn wood for process energy (250 kg), we need an input of 1,25 tons of felled tree.

Please note that we do NOT fill in anything under resources, the extraction of wood from the forest is already taken into account in the felling tree process, and should not be repeated (it would result in a double count). In this saw mill process, we put in 1.25 ton of felled tree, while the felling of the tree was defined for one ton. SimaPro will automatically multiply all inputs by 1.25, so you do not need to pay attention to this.

The use of waste types

In step 4, you were instructed to set the waste type to wood. Waste types can be seen as a label that is added to a material output. As we will see later, these labels are used in the post consumer waste scenarios. It helps SimaPro to recognise, which emissions are to be allocated to a material that is incinerated or land filled.
The idea behind this concept is that in principle all woods have more or less similar emissions in the waste phase. Similarly, all steels will have similar impacts. By using a standard waste type label, we avoid the task of making specific waste scenarios for every material that is added to the database. As we will explain, you do not have to use the waste types, if you consider these are too coarse. You can indeed also develop a waste scenario for a specific material.

Waste types do not always have to be specified. Only materials that are specified in the description of the assembly or subassembly need to have a waste type. The felled trees do not need a waste type, as the consumer will not dispose of felled trees but of planks and perhaps sawdust or bark.

Another example, if a consumer disposes of a plastic bag, SimaPro needs to know that this plastic belongs to the waste type plastic, or more specific, polyethylene. SimaPro does not have to take into account that this material was oil before it was turned into plastic. The oil that went into the plastic does not need a waste type. If in doubt always try to specify a waste type, it will never harm.
As we shall see SimaPro checks, each time a calculation has been added if materials, that should have a waste type specification, indeed have that specification.

3.4.2 Adding electricity, transport and emissions

Energy and transport are added in the same way as the felled tree. We will assume a transport distance of 200 km, between the felling and the saw mill, and we will assume that a 28-ton truck is used, that is loaded for 50%, because the return trip will be empty.

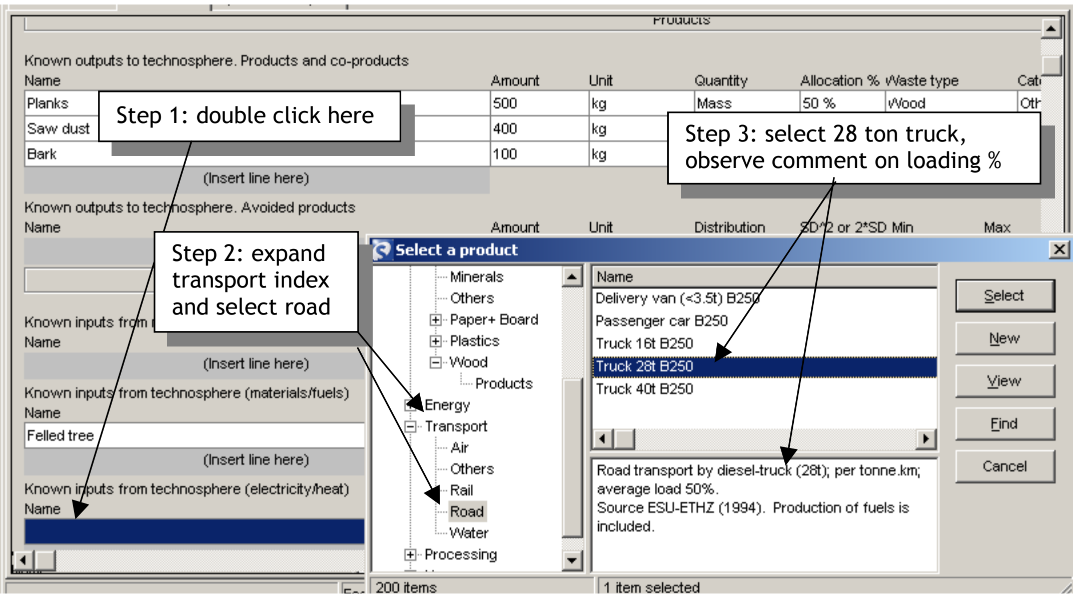


Figure 10: Entering the transport data

The transport process is specified as ton-kilometre (tkm). One ton-kilometre means the transport of one ton over 1 kilometre, or 1 kg over 1000 km, or any other combination that has the same product of distance and weight. In this case, 1.25 ton is transported over 200 km, so you should enter 250 tkm, as quantity. In the description of the transport process you have selected, you can read that the truck drives with an average loading of 50%.
Electricity can be entered in the same way. We suggest you take the UCPTE electricity record. The UCPTE is the European organization of electricity producers, so this record has average European data. You will find this record in the category 'Electricity country mix' at the bottom of the list under 'Medium Voltage'. You may also use the find button and type 'UCPTE B250', Different data sources estimate the sawing energy at about 150 kWh per ton output, so you can specify 150 kWh.

As explained the emissions from transport and electricity are already in the process records you made the links to. However, the emissions for burning of 250 kg wood for drying must still be added. Please add:

- 450 kg Carbon dioxide
- 2.9 kg Carbon monoxide
- 100 g Sulfur dioxide
- 500 g Nitrogen dioxide
- 540 g Particulates, <10 µm

The resulting record should look like the figure below (top of the record not shown)

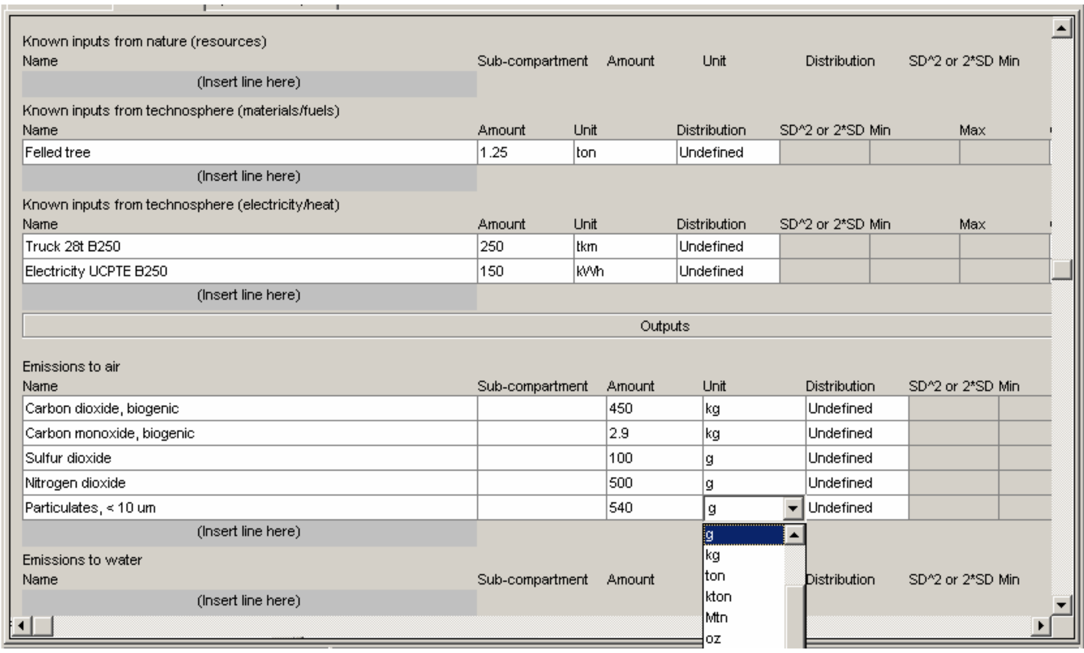


Figure 11: Entering the emissions from the combustion of some of the wood residues for drying

3.4.3 Inspecting the tree

Like in the previous record, we can now quickly inspect the tree, by clicking the  button; the following window will appear, after it gave a warning that not all processes fit in the window.

SimaPro automatically calculates a cut-off to suppress processes that contribute very little to the overall result. (Typically, only 12 processes are shown; however, you can change that default in the options setting in the tool menu). To determine the relevance, it uses the impact assessment method that you have currently selected and the level setting. Of course, the cut-off only affects the display, not the results. Please feel free to experiment with the cut-off setting.

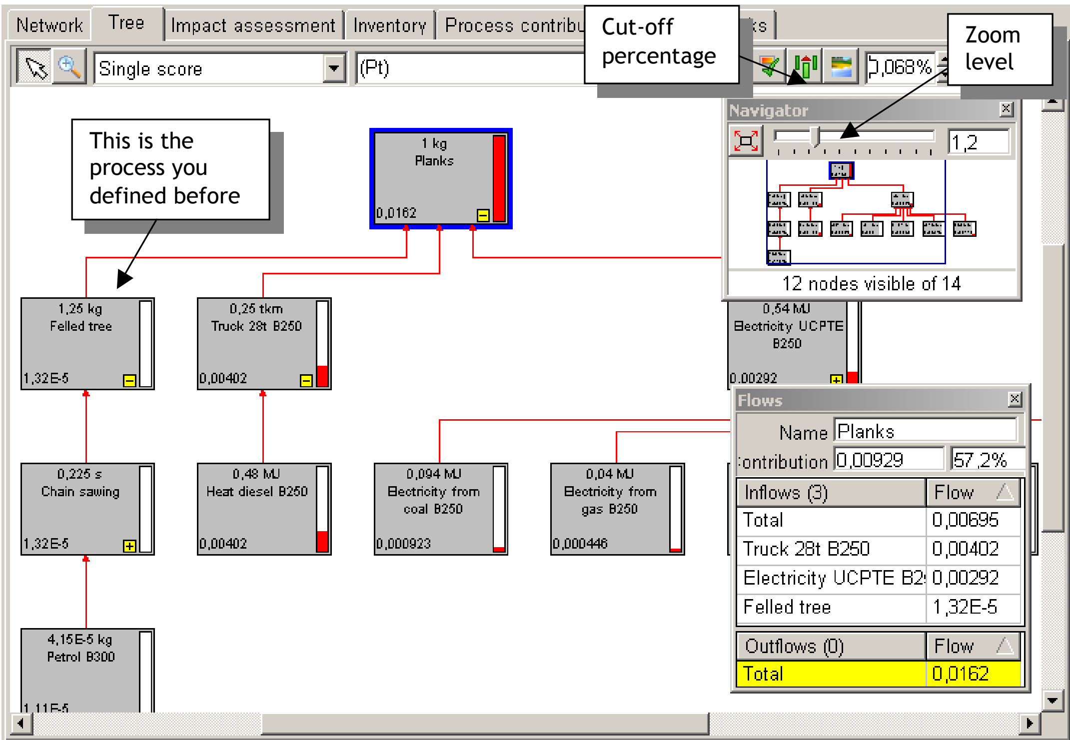


Figure 12: Inspecting the result of your modelling after entering the chainsaw process

The top process is the Planks process. In fact, SimaPro could have taken another name, as sawdust and bark, but as a default, it takes the first product you specify. Below the Planks, you see the felled tree, the transport and the electricity. The electricity is split up in different types of power plants.

Hint: depending on the zoom level and resolution of your monitor, you may not be able to see the full name of the processes. If you click on a process the full name will appear on the right hand side of the window.

3.4.4 Documentation

You can finish the record by entering the documentation: see figure 13.

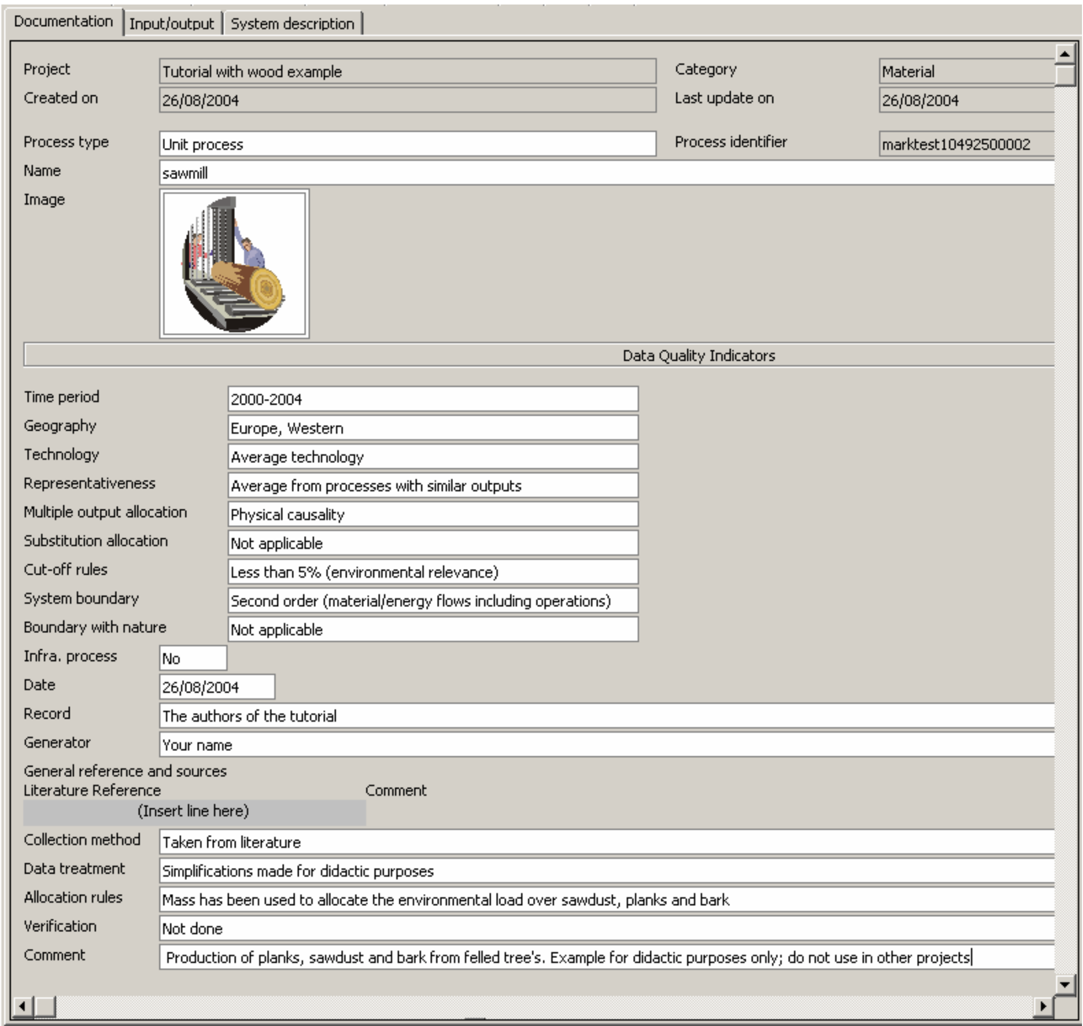


Figure 13: Entering the documentation of the chainsaw process

Now you can save and close this record. You will note that suddenly the number of processes has become 4, as all the three outputs appear as a separate material, while in fact they refer to the same process.

4 Lesson 2b Enter waste treatment and waste scenarios

Overview	
What you will learn	How to develop a waste scenario and the associated waste treatments. Often SimaPro users select one of the predefined waste scenarios without really knowing how these work. In this lesson you get a much better understanding of these features
Required entry level	Lesson 2a should be completed first
Recommended reading	Introduction to LCA with SimaPro, chapter 8.5 gives a background on how waste and disposal scenarios are developed. It is recommended, but not essential, to read this paragraph first
Project needed	Tutorial with wood example
Approximate time needed	60-90 minutes

4.1 Introduction

We have created the model for the production, now it is time to look at the end of life, and develop a waste scenario. For many commonly used materials, SimaPro has more or less standard data, but for this tutorial it is useful to develop your own simplified scenario for post consumer waste. Although we have not defined the shed itself, it will only contain two materials:

1. The planks we have defined in the previous chapter
2. Steel parts, like nails, screws and other metal construction parts

This means that the waste model should at least contain data on the end of life of both, wood and steel.

This tutorial is not aiming to be sophisticated in any way, but just complex enough to show the main features. The characteristics of the scenario are as follows:

- 40% of the wood is burned in open fires at peoples home. In this case, we assume a zero contribution to room heating. As such, stoves are very inefficient and in fact cause large energy losses when the stoves are not working properly due to the uncontrolled ventilation through the chimneys. Of course in a real LCA this issue deserves further attention.
- 60% of the wood is dumped in a modern landfill. Again for simplicity, we assume that this landfill has collection system for methane and that 31% of this methane is used as fuel.

Describing the waste scenarios

When we analyse this scenario, we will see that we need to split the waste in different routes. The first split is between 40% burning in open fires, and 60% landfills.
A second split is between the wood and the nails. Although we cannot assume that the consumer will indeed take out the nail. For our modelling purpose it is very useful, as steel behaves differently than wood when it is burned. As we explained above we will use the so-called waste types to make this split. In landfill a similar split should be made, but for now we ignore this.

SimaPro has a powerful tool to model such splits, the **Waste Scenario**. The waste scenario can be used as a generic splitter, and a waste type specific splitter (wood and nails). However, before we model these, we should also discuss how we model the emissions from the waste.

Describing the impacts of waste treatments

Waste scenarios only describe where the waste flows go, and not the emissions that come form the waste treatment. To describe these, SimaPro has another type of box under the inventory menu, the **Waste Treatment**. A waste treatment record contains data on the emissions from for instance a waste incinerator or a landfill.

For this example we need the waste treatments:
1. A waste treatment that describes the emissions from the open fire when the wood is burned
2. A waste treatment that describes the emissions from the open fire if steel nails are burned (if any)
3. A waste treatment that describes the emissions from the landfill

The positive impacts of some waste treatments

Wood in a landfill will slowly decompose and form methane and carbon dioxide in the first 150 years. About 20% will not decompose and will stay on the landfill as a stable material. The methane part (about 56%) can form a potentially high impact on global warming, as the release of 1 kg contributes over 20 times as much to climate change as the release of 1 kg carbon dioxide. For this reason landfills are being equipped with a methane collection system.
In this example, we assume that most of the methane that is formed in the landfill is collected and used as fuel, or simply burned, as it is better to have an emission of CO2 than methane. By using the methane as fuel, we may assume less natural gas needs to be produced.

To model the useful application of waste or by products SimaPro has an “avoided products” option. If you enter a certain amount of natural gas here, SimaPro will subtract the emissions and resource use associated with the production of natural gas. In ISO terms, this principle is referenced to as expansion of system boundaries (see chapter 3 of the ‘*Introduction to LCA with SimaPro*’ for more explanation).

4.2 Waste treatment record for Landfill

Waste treatment records can be found at the bottom of the inventory processes menu. The way to create them and enter data is quite similar to making material processes.

Please, enter the data as presented in the figure below (figure 14). On the following page, the step-by-step procedure (step 1, 2 and 3) is presented.

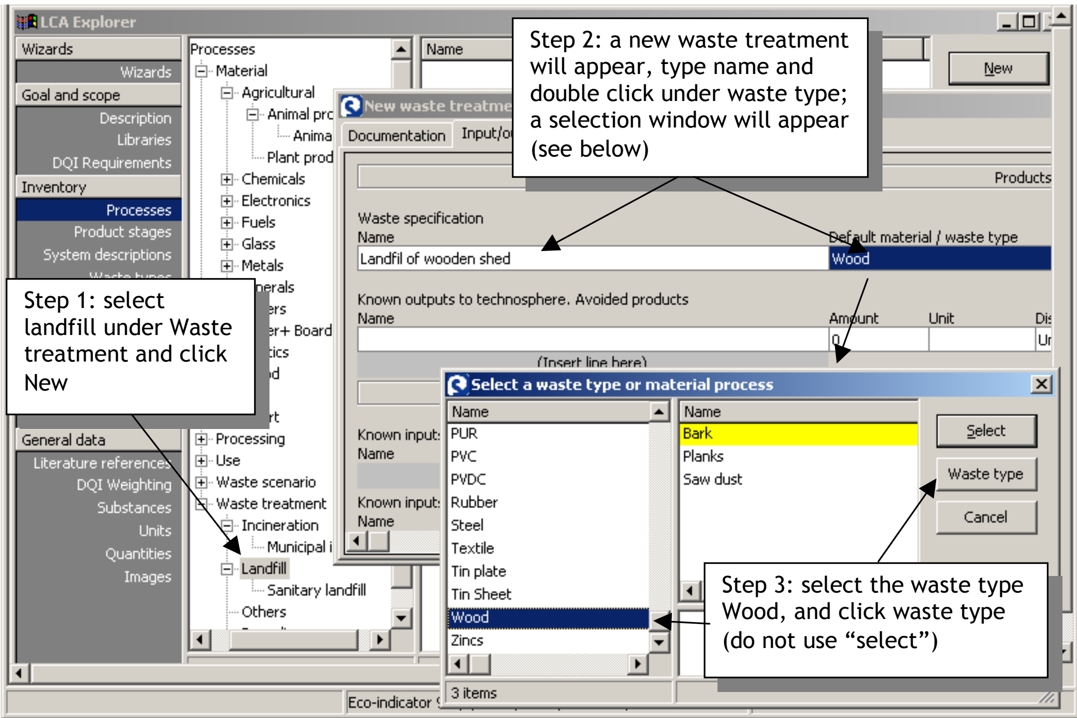


Figure 14 Entering the input to a waste treatment process, and specifying for which waste type this process is valid

- Step 1: Go to waste treatment and take the landfill category; click on the 'New' button on the right hand side to create a new and empty process.
- Step 2: Enter the name of the waste scenario 'landfill of wooden shed'. Please note that this is the name referring to the input and not to the output of the process. Enter 1 kg as amount of this sheet. In a waste treatment the input determines the use of the process.
- Step 3: Now double click under "Def. material/waste type", to get another selection box. Here you define for which waste types this process is valid. Select wood from the list of already defined waste types. You will note that "our processes" plank, sawdust and bark will appear in the right hand window, indicating that these processes are defined with the waste type "wood". Click 'Waste type' to select the waste type wood. As the name of this field suggest, you can also choose to make this waste type only valid for one particular material using the 'Select' button. In this way you can also choose to select "planks" instead of the waste type wood.

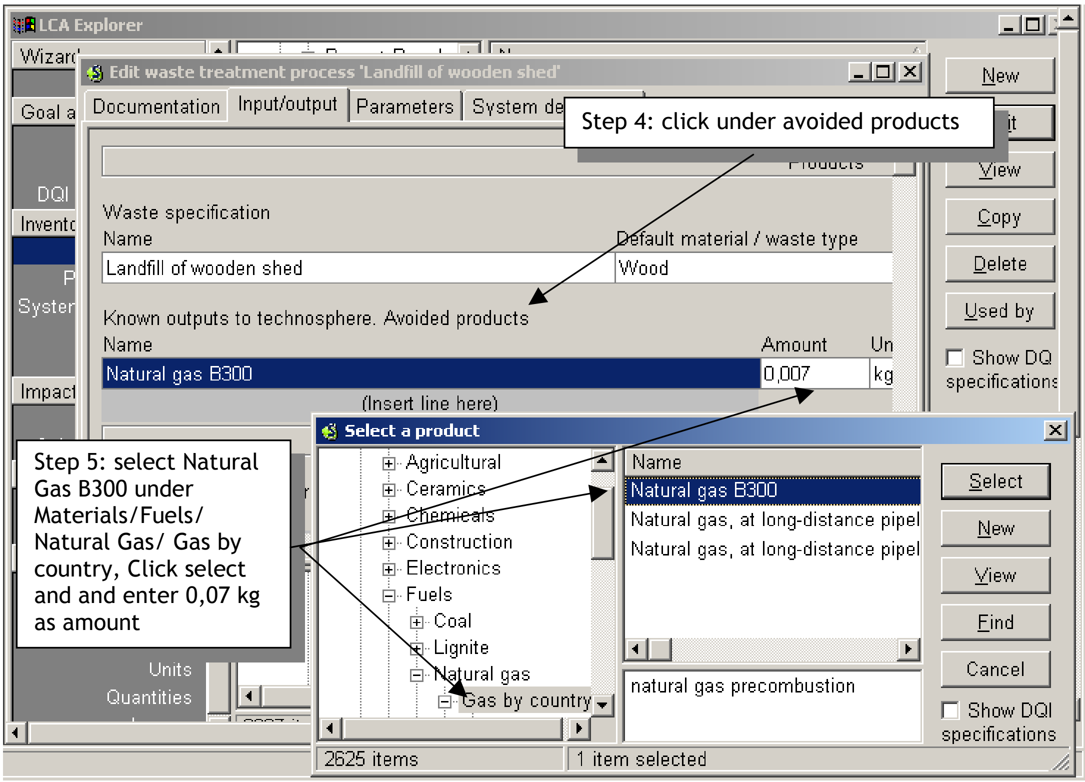


Figure 15: Entering data on the avoided emissions.

- Step 4: Click under Known outputs to technosphere, avoided products. A selection box will appear.
- Step 5: Select Natural Gas B300 from materials/Fuels/Natural Gas/Gas by country. 0.007 kg methane is used for energy production, and her we assume we may interpret this in such a way that one may assume less natural gas needs to be produced elsewhere
- Step 6: enter in materials/fuels the transport for the distance between the municipal waste collection centre and the landfill (16t truck). To transport 1 kg over 20 kilometres, we need a transport amount of 0.001 ton x 20 km = 0.02 ton-kilometre.
- Step 7: now enter the emission of the methane that is not collected (0.02 kg) and the total CO2 (0.5 kg).

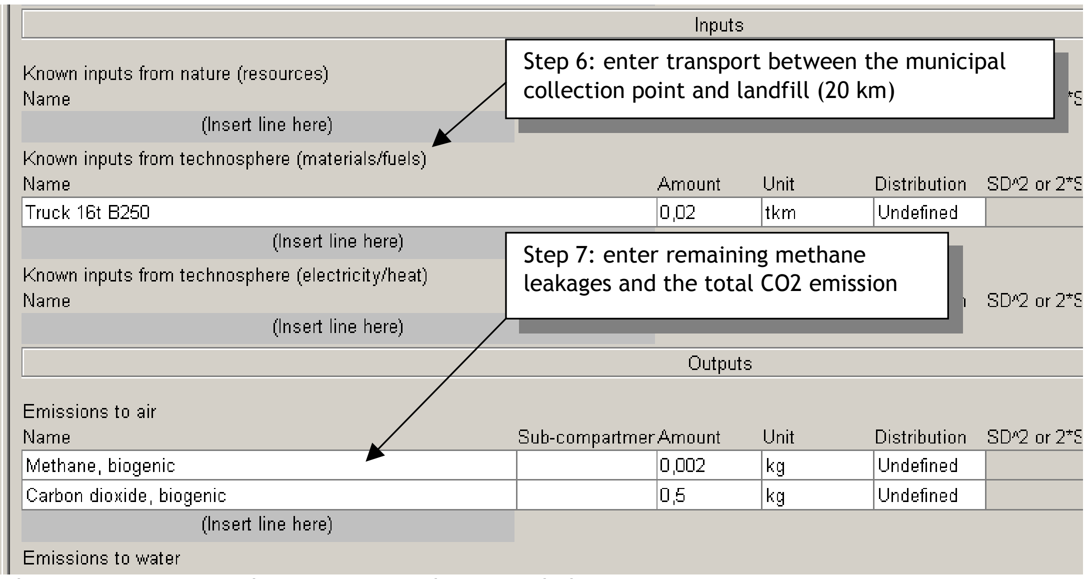
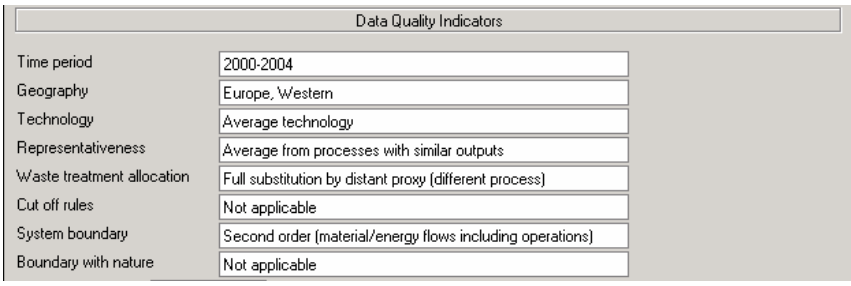


Figure 17: Entering transport and some emissions

You could also specify some remaining waste under final waste flows, but if we assume that all the wood will be decomposed, we do not have to do this, as there will be no remaining waste on the long term. Some practitioners do also register the 1 kg of landfilled waste, because they want to report the short-term waste problem. The choice is up to you.

You can now document the record, using the documentation tab, as we have described before. There is now one new data quality indicator: Waste treatment allocation. Here you can specify that we do indeed use full substitution (see figure 18).



Data Quality Indicators

Time period	2000-2004
Geography	Europe, Western
Technology	Average technology
Representativeness	Average from processes with similar outputs
Waste treatment allocation	Full substitution by distant proxy (different process)
Cut off rules	Not applicable
System boundary	Second order (material/energy flows including operations)
Boundary with nature	Not applicable

Figure 18: the data quality indicators for this waste treatment

You can close the process and check the tree or network again.

4.3 Modelling the impacts of the open fire

In case of the open fire, the waste treatment is a bit easier to enter. We assume no useful by-products that result in avoided emissions. If a well-designed wood stove would replace the open fireplace, we should model the savings on the central heating as an avoided product.

Go to the category Incineration and create a new waste treatment record. Please fill in the record for the open fire as in the example below (figure 19). The airborne emissions come from the Dutch emission registry (not all emissions are entered).

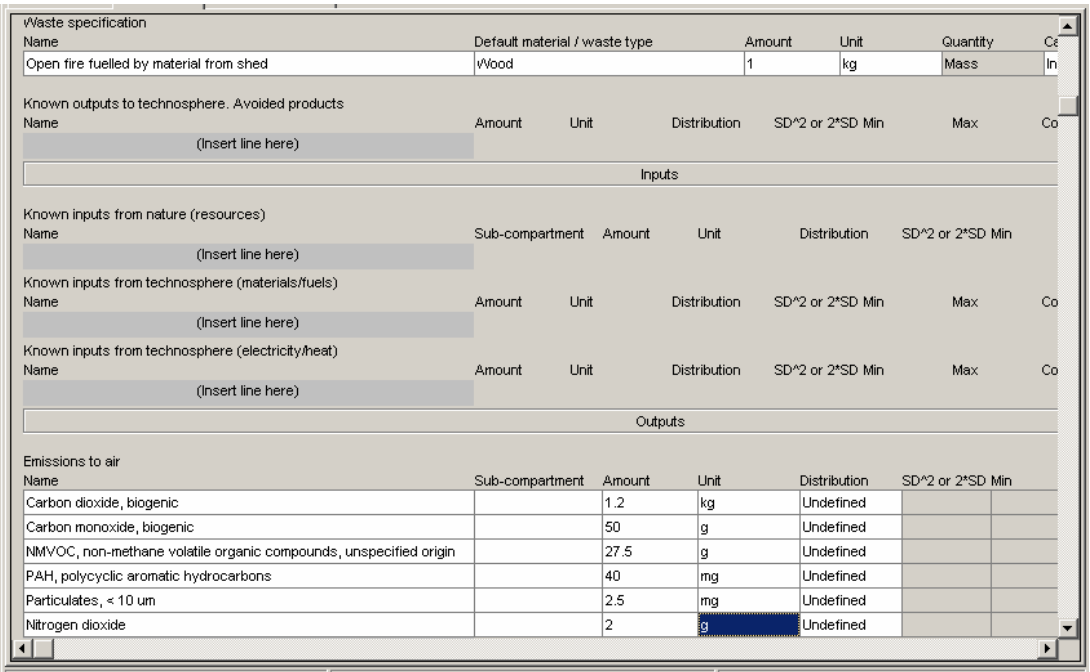


Figure 19: Entering the data for the open fire place

You can now also document this record, as we have done in the earlier processes.

4.4 Waste scenarios

Now we have created the waste treatments, we can specify the waste scenarios. The scenarios describe how much of the waste goes to which treatment. We need three scenarios:

1. One for landfill
2. One for the open fire
3. One that splits up the waste between open fire and landfill

4.4.1 Waste scenario for landfill

As mentioned above, in real life, the material send to landfill is not split. However, for the modelling it is very useful to use a waste scenario as a 'splitter' to ensure wood is sent to the waste treatment for wood, while nails and other metal parts are sent to an already predefined waste treatment for steel.

Go to Waste scenarios (in the processes menu) and sub category Landfill, and click ‘new’ to get an empty waste treatment record, now we can fill in the data:

Step 1: enter the name of this scenario and the amount
Step 2: click in the one but lowest white square as indicated in the figure below
Step 3: select the landfill waste treatment we just created
Step 4: select the waste type “wood” as we have done before and enter 100%
The data we just entered will be interpreted as follows: All wood coming into this waste scenario is send to the waste treatment record “landfill of wooden shed”.

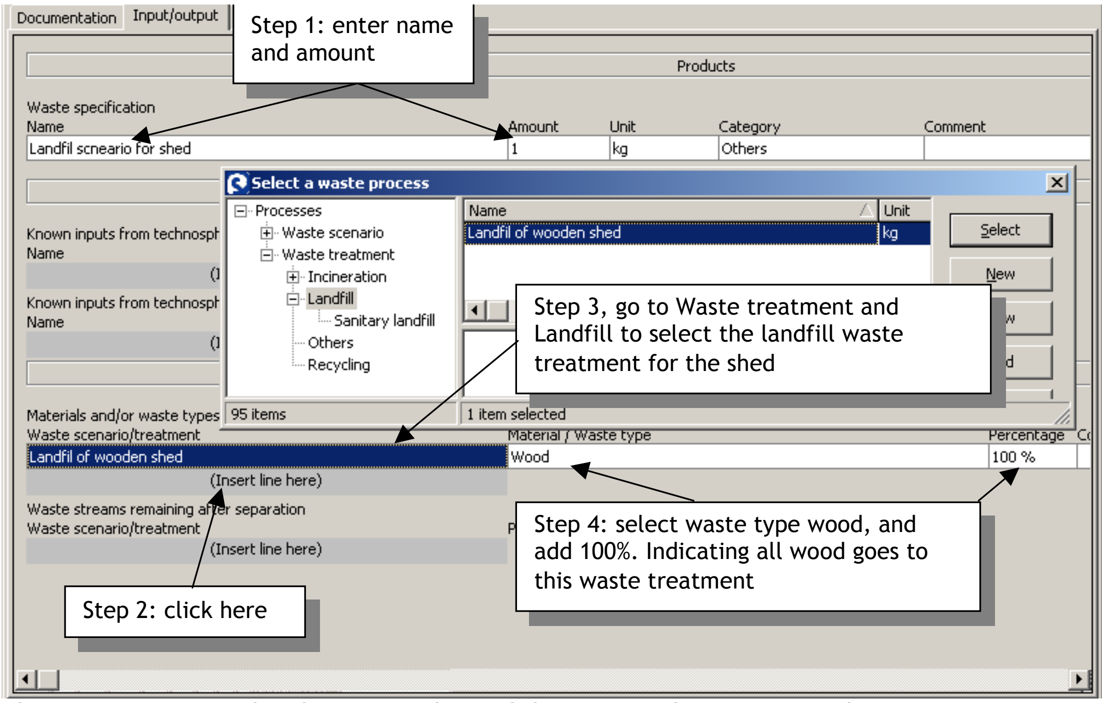


Figure 20: *Entering the name and one of the outputs of a waste scenario*

In the same way, we can now enter the destination of the metal parts. An unfortunate complexity is that in the Buwal library two waste types for steel are used; one for ECCS steel and one for tinned steel. As we have not yet decided, which steel will be used, it is safe to include both steels. As a rule, it is better to include all waste fractions, but in this example, we will stick to using only wood and the two steels.
We do not have to predefine a waste treatment for the steel, as that is already available in the Buwal library.

The following figure shows how you can enter the rest of the data.

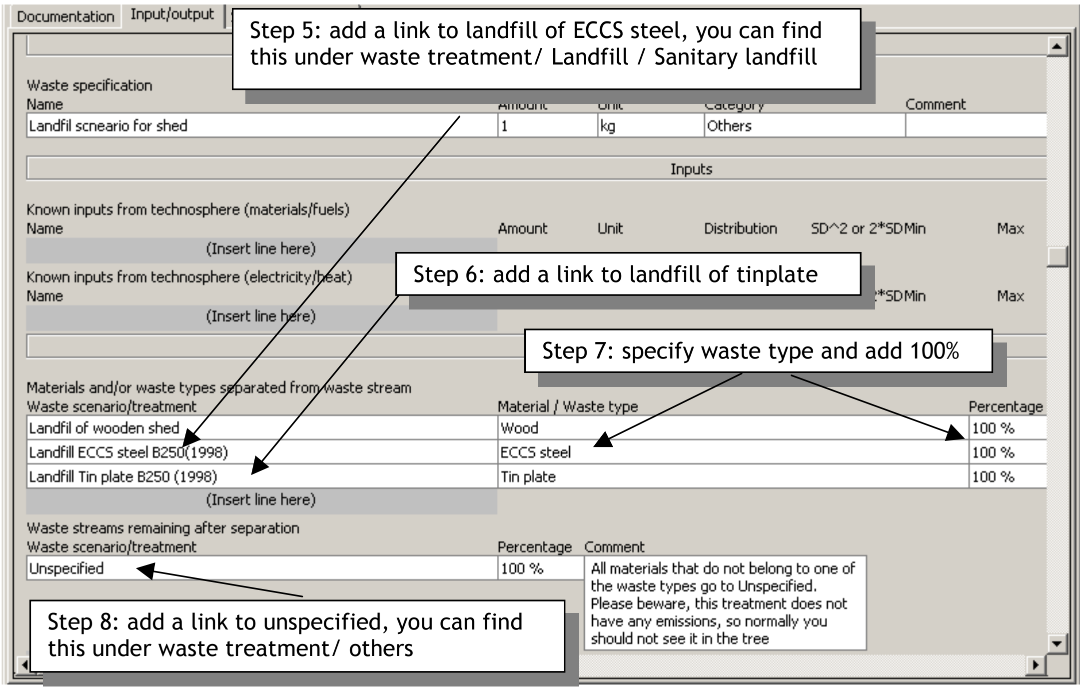


Figure 21: Entering the other outputs of the waste scenario

You can now enter the documentation of the process, as described earlier.

What has been realised now?

All wood that enters this record is sent to the landfill of wooden shed treatment. All metals with the waste type ECCS steel, is sent to the landfill of ECCS steel waste treatment and all metals with the waste type tin plate, is sent to the landfill for tinned steel. All other materials are sent to the waste treatment ‘Unspecified’.

4.4.2 Waste scenario for the open fire

Go to the waste scenario category Incineration and create a record as below. For the steel, we use already predefined records. Here we have used the 1995 version. Buwal also provided a 2000 version. Of course, these waste treatments are not representative for an open fire, but as the amount of steel is low, so for the time being, this is acceptable.

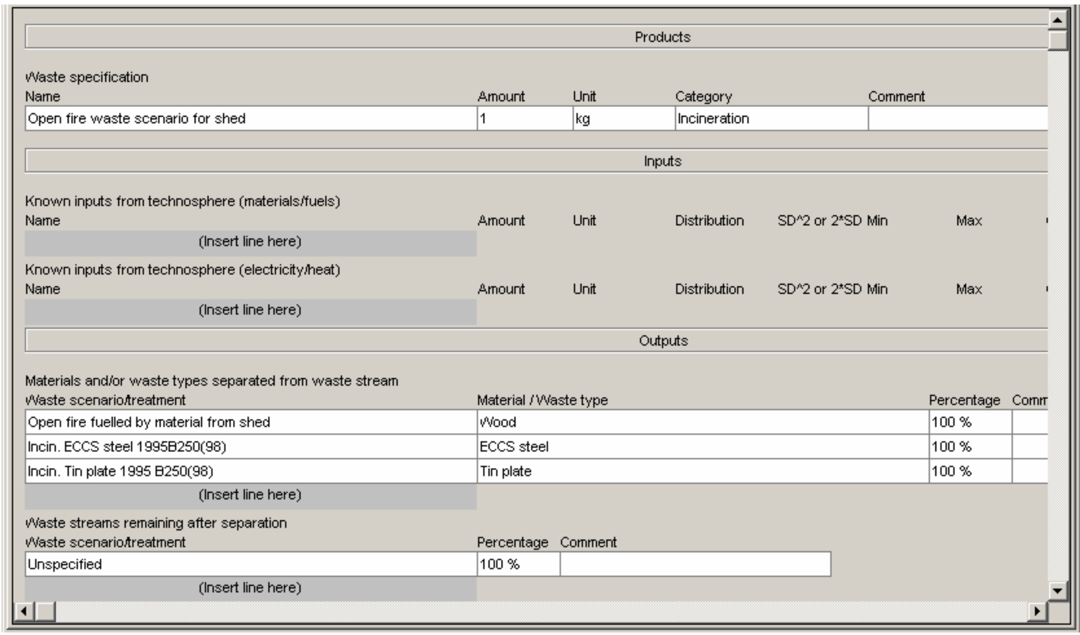


Figure 22: the waste scenario for the woodstove

You can now enter the documentation of the process, as described earlier.

4.4.3 Waste scenario for splitting waste stream

Finally, we develop a waste scenario that splits the waste stream in two:

1. 40% is used in open fires
2. 60% is sent to the landfill

This waste scenario can be made in the category Others. It is relatively easy to make, just follow the steps in the figure below.

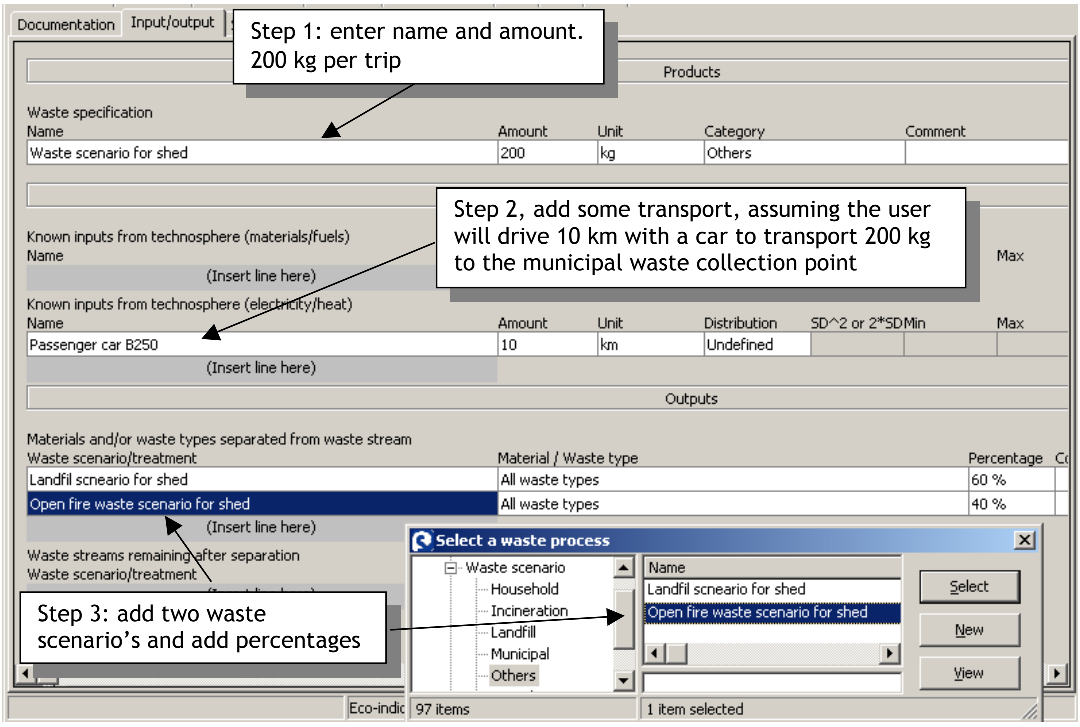


Figure 23 entering the waste scenario that splits the waste over landfill and open fire places

In step 2 we add the transport between the home and the municipal waste collection point. The mass specified in the top line refers to the inputs from technosphere, such as in this case the car.

Please note that in step 3 of this scenario, we do not specify any waste types. We just added percentages to specify how the waste is divided over the different treatments.

You can now enter the documentation of the process, as described earlier. Upon closing the record, SimaPro will warn you that nothing has been specified for the remaining waste. In this case, you can ignore this, as all waste types are sent to the specific waste treatments.

> You cannot get an overview of the waste scenario with a tree. SimaPro does not know yet which materials will be in the waste stream. We first have to define the life cycle and the input to the waste stream. After we defined the life cycle, we can see the structure.

5 Lesson 2c Enter a complete product life cycle

Overview	
What you will learn	Using the process records on planks developed during lesson 2a and the waste scenario in lesson 2c, we will now develop a complete life cycle of a simple wooden shed. Now you will not work with processes, but with so-called product stages, like assemblies and life cycles.
Required entry level	Lesson 2a and 2b should be completed first, although it is possible to skip 2c. In stead you use a standard waste scenario. But the results will differ from what you will see in this tutorial.
Recommended reading	Introduction to LCA with SimaPro. Chapter 8 gives some of the backgrounds. It is recommended, but not essential to read this. For the parameter example we recommend to read chapter 10
Project needed	Tutorial with wood example
Approximate time needed	45-60 minutes.

5.1 Introduction

Now we have seen how process trees are build up in SimaPro. We created a process that describes the impacts of making planks. On the other hand, we prepared waste treatments and scenarios.
The next step is to describe the product and its life cycle. SimaPro uses a different type of record to describe products and life cycles, the so-called product stages. The product stages do not contain environmental information, but the refer to processes like the one we defined. In this tutorial we will use 2 out of the 5 available product stages:

- The assembly is used to describe the shed
- The life cycle describes the use and links to the waste scenario

The three other product stages are not explained here; they are useful if you want to define relatively complex disassembly and reuse scenarios.

5.2 The assembly product stage

The following steps show how to enter the following data:
- The shed is made of 150 kg planks.
- About 2 kg of steel parts are used for nails etc.
- The consumer picks up the wood with his or her private car, and drives on average 5 km to and 5 from the shop; we disregard the possibility that other things are purchased on the same trip, which would require some form of allocation.

All 11 steps needed to create the assembly are specified in the following figures.

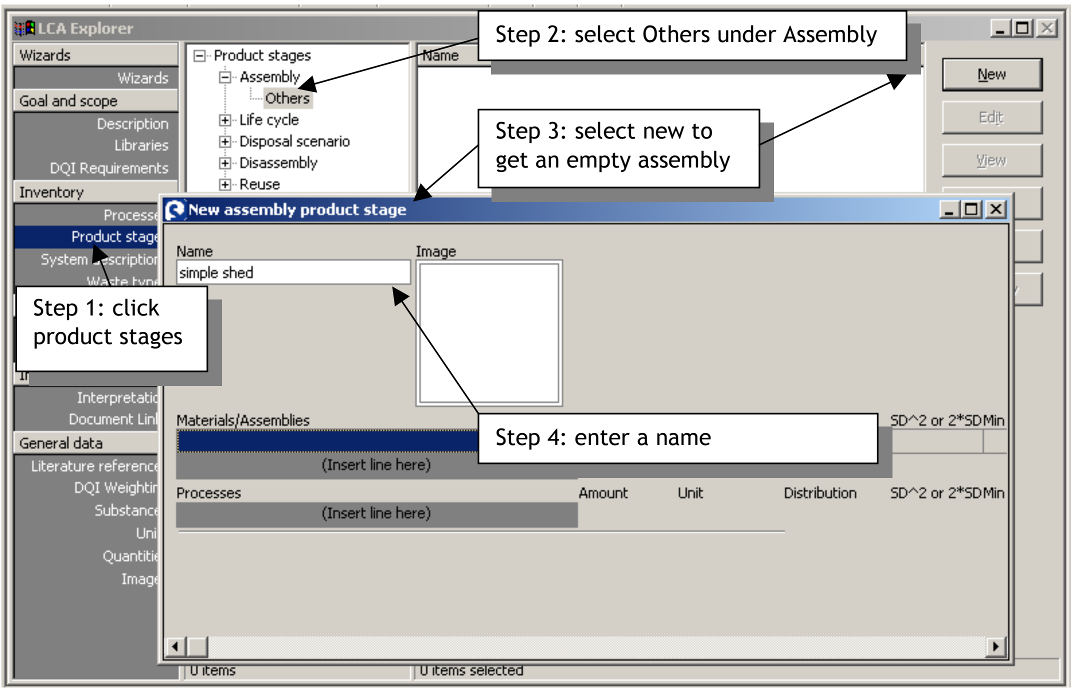


Figure 24: Creating an Assembly and defining the name

In the next figure, we will link the assembly to the plank process. Please note that in step 5, where you click in the white square under materials/subassemblies, you get the choice between entering materials and subassemblies. This shows that you can also create subassemblies, which is very useful for more complex designs. For instance, we could create a separate subassembly for a window or for a door, a floor, or if you want for a table (all with different specifications).

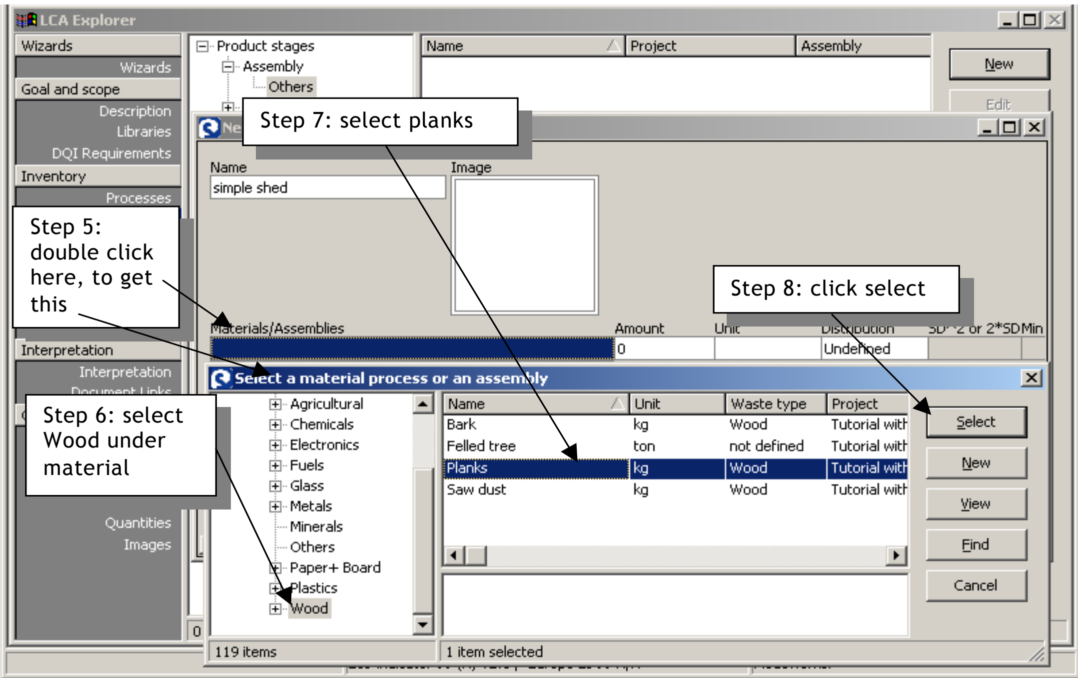


Figure 25: Entering the link to the planks

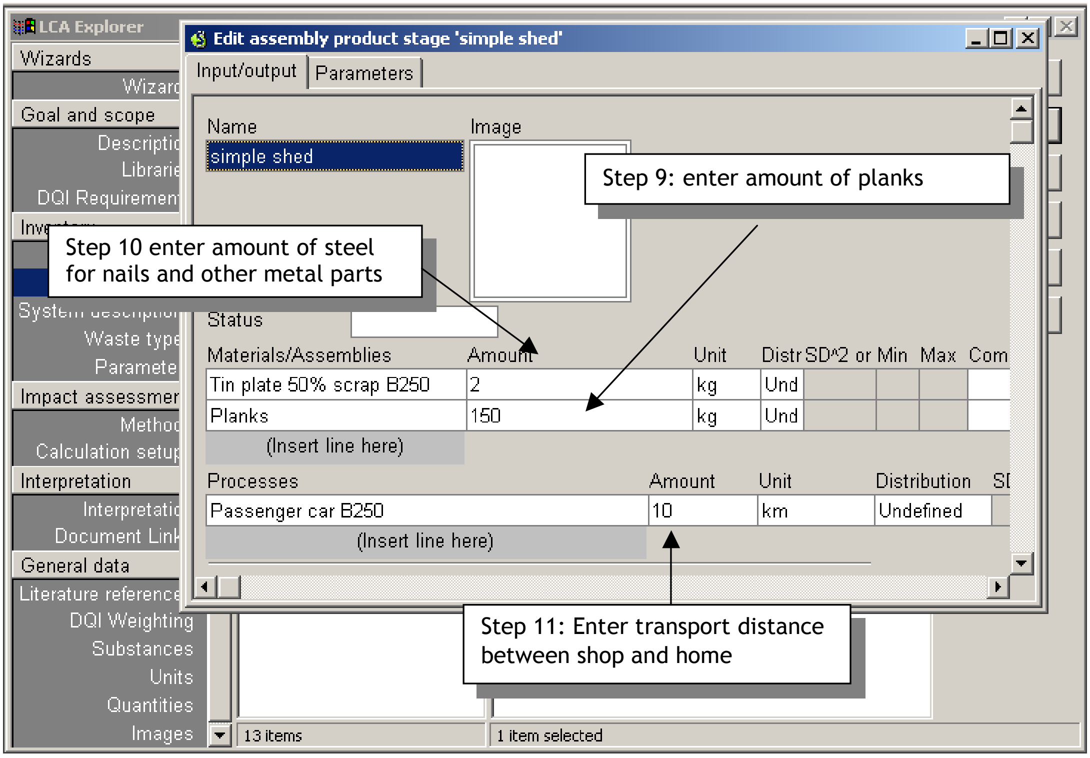


Figure 26: Finalizing the assembly

You cannot set data quality specifications in an assembly. After step 11, you can save and close the assembly.

5.2.1 Inspecting the network

To get an overview of what you just have been modelling, we suggest you click the  button to present the network. SimaPro will give you a warning that not all processes are shown. It calculates a cut-off level in such a way that only the 12 most important processes are made visible. The processes that contribute less than that level are not shown (although their contribution counts in the result of course). You can still see the planks, but the felling of the tree and the chain saw are not visible. If you adjust the cut-off, you can make these visible too.

In the figure below, the line thickness is set to express the environmental load of the flow, in this case also expressed as Eco-indicator 99 score. You can toggle this function on or off, using the indicated button.

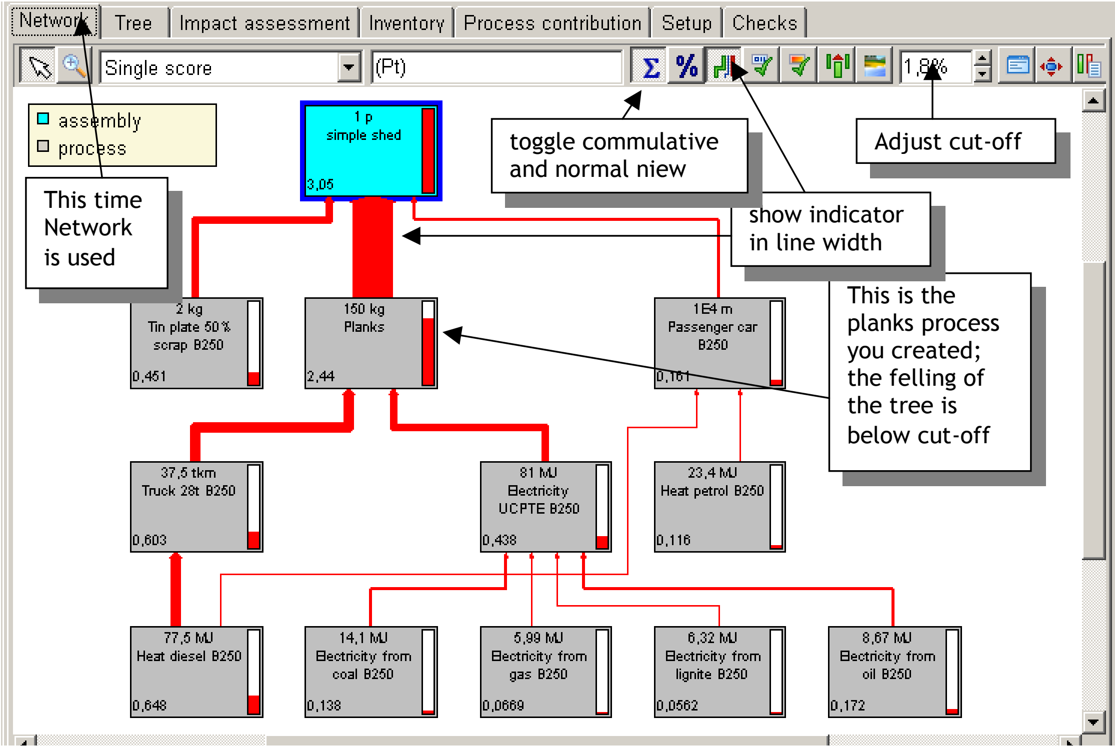


Figure 27: Inspecting the result of your modelling. Note that not all processes are shown

5.2.2 The product life cycle

The product life cycle is created in the same way as an assembly. Only three steps are needed:

Step 1: open a new life cycle and add a name
Step 2: make a link to the assembly. A life cycle can only contain one assembly
Step 3: make a link to the waste scenario. A life cycle can only contain one waste scenario, or one disposal scenario.

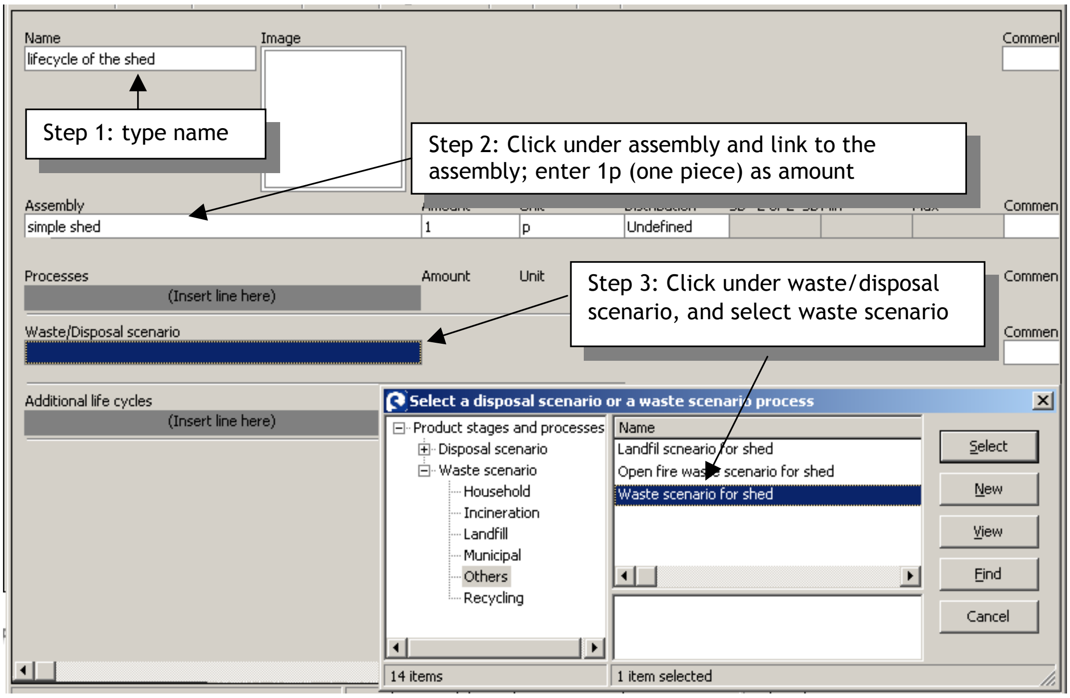


Figure 28: Life cycle of the shed; here the assembly is linked to the end of life

5.2.3 Inspecting the process structure

Now we can get a complete overview over the life cycle, and we can see the end of life scenario, by clicking the tree or network button. Again not all processes are shown, but we can clearly see the assembly (blue) and the life cycle (yellow) and the disposal part.

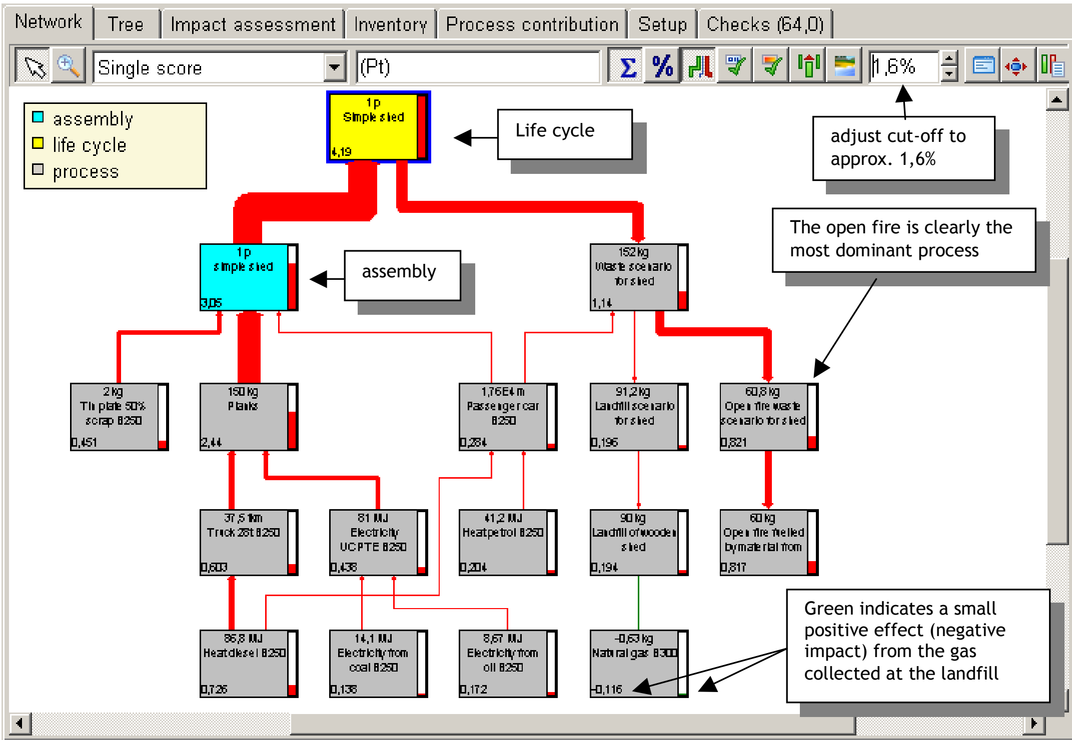


Figure 29: Inspecting the results of your modelling; the life cycle overview

5.3 A parameterised shed

Instead of using fixed dimensions for the shed, SimaPro can also store the dimensions as parameters. In this paragraph we show how this can be done, and how you can use this feature to quickly analyse the impact of changing dimensions.

At the Assembly, defined in paragraph 5.2, we simply added the total mass of wood needed. Of course this amount of wood depends on the dimensions of the shed. The table below lists the dimensions that basically describe the shed.

Dimension	Value	Unit (remark)
Width	3	Meter
Length	2	Meter
Height	2	meter
roof_slope	0,5	slope expressed in radials (57,3 degree =1)
roof_overhang	0,2	meter (the roof is larger than the walls)
wall_thickness	0,0022	m3
sp_mass_wood	800	kg/m3
roof_thickness	0,003	meter

With these parameters, SimaPro can do a number of calculations, like:
The wall surface, that can be calculated as twice the front and back wall (2 x height x width) plus the two side walls (2 x height x depth). If the roof is sloped, we can also add the triangular parts just under the roof. The size depends on the roof angle, and those who remember the old formulas know that you need to calculate the tan(roof angle) to get to the surface of that area.
In fact the angle also determines the roof area, and for this you need to know the cosinus of the roof angle.

The table below summarises the calculations SimaPro can do for you; it calculates the surface of roof and walls, it can calculate the volume of the wood needed and the mass of the wood needed.

Result	Formula	Remark
wall_surface	2*width*height + 2*length*height + 2*width*tan(roof_slope)*width = 29,8	the last part refers to the triangular part of front and back, under the roof
roof_surface	2*(length + 2*roof_overhang) * (2*roof_overhang + width/cos(roof_slope)) = 18,3	the size depends on overhang, roof sloop, length and width
wood_volume	wall_thickness * wall_surface + roof_thickness*roof_surface = 0,121	m3
wood_mass	wood_volume * sp_mass_wood = 96,5	kg

To enter these data and formula, please make a new assembly, and go to the parameter tab. Here you can enter the data and formulas as below.

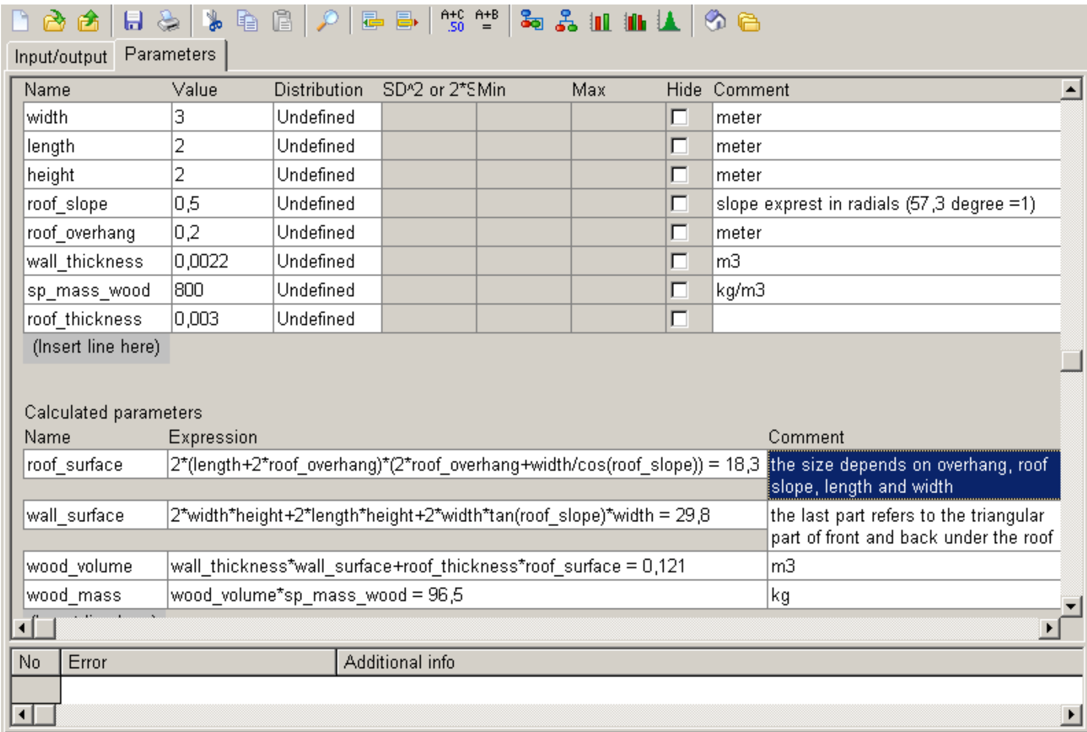


Figure 30 Parameters that describe the size of the shed, and a number of formulas that determine surface, volume and mass

Please in case you make a typing error, you get a message in the window in the bottom. In the section with calculated parameters, do not add the equal sign and the calculated result. SimaPro will do this for you.

Next you can go to the input/output tab of the assembly, and enter the data below. In this example we also added a tinplate roof and a layer of paint. The surface of the roof and the walls are also parameterised, and will also change with changes you make in the dimensions.

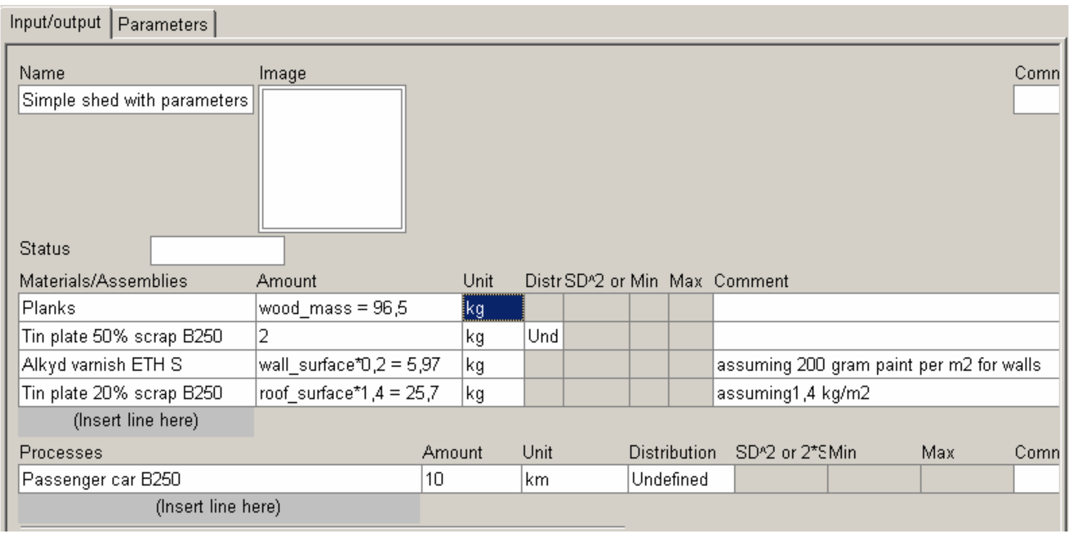


Figure 31: More sophisticated assembly of a shed. The amounts of material are calculated using parameters; a roof and paint is added

Once these parameters are defined, you can now very easily determine:

1. the total amount of wood that will go into the shed
2. the surface that needs to be painted
3. the amount of roofing material needed

This way of developing the shed has the big advantage that, by changing just one or a few parameters, you can analyse many different versions of the same product, and find out the most optimal solution; in paragraph 6.3 we will also show, how you can make comparisons for alternative shed designs using the parameters.

Further sophistication

In general planks come in standard size width and length. If you design a wall with a length of 2 meter, while a standard length is 2.10, you loose 10 centimetres, or 5% of each plank. If you design a 1.90 meter wall you lose even more.
In SimaPro you can calculate how much you loose by taking the “modulo” of the designed wall length and the nearest standard length. The modulo is the part of the result of a division you could also do this for the roof panels and the width of the planks.

6 Lesson 2d: Analysing some of the results

Overview	
What you will learn	How to generate result screens and how to interpret them. How to perform a basic sensitivity analysis
Required entry level	Lesson 2a, 2b and 2c should be completed first, If you have skipped 2b and used a standard waste scenario; the results will be different from the results in this tutorial.
Recommended reading	Introduction to LCA with SimaPro, Chapter 4 and 5 must be read
Project needed	Tutorial with wood example
Approximate time needed	45-60 minutes.

6.1 Inventory (LCI) results

So far, we have analysed the tree as an intermediate check of our work. Now we will discuss a few of the other outputs. We only show a few of the many possibilities and we suggest you experiment yourself. If in doubt about the meaning of a window, click F1 to get online help.
To get the inventory results, select the life cycle product stage and click the analyse button, and click the LCI results tab.

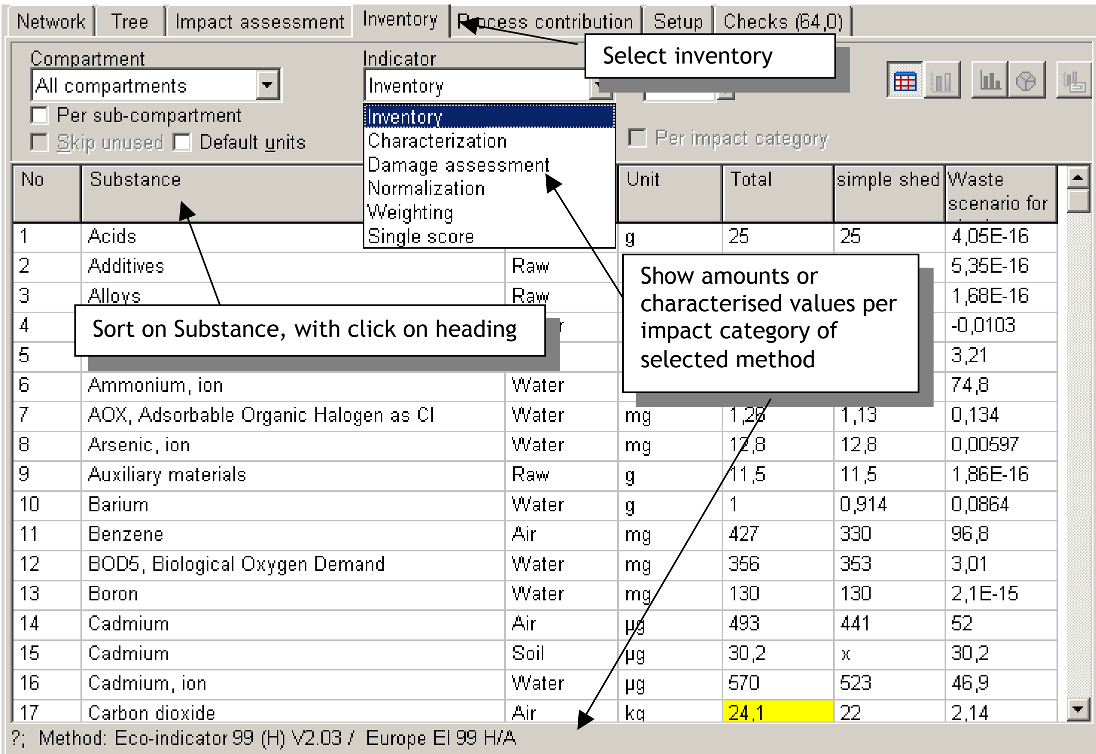


Figure 32: Inventory (LCI) result window

The LCI window has many different features. In fact, you can also use it to show characterized results.

6.2 Impact Assessment (LCIA) results

Apart from using the tree, we can use the LCIA results button, while you have selected the life cycle of the shed, to get a graph as below.

In this graph, we see the characterization result, and a specification of the production of the simple shed (in blue) and the waste scenario of the shed (in yellow). It shows that the production is dominating in some impact category, while the end of life is dominating others. It also shows that there is no data on land-use, which is of course strange, as forests do need land. For simplicity, we left this out, but obviously the damage to land use should have been entered in the "felling a tree" example.

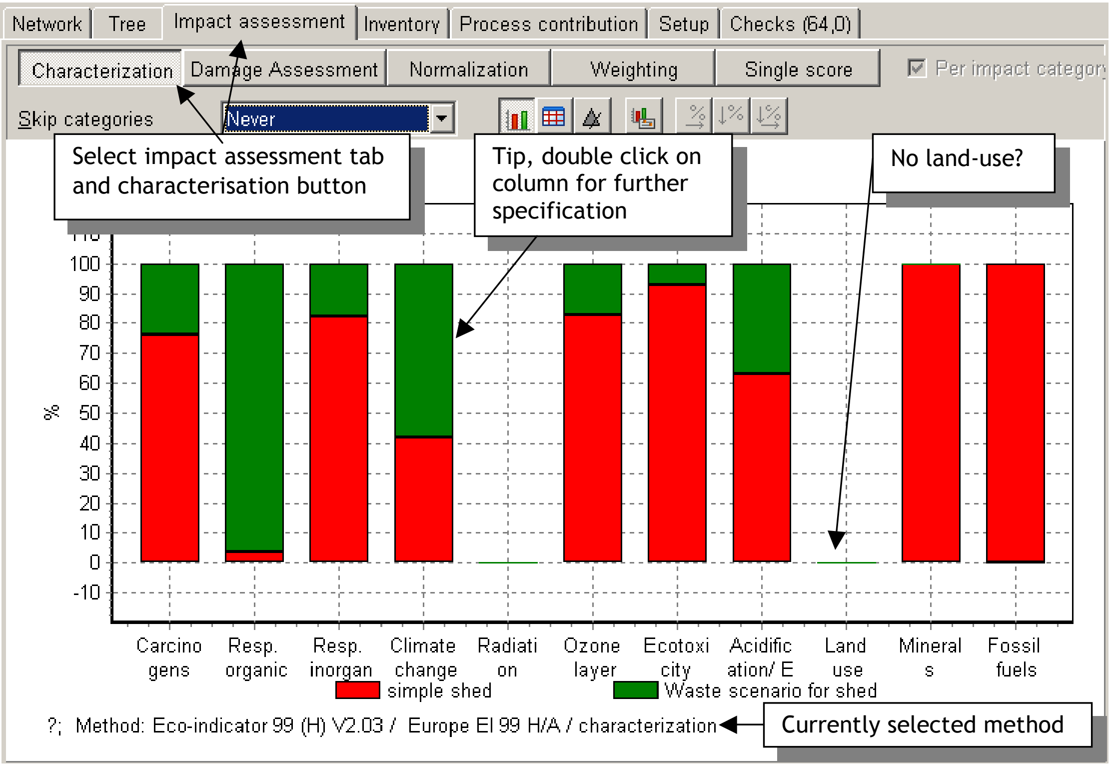


Figure 33: Results of the characterisation step; all impact scores are displayed on a 100% scale; The colours indicate the contribution of production and waste

You can also view your results using another method. To change to a new method, follow the three steps in the window below. We suggest you try different methods, and see if these would lead to different conclusions. The SimaPro database manuals give you an overview of the characteristics of the methods.

If you want to change a method, always copy the method to your project first, and make the changes in the copied version. This will keep your libraries clean.

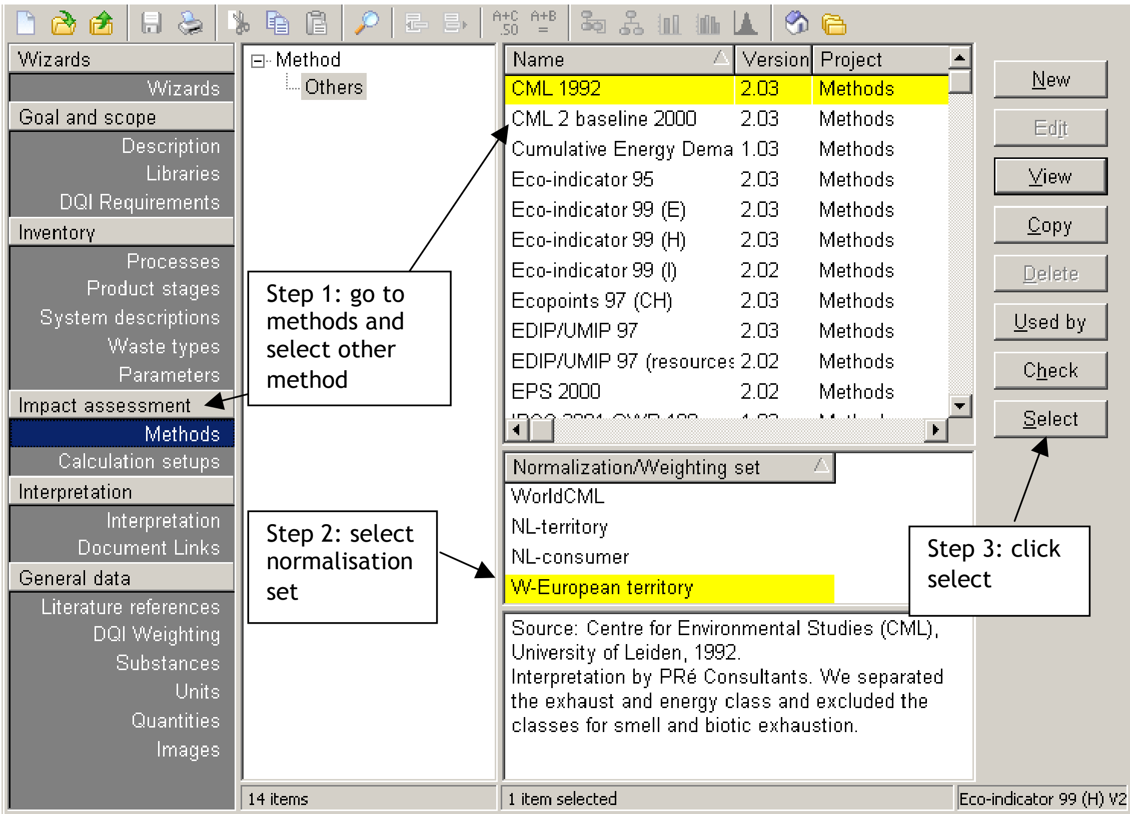


Figure 34: Selecting an alternative impact assessment method

6.2.1 Inspecting the complete network

We can get a complete view, by lowering the cut-off value to zero while you have figure 29 on the window. You can produce a figure as below by setting the desired zoom level (parts of the tree may be outside the window) and use the copy command under Edit, or the Export command under File. The BMP format works best with most software packages.

We are now able to analyse all processes, from cutting the tree to the disposal processes. The saw mill thermometers give the contribution to the environmental load. The line thickness also indicates the total environmental load flowing between processes. Red means an environmental load, green means a negative environmental load, or in fact an environmental benefit.

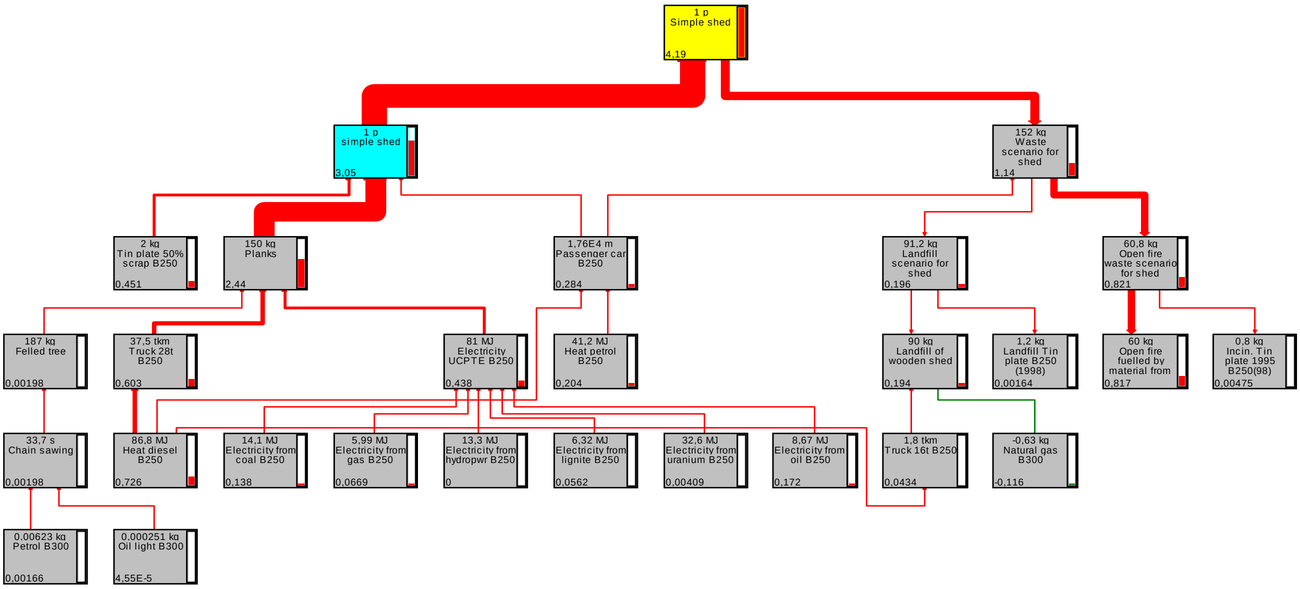


Figure 35: Overview of the complete life cycle presented as a network (all processes shown, cut-off= zero)

6.3 Using parameters for sensitivity analysis

6.3.1 The impact of the allocation principle

In paragraph 3.4.1 we choose the mass allocation principle for planks and sawdust and the bark. We discussed different allocation percentages, based on mass and economic allocation. Switching between two types of allocation can be done by changing the allocation percentage, but you can also make a switch using parameters. The benefit of this procedure is that it becomes very easy to see how important the effect of the allocation choice is.

Below we show how you can redefine the process record with the planks. In the new version, you can change the allocation basis with a simple change of a parameter.

There are many ways in which we can define parameters, but in the example below we define an input parameter “use_econ_all”. If this input parameter is equal to one, it means we want to use economic allocation, is set to zero, it means we want to use mass allocation.
We also define a calculated parameter called “use_mass_all”. This parameter is calculated by SimaPro using the formula:
use_mass_all = 1 – use_econ_all
This simple formula let the mass allocation parameter become equal to one if the economic allocation gets the value zero, and vice versa.

To define these parameters, please reopen the process that defined the planks sawdust and bark, and now click on the parameter tab at the top of the screen. Now enter the formulas as indicated below.

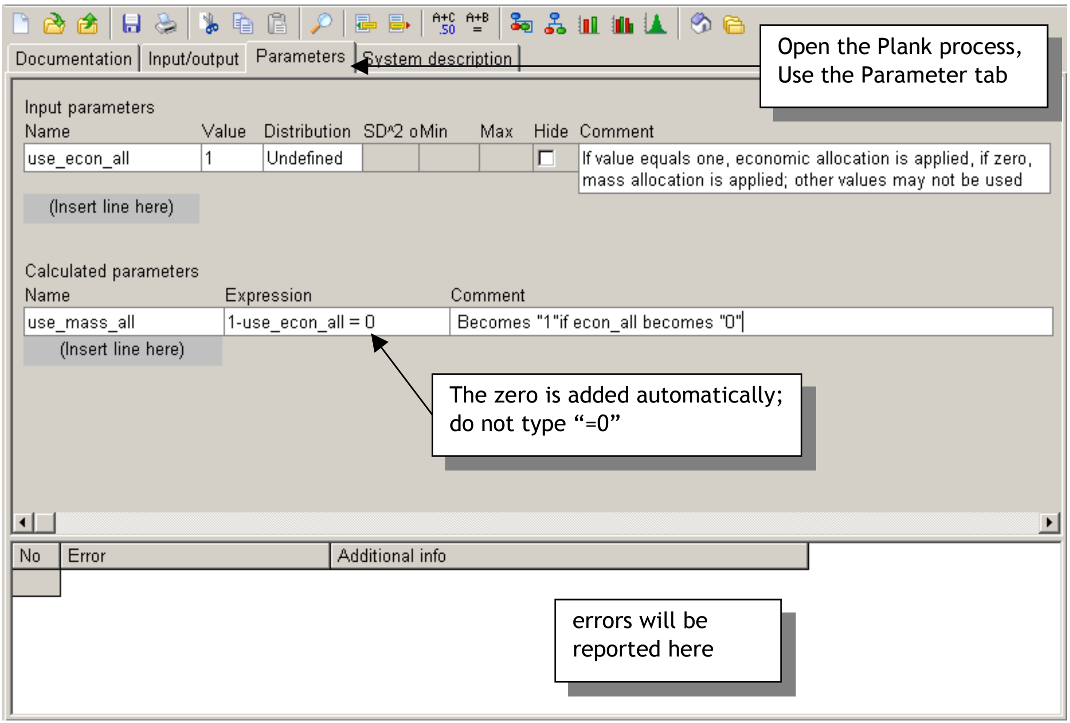


Figure 36: Defining an input and a calculated parameter

Now go back to the input/output section by clicking on the input/output tab. Instead of the fixed percentages for the allocation, you can now enter three other formulas.

For the allocation percentage for planks you enter:
80 * use_econ_all + 60 * use_mass_all.

If you set use_econ_all to one, the allocation percentage will become equal to 80%, if you set use_econ_all to zero, the value for use_mass_all will become one, which means the allocation percentage will become equal to 60%.
For the allocation to sawdust you can enter an equivalent formula, as shown below. For the allocation to bark you can make a simpler formula. In economic allocation the allocation percentage is zero.

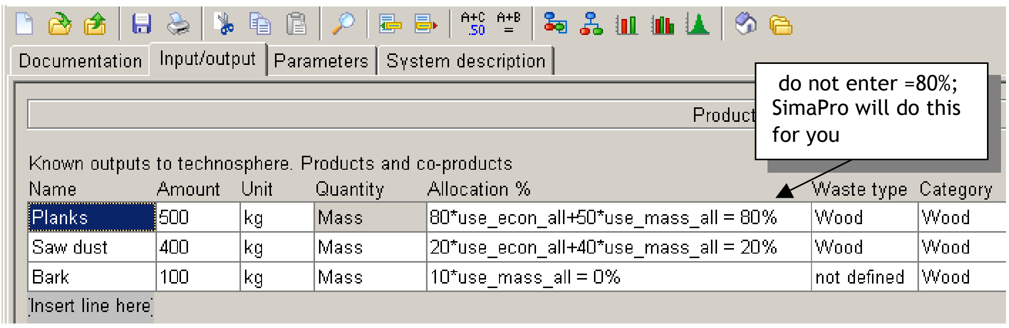


Figure 37: Using the parameters to calculate the allocation percentages

6.3.2 Comparing the impact of alternative allocation principles

SimaPro 7 has a powerful feature that lets you compare two parameter settings. We will use it to compare the difference in environmental load for the two allocation principles.

While you have the planks process selected, click the button. A calculation setup box will appear. At the top, there are three tabs; please select the parameter sets tab in the middle; a screen like the one below will appear; follow the steps.

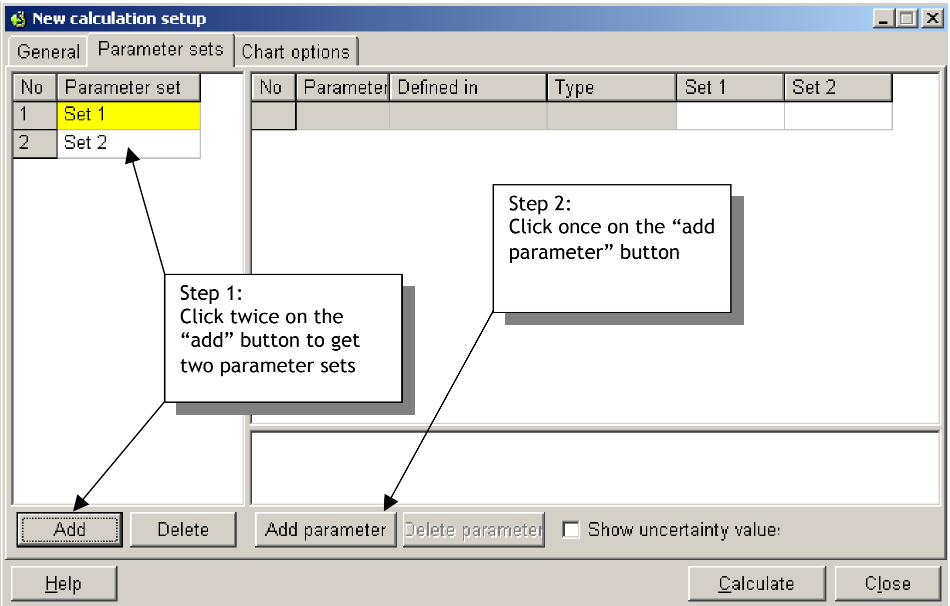


Figure 38: *Creation of two parameter sets*

Next a new screen will appear, from which you can select the parameter you want to use.

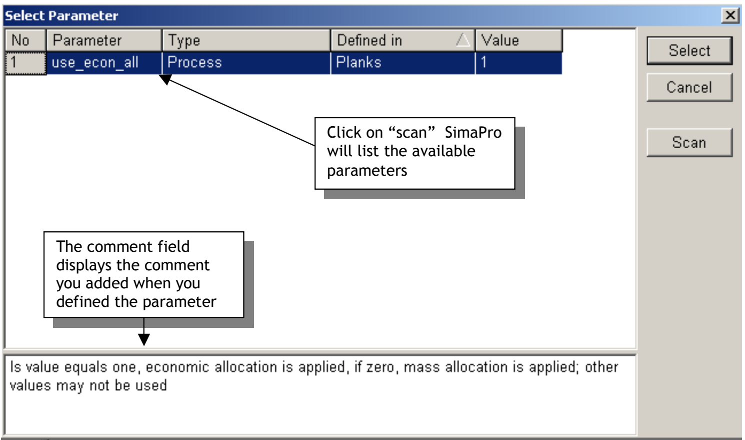


Figure 39: *Selecting the parameter you want to use in the comparison*

After you click “select” a new line is added. For clarification, you should now edit the default names “set 1” and “set 2” at the left-hand side of the box, into something more meaningful, like economic allocation and mass allocation. You will see that these names also appear as heading in the columns on the right-hand side.

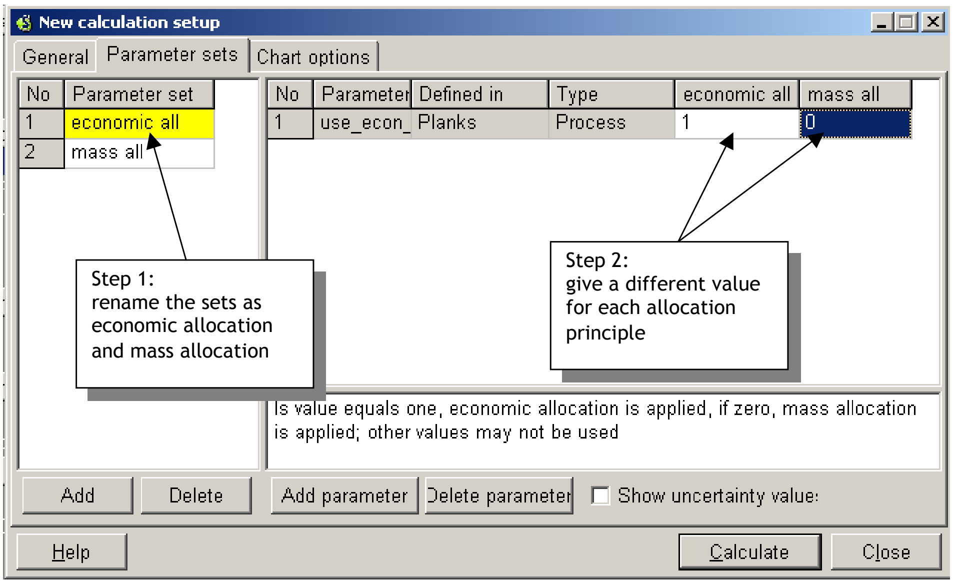


Figure 40: Setting different values for each parameter set

Next you can click the "Calculate" button and now you will see a comparison of the environmental load of plank production with economic and with mass allocation, like in the screen below.

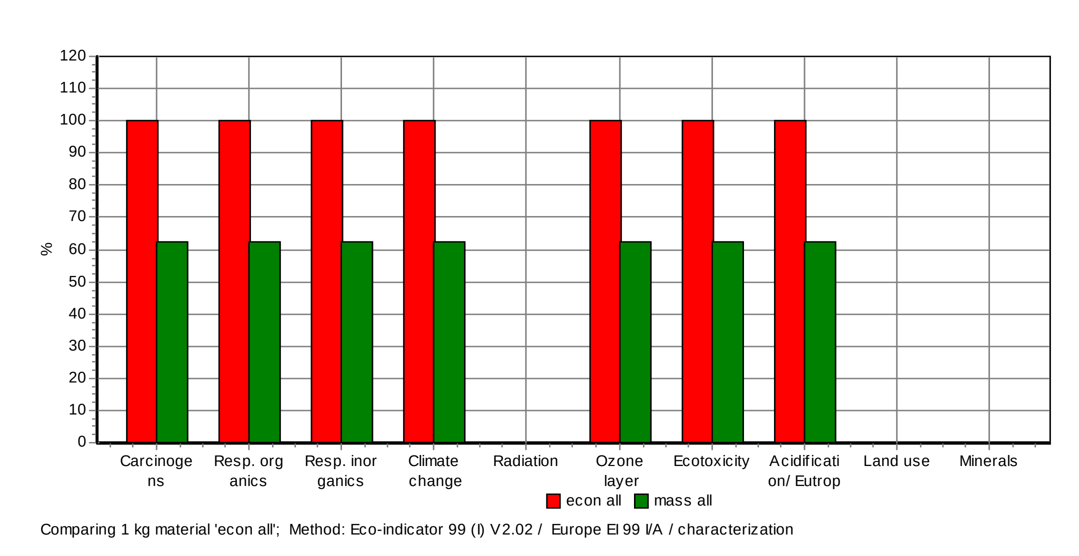


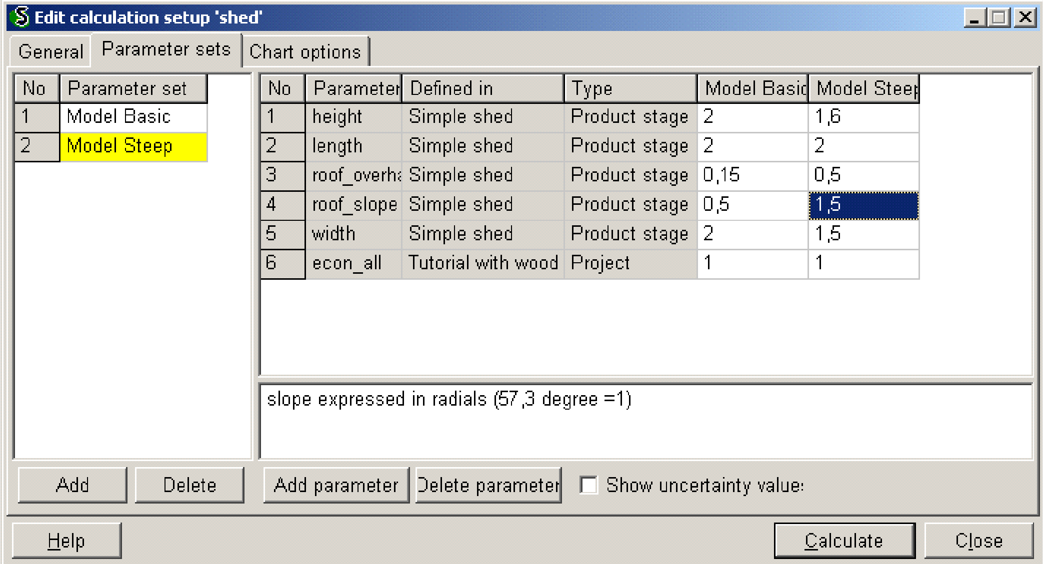
Figure 41: Result of the comparison between parameter sets. The red bars give the impact category indicator scores when economic allocation is used; the green, when mass allocation is used. In this example we use characterisation; the vertical axis is a percentage scale.

The graph shows a comparison between the impacts of a plank with economic and mass allocation. The highest score is scaled to 100%, the lowest is a relative score. In this case the difference between all scores is a fixed percentage of 60/80= 62,5%, as the allocation factor influences all impacts in the same way.

Using parameters to make switches is a really very powerful tool in a full LCA, when there are many allocations you want to switch. Other applications are switches that influence the system boundaries. For instance you could make a switch that determines if the growing of the tree should become part of your LCA. In that case you may want to subtract the CO_2 that is absorbed in the wood. Likewise you may want to set a switch to include or exclude the benefits, such as gas collection from landfills.

Using parameters to compare alternative shed designs

In paragraph 5.3 we demonstrated how you can parameterise the dimensions of the shed. We can use the same principle as described above to compare two or more shed designs using different parameters. If you have made the parameterised set, as described and you use one of the calculation buttons you can define a calculation set-up box as below.



As you can see the parameter for the allocation (last line) is also among the parameters you may want to change.

6.3.3 Contribution analysis

Another way of getting an overview of the results is by using the function "contribution analysis". This feature will help you to get an overview of processes that contribute most to the tot impact of your life cycle.

To make a contribution analysis select your life cycle and click the analyse button , or if you are presently in the inventory window, simply click on the process contribution tab.

- Step 1: Select the tab Process contribution
- Step 2: Click the show chart button
- Step 3: Adjust the cut-off to decrease the amount of processes that is shown in your chart.

In the figure below you can see that the burning of the shed in open fire places contributes most to the total impact of the life cycle, followed by the production of planks (processes in the saw mill). Avoiding energy production with natural gas gives a relative large environmental benefit.

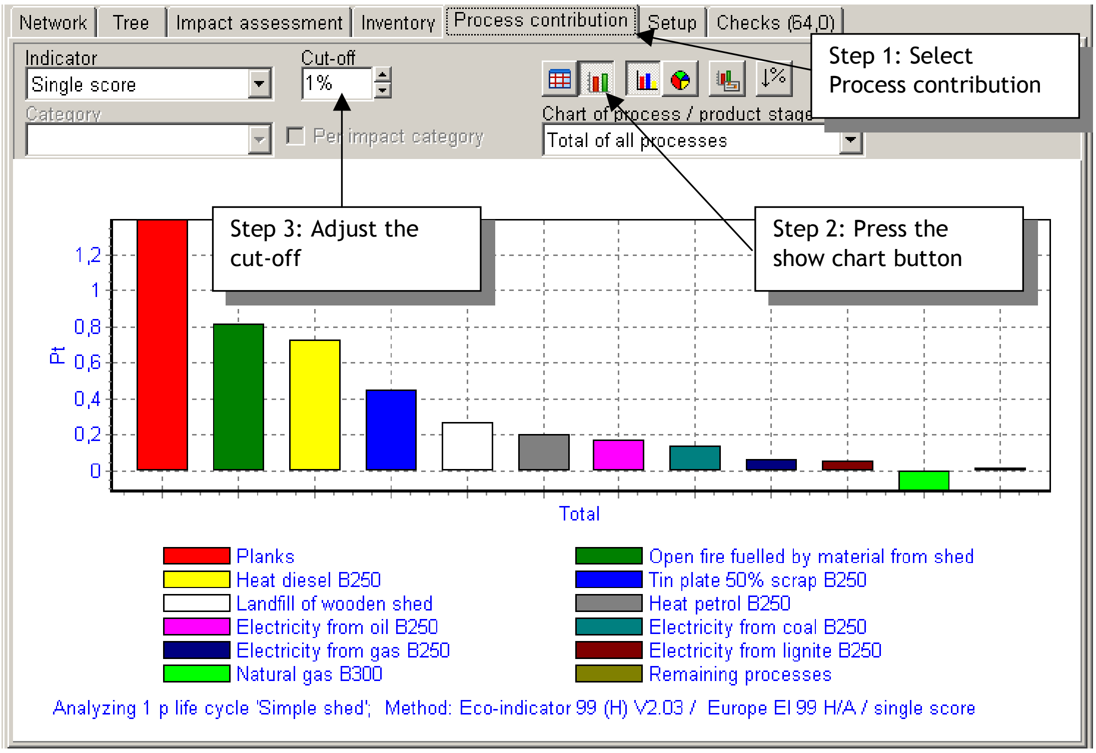


Figure 42: Contribution analysis showing all processes in the network that contributes more than 1%. The total contribution of the processes that are below the cut-off is summarised in the most right-hand column.

6.3.4 Inspecting the details

Finally, we will show one of the most advanced features of the network representation, the "show detail". By clicking the button, you can open a new window in which you can get all results of the process you select in the tree.
The process box you click on determines the content of that window. In the figure below the waste treatment for the open fireplace is selected. You can now see the contents of that record (although you cannot edit the LCI results, the LCIA results, the process contribution and the status of the data quality indicators for the window).

In the figure, we present the LCI results as characterized results, in this case as total indicator score. However, you can also select other impact category indicators or present the LCI results in original form.

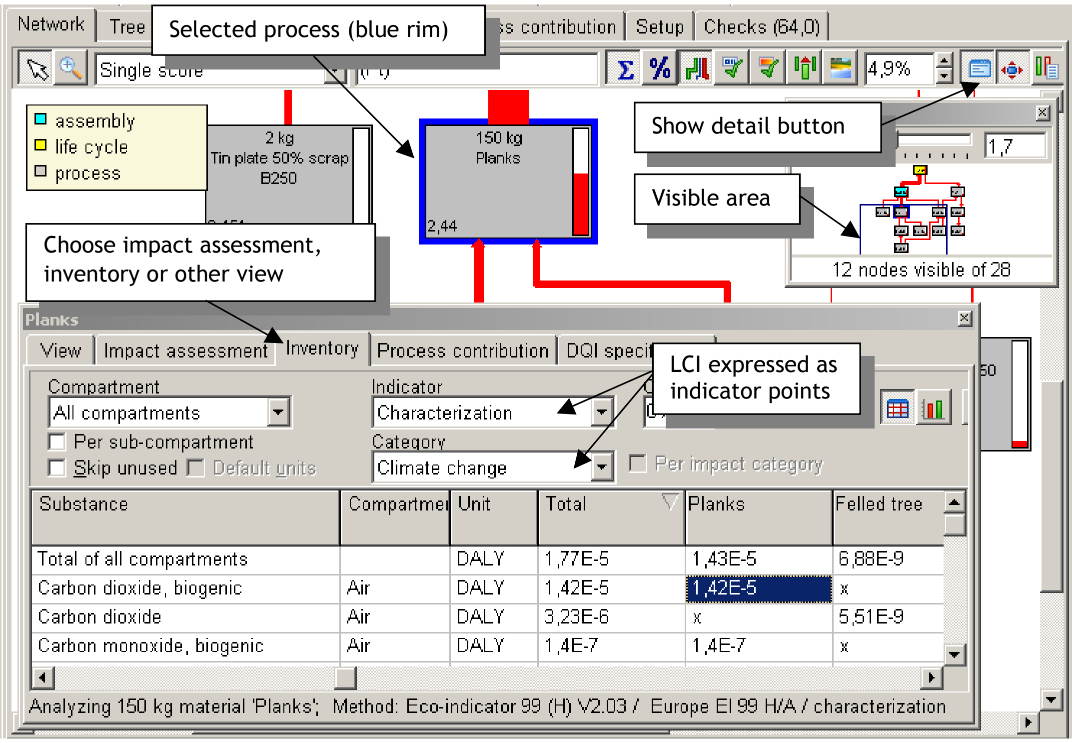


Figure 43: Showing the details of a process in the tree

Advanced features of parameters, linking processes to excel or other data sources

A very advanced feature of the parameters can only be found in the SimaPro developer, and cannot be practised in the demo. In the developer, you can link each process record to an excel spreadsheet or an SQL database. This opens up many possibilities; for instance, if you use excel for data collection, you can ask each data provider to enter data in a certain format in an SQL database or a spreadsheet, and this can automatically update your LCA.
The illustrations below give an example. The excel datasheet is directly linked to from within a spreadsheet.

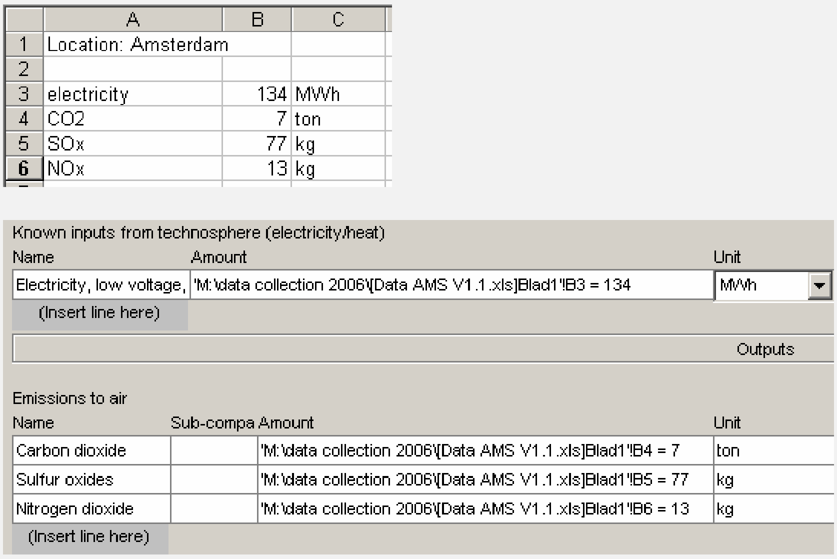


Figure 44: How to link a process record to an excel spreadsheet?

7 Lesson 3: Building sophisticated product stages using the Wizard

Overview	
What you will learn	This exercise shows you how to use the LCA wizard tools in SimaPro to model complex end of life scenarios, in a short time; in fact in a much shorter time than you needed for lesson 2c on waste scenarios.
Required entry level	We recommend to do this lesson after you have done the lesson 2c, but it is also possible to start this lesson after lesson 1.
Recommended reading	Introduction to LCA with SimaPro. Chapter 8 gives some of the backgrounds. It is recommended, but not essential to read this.
Project needed	Introduction to SimaPro 7. Please recheck if the Buwal 250 library is selected under "libraries" at the left-hand side of the screen
Approximate time needed	30-45 minutes.

7.1 The problem

Due to the introduction of DVD films, consumers are expected to start to dispose of their videotapes. Does it make sense (from an environmental point of view) to organize a special recycling system? For this, we need to compare two product systems, one with normal Dutch disposal scenario (landfill and incineration mix), and one without the recycle system.

7.2 The SimaPro solution

Use the LCA wizard to model two product systems, one with recycling and one with the average disposal scenario in the Netherlands. The functional unit is one tape. For this example some simplifications are made in the logistic system and some smaller parts in the tape are left out. There is also no need to define the complete production process, only the material content is important.

7.2.1 Product system without recycling

Open the project 'Introduction to SimaPro 7'. Start the LCA wizard and define one assembly and associated life cycle with the following materials:

1. Tape: 46 gram PET; *use PET granulate amorph B250* in the SimaPro database
2. Cassette 103 gram High impact polystyrene; *use PS (HIPS) B250 (1998);* in the SimaPro database
3. Do not enter processes in the assembly or life cycle
4. Select *Municipal/NL S demo7* as the waste scenario

You will need 18 steps in the wizard; after finishing the wizard, save the product stages and save the product system.

Detailed instructions

If the generic description above is not clear enough, you can follow the detailed instructions below:
Start the LCA wizard
Step 1: Click next.
Step 2: Select Assembly and life cycle.
Step 3: Select Assembly.
Step 4: Enter Videotape without recycling.

Step 5: Enter 1, indicating that the functional unit is just one tape.
Step 6: Yes, enter materials.
Step 7: Select Plastics.
Step 8: Select *PET granulate amorph B250*, this is the main material for the tape.
Step 9: Enter the mass of the tape, in this case 46 gram, or 0.046 kg.
Step 11 to 13, now add the material for the cassette itself, which is High Impact Polystyrene, or *PS (HIPS) B250 (1998);* enter 103 gram as amount.
Step 14: This assembly is ready, you have now entered the main materials.
Step 15: Although the videotape will use energy to play, we leave this aspect out of the comparison, as both the recycled and non-recycled tapes these impacts will not differ, so choose "no processes in the life cycle.
Step 16: Yes, we will enter a waste scenario.
Step 17: Select *Municipal/NL S demo7* ; this scenario contains all information on what percentages are land filled, incinerated and recycled (see also the tree on the background)
Step 18: No additional life cycles.
After step 19: Please confirm that you want to save the product systems, and also confirm that you do want to save a product system. Give the product system a name as "Video tape without recycling".

7.2.2 Product system with recycling

Defining this product system is somewhat more complex. You will need 40 steps. The key issue is to make SimaPro understand that the tape and the cassette have different disposal scenarios and that there is a disassembly operation. To achieve this, you must define an assembly with two subassemblies, one called *tape only* and one called *cassette only*. The LCA wizard is slightly counter intuitive as, when you define a subassembly, it first asks about the disposal of the subassembly, and after you entered this it will ask about what is actually in the assembly.

Start the LCA wizard, but this time enter in step 3 that you want to work with subassemblies, and confirm you will work with a *Disposal* model in step 4.

1. Define a main assembly called *Video tape with recycling*, and *choose Incineration/CH S demo7*. Specify that 100% of the waste is send to disassembly. Do not add materials or processes, but create a subassembly in step 11.
2. Specify the name "Tape only" for the first subassembly, and specify *Incineration/CH S demo7* and specify that 100% of the tapes go to this waste scenario. Now specify that the tape contains 46 gram PET (*use PET granulate amorph B250*), and no other materials and processes.
3. Create a new subassembly (step 22), for the tape. Specify *Recycling only avoided demo7,* and again specify 100% is send to this waste scenario (In SimaPro recycling is also seen as one of the waste scenarios). Now specify 103 gram high impact polystyrene (*Use PS (HIPS) B250 (1998)*) for the cassette.
4. For the collection process, add *Transport, van <3.5t/PER S demo7* to the life cycle in step 34 and 35, and add 0.03 ton.km (tkm) as transport amount (The weight of the cassette is 149 gram; which is multiplied by the average transport distance 200 Km; the rounded value is thus 0.03 tkm).

You will need 40 steps in the wizard; after finishing the wizard, save the product stages and save the product system.

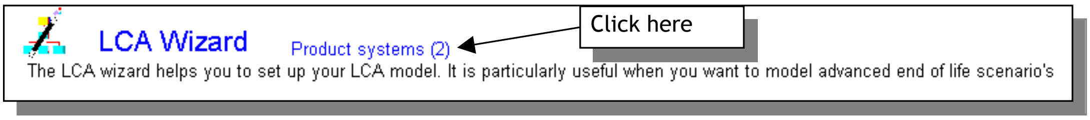
Detailed instructions for the Videotape recycling product system

If the generic description above is not clear enough, you can follow the detailed instructions below:
Start the LCA wizard
Step 1: Click next
Step 2: Select Assembly and life cycle
Step 3: Select Assembly with Subassemblies
Step 4: Select Disposal
Step 5: Enter the name of the assembly: "Video tape with recycling"
Step 6: Enter 1
Now, and this seems a bit counter intuitive, the Wizard first wants you to specify how the tape is disposed off.
Step 7: Select Incineration/CH S demo7; This waste scenario has all data on the incineration of waste, including the reclamation of energy
Step 8: Enter 100% in the field disassembly, indicating that all tapes are send to disassembly
Step 9: Click next
Step 10: Read and click next
Now SimaPro finally wants to know which materials are in the tape
Step 11: Now create subassembly. This is the first subassembly we create
Step 12: Enter name: *Tape only*
Step 13: Enter 1
Step 14: Select Incineration/CH S demo7; Indicating that the tape will be incinerated.
Step 15: Enter 100% in the field for subassemblies send to waste. Indicating that all tapes are send to the waste scenario you just selected (incineration)
Step 16: click next
Step 17:Yes, enter materials
Step 18: Select Plastics
Step 19: Select PET granulate amorph B250, this is the main material for the tape (if you started while you did not select the BUWAL library, you may not find this. You can also select another material and change this later in the product system (see below)
Step 20: Enter the mass of the tape, in this case 46 gram, or 0.046 kg. Note that you will see that in the tree not only the material is added, but also the waste scenario and waste treatment for PET
Step 21: No, This subassembly is ready
Step 22: Yes add another subassembly
Step 23: Enter *Cassette only* as name for the subassembly
Step 24: Enter 1
Step 25: Choose Recycling only avoided demo7
Step 26: Enter 100% in the field *waste*, indicating that all tapes are send to the waste scenario you just selected (recycling)
Step 27: Click next
Now SimaPro finally wants to know which materials are in the cassette
Step 28: Yes, enter materials
Step 29: Select Plastics
Step 30: Select *PS (HIPS) B250 (1998);* this is the main material for the cassette. If you cannot find this, select another, similar material.
Step 31: Enter the mass of the tape, in this case 103 gram, or 0.103 kg
Step 32: The Subassembly is ready
Step 33: No, do not enter other subassembly (or you may want to experiment with a separate subassembly for the screws and the Reels (made of POM)
Step 34: Yes, Add processes to the life cycle
Step 35: Choose transport
Step 36: Choose Transport, van <3.5t/PER S demo7
Step 37: enter 0.03 tkm (ton.kilometer) or 30 kgkm . The weight of the cassette is 149 gram; multiply by the average transport distance (200 km); the (rounded) value is thus 0.03 tkm
Step 38: No, do not enter additional processes (the processes needed for the recycling are already in the selected recycling scenario)
Step 39: No, do not add additional life cycles
Step 40: Click next
After step 40, please confirm that you want to save the product systems, and also confirm that you do want to save a product system, Give the product system a name as "Video tape with recycling"

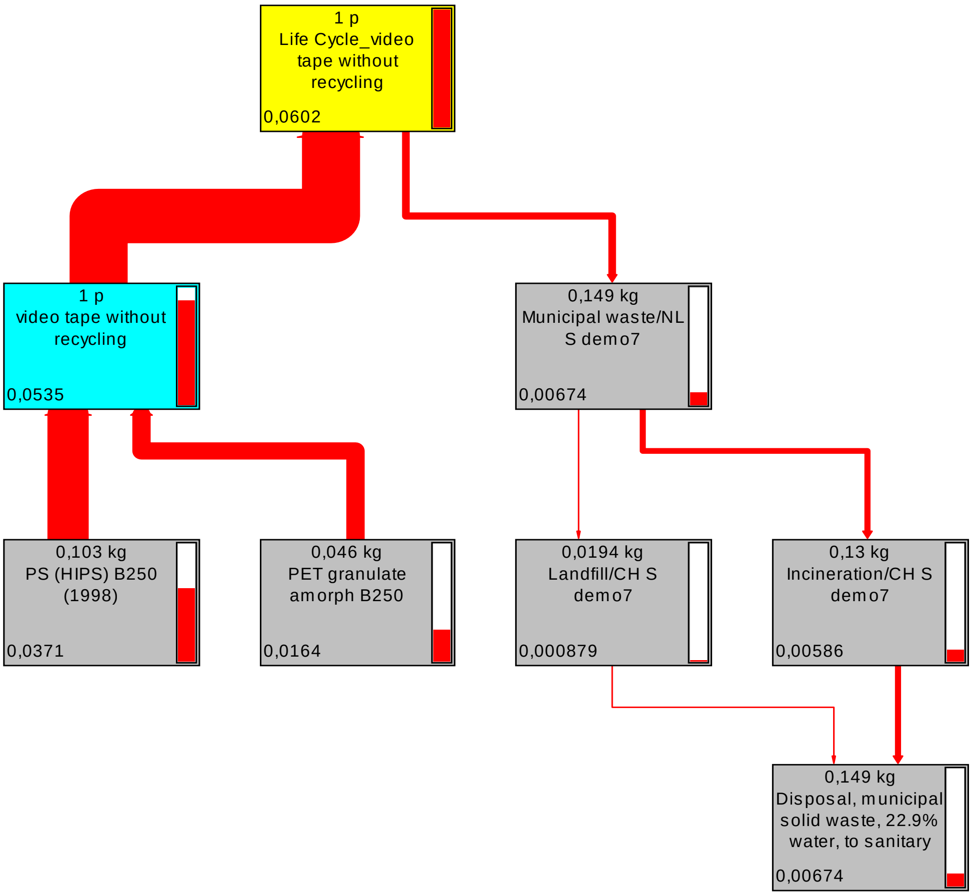
7.3 Analysing the results

7.3.1 Analysing the product system without recycling

Next open the product systems you just created; and open the Product system without recycling. Here you see an overview of the data you have just entered.

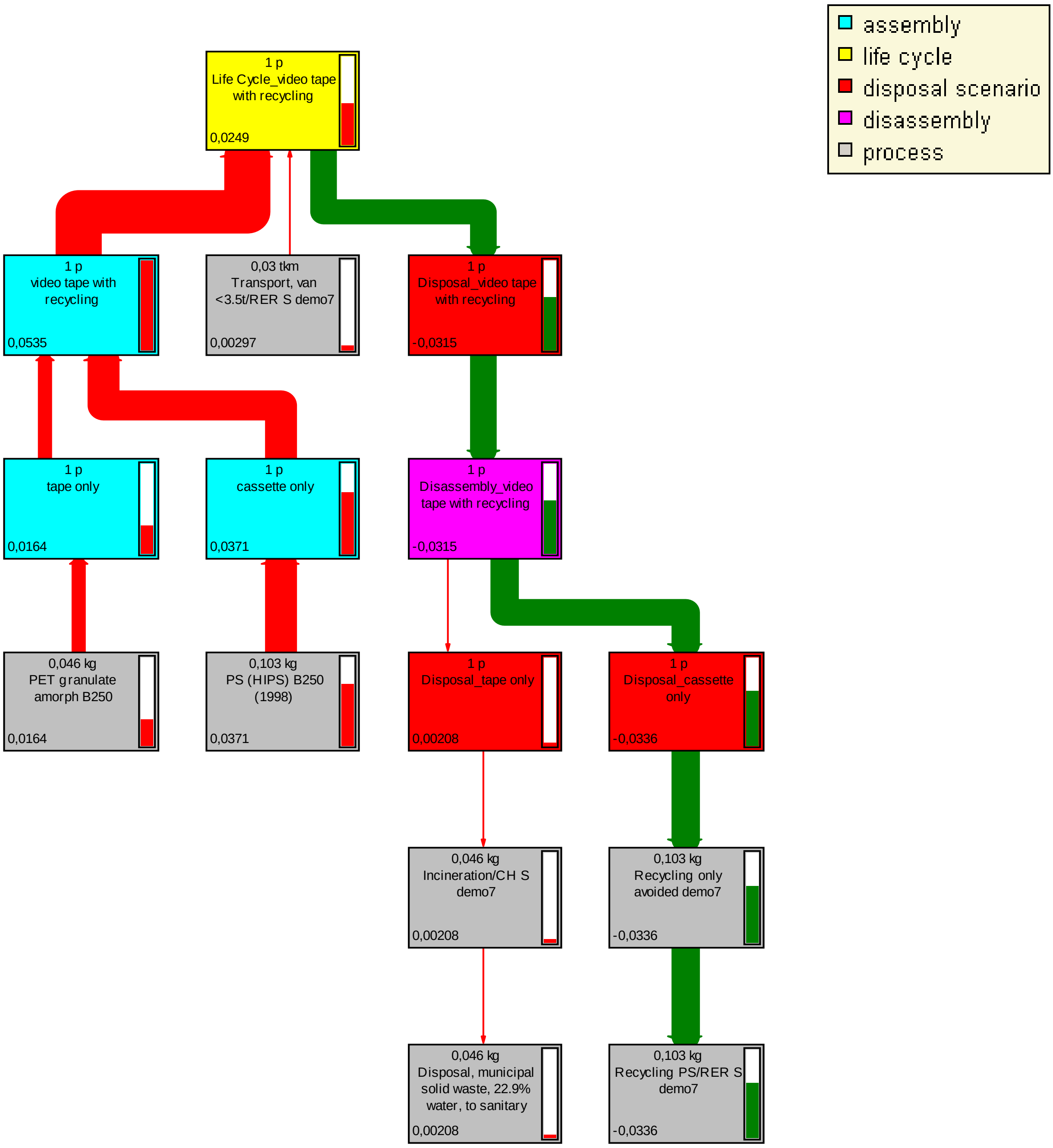


Next, click on the Network button to get an overview of the process system, like below. You can see the PET and HIPS flow into the (light blue) assembly and the life cycle. The Municipal waste handling has a relatively low contribution. The waste scenario splits the waste stream in a part that is land filled and incinerated. SimaPro has special waste treatment records to model the incineration and landfill. SimaPro automatically analyses the material content in the waste flows and connects them to the proper waste treatment record (for this each material has a label that describes the waste type). In this example we used the avoided emission example, meaning that the electricity generated in the incineration process is assumed to avoid regular Dutch electricity production. You can see that this electricity has a negative environmental load.
Use the product system to change the waste scenario and regenerate the tree to inspect other waste scenarios; for instance use Household waste/NL S demo7.



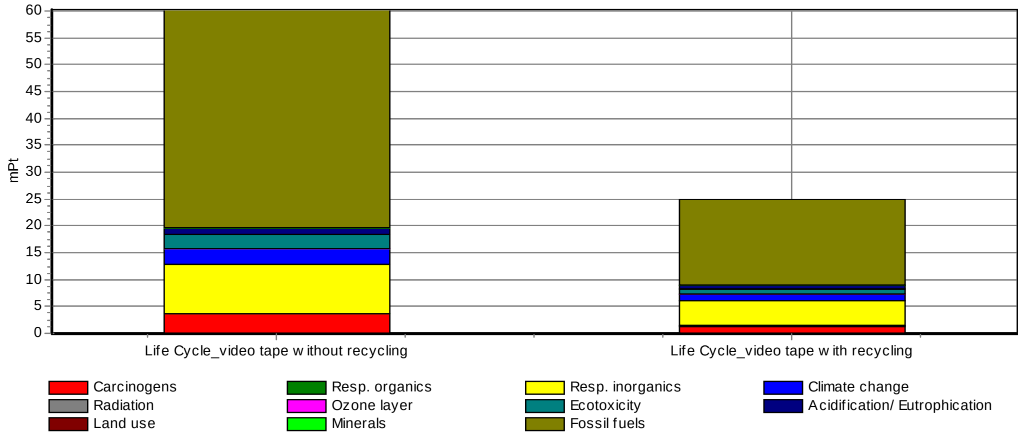
7.3.2 Analysing the product system with recycling

A similar analysis can be made of the system with recycling. After you generate the process network button please set the cut-off level at 0%, to get a full overview, like below. You will now note that two subassemblies feed into the main assembly, and that the end of life treatment is very different. A disposal scenario feeds into a disassembly, and from there, two separate disposal scenarios start for the tape and the cassette. The impacts of the tape incinerations are very small, as the avoided electricity production avoids all impacts. The impacts of the cassette recycling are clearly negative, as the recycling leads to a significant avoidance of the HIPS production. This leads to an overall negative impact for the whole disposal.
Note that a transport process is connected to the life cycle. The impact of this collection effort is clearly lower as the benefits for the recycling system.



7.3.3 Comparing both systems

Now open both product systems at the same time (click on both systems, while keeping the ctrl key down), and click the compare button. Choose the impact assessment method you want to use (the default is the Eco-indicator 99 method). The recycling system is indeed preferential over the traditional disposal system. if one uses the single score representation, like below. You can recheck this by using other impact assessment methods.



Comparing 1 p life cycle 'Life Cycle_video tape w ithout recycling' w ith 1 p life cycle 'Life Cycle_video tape w ith recycling'; Method: Eco-indicator 99 (H) V2.

Note that the outcome is heavily dependent on the way the benefits of recycling and energy reclamation from incineration are modelled.

7.3.4 Detailed analysis using the traditional user interface

Working with product systems is easy, but has some limitations. If you want to get to the details of the system you have build go to the *product stages* section. Under *Assembly*, with the subcategory *"others"*, you will find the four assemblies you have defined in the Wizard. You can open these and inspect or edit them. Similarly, you will find the *life cycles*, the *disposal scenarios* and the *disassembly* stages, they are stored under the subcategory *"others"*. Note that if you make changes in these product stages, these changes will not be made in the product systems.

8 Lesson 4: Using input output

Overview	
What you will learn	How and when to use input output data.
Required entry level	Lesson 1 should be completed.
Recommended reading	Introduction to LCA with SimaPro. Chapter 3.5 gives some of the backgrounds. It is essential to read this.
Project needed	Tutorial with wood example, or any other project. Activate the library *USA Input Output Database 98.* Please not that this library is not available in the "small" demo downloaded from internet
Approximate time needed	30-45 minutes.

8.1 Introduction

SimaPro 7 includes very comprehensive new Input Output database containing environmental data for all 500+ Commodities in the USA economy. Commodities are generic names of groups of products and services, such as Iron and Steel, but also "Banking services". Data are specified per $ trade value. This type of data opens up many new possibilities.

Note, some versions of the demo do not have the input output data used in the following examples.

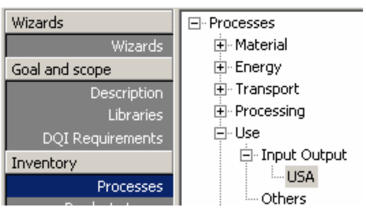
8.2 Problem 1: Priorities for sustainable consumption

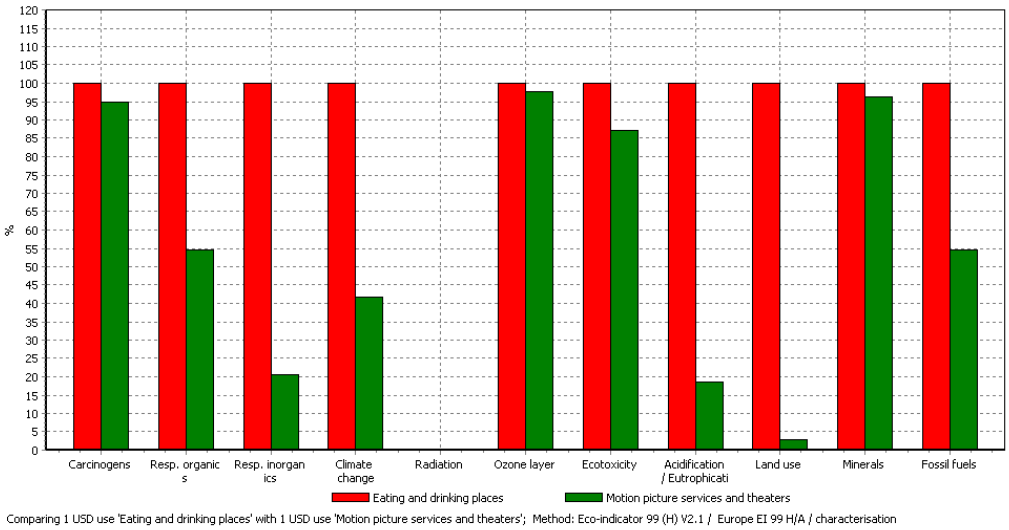
The Japanese, Dutch and Danish governments as well as the Joint European Research Centre are currently determining which priorities should be set for policies aiming at reducing the environmental load of consumers.

8.2.1 The SimaPro solution

Determine the average spending by consumers, on product groups, and link these to the input output database. Such expenditure patters are usually available at statistic bureaus, as they are needed to determine inflation figures.

To illustrate the idea, we will just compare the environmental impacts of spending a dollar on a cinema or theatre with spending a dollar at a restaurant. Before starting, check if the library *USA Input Output Database 98* (underneath Goal and Scope) is activated. Then, go to Processes\Use\Input Output\USA and select *Eating and drinking places*. Next, scroll to *Motion Pictures and Theatres*. Select this, while holding the CTRL key down. Now click the compare button  , and see that from a sustainable consumption point of view it would be better if consumers shift spending from restaurants to theatres.





8.3 Problem 2: Guiding strategic investments

Determine the environmental impacts of changing the business portfolio for a company that is in the entertainment sector.

8.3.1 The SimaPro solution

Suppose your company is managing restaurant chains, and is contemplating to expand in other fields of entertainment, like movies and cinema's. The same comparison described below, can also be used to estimate the impact on the overall performance of the company. It provides a quick view on the probable changes of the eco-efficiency ratio; for instance the annual CO_2 emission per unit of turnover, will be substantial reduced. Again some care must be taken about the exactness, but the general trend will be quite reliable.

8.4 Problem 3: Include the impact of services in the LCA

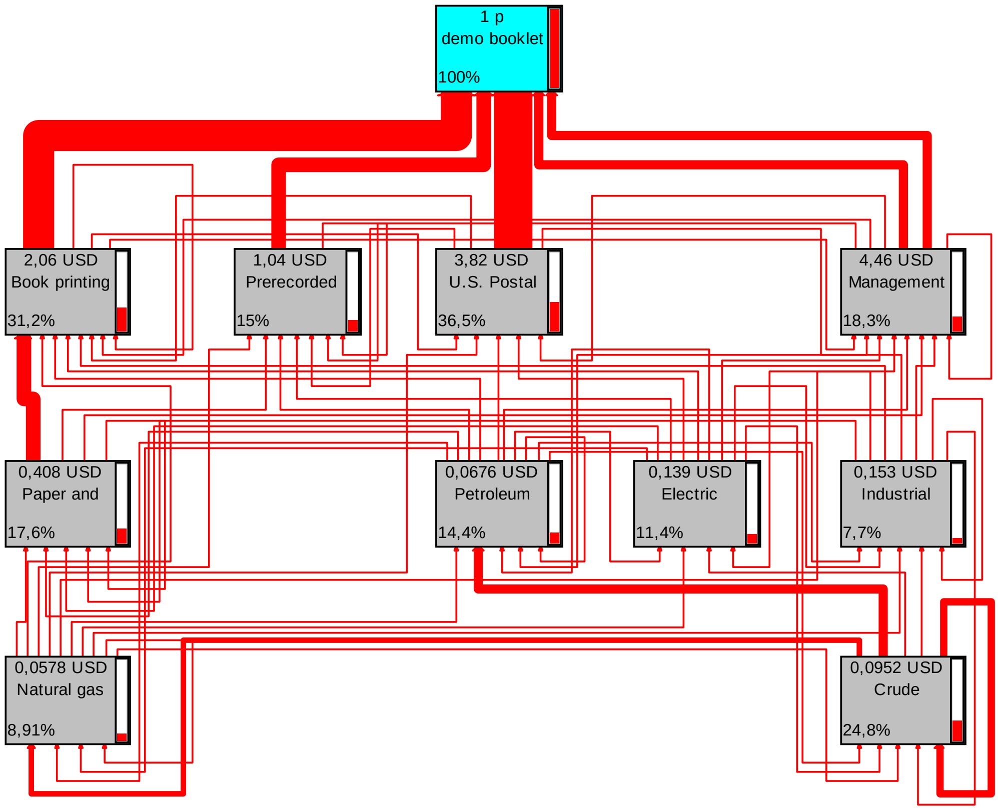
The main costs of producing the Demo booklet and Demo CD are in the design and distribution. In a traditional LCA these services are often not included.

8.4.1 The SimaPro solution

Determine the costs spend per booklet and CD, and select the commodities that are representing these costs. The table below shows the basic data, and indicates where you can find the data, as some are stored under Materials/input output/USA, and some are stored under Use/input output/USA. Use the Find function if you cannot locate data.

Item	Amount	Locate under Materials	Locate under Use
Development cost	$ 2	/	*Management and Public relation services*
Graphic design	$ 2.10	/	*Management and Public relation services*
Printing	$ 2	*Book printing*	/
CD production	$ 1	*Prerecorded records and tapes*	/
Postage	$ 3.75	/	*U.S. Postal service*

Enter these data in a new Assembly, and click the network button and set the node cut-off at 7%.



The network indicates that the environmental loads connected to mailing are the most dominant. In the example we assumed regular mail was used and no courier. As the courier services would be in the same sector, you can experiment, by just changing the cost for sending to the regular courier service costs.
The environmental load of the costs for developing the booklet (at the offices of PRé), as well as the graphic design companies are also quite important.

8.4.2 Limitations

The example also shows some limitations. For instance, we cannot distinguish between different printing techniques, or different ways to send mail. Within a commodity, only the value determines the environmental load. Another shortcoming is that it is very difficult to determine the impacts of waste handling.

8.4.3 Hybrid LCA

To compensate for these shortcomings, SimaPro supports the use of Hybrid LCA, This means you can use traditional LCA processes for printing and papermaking, and add a “normal” waste scenario, while you use the input output data to model the services.

9 Lesson 5: Solving the weighting debate?

Overview	
What you will learn	How to use the weighting triangle that is part of SimaPro. This triangle is a powerful way to involve stakeholders in solving weighting problems when interpreting LCA results
Required entry level	Lesson 1
Recommended reading	Introduction to LCA with SimaPro, Chapter 4, is essential reading material
Project needed	Tutorial with wood example, or any other project
Approximate time needed	15-30 minutes

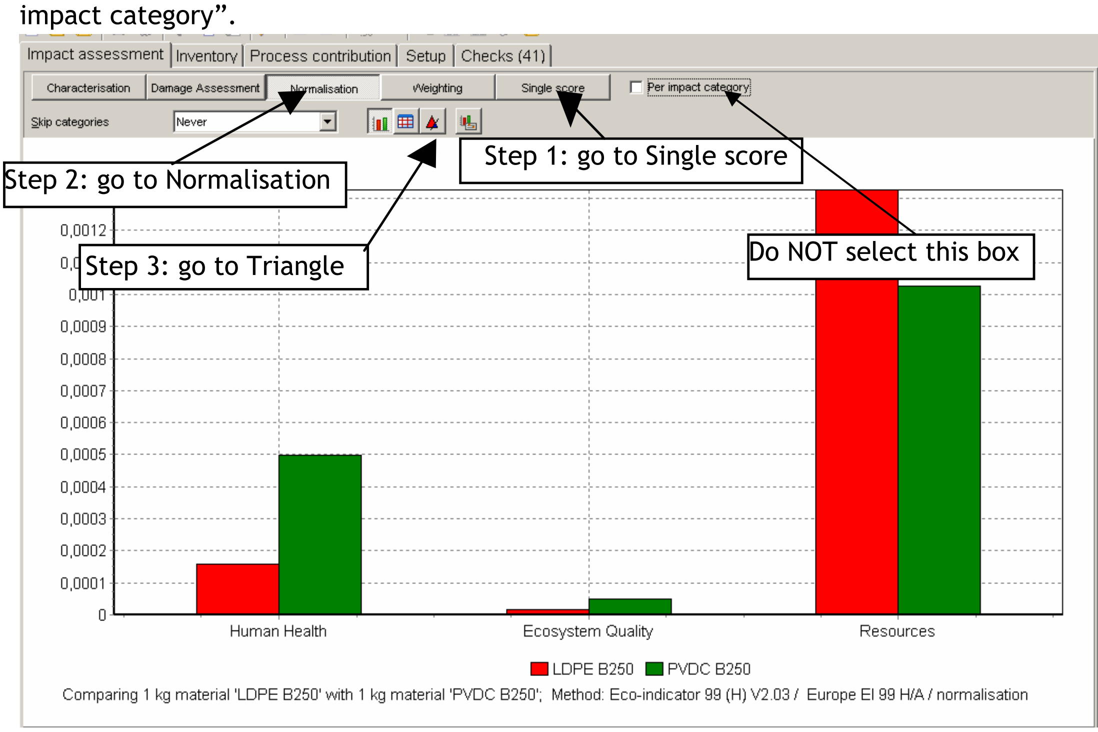
9.1 The problem

Weighting across impact categories, is not allowed for public comparisons (ISO 14042). So, how to compare the environmental load of two materials without using the default weighting sets. We take the case of comparing the production of 1 kg LDPE and 1kg of PVDC.

9.2 The SimaPro solution

Go to Processes/Materials/Plastics/ thermoplasts and select LDPE from the Buwal library.

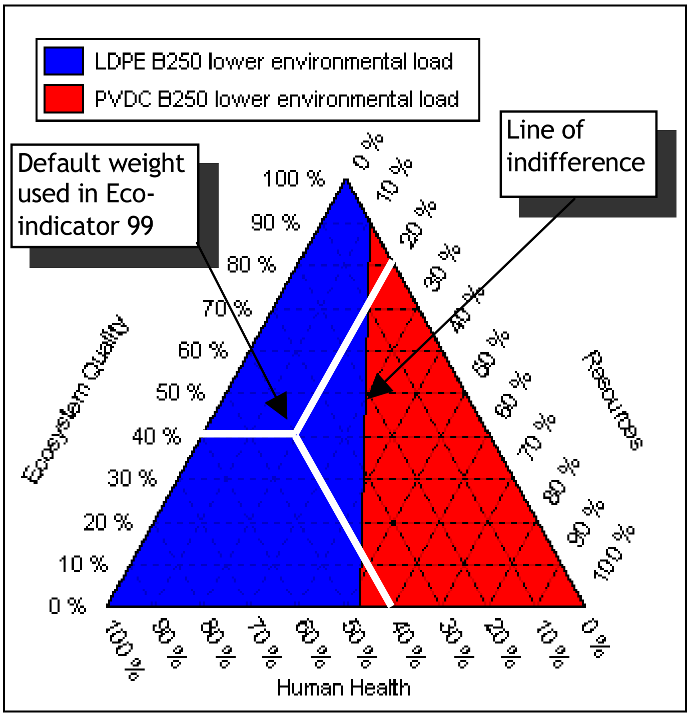
Now also select PVDC, wile keeping the CTRL Key down. Click the compare button , use the Eco-indicator 99 method, and go to single score. You will see that the LDPE seems to have a slightly lower environmental load per kilo. However, the single score is computed using a weighting set, and this is not what we want.
Go to Normalisation, and be sure you have NOT selected the checkbox labelled “per impact category”.



As you will see, LDPE has a lower score on human health, but a higher score on Resources. This is because over half the raw material in PVDC is salt.
Now click on the triangle button to get the window below. On the sides of the triangle, the weights for the three damage categories are plotted between 0 and 100%. All points within the triangle can be seen as a possible weighting set. The white lines indicate the weighting set used as default for the Eco-indicator method:

Human Health 40%
Ecosystems 40%
Resources 20%

One can imagine that there are weighting sets for which both plastics will have the same environmental loads. These points are forming the “line of indifference”. In this example, all the points on the left-hand side of this line are weighting sets, for which LDPE has a lower environmental load; this is the blue area. The red area indicates the weighting sets for which LDPE would have a higher load. To determine the question whether LDPE is preferable or not, is clearly depended on the weighting set you apply.



The triangle does not solve the weighting, but you can now discuss the weighting issue in a much more constructive way. You can present the triangle to stakeholders and ask whether they would find it more reasonable if their weighting set would be in the blue or the red area, or somewhere close to the line of indifference. Or to put it in another way, would it be conceivable that the weight for human health is much lower than 40% while the weight for resources is much higher than 40%?

Experience shows, that this type of discussions with stakeholders can be very productive. In the example given, many would probably not come to a conclusion, but if you repeat the example with a comparison between LDPE and PVC, it will become much more clear how to draw a conclusion.

10 Lesson 6: Monte Carlo analysis

Overview	
What you will learn	Use and interpret Monte Carlo simulations in SimaPro to determine the absolute uncertainty, and to determine how certain you can be if the difference between two product systems is indeed real.
Required entry level	Lesson 1 and 3 must be completed first, as this lesson 1 builds on the same example of the coffee machine, and lesson 3 gives a better understanding of disposal scenarios used here.
Recommended reading	Introduction to LCA with SimaPro. Chapter 9 is essential to read this.
Project needed	Introduction to SimaPro 7.
Approximate time needed	45-60 minutes.

10.1 The problem

LCA data are full of uncertain numbers. These uncertainties can have different causes, like uncertain measurements, or uncertainty about how representative a figure is, for the actual problem we are studying. This means we must ask ourselves how certain, or uncertain the results are, especially when we are comparing data.
In this example we will focus on the same coffee machine case, as discussed before, but now on the question whether it is useful to recycle the aluminium coffee machines called model Pro. For a good understanding of this example you should have gone through Lesson 1 and 3.

10.2 The SimaPro solution

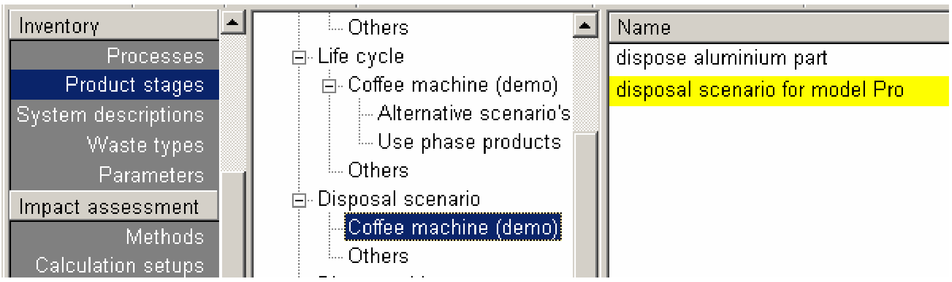
Uncertainty calculations can be made in the SimaPro Analyst, Developer and PhD versions. You can specify uncertainty on each input and output of a process, or a product stage. In almost all parameters in the ecoinvent database uncertainty is specified as log normal distribution. Unfortunately, this database is not in the demo, which makes the example presented here somewhat artificial.

SimaPro supports 4 types of distributions:

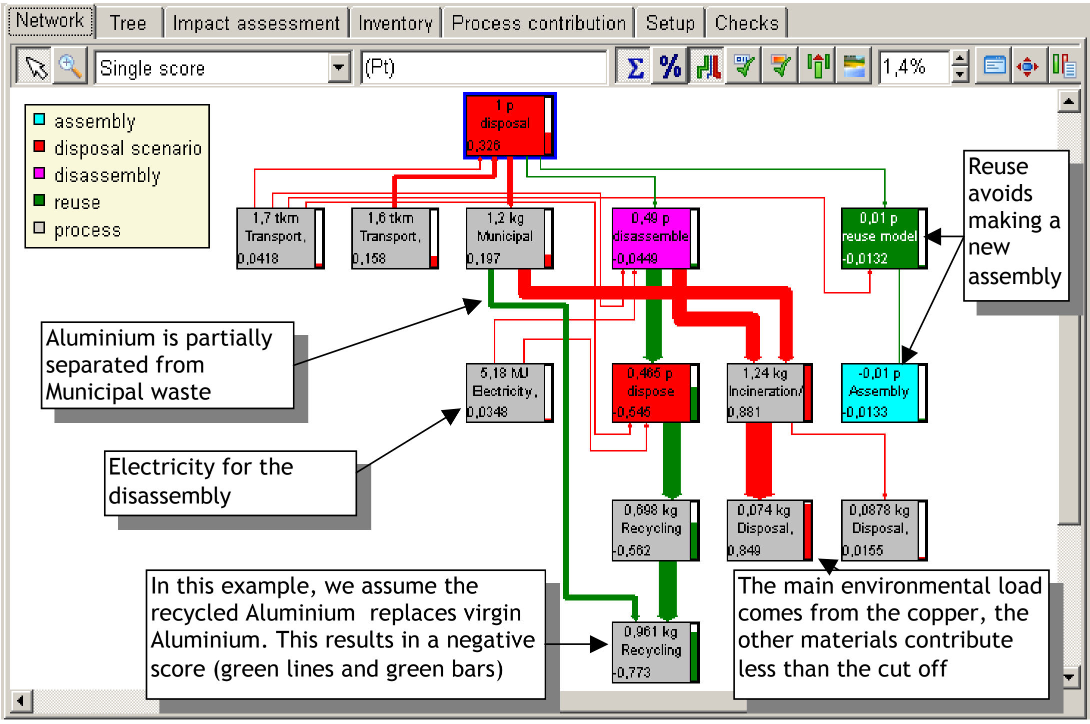
Distribution	Data needed	Graphical presentation
Range	Min and Max value	
Triangular	Min and Max value	
Normal distribution	Standard deviation	
Log normal distribution	Standard deviation	

10.3 Recycling of model Pro

The recycling model is described in a disposal scenario, see also lesson 3. To inspect this, select the *disposal scenario for model Pro.* This can be found under *Product stages\Disposal\coffee machine (demo)\disposal scenario for model pro*.



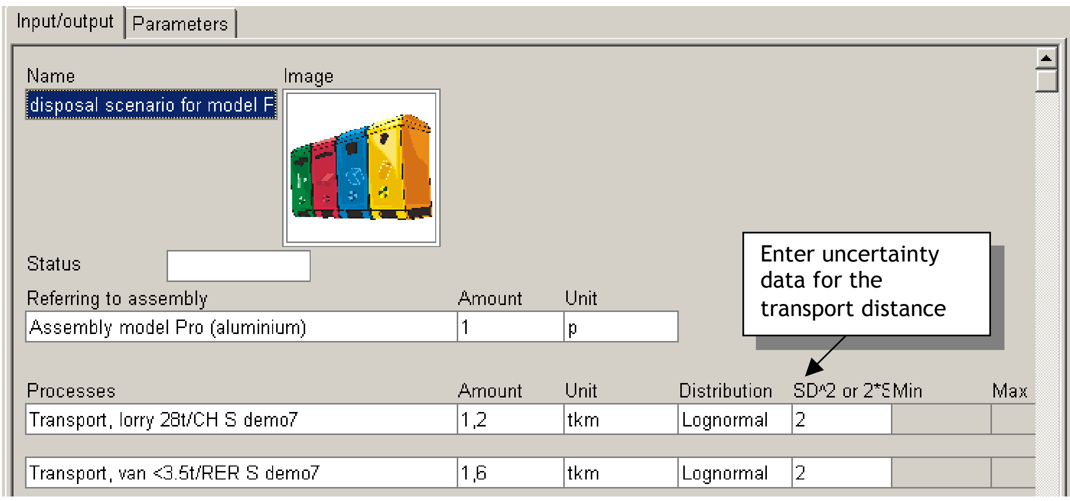
Generate a process network, to get a window like on the next page. (node cut-off set at 1.4%)



The main uncertainties in the system are summarised below:

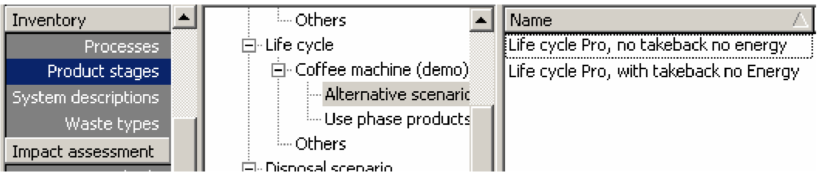
- Transport for collection; uncertainty is at least a factor 2
- Energy consumption for disassembly, uncertainty is a factor 1.5

These data have been specified in the Disposal and Disassembly scenarios as a lognormal distribution with a square root of the distribution interval of 2. This means 95% of all values are between the estimated value divided by two and the estimated value times two.



10.4 Does the recycling system seem to be beneficial?

In order to understand the usefulness of the recycling system, we now compare two life cycles; one with and one without recycling. We have seen in example 1 that the life cycle is heavily dominated by the energy consumption, and the use of filters. As these parameters are the same for both systems, we will use two special versions of the life cycles, see below.

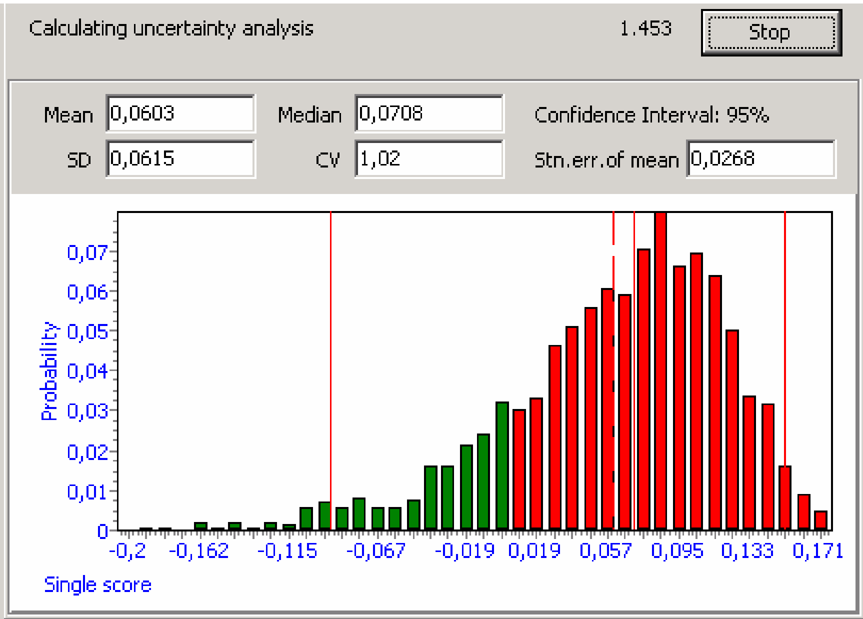


Select both life cycles, and click the compare button. If we compare per impact category, the picture is mixed; for instance climate change will be reduced with recycling, ecotox will be increased.

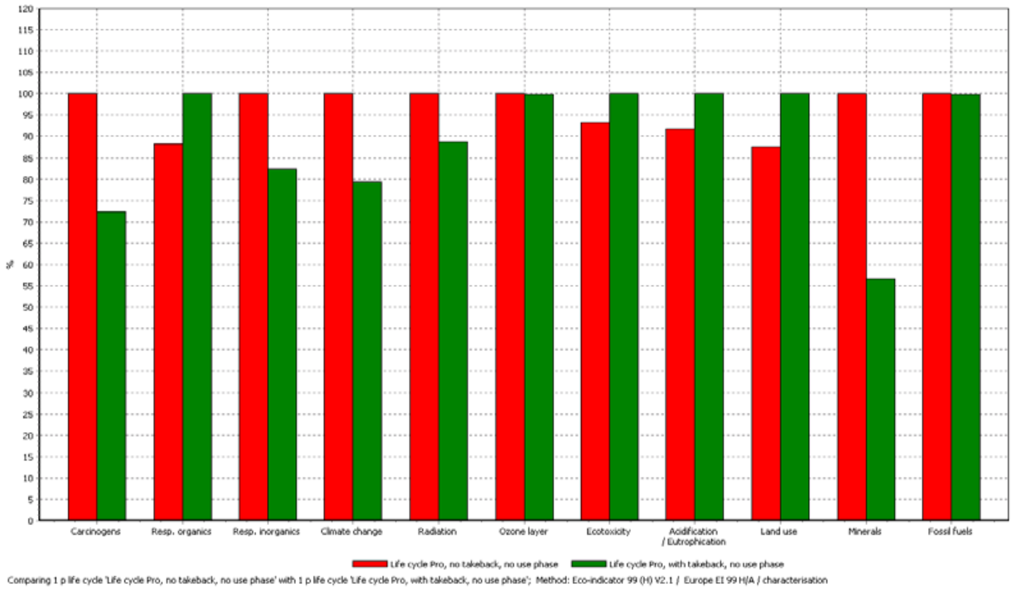
You will see that on the single score level, there is indeed a difference. The recycling system seems to have its benefits.

10.5 Monte Carlo analysis

To address the uncertainties, minimise the comparison window, select both life cycles, and click the Monte Carlo button .
SimaPro will now start to repeat the comparison. Each time another value is selected for the transport and energy, as these were the factors specified with an uncertainty range. The different samples are chosen in such a way that all samples together conform to the distribution specified in the data.



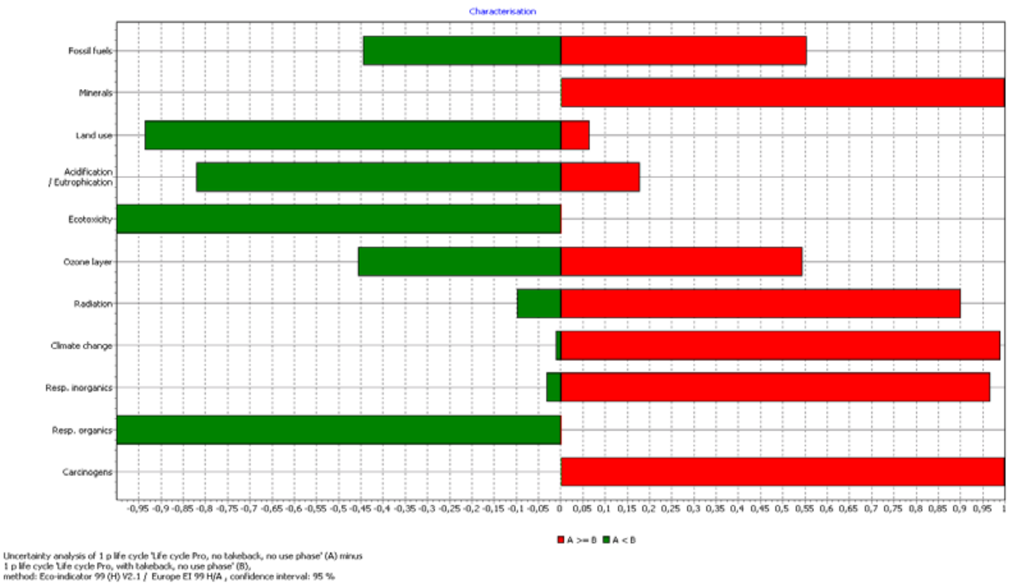
The window in front of you shows the distribution of the DIFFERENCE between the weighted single score for each run. A very important feature of SimaPro is that for each comparison the same samples are used; in other words, the correlations are taken into account. To date most LCA software does not do this.



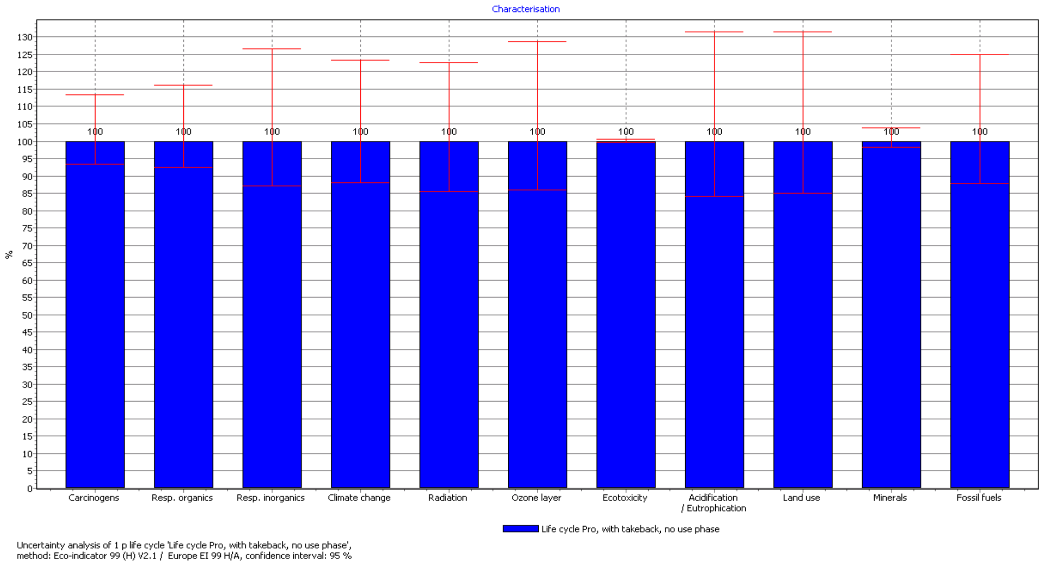
You may stop the calculation after a couple of hundred runs. Depending the number of runs you allow, you will get a result that looks somewhat like the picture above. The red bars represent the positive values; the green represent the negative values. This result indicates that there is about an equal chance that the difference is positive or negative, indicating that it is very unclear if the recycling system is beneficial at all.

10.6 Compare per impact category

After you stop the calculation, a similar comparison is shown on the impact category level. Each bar represents an impact category.



The green bars represent the number of times the scenario without recycling had a lower load than the life cycle with recycling. For instance, it shows that in 100% of the cases the ecotoxicity score is lower without recycling. In about 5% of the cases the climate change score is lower; meaning that it is almost certain that for climate change



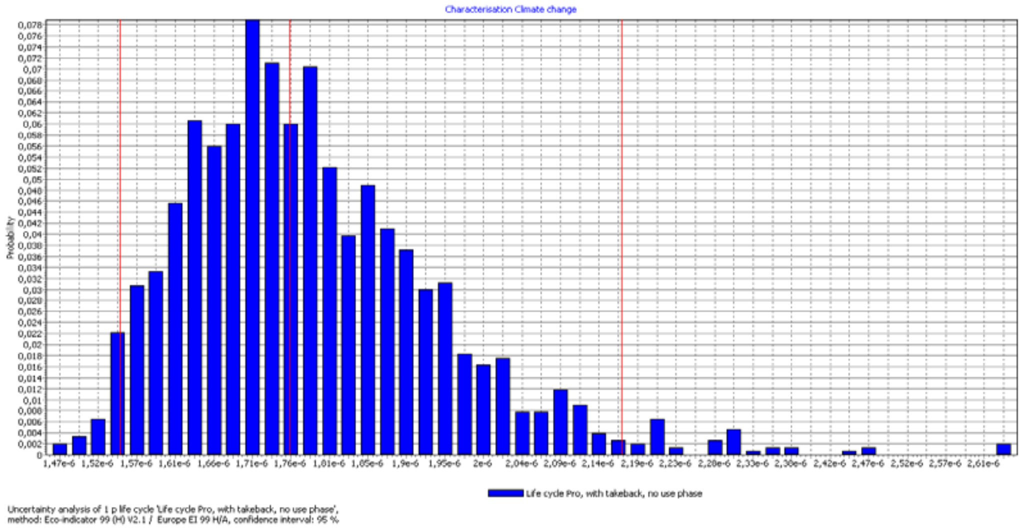
the recycling would be better. For some other impact categories it is not so clear if recycling is better.
Please take some time to explore the many other features of the window, and check the comparisons per emission in the inventory section.

10.7 Absolute uncertainty

You may also want to run the Monte Carlo analysis for the take back system without comparing, but just to see the absolute uncertainty. Select this life cycle and click the Monte Carlo Button. Please note, this can only be done when uncertainty data is included.

In this graph, the 95% confidence interval is given for each impact category, and as you can see the range is considerable. Technically it would be no problem to show such a range in a comparison, but this would only create confusion, as the absolute uncertainty of a single system is usually much higher then the differential uncertainty, due to the correlations.

It is also possible to inspect the uncertainty for an individual emission, or for an impact category. Below the uncertainty graph for climate change is given.

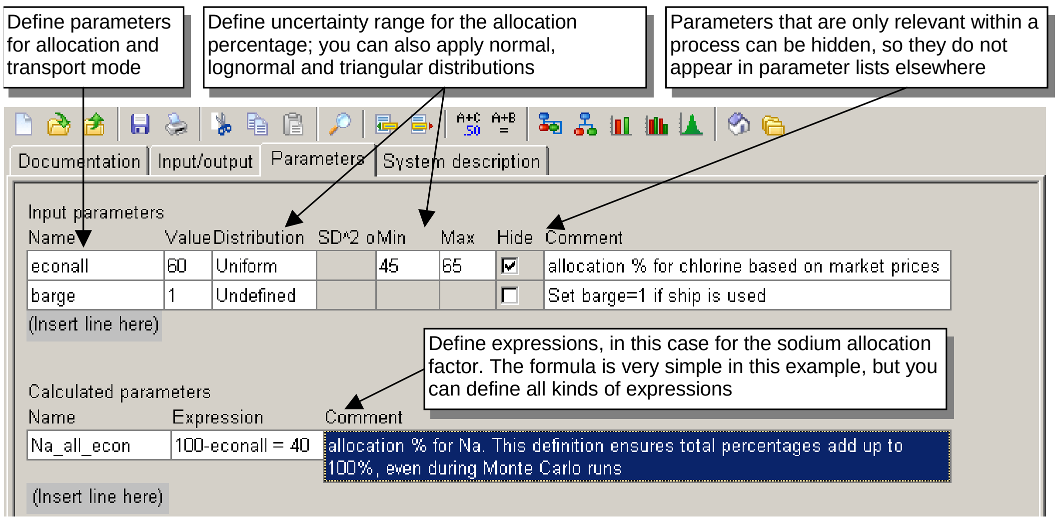


10.8 Final remark for this example

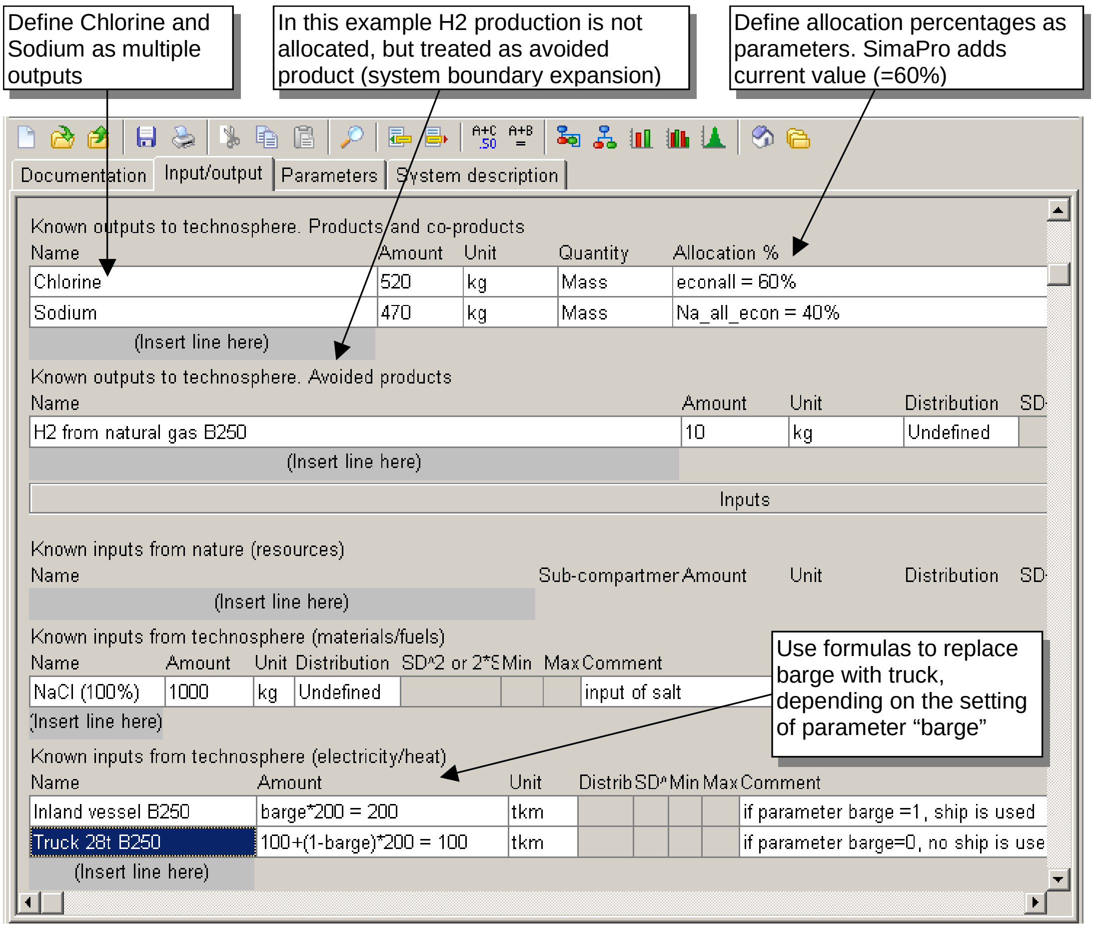
The example shown here is somewhat artificial, as only a few parameters have an uncertainty range. If you use the ecoinvent database, almost all parameters have uncertainty data. This will provide a real insight in the uncertainty.

10.9 Uncertainty on parameters

Parameters can also contain uncertainty information, and this information is evaluated in the same way in the Monte Carlo analysis. There are many applications for this feature, but here we show how you can add an uncertainty factor to an allocation parameter.
In the figure below we show how you can define a parameter for the uncertainty on the allocation of Chlorine production, if you use economic allocation. Note that the sum of the allocation factor for Chlorine and Sodium will always add up to 100%, even while in a Monte Carlo procedure.



Below we show how you can apply these parameters.



This example gives only one of many applications of uncertainty functionality on parameters.

product ecology
consultants

PRé Consultants bv
Plotterweg 12
3821 BB Amersfoort
the Netherlands

phone + 31 33 4555022
fax + 31 33 4555024
e-mail support@pre.nl
web site www.pre.nl