

SimaPro Tutorial

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SimaPro was developed by PRé with the goal of making sustainability a fact-based endeavor. PRé has been a leading voice in sustainability metrics and life cycle thinking development for more than 30 years, pioneering the field of environmental and social impact assessment. We develop tools that help you create value and drive sustainable change.



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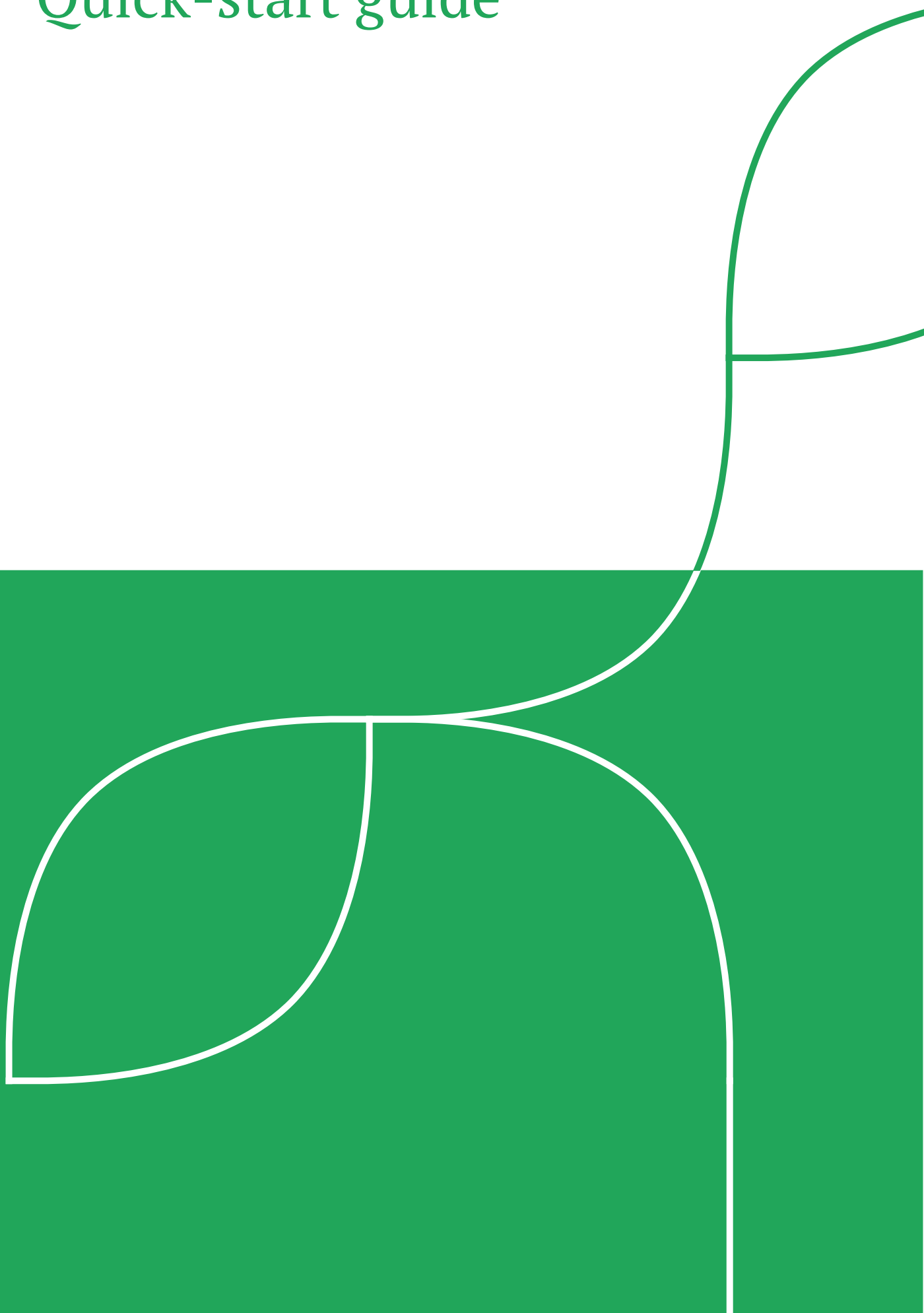
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Quick-start guide



Quick-start guide

This section contains some general information about modelling in SimaPro. This, by no means, replaces the explanations on the next chapters. Please still follow each chapter carefully to get a thorough understanding of SimaPro and use this short guide as reference.

Creating a new project

To create a new project in SimaPro:

1. Open SimaPro
2. Open the Professional database. The database name is found in the top left corner of the SimaPro window. If the database is not yet opened, go to File > Open SimaPro database and select the Professional database or another database you want to create the project in. If you do not see the database name on the "Open database" window, you can click *Browse* and choose the right database. The default location for the SimaPro database is C:\Users\Public\Documents\SimaPro\Database. The default location for the SimaPro database is C:\Users\Public\Documents\SimaPro\Database
3. Once your database is opened, click *New*
4. Enter the name of your project
5. Select the libraries you want to use in your project
6. Make sure to also select the *Methods* library because it is needed to calculate the impact assessment

Opening an existing project

You do not always need to create a new project. You can, for instance, continue working on your existing project. After selecting the right database you want to work in, you can simply open your project:

1. Select the project you want, click *Open*
2. Alternatively, select the project and press *Enter* and or open by double-click the project

Creating a new process

After you created a new project, you want to start entering your data and building your model. To create a new process:

1. Go to *Inventory > Processes*
2. Select *Processes > Material*
3. Right-click under *Material* and choose *New category*. Alternatively, you can also create the new process under the existing sub-categories directly
4. Enter the name of your category
5. Select the newly added category and then click *New*

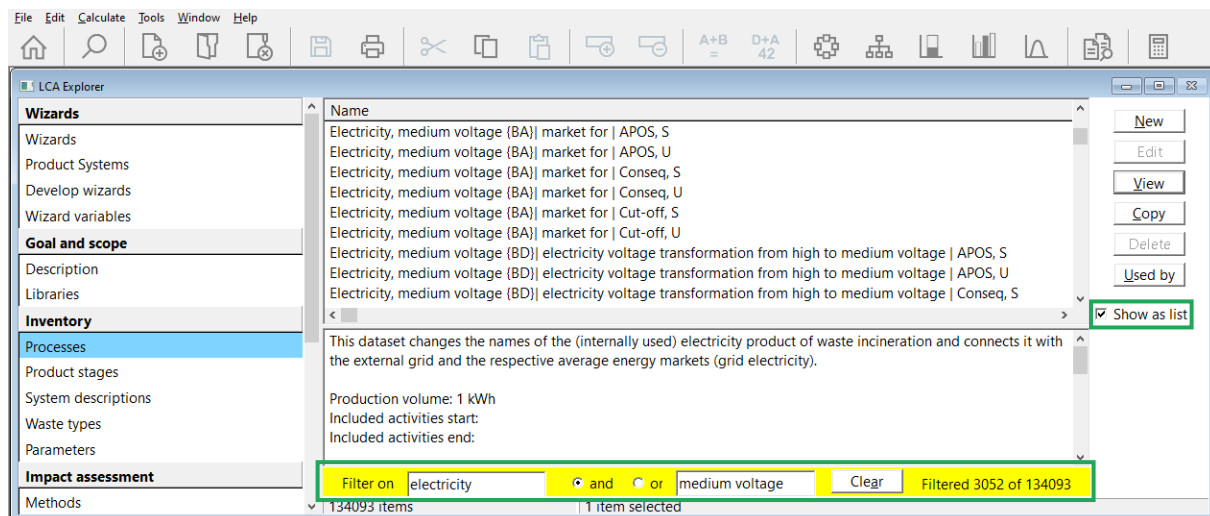
6. You can now start to fill in your process data under the *Input/output* tab. To do this, simply double-click or press *Enter* on the *Add* button
7. To move from one field to another under the same section (for instance, from Amount to Unit under the *Outputs to technosphere*), you can simply click the field or use the *Tab* key
8. You can also add more comments under *Documentation* tab, parameters under *Parameters* tab, and details of the system under *System description* tab
9. Once you are done with entering your data, click the disc icon on the toolbar to save your entry. Alternatively, you can press *CTRL + S*

Mostly, we model under the Processes / Material category. However, in some cases you may also use the Processes / Processing category or model under Product stages. Further explanation on when to use what and the differences between the two is explained in [Chapter 2](#).

Selecting processes

To easily find the required material/process from the large inventory database, determine the material/process type and search it accordingly under the respective categories.

When you click on the **Show as list** checkbox on the right side of the process window, you will see the complete list of materials and processes from the libraries with background datasets that you have selected. You can then use the **Filter on** option at the bottom of the window to search for the materials/processes under different sub-categories by entering its name/other corresponding keywords, as seen in the image below.



You can also select multiple items at once in SimaPro. To do that, SimaPro uses the Windows conventions. Hold down *CTRL* + mouse click to select multiple individual entries and use *SHIFT* + mouse click to select a list of items. *CTRL* + *A* will select all items within the category.

Background data

The following data is used as the default throughout this tutorial:

- Library: Ecoinvent 3 – allocation, cut-off by classification – system (ecoinvent 3.9.1)
- Method: ReCiPe 2016 Endpoint (H) (version 1.08)
Normalization/Weighting set: World (2010) H/A

Geography abbreviations

Processes may be available for different geographical resolutions, whether it is national, regional, or global. In this tutorial, the global type market process {GLO} is used whenever possible for all materials and processes involved in the bike components production and during the bike life cycle stage. If no relevant market process is available or if there is no appropriate data for these materials and processes, then the data for the average of all European countries {RER} is used.

For aluminium-data related, the {IAI} regions are used wherein IAI stands for International Aluminium Institute.

For freight transport processes, we use the EURO5 data as the default. EURO5 refers to vehicles manufactured according to the 5th European Emission Standard. The European Emission Standard specifies the acceptable exhaust emission limits for vehicles. The unit used to represent freight transport is kgkm which represents the mass of one kg of goods transported over one km of distance.

Transport formula

The following formula is used to calculate the amount of freight transport needed











$$\text{Freight transport amount (kgkm)} = \text{weight of transported goods (kg)} \times \text{transport distance (km)}$$

However, ecoinvent also includes data on passenger transport. The amount of passenger transport is represented by km unit, which refers to the transport of an average number of passengers over one kilometer.





Note that for passenger transport only the distance is important as input value, while for freight transport both distance and weight are important input values.




Buttons in SimaPro

In the LCA Explorer screen, you will find some buttons in the Toolbar that will often be used throughout this tutorial. These are briefly mentioned below.

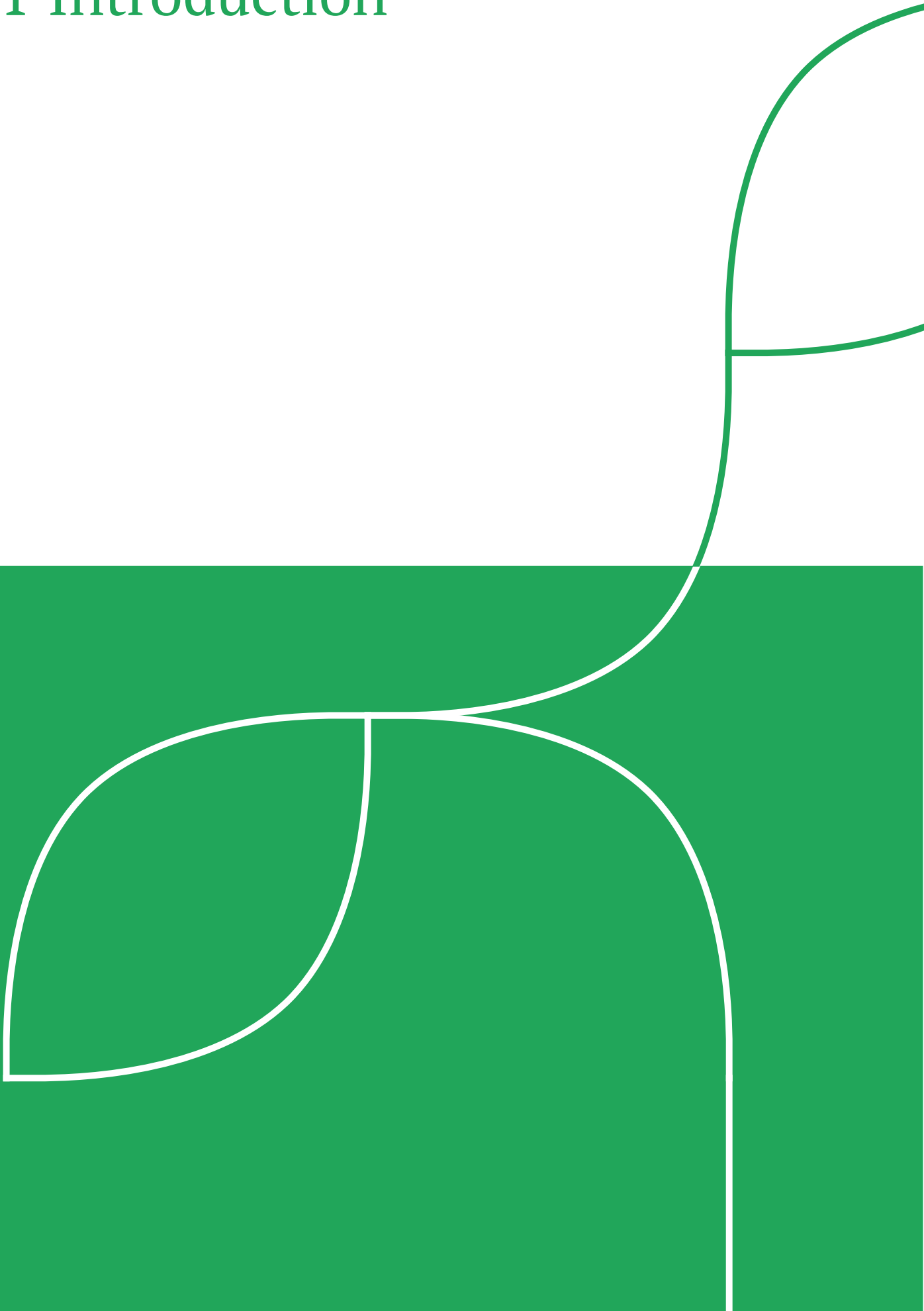
Buttons	Function name
	New project
	Open project
	Close project
	Save
	Network
	Tree
	Analyze
	Compare
	Uncertainty analysis
	Show data of all projects

In the Network and Tree window, you will find additional buttons. Only some of the important and commonly used buttons are listed below. For complete explanation, please refer to [section 3.2.4](#).

Buttons	Function name
	Show cumulative indicator
	Show indicator as percentage
	Exclude long-term emissions
	Show flow indicator

<input type="text" value="0 %"/> ▲▼	Node cut-off
	Show navigator
	Show process or product stage and calculation details
	Show analysis groups

1 Introduction



1 Introduction

1.1 The goal of the tutorial

This tutorial aims to guide you through your first experience with SimaPro desktop by taking you through a series of simple examples. For the SimaPro Online Platform, separate guides are available on the [SimaPro Help Center](#).

This tutorial does not attempt to explain the theory behind LCA and all its methodological issues. The basic theory and main concepts behind LCA are described in a separate manual '[Introduction to LCA with SimaPro](#)'. This tutorial focuses on environmental LCA, not paying attention to social impact and life cycle costing. Each chapter in this tutorial starts with a summary of what you will learn and what you should read beforehand. For better understanding, we suggest you use this tutorial in complement to the SimaPro software.

Following the examples in the tutorial

You need to have a registered version of SimaPro. The demo version has the same functionalities as the full version, but there are some important differences: you can enter, edit and save data, but you cannot create new projects and the save command can only be used 16 times. Copying and editing the library data is also not possible if you are using the SimaPro demo version. Please note that reinstalling the demo will not reset the counter.

SimaPro 9.5

Please note that this manual has been developed using SimaPro 9.5. If you are using another version of SimaPro, your results and screens may differ from what is presented here.

1.2 Tutorial structure

We have used one broad example of a road bike model throughout this tutorial to help you get acquainted with SimaPro. Using this example, we have also prepared similar LCA model exercises so that you can model LCA projects using SimaPro efficiently in the future.

Important remark

All inventory data for modelling examples in this tutorial is fictitious and does not reflect any actual case. Therefore, results from these cases should be regarded as such.

Chapter 2: SimaPro – Basic Introduction

This chapter gives you an idea of how the SimaPro databases are designed and explains the use of different options and SimaPro features. In addition, you will learn how to build LCA models theoretically. It also serves as an introduction to Chapter 3 where you will start modeling yourself.

Chapter 3: Building your first model

This chapter will explain how to model the impacts over the life cycle of a road bike. You will first model the different types of frames used in a road bike and then analyze, compare, and interpret their impacts. We will show you an example to model one bike frame from which you will model the remaining frames in the form of exercises.

Chapter 4: Building an advanced model

You will model the different components used in a road bike, its use stage, and final disposal stages i.e., in short, you will be building a more advanced model of the road bike.

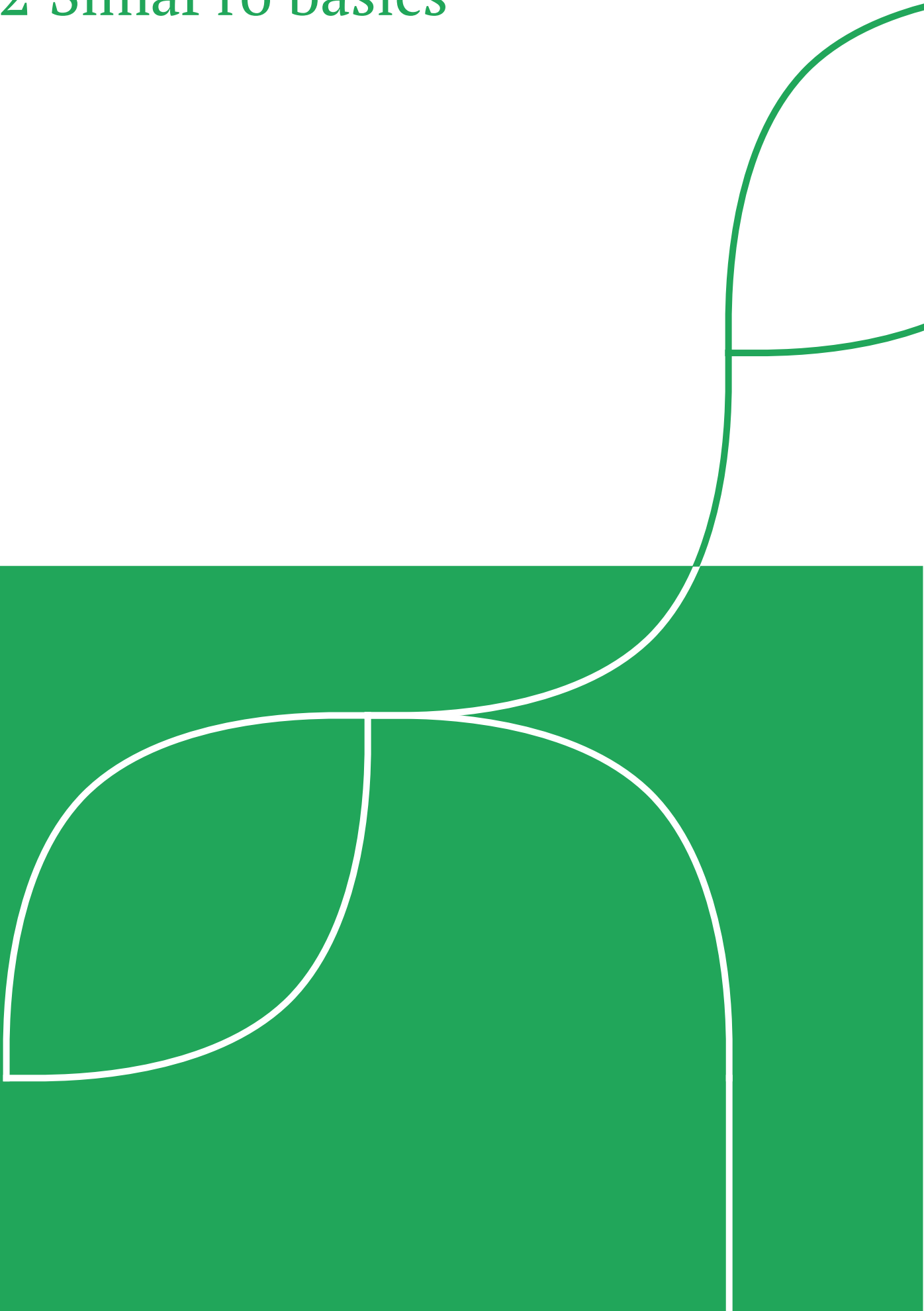
Chapter 5: A parameterized bike model

Sometimes, you have to input data assumptions for your LCA model which might/will result in uncertain calculations. Using the Parameters option in SimaPro, you can compare the impacts of different input scenarios. In this case, we will compare the impacts of different scenarios with respect to the inputs of the road bike LCA model.

1.3 SimaPro training

With this tutorial, you will learn how to use SimaPro by yourself. If you want to develop more advanced skills, PRé and its global partners provide dedicated SimaPro trainings. Please check [this](#) page for more information. Some trainings require you to first perform some of the lessons in this tutorial, to ensure that everyone attending the course understands the basics. This also allows for more time to be spent on more advanced subjects.

2 SimaPro basics



2 SimaPro basics

What you will learn	Get to know the structure of SimaPro databases, become familiar with the result screens and explore the features of SimaPro. This chapter serves as the basis to build your models.
Required entry level	Basic understanding of what LCA is about - this is intended to be your first experience with SimaPro
Recommended reading	Introduction to LCA with SimaPro , Chapters 1, 2, 3 and 4
SimaPro license type	Classroom/Faculty/PhD/Analyst/Developer

2.1 Building blocks of SimaPro

A SimaPro database consists of projects, libraries, and general data as seen in Figure 2.1.

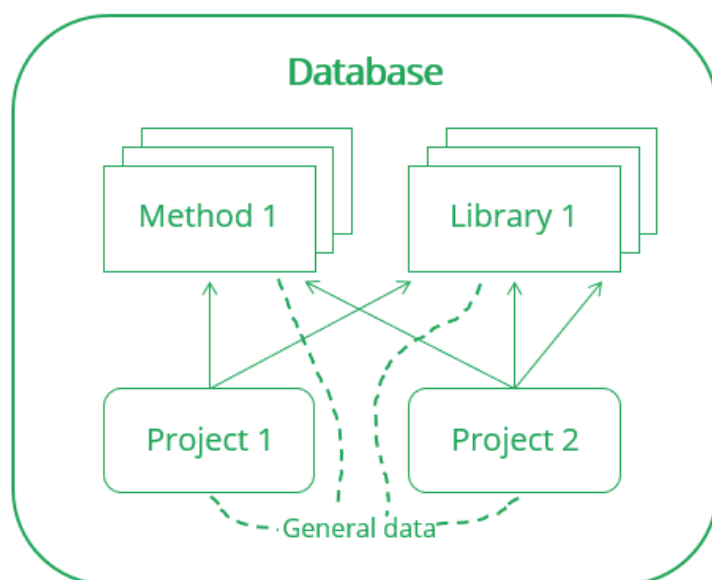


Figure 2.1 Building blocks of SimaPro

General data: The common supporting data for all libraries and projects are stored in the General data. This includes literature references, substances, units, and quantities. Each of these elements is explained in [section 2.2](#).

Libraries: Life cycle inventory (LCI) databases are stored as libraries. SimaPro includes many LCI databases, like the renowned ecoinvent database and the industry-specific Agri-footprint database. LCI databases contain information about the inputs, outputs, and emissions of industrial and agricultural processes. These processes can be used as background data for your LCA model. Further information is available in [section 2.4](#).

Projects: Your model is saved in a project. Enter the input data for your model by creating your own processes (if you have detailed data) and/or by linking the processes already predefined in the LCI databases to your project. The projects are interlinked with the general substances and different libraries since they are modeled using the data from these substances and libraries.

2.2 General data

Once you start SimaPro, you will see the “General data” column below on the left (indicated with a green box in Figure 2.2) with different categories under it.

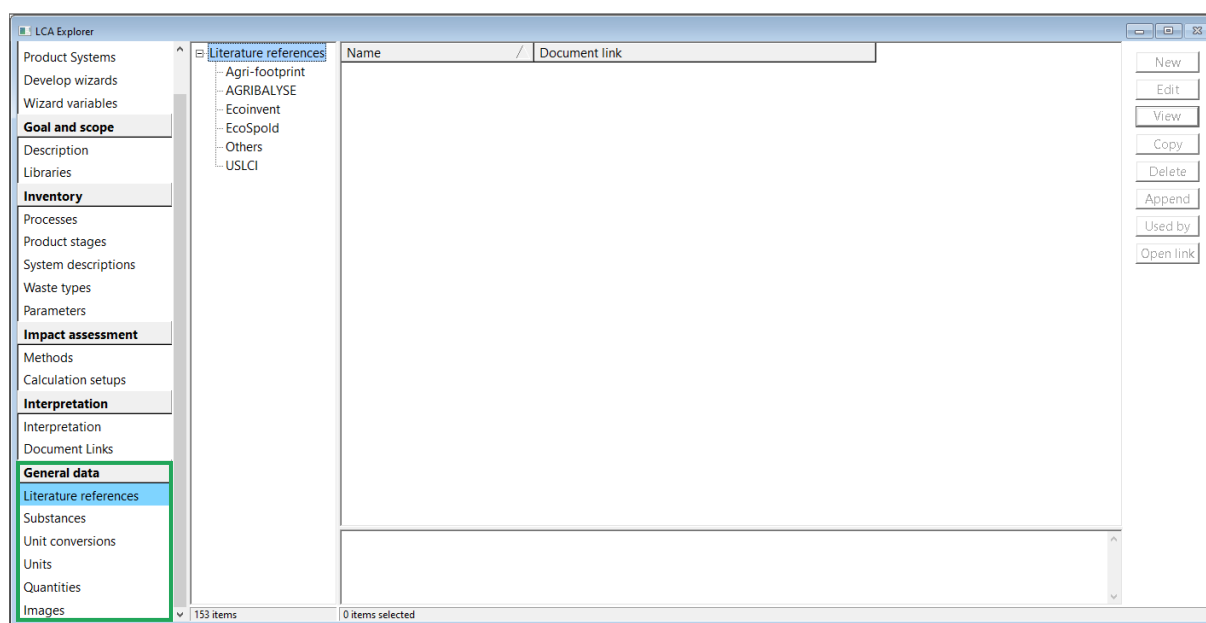


Figure 2.2 LCA Explorer: General data

These include:

Literature references: Contain website links and references to the documents of the datasets used as part of the different Life Cycle Inventory (LCI) libraries or to your projects.

Substances: A single list of all the substances which are linked to the various materials and processes in the database.

Units: Define the conversion factors and units for the different quantities in SimaPro.

Quantities: Overarching the various quantities (like mass, volume, energy, etc.) to group units.

2.3 Libraries

You will see Figure 2.3 when you click on *Libraries* on the left column under “Goal and scope” after opening a project or creating a new project. These libraries contain the inventory databases for all the processes you can select for your model and one library project that contains all default methods.

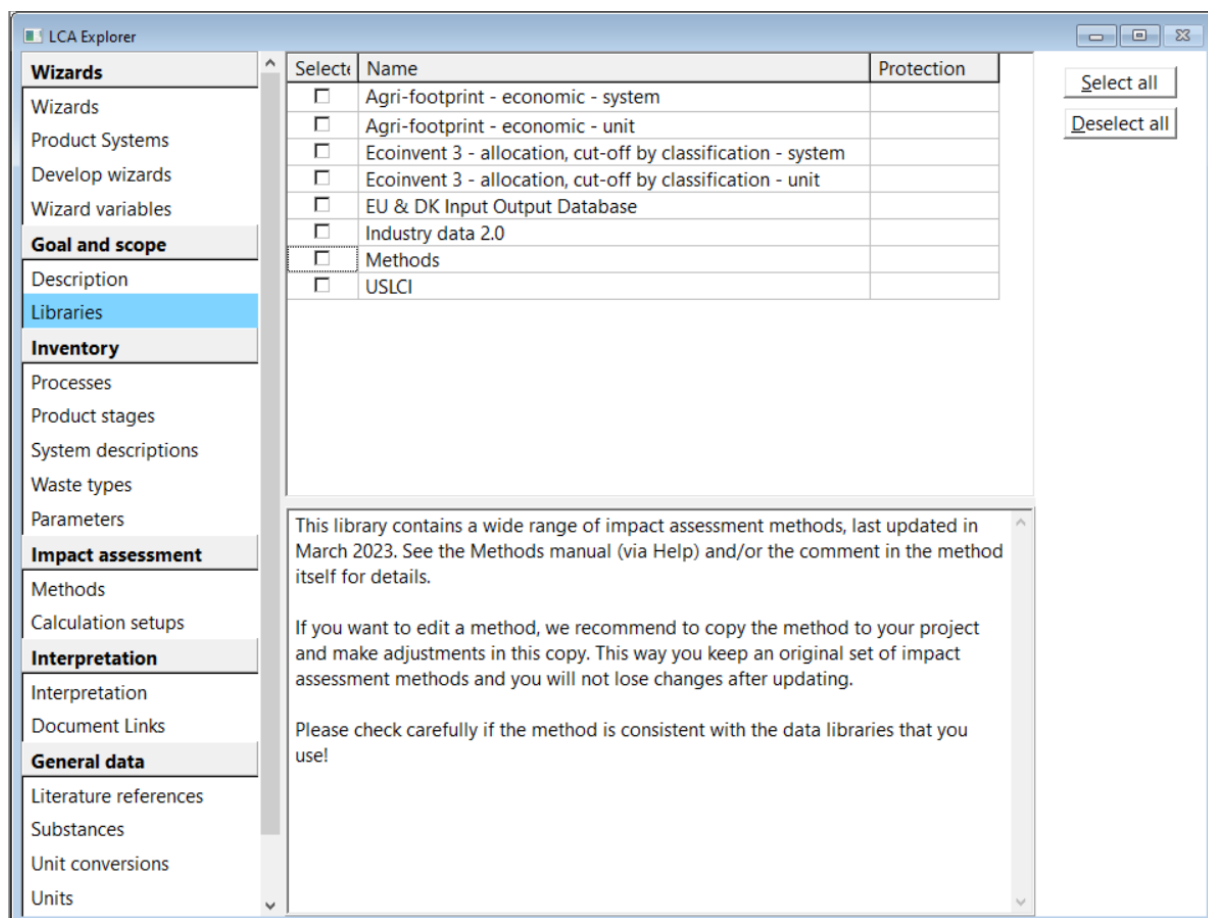


Figure 2.3 LCA Explorer: Libraries

Additional data available for SimaPro users

Figure 2.3 provides an overview of the default libraries in the SimaPro Professional database (given users have a valid ecoinvent license). For a full overview of data available for SimaPro users, please refer to this [article](#).

2.3.1 Library design

Any model will have four main life cycle stages associated with it as shown in Figure 2.4.



Figure 2.4 Overall life cycle stages of products

During these life cycle stages, background processes are also involved. Background processes are not the direct subject of your LCA but are necessary to model your result. For example, transportation- and energy- processes each cause raw material usage and emissions. The amounts and type of transport and energy needed for your model are foreground information, the processes describing transport and energy production are background processes.

The LCI libraries (inventory databases) include processes containing inputs and outputs. The input can come from nature as well as from other industrial processes included in the same library. The outputs are products, emissions to air, water and soil and also material for further processing (waste treatment). Figure 2.5 gives an overview of how SimaPro inventory processes are built.

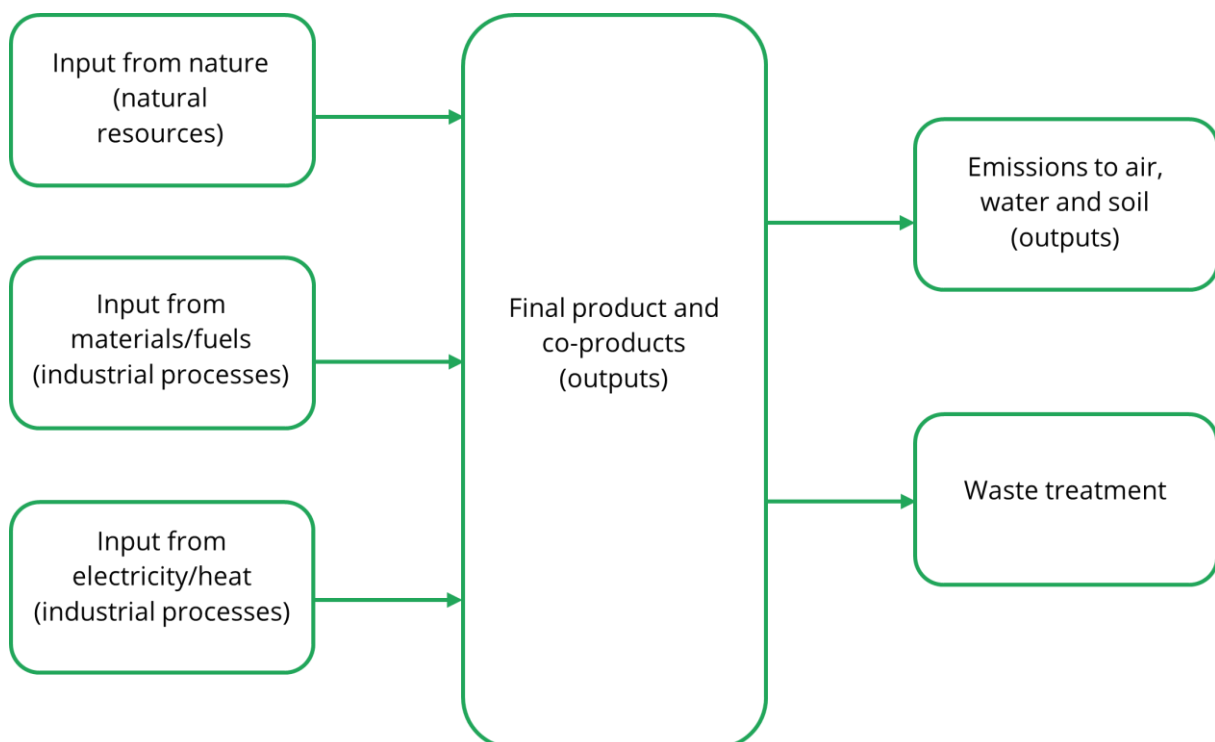


Figure 2.5 SimaPro inventory processes

2.3.2 Library types in SimaPro

From Figure 2.3 you can see that different libraries can be used for your project. Overall, apart from the one library project that contains all default methods, there are two types of libraries with inventory data: process data and input-output data libraries.

The process data libraries should be used to determine the environmental impacts of products or processes according to their mass or other relevant quantities. For example, what is the environmental impact of using 1 kg of cement or 1 kWh of electricity from the grid in The Netherlands?

Similarly, the input-output data libraries are used to determine the environmental impacts of investments or purchases you make within a sector or between different sectors. For example, what is the impact of buying X euros of goods from the agricultural sector in the country of region Y?

2.3.2.1 Process Databases

Agri-footprint

This library developed by Blonk Consultants allows you to do agricultural LCAs, provides information about bio-based production methods for the chemical and energy industry, and allows you to perform ISO-compliant LCAs. It contains thousands of products and processes specific to agricultural LCA: crops, products and intermediate products, feed compounds, food products, animal production systems, and background processes such as transport, auxiliary inputs for processing, and fertilizers. Most of these products have three predefined allocation options – mass, energy, and economic- and have entries for different locations in the world. Read more about the detailed list of products included in the database on the [Agri-footprint website](#). Extensive documentation on the [methodology and modelling](#) principles is available. The description of data is also well documented.

ecoinvent

The ecoinvent Life Cycle Inventory (LCI) database developed by the ecoinvent center is the most complete and well-documented LCI database that is currently available. It consists of many thousands of datasets on energy supply, agriculture, transport, biofuels and biomaterials, bulk and specialty chemicals, construction materials, packaging materials, basic and precious metals, metals processing, ICT and electronics, dairy, wood, and waste treatment. Read more about the ecoinvent methodology at [ecoinvent overview and methodology](#).

The following ecoinvent databases are available for SimaPro: Allocation at point of substitution (APOS), Allocation cut-off by classification, Substitution, consequential, long-term and Allocation, cut-off, EN15804. For more information see the [ecoinvent system models](#). System and unit processes are available for all four modelling options.

What is the difference between unit and system processes?

The unit process contains only emissions and input of raw materials from one process step, plus references to inputs from other unit processes. So, for instance a unit process called “Steelmaking”, contains data on “transports of hot metal and other input materials to converter, steelmaking process and casting”. This means the unit process starts at the point where molten iron comes in from another process. The environmental load connected to ironmaking is described in a series of upstream unit processes, which you can look into. When you select this process, SimaPro will automatically include all these upstream processes.

For the same steelmaking process, the system process version includes all emissions from mining to steelmaking as part of this one process record. You will also find that there are no links to other processes. A system process is the aggregated inventory result of an overall LCA on steel making and gives no insight into the inputs and outputs of the separate supply chain processes in the production system. A system process is, therefore, considered as a black box. The outcome of a calculated inventory of a unit process (including [infrastructure processes](#)) is identical to that of the system process with the same name.

The main differences between unit and system processes are visible in Figure 2.6 and Table 2.1.

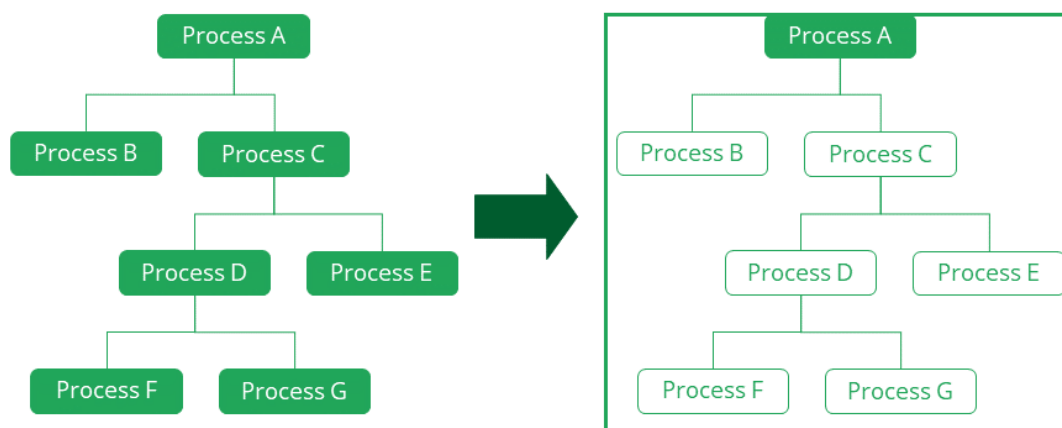


Figure 2.6 infographic on unit process (left) and system process (right). Unit process consists of large network for every process, while system process is aggregated data (one box per process)

Table 2.1 main differences between unit and system processes

Unit process	System process
Transparent (but big) process tree, that allows you to trace the contribution of all individual unit processes	One aggregated process. No process tree or network with individual unit processes
Contains uncertainty information, which allows you to run statistical analysis (Monte Carlo)	No uncertainty information
Relatively slow calculation	Fast calculation

Whether you use Unit processes or System processes, will not influence the final results. However, it is recommended to choose System processes by default as this will greatly improve the calculation speed in SimaPro. Additionally, using System processes is handy to deal with confidential data as datasets may be transformed into a single system process and all underlying details are removed. On the other hand, using the unit processes when analyzing provides insight into where a certain emission or impact upstream exactly takes place.



Library switch feature

Although we recommend the use of System processes by default, your project might benefit from using the Unit processes, and vice versa. An easy way to switch between these two libraries in SimaPro is by using the library switch function. This allows you to replace all data from one library to another, given that processes in both libraries have the same names. To do this, go to the Calculation setup window. Select the library the process is now using under the *Current library* field and then click the library you want to switch to under the *Replacing library* field.

This switch can not only be used to switch between System and Unit libraries, but also between different ecoinvent system models as long as processes have the same names in both libraries.

USLCI

The U.S. Life Cycle Inventory ([USLCI](#)) database developed by the National Renewable Energy Laboratory (NREL) allows you to analyze the environmental impacts of a material/component/assembly manufactured in the USA. Read more about the plans to achieve the goals of the LCI Database project in [U.S. Life Cycle Inventory Database Roadmap](#). Sometimes this USLCI library in SimaPro contains dummy processes (i.e., no environmental impacts are associated with these processes). In that case, the LCA practitioner should use proxy data from other sources to bridge the gaps.

Industry data 2.0

This library contains more than 300 datasets collected by industry associations, Plastics Europe, World Steel, and ERASM (European Detergents and Surfactants Industries). These three industry databases contain data that is specific to each industry but are also relevant to many other sectors downstream. The data is provided in aggregated form (as system processes) meaning that unit processes are not available. PlasticsEurope contains roughly 85 system-level datasets including high volume, bulk polymers, some of the widely used engineering plastics and other common plastic conversion processes. Worldsteel contains 46 datasets related to steel products. ERASM includes 32 life cycle inventories for unit processes, covering 15 surfactants and 17 precursors. Read more about the industrial associations at [Plastics Europe](#), [worldsteel](#) and [ERASM](#).

2.3.2.2 Input Output Databases

Input output databases allow you to assess the environmental impact of services and study consumption patterns. They are also useful for screening LCAs or to assess the importance of missing data. You can find out more about input output databases under Help> SimaPro Manuals. The following input-output database is available in SimaPro by default:

EU & DK Input Output Database

The European Union and Denmark (EU & DK) input output database allows you to model the environmental impacts for the imported products to Denmark and produced in 27 EU countries. Read more about this database at [EU & DK Input Output Database Manual](#).

See our [website](#) for more information on databases available for SimaPro.



Editing library data

If you want to make changes in the library data, please always first copy these library processes or methods to your project and then make the changes to the data accordingly in the copied library datasets. By doing so you keep the libraries as delivered by PRé intact and prevent unwanted overwriting of your adapted processes or methods when updating a library.

2.4 Projects

Your work in SimaPro will be saved in a project. When you open SimaPro, and whenever you click on the “Open project” icon, you will see a window like Figure 2.7 with all projects listed.

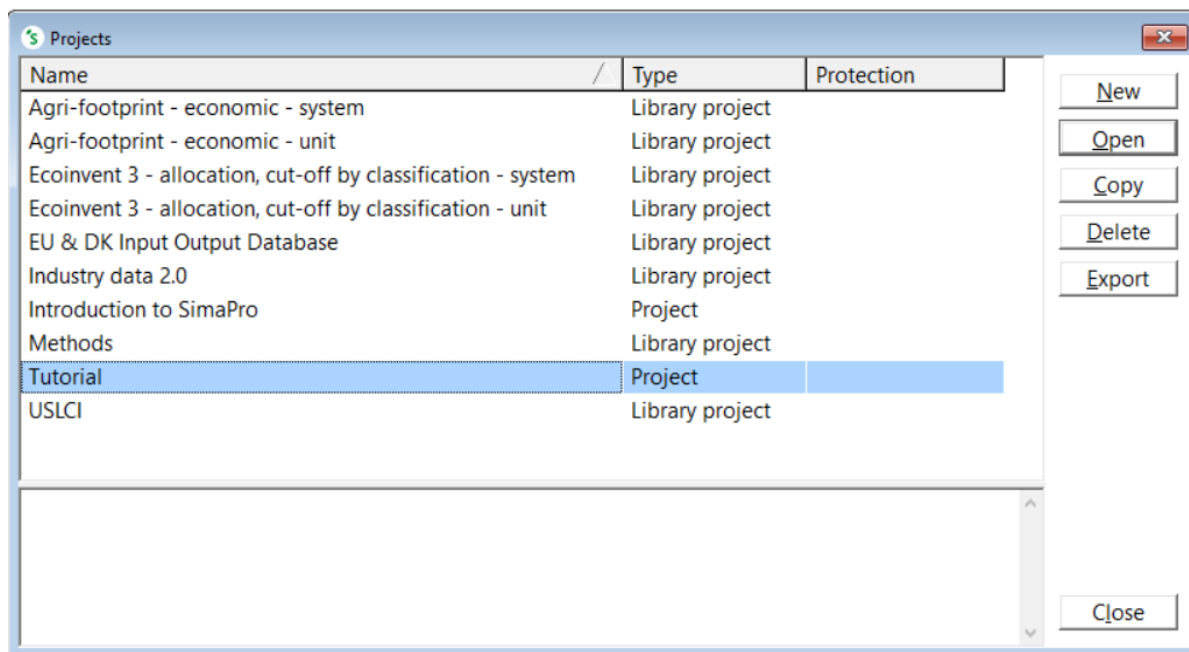


Figure 2.7 Projects window

To start a new project, select *New* to enter the name of your project and click *OK* to save it. To continue working on an already existing project, select a project and click on *Open* to continue building your model. Or simply double-click on a project's name. For this tutorial, we used the “Tutorial” project, as available in the SimaPro Professional database. You could use this project for modelling the tutorial examples and exercises.

Two types of projects

You can notice that there are two types of projects, ‘Library Project’ and ‘Project’ in the above window. Please ensure that you don’t work in any standard library project available in the Professional database for database management reasons. Libraries consist of the background inventory data to be used in different projects. To make sure that you don’t work in a library project, you can sort the projects according to their type by clicking on the Type pane above.

If you choose to make a new project this will by default, always be a ‘Project’.

2.4.1 Goal and Scope

Once you open a project, enter the goal and scope details of your project by selecting 'Description' column on the left, just like the first step of a Life Cycle Analysis (LCA) of any system. You will see a window similar to the image in Figure 2.8.

The screenshot shows the 'LCA Explorer' application window. On the left is a sidebar with a tree view containing the following categories and items:

- Wizards**
 - Wizards
 - Product Systems
 - Develop wizards
 - Wizard variables
- Goal and scope** (selected)
 - Description** (selected)
 - Libraries
- Inventory**
 - Processes
 - Product stages
 - System descriptions
 - Waste types
 - Parameters
- Impact assessment**
 - Methods
 - Calculation setups
- Interpretation**
 - Interpretation
 - Document Links
- General data**
 - Literature references
 - Substances
 - Unit conversions
 - Units
 - Quantities
 - Images

The main area on the right contains a form with the following fields:

- Name:
- Date:
- Author:
- Comment:
- LCA type: (dropdown menu)
- Goal:
- Reason:
- Commissioner:
- Interested party:
- Practitioner:
- Functional unit:
- Reference flows:
- Alternative scenarios:
- Product name suffix:

At the bottom right of the form are two buttons: 'Save changes' and 'Undo changes'.

Figure 2.8 LCA Explorer: Goal and scope, Description

You can enter the name, date, person/persons involved, brief description of your project under the "Name", "Date", "Author" and "Comment" fields respectively. Choose the type of your LCA study under the "LCA type" field. A brief description of each LCA type will be visible in the drop-down menu for the corresponding type. The "Reason", "Commissioner", "Interested party" and "Practitioner" fields won't be required unless you are performing an LCA for specific companies. You do not need to fill all fields to complete this tutorial. The following description of the goal and the scope of an LCA is just to inform you on the standard procedures in life cycle assessment.

Goal: Define the main goal of your LCA study. According to the ISO 14040 LCA standard, the description of the goal of an LCA study should contain the following elements:

- The intended application of the LCA
- The reason for carrying out the study
- The intended audience
- Whether the results are intended to be used to support comparative assertions intended to be disclosed to the public

Scope: According to the ISO 14040 LCA standard the scope of an LCA study should contain the following elements:

- The product system to be studied
- The functions of the product system(s)
- The functional unit and respective reference flow(s)
- The system boundaries
- Allocation procedures
- Impact categories selected and LCIA method
- Data requirements
- Assumptions
- Limitations
- Initial data quality requirements
- Type of critical review, if any
- Type and format of the report required for the study

Functional unit: When comparing two or more products it is essential that they can fulfill the same function. A measure of this function is defined as functional unit (FU). The functional unit consists of quantitative and qualitative elements defining the “what,” “how much,” “how long” and “how well”.

Functional unit example

If you compare the environmental impacts of two different hand drying systems (for example, paper towels and electric hand dryers), then the function is drying hands. The functional unit can be defined in the following way:

What	Dry hands
How much	1 pair of hands
How long	Right after drying
How well	Less than 0,1 gram of water remaining per hand

Reference flows: The reference flows of the system you model. Mention the other systems which are required to fulfill the functional unit of your system under this field.

Reference flows example

If you are calculating the environmental impact of paper towels, with the functional unit being one pair of dry hands with less than 0.1 gram of water remaining after drying, then the appropriate reference flows would be two paper towels and corresponding packaging systems involved, dispenser, waste bin and bin liner used. Without these components, it would be impossible to fulfill the functional unit.

Alternative scenarios: Describe the alternative scenarios you modeled with respect to your system life cycle. Sometimes you have to make various input data assumptions while modeling, which results in variable/uncertain results. Thus, you have to model alternative scenarios (using variable inputs) to understand the level of uncertainty associated with the results. This will be discussed more in detail as parameters in [Chapter 5](#).

Alternative scenarios example

In the above reference flow example, we mentioned that two paper towels would be required for drying a pair of hands. But you can also model the environmental impacts of using one or three paper towels for drying a pair of hands as part of the alternative scenarios since the number of paper towels used for drying a pair of hands varies from person to person.

When you click on the “Libraries” beneath Goal and scope on the left, you can see the different libraries containing LCI databases on the right. [Section 2.4.1](#) includes a description of these libraries. You can also see a brief description of a library when you single-click on it. Select the appropriate libraries for your project. Please make sure to also select the ‘Methods’ library by default, so that you don’t experience problems while modeling the impacts of your system (which will be discussed in [Chapter 3](#)).

For this tutorial, we selected the “Ecoinvent 3 – allocation, cut-off by classification – system” and “Methods” library. After selecting these libraries, you will see the following window (Figure 2.9).

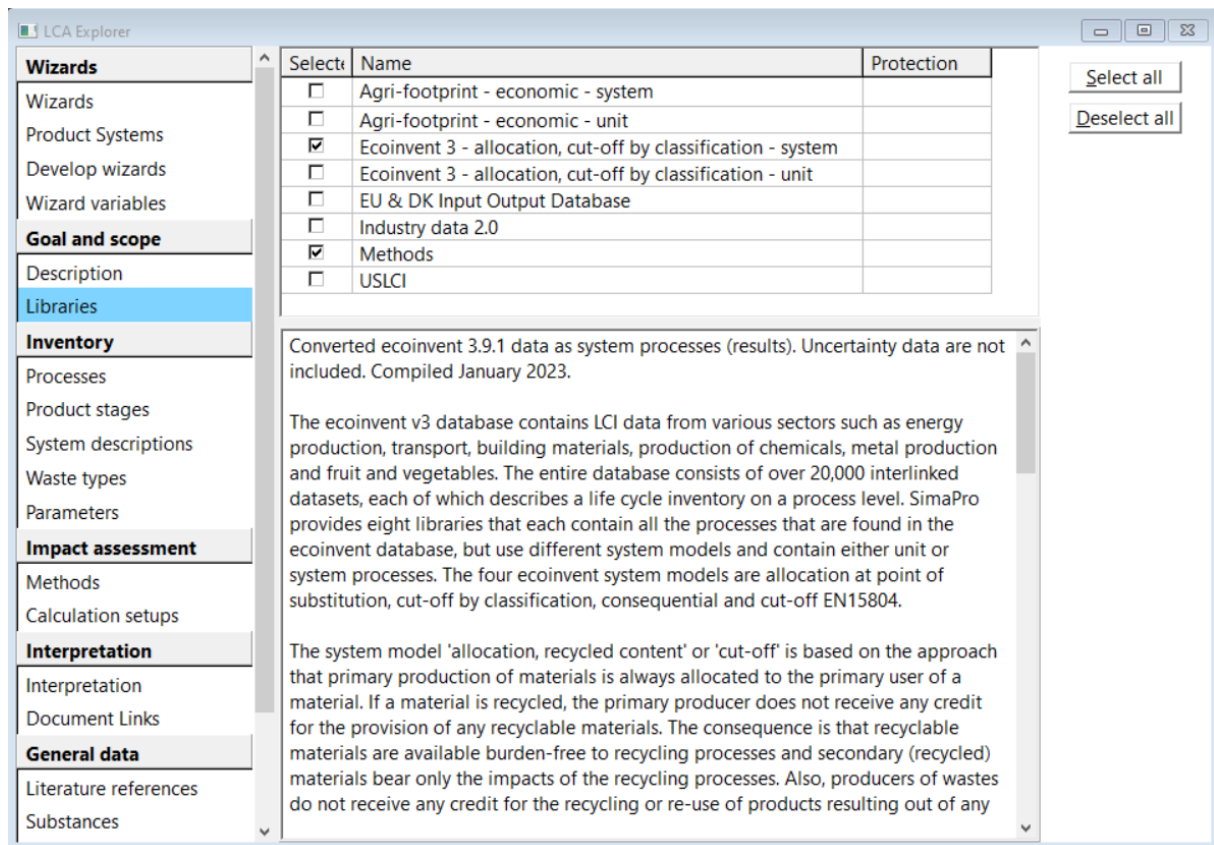


Figure 2.9 LCA Explorer: Libraries

Methods library

Please don't forget to select the 'Methods' library by default, so that you don't experience problems while modelling the impacts of your system (will be discussed in Chapter 3).

Multi-functionality

Sometimes a process can result in more than one product (output) being produced i.e., co-products. This is called a multi-functional process. It is therefore important to identify the environmental impact associated with multiple product outputs or functions. For example, in a sawmill, the logs are converted into planks, sawdust and bark (Figure 2.10). Thus, you have to allocate the environmental impact of the sawmill process across the products planks, sawdust and bark.

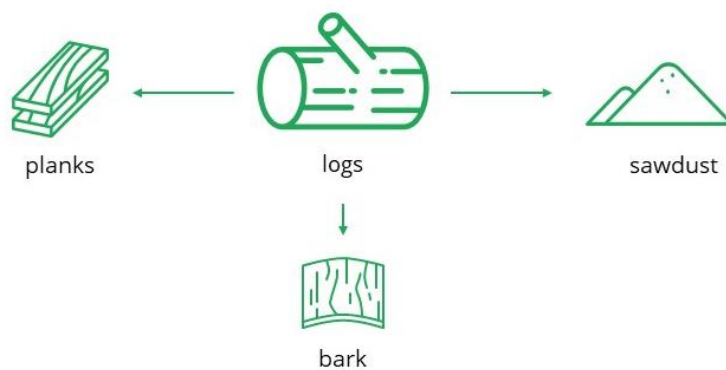





Figure 2.10 Example of a multi-functional process

Allocation of a multi-functional process

There are different types of allocation such as mass, economic, area and volume allocation. Mass and economic allocation are most commonly used. In mass allocation, you are allocating the impacts of the process according to the mass (weight) of the product and co-products. This means, the higher the weight of the product relative to the total weight of outputs, the higher the percentage of the allocated impact becomes. So, for example, when the mass of planks is 60% of the total weight, 30% is sawdust and 10% is bark, then the environmental impacts are allocated accordingly: 60% of the environmental impact to the planks, 30% to the sawdust and 10% to the bark.

When the different outputs vary strongly, likely reflected by the difference in revenue per kg planks on one hand, and sawdust and bark on the other hand, economic allocation might be more appropriate. For the economic allocation, you are allocating the environmental impacts according to the revenue generated by the products and co-products i.e., the higher the product revenue, the higher the allocation percentage. So, for the above sawmill process example, you have to allocate the environmental impacts based on the revenue generated by the planks, sawdust and bark. For instance, if the planks generate 85% of the revenue, the sawdust 10% and the bark 5%, the environmental impacts are allocated accordingly: 85% of the environmental impact to the planks, 10% to the sawdust and 5% to the bark. See Table 2.2 on how to calculate the allocation percentage.

Table 2.2 Allocation example for a multifunctional process

Logs products		Mass	Economic
	Planks	$\frac{\text{Mass planks}}{\text{Mass planks} + \text{Mass sawdust} + \text{Mass bark}}$	$\frac{\text{Value planks}}{\text{Value planks} + \text{Value sawdust} + \text{Value bark}}$
	Sawdust	$\frac{\text{Mass sawdust}}{\text{Mass planks} + \text{Mass sawdust} + \text{Mass bark}}$	$\frac{\text{Value planks}}{\text{Value planks} + \text{Value sawdust} + \text{Value bark}}$
	Bark	$\frac{\text{Mass bark}}{\text{Mass planks} + \text{Mass sawdust} + \text{Mass bark}}$	$\frac{\text{Value planks}}{\text{Value planks} + \text{Value sawdust} + \text{Value bark}}$

2.4.2 Inventory

Under the “Inventory” section, you can enter the materials and processes (input) details for building your system.

Market versus transformation processes in the ecoinvent library

Since we selected the ecoinvent library for this tutorial, many of the materials/processes will have two categories: market and transformation.

The market processes include transportation inputs and production inputs from several countries. Use the ‘market’ process {GLO} when the supplier is unknown.

The transformation processes include all the inputs and outputs for making a product or service, including the material and energy inputs, transportation of material inputs and resource extractions and emissions.

In SimaPro, you should only use **Processes** and **Product stages** to build your model as seen in the highlighted category in Figure 2.11.

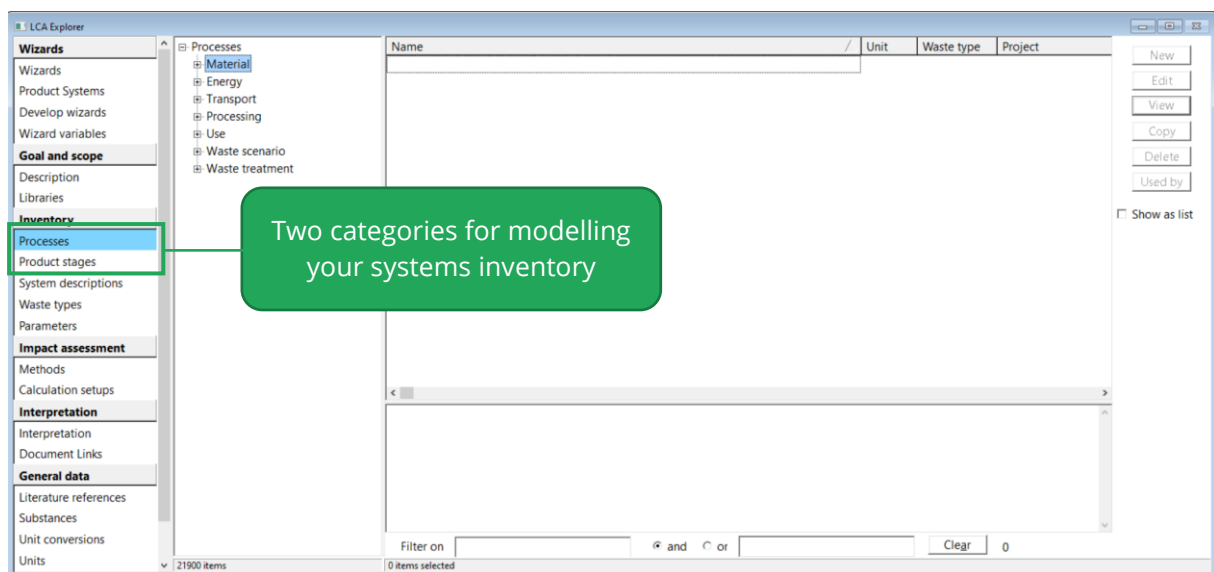


Figure 2.11 LCA Explorer: Inventory, Processes and Product stages

As illustrated in Figure 2.12, you can directly link processes to substances while in product stages, there is no link to nature. Waste scenarios are the exception because they only contain scenario information (percentages linked to waste treatment processes) – no substances.

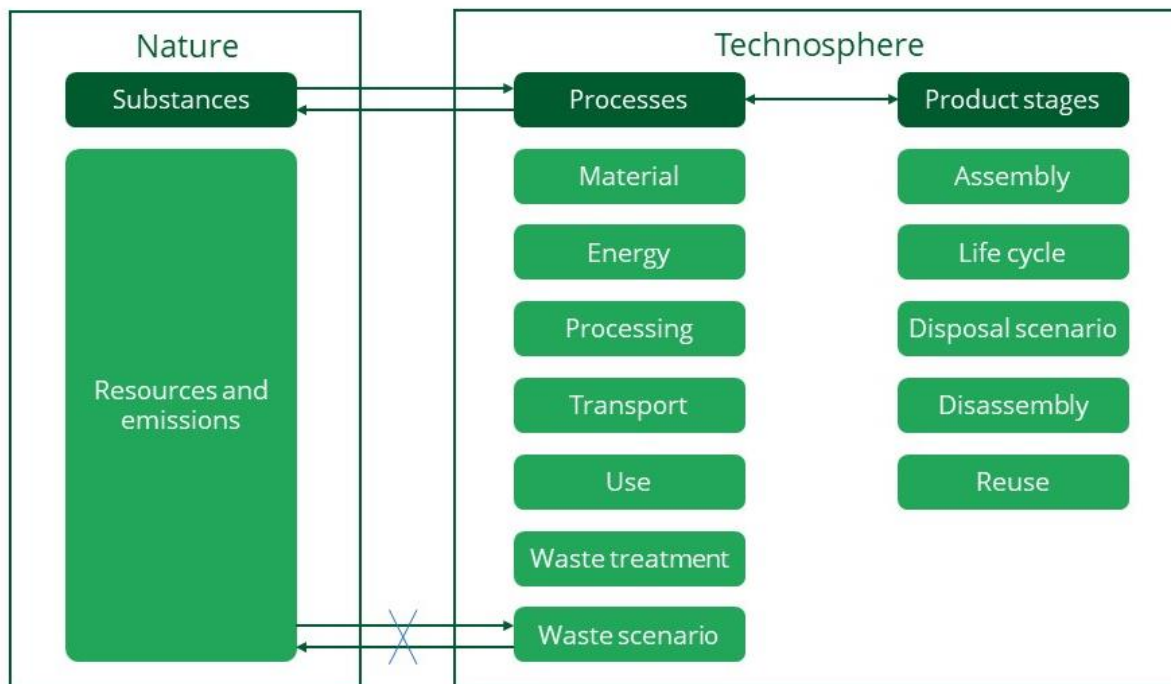


Figure 2.12 An overview of where you model in SimaPro.

When to use processes and product stages?

Use processes, if you are only interested in doing cradle-to-gate modelling of your product i.e., if you only want to analyze the environmental impact of a product associated during its manufacturing. Also, you want to use the processes, if your modelled components/processes shall be highly interconnected and e.g. if the processes shall be used in other projects and/or included in new libraries.

Use product stages, if you want to look at the environmental impact caused during the overall life cycle of a product (manufacturing, use and disposal), i.e. cradle-to-grave modelling. Utilize this also if the product involves the use of (reusable) components that are disposed differently, and you want to use the waste scenarios in SimaPro.

If you want to model production waste, with the associated additional material needed and waste processing, you have to create a process first and link the assembly (product stage) 1-on-1 to the process's product output.

In the upcoming sections, you will learn how to build new models and enter their life cycle details under the **processes** and **product stages** in SimaPro.

2.4.2.1 Processes

The **processes** contain environmental data for many materials, energy, transport, processing and use processes alongside the waste scenario and waste treatment processes in SimaPro Figure 2.12. You can also create a new process in the database or if required copy an existing one already in the database, edit its inputs and outputs and save it. When you click on "Processes", you can see seven main categories as seen in Figure 2.13.

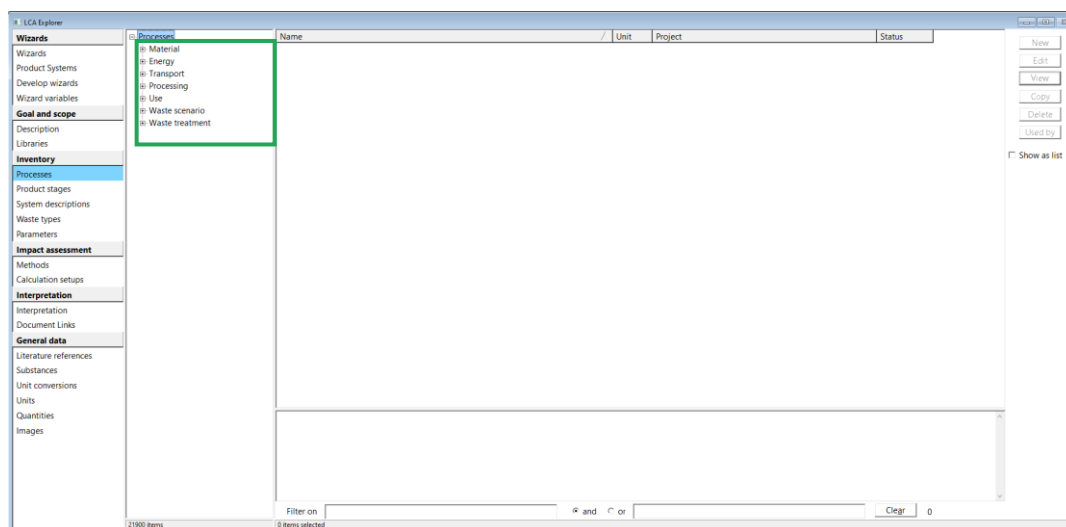


Figure 2.13 LCA Explorer: Inventory, Processes, Processes: Material, Energy, Transport, Processing, Use, Waste scenario, Waste treatment

In addition, you can also create a new category by right-clicking on any one of these seven main categories and selecting *New Category*. Enter a name and you can save all your project processes here. In this tutorial, we used the material category but you can choose any sub-category to create your process. For this example below, we simply chose the sub-category “Animal feed” under “Agricultural”. In the following example, you can find the basic instruction for creating a new process while in [Chapter 3](#), you will be presented with a guided example to model in SimaPro.

- 1) Double-click on the *Material* category, select any sub-category and click on *New* on the right side. The following window will open where you can enter the inputs and outputs of a system. In the ensuing window, you can see that there are four different tabs: “Documentation”, “Input/output”, “Parameters” and “System” description. Select the *Input/output* tab. You will see a window like Figure 2.14.

New material process

Documentation | **Input/output** | Parameters | System description

Products

Outputs to technosphere: Products and co-products	Amount	Unit	Quantity	Allocation	Waste type	Category	Comment
	0	kg	Mass	100 %	not defined	Agricultural/Animal feed	
Add line							

Inputs

Inputs from nature	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Inputs from technosphere: materials/fuels	Amount	Unit	Distribution	SD2	Min	Max	Comment
Add line							

Inputs from technosphere: electricity/heat	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line							

Outputs

Emissions to air	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Emissions to water	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Emissions to soil	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Final waste flows	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Non material emissions	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Social issues	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Economic issues	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line								

Outputs to technosphere: Waste treatment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line							

Figure 2.14 Material process (tab Input/output)

Material versus Processing category in SimaPro

Production of (intermediate) products is typically modelled under the "Material" category. Here you can assign a waste type to your product that will be used in the end-of-life modelling (after the use phase) to make sure the proper waste scenario is selected.

Processing of materials and products is typically included in the "Processing" category, where this waste type is excluded, but production waste treatment processes can be selected if relevant. Therefore, you can model in the "Processing" category if you think your process doesn't produce materials that need to be taken care of through the waste scenario after the use phase.

Either way, this shouldn't bring differences to the result for the production process. Material processes can refer to processing processes and vice versa.

- Under "Outputs to technosphere: Products and co-products" enter the final product name which you want to calculate the impacts for. The default quantity is Mass, which is most often preferred but can be changed under the field "Quantity". Enter its value and respective unit in the fields "Amount" and "Unit". Choose the corresponding waste type for your new system under the field "Waste type". Choosing a waste type is only possible for the mass quantity. The field "Allocation %" field will be described in the next paragraph.

- 3) In some cases, useful co-products are produced along with the main product or process. For example, a cow produces not only milk but also meat, skin and bone as marketable products. The environmental impact should be allocated to these different products, considering their quality and quantity. See how to deal with allocation in the "Multifunctionality" section under the [Goal and Scope](#).
- 4) Choose the raw materials (inputs) directly obtained from natural resources/processes by double-clicking the *Add* button under "Inputs from nature" and mentioning its amount and unit under their corresponding fields. Examples of raw material obtained from natural resources are "Wood, unspecified, standing/m3", "Zinc, Zn 3.1%, in mixed ore" and "Water, well, NL". These raw materials are just substances in SimaPro and in themselves do not contain any associated human activities. These raw materials are characterized in the end and then contribute for example to resource use (or abiotic depletion) and water use.
- 5) Similar to the above step, choose the materials obtained from industrial processes by double-clicking the line under "Inputs from technosphere: materials/fuels" or for energy processes under "Inputs from technosphere: electricity/heat" and mention the respective amount and unit required to produce the final output (material/process/product).
- 6) Once you enter all these input details, select the corresponding substances released as emissions to "air", "water" and "soil" by double-clicking the line under their respective fields. Like with raw materials these emissions are characterized in the end and then contribute to for example acidification, ozone depletion and toxicity. Select the final waste produced (if any) by double-clicking the line under the "Final waste flows" field. Under the "Non-material emissions" fields you can enter non-material inventory like noise.
- 7) Specify the wastes that are treated in waste treatment under the "Outputs to technosphere: Waste treatment" field. For example, choose Coal slurry {GLO}| market for coal slurry | Cut-off. You can define how production wastes are handled in this field i.e., whether these wastes are incinerated/landfilled/recycled.

Documentation

Once you finish creating a new process, specify the characteristics of this process by clicking on the **Documentation** tab. You will see a window similar to Figure 2.15.

The screenshot shows the 'New material process' window with the 'Documentation' tab selected. The form contains the following fields and values:

Name			
Process type		Process identifier	
Infrastructure process	No	Status	None
Date	28-3-2023	Image	
Comment			
Collection method			
Data treatment			
Allocation rules			
Verification			
Record			
Generator			
External links	Add line	Comment	
Literature reference	Add line	Comment	
Project	Tutorial	Category	Material
Created on	28-3-2023	Last update on	28-3-2023

Figure 2.15 Material process (tab Documentation)

Process name in SimaPro

Under the Documentation tab, you can enter the process name. Please note that this is only for your own reference and this name is not used anywhere. Processes are identified by the name defined under the Input/Output tab in the product section. Therefore, if you want to search for a certain process, you should use the product name defined in the Input/Output as the keyword.

It is not required to fill in the documentation fields to make an LCA model and run the calculations, but we do advise to keep good track of the data you collect and enter in SimaPro. This will make your reporting a lot easier.

- 1) Enter the name of your new material/process under the Name field
- 2) Select the type of process (Unit or System process) under the Process type field.
- 3) Enter the system boundaries, production volume, geography, start and end dates and other relevant details of your new material/process under the Comment field.
- 4) Enter the data source under the Collection method field.
- 5) Enter the person/organization responsible for the data entry and generation under Record and Generator fields respectively.
- 6) Mention the external links and other literature references you used for your model under the External links and Literature reference fields respectively.

You can also look at the documentation of existing materials and processes in SimaPro for reference.



Selecting status in SimaPro

You can select different status of your processes or product stages in SimaPro. For processes, this can be found under the Documentation tab, while for product stages, you can find this in the Input/Output tab. The available status are: temporary, draft, to be reviewed, to be revised, and finished. By filling in the status, you can search for processes with a specific status using the “Find” (CTRL + F) function. However, it is not compulsory to do so as this field is merely for informational purposes and it will also not influence your results.

Waste treatment

Waste treatments document the emissions and other impacts which arise from landfilling, incinerating and recycling. To define this, SimaPro already has predefined waste treatments with data on the emissions for the different types of waste treatment. You can view the predefined waste treatments available for the different materials under the Inventory > Processes > Waste treatment and then select the corresponding waste treatment. The waste treatments are available according to the material type and waste destination. You can use these predefined waste treatments or create your own waste treatment process for the input materials. Creating a waste treatment process is similar to creating a new material process discussed above. You can also have a look at how the predefined waste treatments are modelled in SimaPro for reference.

Waste scenario

Waste scenarios allow you to model the end-of-life (disposal) stages for the input materials used in your system. The waste materials are sorted according to their type and sent for treatment. SimaPro already has predefined waste scenarios which you can use for your model. However, this waste scenario works only for the systems modelled as an assembly (see: product stages). The illustration of how waste treatment and waste scenario are specified in SimaPro can be seen in Figure 2.16.

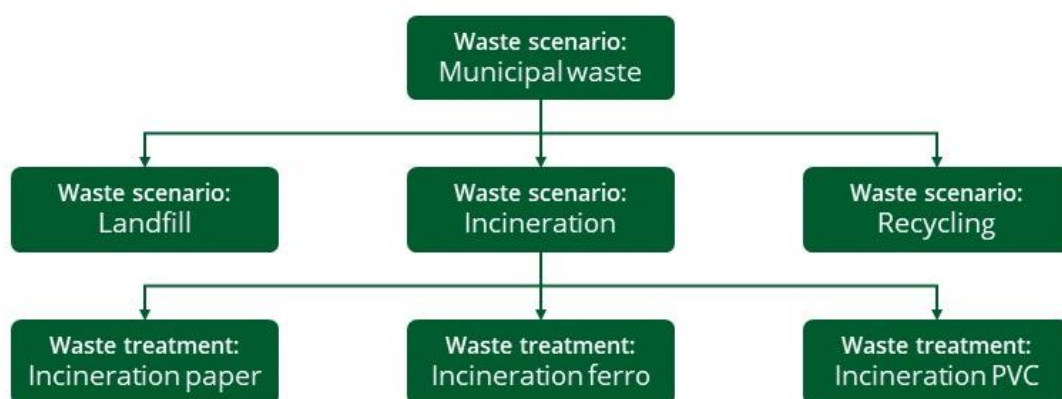


Figure 2.16 A waste scenario specifies how a waste stream is split up and sent to other waste scenarios or waste treatments. This splitting can be specified per waste type (as seen in this figure) or material. A waste treatment specifies what actually happens i.e. if a material is landfilled, incinerated or recycled.

Creating a new waste scenario

- 1) Double-click on *Waste scenario* under Inventory > Processes (make sure that the box “show as list” is not selected) and you will see the different predefined waste scenarios in SimaPro. Select the corresponding waste scenario category you want to model and click on *New* on the right side. In this case, we selected the Landfill waste scenario. The following window will open (Figure 2.17):

The screenshot shows the 'New waste scenario process' window with the 'Input/output' tab selected. The window contains several input fields and tables for defining a waste scenario.

Products

Waste specification	Amount	Unit	Category	Comment
		kg	Household	

Inputs

Inputs from technosphere: materials/fuels

Amount	Unit	Distribution	SD2	Min	Max	Comment
Add line						

Inputs from technosphere: electricity/heat

Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line						

Outputs

Materials and/or waste types separated from waste stream

Material / Waste type	Percentage	Comment
Add line		

Waste streams remaining after separation

Percentage	Comment
Add line	

Figure 2.17 Waste scenario (tab Input/output)

- 2) Enter the name of your waste scenario and its amount of waste input under *Waste specification* and *Amount* field respectively along with its corresponding Unit.
- 3) If there are materials, energy or transport needed for the handling of the mixed waste this can be entered in the same way as under processes, at the Inputs from technosphere: materials/fuels and Inputs from technosphere: electricity/heat.
- 4) Select the *Materials and/or waste types separated from waste stream* and its corresponding Material and/or Waste type. Enter the percentage of the material separated under the *Percentage* field. For example, 90% of glass is collected separately.
- 5) Choose what happens to the remaining percentage of waste materials (i.e., how they are treated) under *Waste streams remaining after separation* field and percentage of treatment under *Percentage* field. For example, you can state that 40% of the remaining waste is incinerated and 60% is landfilled.

2.4.2.2 Product stages

Under Inventory, select *Product stages* and click *Product stages* in the second column. You will now see the following window:

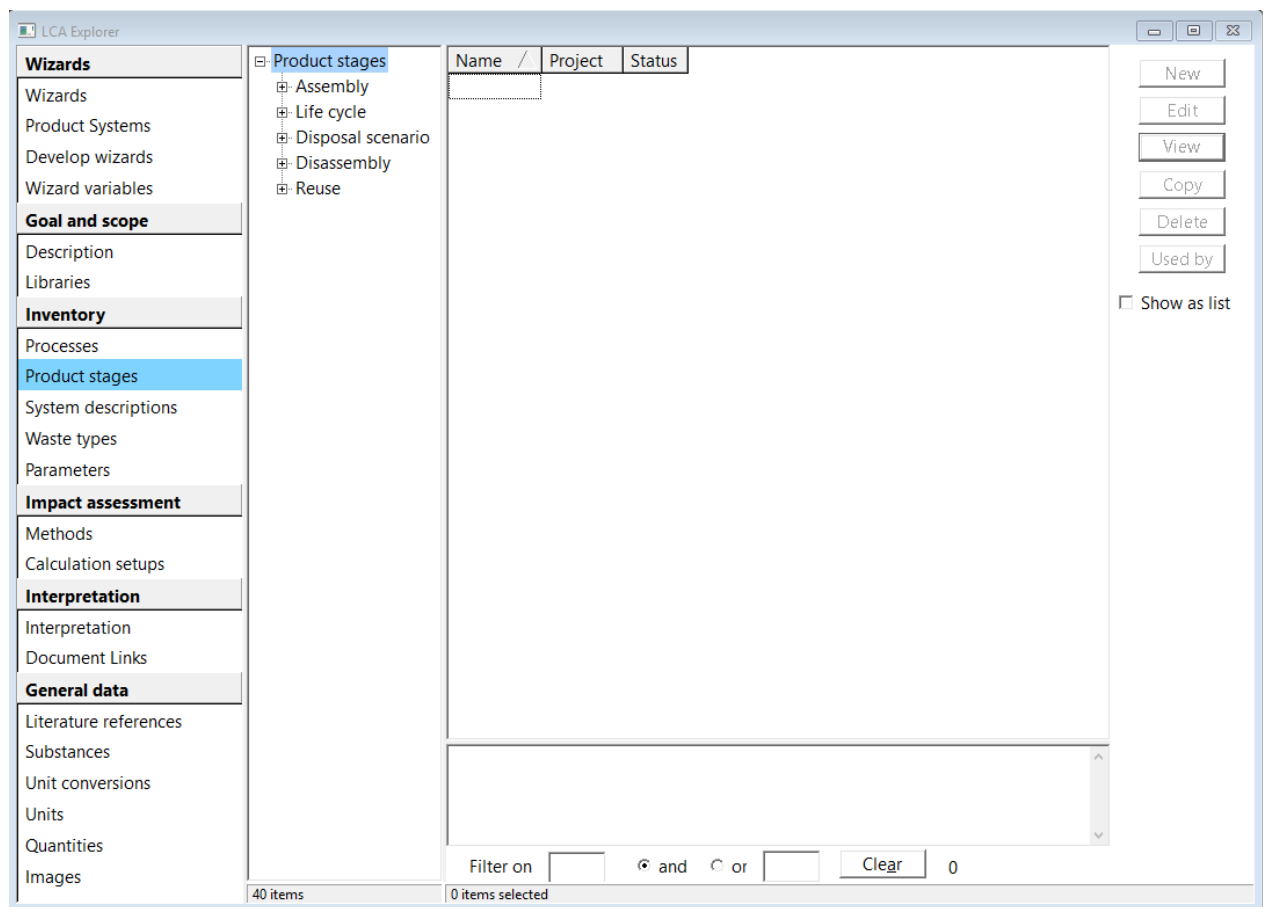


Figure 2.18 LCA Explorer, Inventory, Product stages: Assembly, Life cycle, Disposal scenario, Disassembly, Reuse

Figure 2.18 shows the **Product stages** divided into five categories: *Assembly*, *Life cycle*, *Disposal scenario*, *Disassembly* and *Reuse*. Each category allows you to enter details of the model with respect to its life cycle stages. You can see a brief overview of these categories below:

Assembly: Enter the details (materials and processes) which are related to manufacturing a product assembled from one or more materials (cradle to gate).

Life cycle: Enter the use stage processes of the product. It also allows you to link the waste disposal scenario of the product.

Disposal scenario: Enter the product disposal details, i.e., the percentages of the product or subassembly being discarded (with different waste scenarios)/disassembled/reused.

Disassembly: If the product is dismantled enter the corresponding details.

Reuse: If the product is reused completely, enter the respective details.

All these categories are explained in detail in the upcoming paragraphs.

Assembly

Enter the assembly details of your model by single-click on Assembly > Others and clicking on *New* on the right side. The following window will open (Figure 2.19):

Figure 2.19 Assembly (tab Input/output)

- 1) In the Name field, enter the name of your model in the Input/output tab.
- 2) In the Materials/Assemblies field, you can choose the materials used for assembling the product under study. If you are building a complex model which requires other assemblies to be modelled, you have to link these sub-assemblies under this field. This step is important, especially if each individual assembly is disposed of in a different way. Enter the amount of material/assembly input in the Amount field.
- 3) In the Processes field, choose the processes involved in the production of the model. These production processes can be energy, transportation or other industrial processes.
- 4) In the Comment field, enter the assembly description. You can enter the current status of the assembly being built under the *Status* field.
- 5) Once you finish entering all the details, press CTRL + S or the Save icon at the top to save the product assembly model.

Life cycle

Enter the use stage processes of your model by clicking on Life cycle > Others and click on *New* on the right side. The following window will open (Figure 2.20):

Figure 2.20 Life cycle (tab Input/output)

- 1) In the Name field, enter the name of the model for which you want to enter the use stage processes.
- 2) In the Comment field, enter the life cycle description.
- 3) Refer to the corresponding model assembly in the Assembly field and enter the number of model assemblies you want to calculate the impacts for under the Amount field.
- 4) In the Processes field, enter the use stage processes of the model. These use stage processes can be energy/transportation/other industrial process based.
- 5) In the Waste/Disposal scenario field, link the disposal system of your model. This will be discussed more in detail in the next section.
- 6) In the Additional life cycles field, you can link the life cycle model of another system which plays a role in fulfilling the main purpose of the model that you are currently building in SimaPro.
- 7) Save the life cycle model after entering all the details.



Additional life cycle example

If you are modelling the environmental impact of paper towels, you can link the life cycle model of their dispensers under the Additional life cycles field, since the dispensers are required for dispensing the paper towels.

2.4.2.3 Modelling end of life (under Product stages)

This section deals with the Disposal scenario, Disassembly and Reuse. Their relation is explained as well as the relation with the Assembly, Life cycle and Waste scenario and Waste treatment.

Disposal scenario

In a Disposal scenario reuse of a total product, disassembly and waste treatment through scenarios can be addressed. Select Disposal scenario > Others and click on *New* to model the end-of-life scenarios for your system and the following window will open (Figure 2.21):

Figure 2.21 Disposal scenario (tab Input/output)

- 1) Mention the name of your disposal scenario under the Name field.
- 2) In the Comment field, enter the system disposal description.
- 3) In the Referring to Assembly field, double-click the line below and refer to the corresponding assembly for which you want to model the disposal scenario and enter the number of specific assemblies you'd like to model the impacts for under the Amount field.
- 4) In the Processes field, enter the waste sorting and transport process details related to your assembly's disposal. These industrial processes can be chosen from the Processes subcategories Energy, Transport, Processing or Use.
- 5) In the Waste scenarios field, choose the scenario from the Waste scenarios subcategories Household, Incineration, Landfill, Municipal, Others or Recycling and enter the percentage that follows this scenario.
- 6) In the Disassemblies field, select *New* on the right side and enter the name of your disassembly model, click *OK* and mention the disassembly percentage in the percentage field. The newly made disassembly should be specified later. See below at Disassembly.
- 7) If you reuse your system at the end of its life cycle, in the Reuses field, select *New* on the right side and enter the name of your reuse model. Next, click *OK* and enter the reuse percentage. The newly made reuse model should be specified later. See below at Reuse. Please note that the total percentage needs to be 100.
- 8) Save this disposal scenario by pressing CTRL + S after you finish entering the details.

Waste scenarios versus disposal scenarios

Waste scenarios are processes that refer to material flows, without observing any product characteristics. In waste scenarios, information on how the product is split up into different components (subassemblies) is omitted and only information of the materials in the waste stream is maintained.

Disposal scenarios are product stages that refer to product flows (1 disposal scenario refers to 1 assembly). Here the information on the way the product can be split into components (subassemblies) is kept, allowing you to model disassembly and (partial) reuse operations.

Disassembly

If your system is dismantled at the end of its life cycle, click on Disassembly > Others and click on *New* on the right side. You will then see a window like Figure 2.22.

Figure 2.22 Disassembly (tab Input/output)

- 1) Enter the name of your system disassembly model under the Name field.
- 2) You can provide a description of your disassembly model in the comment field.
- 3) Link to your corresponding system assembly (to be dismantled) by double-clicking the line in the Referring to assembly field and enter the number of dismantled system assemblies you wish to model the impacts for in the Amount field.
- 4) Enter the processes related to the dismantling of your system in the Processes field. These processes can be energy/transportation/other industrial processes. Enter the corresponding value for the process in the Amount field with its respective units.
- 5) In the Disposal scenarios field, enter the name of your assembly disposal scenario. If you modelled sub-assemblies in the assembly that this disassembly refers to, they will already be linked under the Sub-assembly field. You can enter the percentage of the sub-assembly treated via a disposal scenario in the percentage field. An example will be presented in the next chapter.

- 6) Choose the waste scenario for the treatment of the remaining waste percentage of sub-assemblies (which aren't treated via a disposal scenario) in the "waste scenarios" field.
- 7) Save this disassembly model by pressing CTRL + S after you finish entering the details.

Reuse

If your system is completely reused at the end of its life cycle, click on Reuse > Others and click on *New* on the right side (Figure 2.23).

The screenshot shows the 'New reuse' dialog box with the 'Input/output' tab selected. The 'Name' field is empty, 'Status' is set to 'None', and 'Comment' is empty. Below these is a table for 'Referring to assembly' with columns for 'Referring to assembly', 'Amount' (set to 0), 'Unit', and 'Comment'. At the bottom is a table for 'Processes' with columns for 'Processes', 'Amount', 'Unit', 'Distribution', 'SD2 or 2SD', 'Min', 'Max', and 'Comment'. An 'Add line' button is next to the Processes table.

Figure 2.23 Reuse (tab Input/output)

- 1) Enter the name for your system reuse model in the Name field.
- 2) Link to the system assembly you want to reuse by double-clicking the line under Referring to assembly and mention the number of reuse system assemblies you want to model the impacts for in the Amount field.
- 3) Enter the processes related to your system reuse in the Processes field. These processes can be energy/transportation/other industrial process. Mention the corresponding value for the process in the "Amount" field.
- 4) You can provide a description of your reuse model in the comment field.
- 5) Save this reuse model by pressing CTRL + S after you finish entering the details.

2.4.2.4 System descriptions

Systems description describes how a system model (i.e., a combination of unit processes) is built. In this tutorial, it is neither used nor needed. For example, the steel processes in the ecoinvent library 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.

System description provides background information about the way the system model was built. We suggest you inspect some of these system descriptions in the ecoinvent library.

2.4.2.5 Waste types

The **Waste types** option is seen as a complete list of waste labels (under Inventory > Waste types option) that is added to a material/process output. As mentioned earlier in the **Waste scenario** paragraph above, the waste materials are split up into different waste types before being sent to treatment. A waste type is a generic term such as Glass, Newspaper, Ferro metals, etc. In SimaPro you can define your own waste type and specify which materials belong to a waste type.

For instance, all steel materials will have almost similar emissions in the waste phase. 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 them too coarse. You can 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 sub-assembly need to have a waste type. Another example is when a consumer disposes of a plastic bag. SimaPro needs to know that this plastic belongs to the waste type plastic, or more specifically, to 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. With each calculation, SimaPro checks if materials that are used in assemblies indeed have a waste type.

2.4.2.6 Parameters

The **Parameters** option allows you to analyze and compare the impact of variable inputs in SimaPro. This option will be discussed in detail in [Chapter 5](#).

2.4.3 Impact assessment

During the impact assessment step of an LCA study, all used raw materials and emissions during the life cycle of a product are translated to environmental impacts. To see all the different impact assessment methods used in SimaPro, go to Impact assessment > Methods and then double-click the Methods on the second column. A brief description of each method will be visible when you click on it.

There are five different steps in a Life Cycle Impact Assessment (LCIA) process. These steps are:

- 1) **Characterization:** All substances are multiplied by a factor which reflects their relative contribution to the environmental impact, quantifying how much impact a product or service has in each impact category.
- 2) **Damage assessment:** This (optional) step defines the contributions of different impact categories to the endpoint impact (Damage) categories of the selected impact assessment method (i.e., in a more aggregated manner).
- 3) **Normalization:** In this (optional) step, the results are compared to a reference value, like the average environmental impact caused by one person in one year.

- 4) **Weighting:** This (optional) step multiplies the normalized indicators of each impact category with a weighting factor. Higher weighting factors can be attributed to more “important” impact categories. The weighted results all have the same unit and can be added up to give a single score.
- 5) **Single score:** In this step, the weighted results are aggregated into a single score, representing the overall environmental impact.

Some of the impact assessment methods in SimaPro do not have normalization/weighting sets which makes it impossible for you to view the normalized/weighted/single score results when you select these methods. You can view the different normalization/weighting sets available for each method (visible at the lower part of the screen above the description) when you click on a specific method. Read more about the methods in Chapter 4 of the [‘Introduction to LCA with SimaPro’](#) and in the [‘Methods manual’](#).

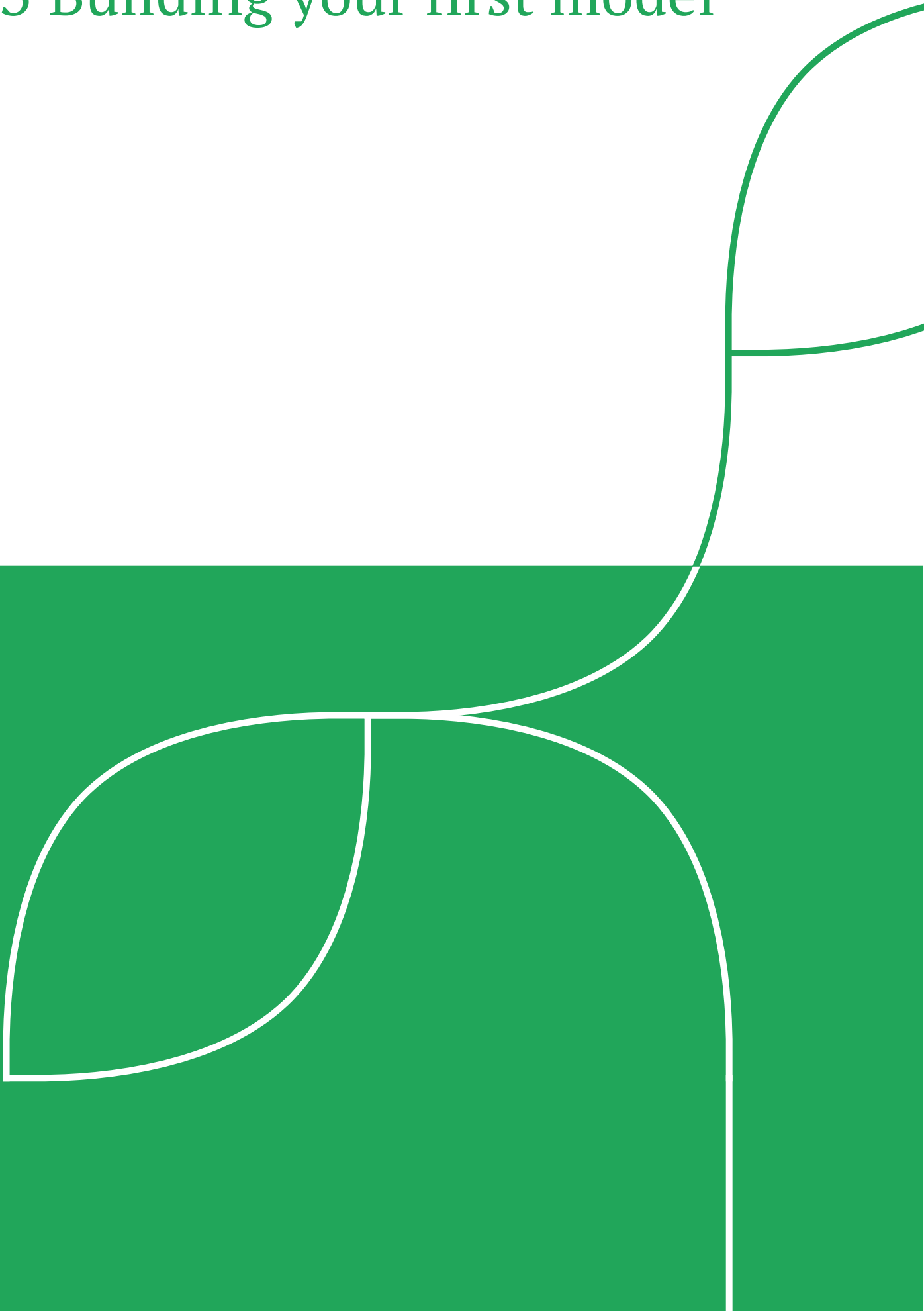
The **Calculation setups** option stores the analysis and comparison (impact assessment) calculations you made for your model in SimaPro. You have to give a name for the calculation setup and save it. It will be discussed more in detail in the upcoming chapters.

2.4.4 Interpretation

The **Interpretation** option allows you to formulate the final conclusions of your project and the text fields serve as a checklist of the issues to be addressed before completing your project.

Document Links provides website links to read more about amongst others the ‘ecoinvent’ libraries, and email addresses for specific questions about amongst others the ecoinvent database.

3 Building your first model



3 Building your first model

What you will do	Get hands-on experience in making an LCA model of different bicycle frames, calculate the environmental impacts and interpret the results
Required Entry level	Chapter 2 should be completed first
Recommended reading	'Introduction to LCA with SimaPro' Chapters 2, 3, 4 and 5
SimaPro license type	SimaPro Classroom/Faculty/PhD/Analyst/Developer

In this chapter, from section 3.2.2, you will start to build the LCA model for the production of different types of road bike frames, analyze it and compare their impacts.

First, the road bike life cycle is presented in section 3.1. This section contains not only the information for modelling the frames in this chapter, but also for modelling the parts, the use phase and the disposal stage in [Chapter 4](#).

3.1 Overview of a road bike life cycle

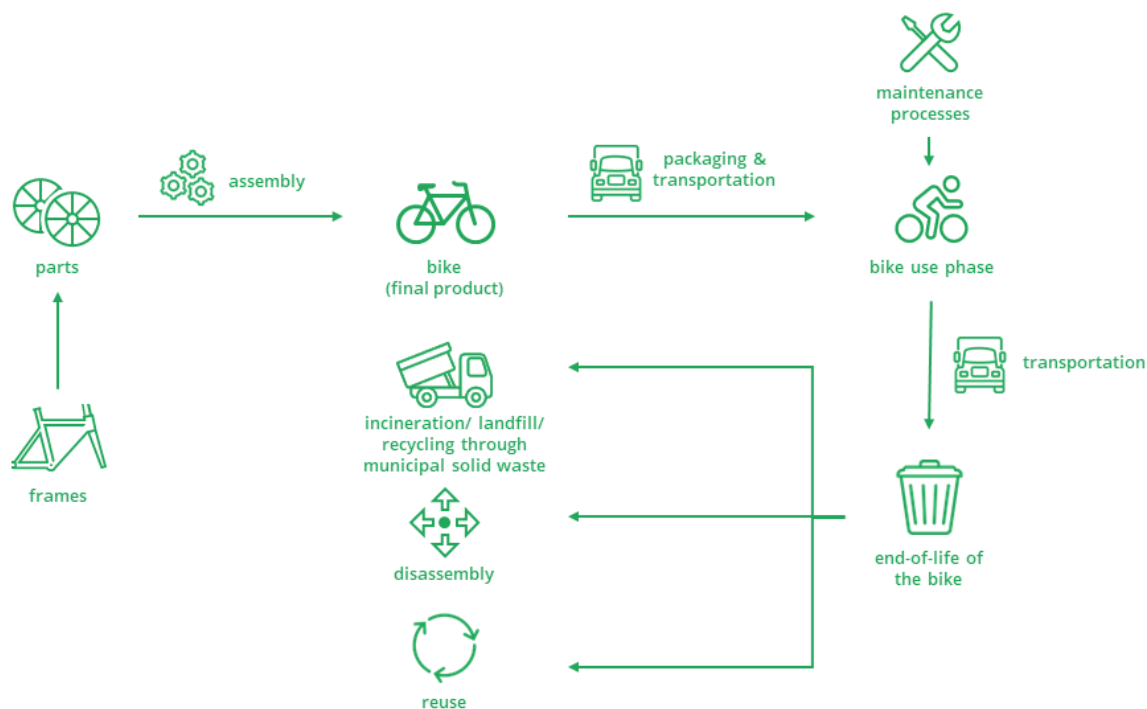


Figure 3.1 The life cycle of a bike

You can see the life cycle of a road bike in Figure 3.1. In a real-life scenario, a bike is assembled using a frame and different components like gears, wheels, brakes, etc. at a manufacturing plant. It is packed and then transported to the final users via distributor organizations. During the use

stage, the bike needs maintenance to ensure its smooth functioning. At the end of life, the bike is either reused completely, dismantled with some components reused or disposed of with some material recycling, incineration and landfill. Based on these life cycle processes, a bike model is formulated below in [section 3.1.1](#).

Fictional example

We used a fictitious example of the bike model in this tutorial since the main goal is to make you understand the main SimaPro features with the help of a simple yet practical example.

3.1.1 The bike description

Introduction: As we saw above, a bike is assembled using different components and frames. Most of the bike frames are made of one of the following four materials:

- Aluminium
- Titanium
- Carbon fiber
- Steel

Based on the assumption that the user would want to choose a road bike with an environmental-friendly frame, this LCA bike project has the following goal:

Goal: The goal (to be reached in [Chapter 4](#)) is to analyze and compare the environmental impacts over the entire life cycle of bike using four different frames (carbon fiber, titanium, aluminium and steel).

Input data: The weights of the different bike frames are included in Table 3.1.

Table 3.1 Type of frames and their weight

Type of frame	Weight (kg)
Aluminium	1.5
Titanium	1.36
PAN (PolyAcryloNitrile) carbon fiber	1
Steel	1.8

The bike is assembled using the components listed in Table 3.2 and packaging in Table 3.3. These details are used to model the bikes in [Chapter 4](#).

Table 3.2 Details of the bike components

Type of frame	Weight (g)	Quantity
Groupset (Chain, cassette, crankset, derailleurs, shifters and other moving parts of the bike)	1676	1
Handlebar	350	1
Saddle	280	1
Set of brakes	679	1
Wheel	1400	2

Each wheel weighs 1400 grams. So, the total weight of the two wheels used in the bike is 2800 grams. The bike is packed using the material specified in Table 3.3.

Table 3.3 Packaging for the bike

Type of frame	Weight (kg)	Quantity
Cardboard	3	1

The following assumptions are made for the use and disposal stages of the bike:

- The bike is used in the Netherlands for a total of 100,000 km over a lifetime of 15 years after which it is disposed.
- The bike is assembled in a manufacturing plant and transported to the final use location in the Netherlands via distributors in a 4000 kg EURO5 truck over a total distance of 500 km. For your information, “EURO5” refers to vehicles manufactured according to the 5th European Emission Standard. The European Emission Standard specifies the acceptable exhaust emission limits for vehicles.
- During the use stage, the bike is taken to the maintenance center at least three times a year in a medium-sized diesel fuel-powered EURO5 car over an average distance of 10 km per trip (two-way).
- At the end of its lifetime, 30% of the bikes is reused completely, 65% of the bikes is collected for processing and dismantled with partial reuse and the remaining 5% of the bikes ends up as municipal solid waste resulting in material-dependent recycling, incineration and landfilling.

Inventory data

The inventory data (materials and processes) for the production of different bike frames is mentioned in the upcoming sections of this chapter. The inventory details for the different components and other process details related to the bike disposal will be mentioned in [Chapter 4](#).

3.2 Modelling the bike

In this section, you will start modelling the bike by learning to enter its goal and scope details and modelling the different bike frames. After opening SimaPro, and opening the standard (Professional) database, select the project Tutorial and click **Open**. After that, select the libraries you want to use. In this tutorial, we use "Ecoinvent 3 – allocation, cut-off by classification – system". Please also select the "Methods" library for this project (and also for all the LCA projects you do in the future using SimaPro) since you will need the methods for the impact assessment.

3.2.1 Goal and scope of the bike project

In this project, start modelling your bike by entering its basic details under **Goal and Scope** on the left column:

By clicking on *Description* option,

- 1) Mention your name in the Author field. Leave out the Comment field.
- 2) Choose "Internal LCA" as the LCA type.
- 3) Under Goal field, enter "To compare the environmental impacts of bikes using different frames over its entire life cycle".
- 4) Leave out the Reason, Commissioner, Interested party and Practitioner fields for this tutorial example.
- 5) In the functional unit field, enter "Cycling 100,000 km over a lifetime of 15 years".

Functional unit of the bike

Following the same rule as mentioned in [section 2.5.1](#), the functional unit of a bike can be defined in the following way:

What	Cycling
How far	100,000 km
How long	A lifetime of 15 years

The functional unit in this case is: cycling 100,000 km over a lifetime of 15 years.

- 6) In the reference flows field, enter "One frame, two wheels, one handle bar, one groupset (moving parts of the bike), a set of brakes, one saddle, one cardboard packaging".

Reference flow of the bike

In accordance to the functional unit of a bike, the appropriate reference flows would be the amount of products needed to fulfil the functional unit. These are one frame, **two wheels, one handlebar, one groupset (moving parts of the bike), a set of brakes, one saddle and one cardboard packaging**.

- 7) Mention “Variable weights of bike”, “Variable types of materials” and “Variable transportation distances” under the Alternative scenarios field, since we plan to do a sensitivity analysis on these scenarios using parameters in [Chapter 4](#).
- 8) After you enter all the above details, select *Libraries* on the left column (if you didn't save yet, you are asked to save) and select the “Ecoinvent 3 – allocation, cut-off by classification – system” and “Methods” library for this project (if you didn't select them yet). The ecoinvent library was chosen since it is the most comprehensive one.

3.2.2 Bike frame inventory data

In this section, you are going to model the production stage impacts of the different bike frames (aluminium, titanium, carbon fiber and steel). Enter the frame details and save them under a new category. To create a new category, click on *Processes*, right-click *Material* and select *New Category*. Enter Name as “_Different types of bike frame”. By starting this name with an underscore it will appear on top of the list under Material.

We will show you how to model the aluminium frame under this category as an example after which you will model the remaining frames as exercises under the same category. The aluminium frame is constructed using the following materials and processes as shown in Table 3.4.

Table 3.4 Inventory data for the production of 1.5 kg of aluminium frame

Materials input			
Data	SimaPro category	Amount	Comment
Aluminium, primary, ingot {IAI Area, EU27 & EFTA}	Processes > Materials > Metals > Non Ferro > Market	1.579 kg	5% of production losses estimated
Processes input			
Data	SimaPro category	Amount	Comment
Powder coat, aluminium sheet {GLO}	Processes > Processing > Metals > Coating > Market	0.375 m ²	
Impact extrusion of aluminium, 3 strokes {GLO}	Processes > Processing > Metals > Chipless shaping > Market	1.51 kg	
Welding, arc, aluminium {GLO}	Processes > Processing > Metals > Welding > Market	0.75 m	
Electricity, medium voltage, aluminium industry {IAI area, EU27 & EFTA}	Processes > Energy > Electricity country mix > Medium voltage > Market	31.5 kWh	Energy use for bending, hydroforming, furnace, quench tank and screwing.
Output			

Outputs to technosphere: Waste treatment

Aluminium (waste treatment) {GLO}	Waste treatment > recycling > transformation	0,079 kg	Assuming that production losses need to be treated (coating ignored).
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3.2.3 Modelling the aluminium frame

Modelling as process or as assembly?

The aluminium frame could be modelled directly as an assembly in Product stages instead of in a Processes. In this case we model the aluminium frame as a process to be able to model production waste correctly (both additional material needed and waste processing). To be able to make use of the life cycle and disposal (waste scenario) features we still have to create an assembly. In chapter 4, we will use the product stages and model the bike frame as an assembly.

- 1) Create a new process by selecting Processes in the Inventory column on the left and then clicking on Processes > Material > _Different types of bike frames. Select *New* on the right and name it "Aluminium frame" in Outputs to technosphere: Products and co-products field. Enter its Amount as "1.5", **because the default Quantity is Mass with kg as default Unit**. Allocation will be the default: '100%', since you allocate 100% of the environmental impact to the only product produced: 1.5 kg aluminium frame. Choose *Aluminium* under the Waste type field, since we are modelling an aluminium frame.
- 2) Under Inputs from technosphere: materials/fuels field, enter the materials and processes involved to produce the aluminium frame as seen in Table 3.4. Select category *Material*, sub-category Metals > Non Ferro > Market and then choose Aluminium, primary, ingot {IAI Area, EU27 & EFTA} | market for aluminium, primary, ingot | Cut-off, S. Otherwise, you can also click *Show as list* and then filter on the correspondence keywords (See Figure 3.2). Once the process is selected, fill in 1.579 as the amount and kg as the unit. Since 1.579 kg of primary aluminium ingot is used for producing the final aluminium frame with a 5% production loss, you can mention this as an additional comment in the Comment field.

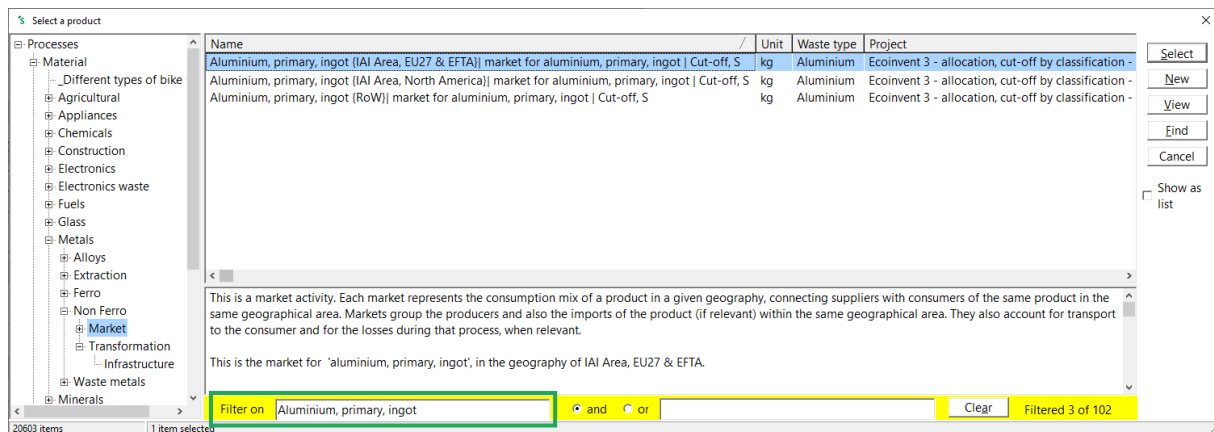


Figure 3.2 Filter on a material, product, or process

- 3) Following the same step in (2), enter the processes input for powder coat, impact extrusion of aluminium, and welding using the data as stated in Table 3.4.
- 4) Under Inputs from technosphere: electricity/heat create a new line, select category *Energy*, sub-category Electricity country mix > Medium Voltage > Market and choose Electricity, medium voltage, aluminium industry {IAI Area, EU27 & EFTA} | market for electricity, medium voltage, aluminium industry | Cut-off, S and enter its Amount as 31.5, Unit as kWh, since '31.5' kWh of electricity is used for bending, hydroforming, furnace, quench tank and screwing processes during the frame production.

After all the materials and processes are entered, the window should look like Figure 3.3.

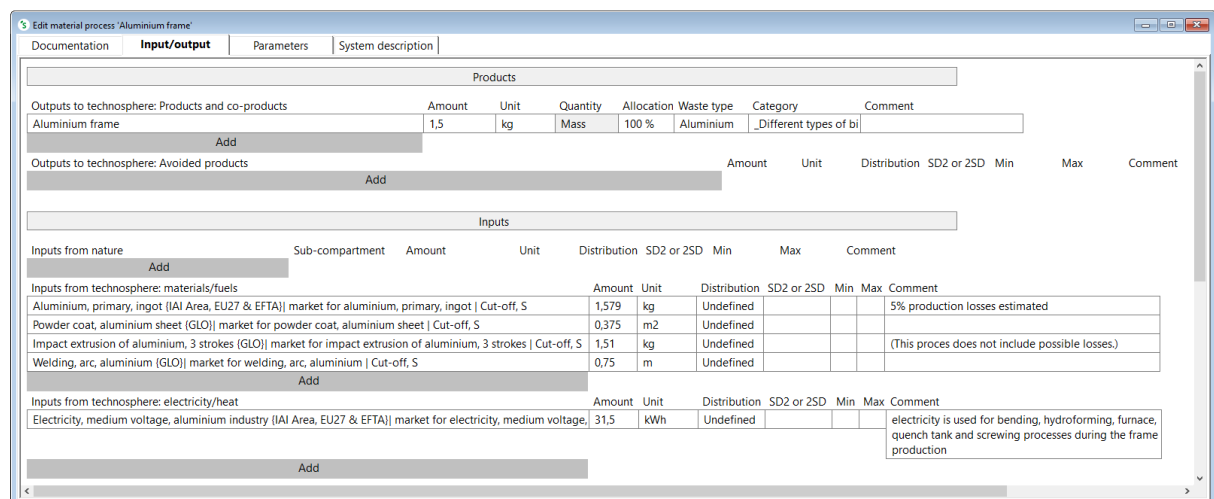


Figure 3.3 Material process (tab Input/output) with materials and processes for Aluminium frame

The **emissions** fields below (not seen in the window above) are left empty since we assume no specific emissions in this process. In the materials and processes we made the links to under the input from technosphere: materials/fuels fields emissions and waste treatment are included.

- 5) To get our mass balance right for the treatment of scrap we include under Outputs to technosphere: Waste treatment at the bottom of the process Aluminium (waste treatment) {GLO}| recycling of aluminium | Cut-off, S 0.079 kg. This Aluminium (waste treatment) is an empty process because of the cut-off at recycling.

(The powder coat mass is ignored for this tutorial example). The bottom part of your process tab input/output should now look like Figure 3.4.

Outputs to technosphere: Waste treatment	Amount	Unit	Distribution	SD2 or	Min	Max	Comment
Aluminium (waste treatment) {GLO} recycling of aluminium Cut-off, S	0,079	kg	Undefined				Assuming that production losses need to be treated (coating ignored).

Figure 3.4 Material process (tab Input/output) with Waste treatment process for Aluminium frame

The systems description and documentation tabs are also left empty for simplicity reasons. The parameters tab will be discussed later in [Chapter 4](#).

- 6) Save the aluminium frame model by pressing CTRL + S.



Tips for data search

When searching for a certain material or process, use the 'Find' function (CTRL + F) for a quick overview. Enter your keyword in the 'Text' field, select which project or libraries you want to search, and click 'Find'. A list of records that match your keywords will appear. To find out more about a record and its original source, either click 'Go to' or double-click on it.

3.2.4 Analysis of the aluminium bike frame

After you entered the inventory data for the aluminium frame and saved it, we need to calculate results to view the environmental impacts of the aluminium frame. To do this, click on the Network button or click *Calculate* menu at the top and then select *Network* or press *F10* key. Enter the following details in the Calculation setup window:

- 1) In the name field, enter "Network diagram of aluminium frame". Leave the Comment field empty.
- 2) Double-click the line under the *Method* field, choose Global on the left side and then select ReCiPe 2016 Endpoint (H) method. Choose World (2010) H/A below under the Normalization/Weighting set. This method was chosen for this tutorial since it covers a wide range of impact categories and includes weighting to calculate single score results.



Selecting default method

You can set a method as default for your project, so you do not have to choose it every time you perform a calculation. To do that, go to the Impact assessment menu on the LCA explorer screen and click Methods. Under the Methods category, choose the corresponding method and click "Set as Default". A confirmation of your choice will be displayed.

For this tutorial, we use ReCiPe 2016 Endpoint (H)" with "World (2010) H/A" Normalization/Weighting set as the default method.

- 3) Enter 1.5 kg under the Amount field for the aluminium frame, since we have to model the impacts for assembly of 1.5 kg of aluminium frame.

The window should look like Figure 3.5 after entering all the details.

New calculation setup

General | Parameter sets | Analyze groups | Chart options

Name:

Comment:

Calculation function:

- ☒ Network
- ☐ Tree
- ☐ Analyze
- ☐ Compare
- ☐ Uncertainty analysis

Method:

Product	Amount	Unit	Project	Comment
Aluminium frame	1,5	kg	Tutorial	

Current library: Suffix:

Replacing library: Suffix:

Switches:

- ☐ Inventory per sub-compartment
- ☐ Exclude infrastructure processes
- ☐ Exclude long-term emissions

Monte Carlo stop criterion:

- ☒ Fixed number of runs:
- ☐ Use stop factor: Value:
- ☐ Seed value:

Buttons: Help, Calculate, Close

Figure 3.5 Calculation setup for Aluminium frame

Long-term emissions

Long-term emissions are emissions that occur after more than 100 years. When they are assigned to specific subcategories (labeled 'long term'), it's possible to distinguish them from emissions occurring within the first 100 years. See [this article](#) for examples.

There are two ways in which long-term emissions can influence your results.

The first one is by not taking the inventoried long-term emissions into account. Practically that is a cut-off for emissions labeled as long-term. The "Exclude long-term emissions" checkbox in the calculation setup (see **Figure 3.5**) can be used for this.

The second way, that long-term emissions can influence your results, is when the

characterization factors in your method are different for long-term emissions. If there are no separate characterization factors for long-term emissions present in the method, all emissions will be treated equally.

- 4) Click on Calculate button at the bottom. If you did not already save this calculation setup, there is a pop-up asking if you want to save the calculation setup first. You will then see Figure 3.6.

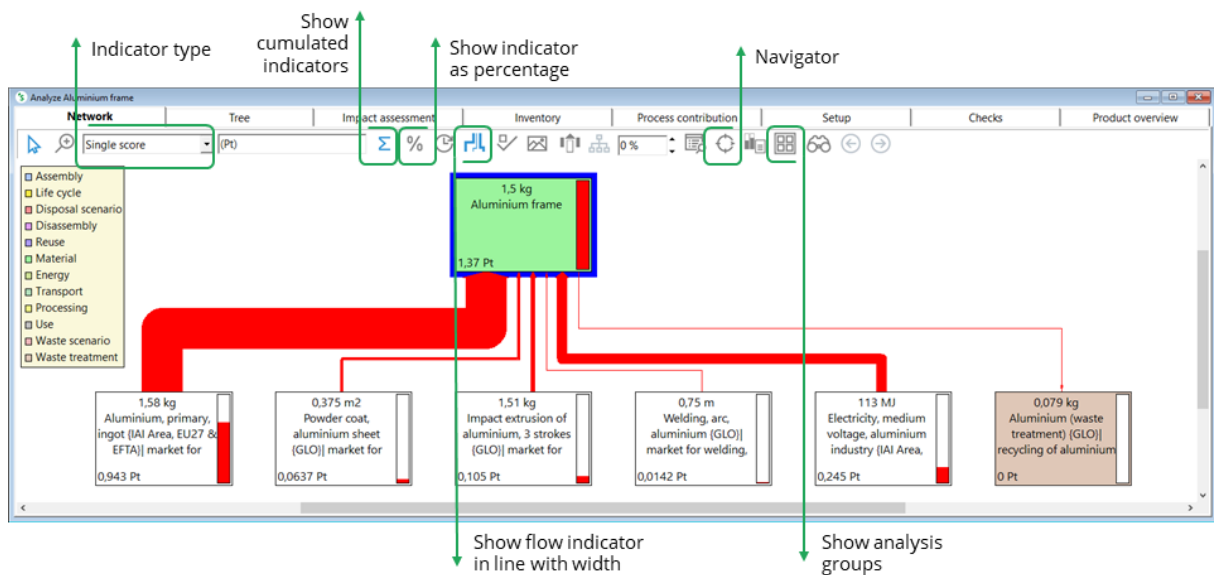


Figure 3.6 Analyze Aluminium frame, Network diagram



Change the Network colors

Please note that the colors of the boxes may differ on your screen. You can define your own color settings by right-clicking the background area and then selecting Colors.

With the node cut-off percentage (Figure 3.6) you can create a view only showing the most contributing processes in your network. Processes that contribute less to a selected indicator than the specified percentage will not be shown. If you set the cut-off percentage to zero, then you will see all processes.



Using threshold for Network or Tree in SimaPro

The effect of using cut-off criteria can be seen in the process tree or network window in SimaPro. In many LCAs, process trees become large. These process trees contain many processes that have negligible contribution. This can be illustrated by setting the cut-off threshold for displaying processes in the process tree at e.g. 0.1 % of the environmental load (for a single score or an impact category). This way, it is much easier to see the relevant issues in the

process tree. By default, SimaPro initially shows 12 nodes and displays the corresponding cut-off percentage.

Now we will look at some of the **Network** tab features. Only the important features of Network diagram will be discussed here. You can explore the remaining easy-to-understand features.



Exploring the Network tab

To deep dive further into how to get the most out of your results from the Network window, please refer to [this](#) video.

Indicator type: here you can select which indicator, substance or product flow will be represented by the thermometers in the nodes below. In the above figure for instance, the **Single score** type is selected, which gives the single score environmental impact of the aluminium frame. If you take a look at the thermometers and indicator values, you can see how many points each material/process contributes to the aluminium frame production impact. In this case, aluminium primary ingot material has the largest contribution. You can also explore other options like Inventory, Characterization, Damage assessment, Normalization, Weighting and Single product flow from the drop-down box.

Show cumulated indicators: This button allows you to see the flow indicator as an aggregated result. Having this option selected, you can see the contributions of the different materials and processes to the aluminium frame (top node) production impact. You can use the “Show indicator as percentage” button (to show the relative contribution in percentages) only when this button is selected.

Show flow indicator in line width: This option allows you to create a Sankey diagram. This means that the thickness of the flow line depends on their environmental impact (as seen in Figure 3.6). If you deselect this option, the flow lines will be represented by identical arrows throughout the network model.

Navigator: This feature is used to navigate through the nodes in Tree/Network. You can zoom in or out and drag the blue box to determine what you want to see in your screen. Use the *fit to page* button to reset the setting and show the full Tree/Network again in your screen.

Show analysis groups: For better understanding, the use of this button will be explained in [Chapter 4](#). The main difference between Network and Tree view (the latter is not available in SimaPro Classroom and Faculty versions) is that the Tree view doesn't use looped data whilst the Network view uses looped data.

When you click on the **Impact assessment** tab, you will see Figure 3.7 which shows the **characterization** result of the production of 1.5 kg of the aluminium frame:

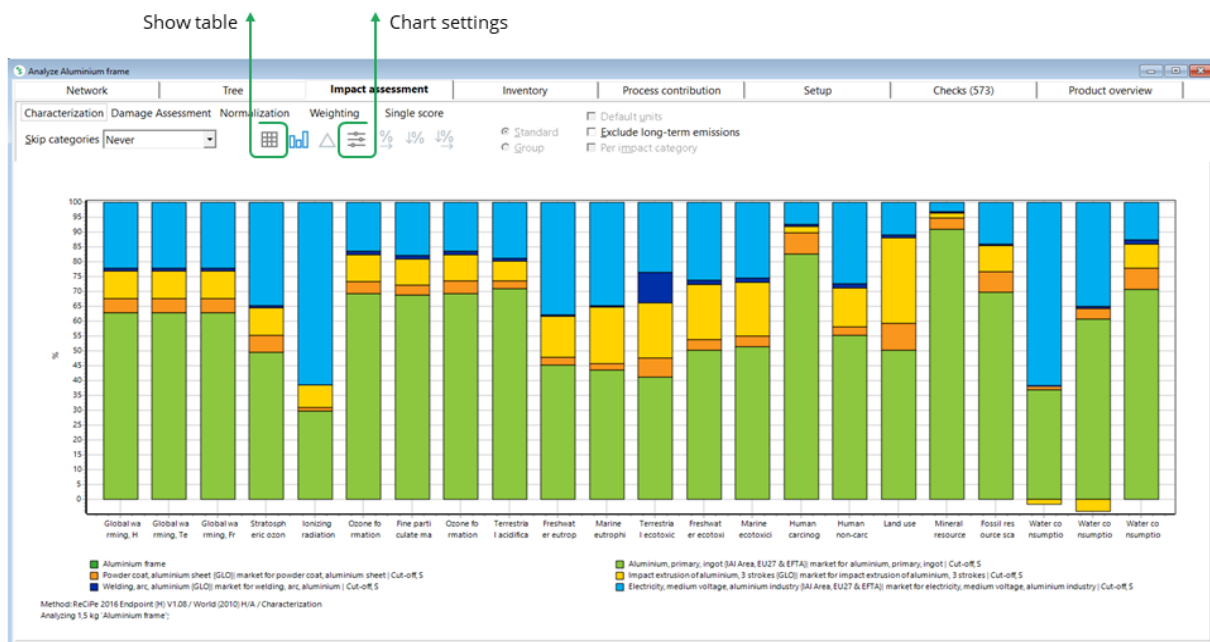


Figure 3.7 Analyze Aluminium frame, Characterization results

Network vs Tree

When showing the data as Network, every process is only shown once while when choosing Tree, each process is shown with its inputs. For example, if there are two processes referring to the same process, it will be shown twice in Tree but only once in Network. This makes the structure for Tree can easily become large but easier to understand because everything is shown and vice versa for Network. Please keep in mind that you cannot show looped data in Tree, otherwise, the number of processes would become infinitely large. Showing looped data is only possible in Network.

Showing the full legend and axis

Depending on the number of items in the legend and the length of item names, you may notice that sometimes not all items are shown in SimaPro. You may also see that some texts on the axis are cropped, depending on the method used. To show the complete text, you can try to change the font to a smaller size via Tools > Option > Desktop > Font or simply change the position of the legend by right-clicking on the white space of the chart area > Edit chart properties > Legend > Position. Under the same right-click menu, you can also copy the chart to Excel to show all data. Excel will open automatically and create a new sheet that includes 2 tabs: one for the chart and one for the data. Please note that this feature is not available in SimaPro Classroom and Faculty licenses.

Figure 3.7 shows the percentages of environmental impacts (characterized results) of the different materials and processes used for manufacturing the aluminium frame with respect to the various midpoint impact categories. Click on the “Show table icon” if you want to see the different impact category values according to their corresponding units (in numbers) instead of percentages. The “Chart settings” icon allows you to change the colors of the graph bars, series and background, and it allows you to edit the legends and axes of the graph.

How to interpret the characterization results?

Simply click on the bar chart columns to see the exact percentage contribution of the different materials and processes to the corresponding impact category. In this figure, you can check that for the global warming impact, the aluminium primary ingot material causes 62.8% of its impact, powder coating the aluminium sheet (4.72%), the electricity usage (22.1%) and the impact extrusion of aluminium (9.43%). The remaining global warming impact percentage is caused due to welding. Similarly, you can interpret the results for the remaining impact categories.

When you click on the **Damage Assessment** tab, you will see Figure 3.8.

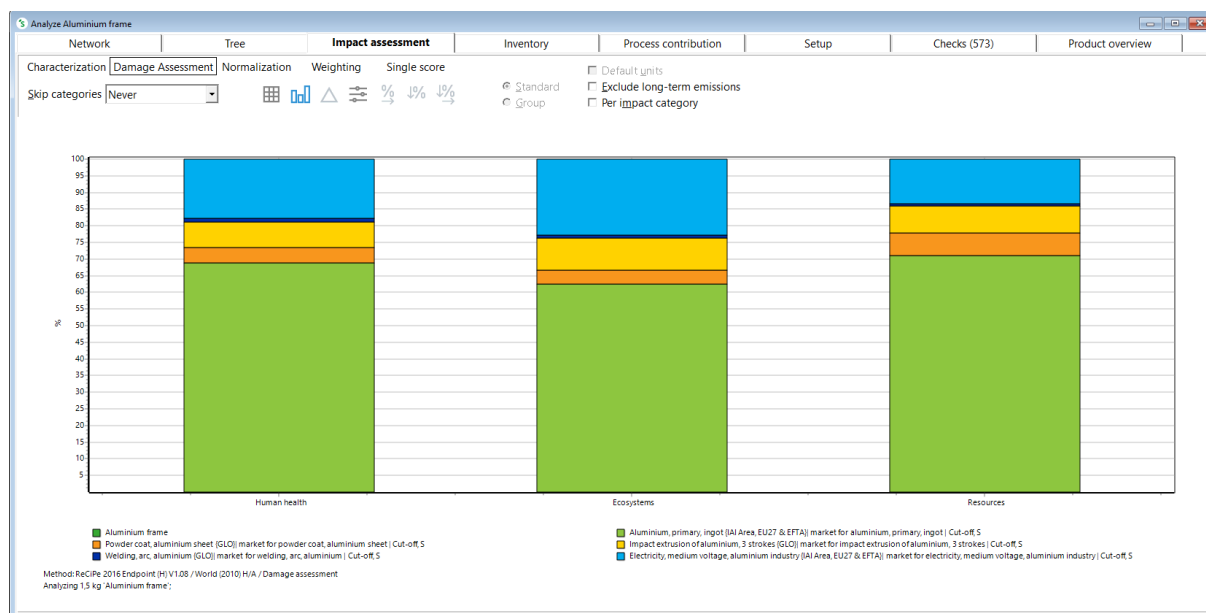


Figure 3.8 Analyze Aluminium frame, Damage assessment

The damage assessment results are similar to the characterization results above but now the endpoint indicators (Damage to Human health, Ecosystems and Resources) of the ReCiPe impact assessment method are calculated. The difference is in the damage assessment, results are presented in a more aggregated manner. You can read more about the midpoint and endpoint impact categories of the ReCiPe impact assessment method and all other methods in SimaPro in the [Methods manual](#).

How to interpret the damage assessment results?

Figure 3.8 shows that the use of the aluminium primary ingot has the largest contribution to human health (68.9%), ecosystems (62.6%) and resources (71.1%). When you select the **Per impact category** box, you will again see the characterization results of the aluminium frame.

When you click on the **Normalization** tab, you will see Figure 3.9.

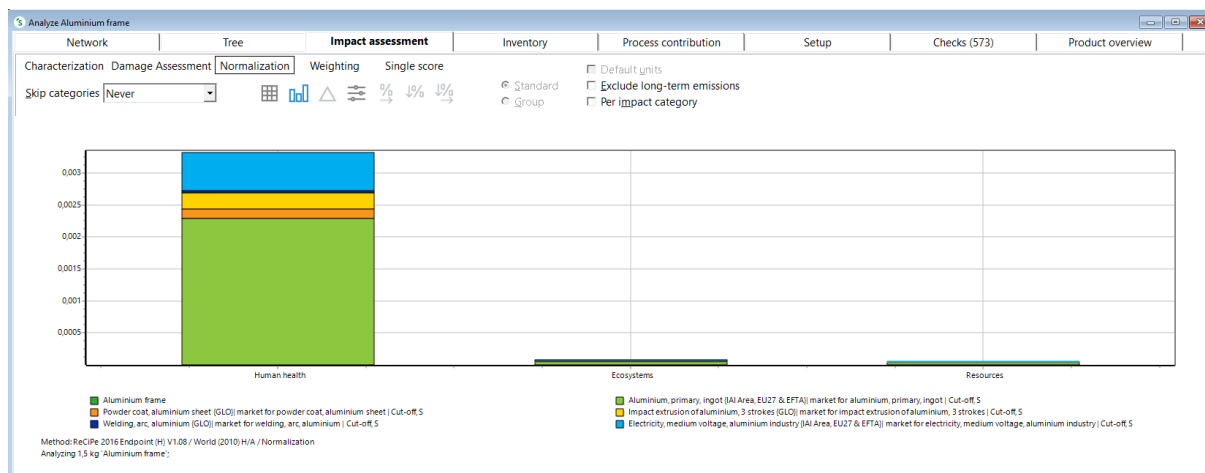


Figure 3.9 Analyze Aluminium frame, Normalization results

In this figure you can see the normalized contribution of the different materials and processes to the impacts of the aluminium frame production. These results express the relative contribution of the different materials and processes used for the aluminium frame to the average environmental impact of one person in the world per year, since you chose **World (2010) H/A** Normalization/Weighting set while selecting the impact assessment method.

How to interpret the normalized results?

When you click on the **Show table** icon at the top, you can see the normalized score of the materials and processes involved in the production of the aluminium frame for the various damage categories. See Figure 3.10.

Sel	Damage category / Unit	Total	Aluminium frame	Aluminium, primary, ingot (AI Area, EU27 & EFTA) market for aluminium, primary, ingot Cut-off 5	Powder coat, aluminium sheet (GLO) market for powder coat, aluminium sheet Cut-off 5	Impact extrusion of aluminium, 3 strokes (GLO) market for impact extrusion of aluminium, 3 strokes Cut-off 5	Welding, arc, aluminium (GLO) market for welding, arc, aluminium Cut-off 5	Electricity, medium voltage, aluminium industry (AI Area, EU27 & EFTA) market for electricity, medium voltage, aluminium industry Cut-off 5	Aluminium (waste treatment) (GLO)
<input checked="" type="checkbox"/>	Human health	0,00332	x	0,00229	0,000154	0,000252	3,45E-5	0,000591	x
<input checked="" type="checkbox"/>	Ecosystems	8,04E-5	x	5,03E-5	3,34E-6	7,68E-6	7,61E-7	1,83E-5	x
<input checked="" type="checkbox"/>	Resources	5,43E-5	x	3,86E-5	3,66E-6	4,45E-6	3,45E-7	7,25E-6	x

Analyzing 1,5 kg 'Aluminium frame'; Method: ReCiPe 2016 Endpoint (H) V1.08 / World (2010) H/A / Normalization

Figure 3.10 Analyze Aluminium frame, Normalization results (damage category, table)

For instance in this case, you can see that the production of the aluminium frame has an overall normalized score of 0.0033 for the Human health damage category, which implies that the environmental impact for production of 1.5 kg of the aluminium frame is equivalent to the human health damage impact caused by 0.0033 person per year or 0.33% of human health damage caused by an average person in a year on a world level. Similarly, you can interpret the results for the remaining damage categories or according to the specific materials/processes. Select the **Per impact category** box to see normalized scores according to the different midpoint impact categories. You will now see a table like Figure 3.11.

Analyze Aluminium frame

Network Tree **Impact assessment** Inventory Process contribution Setup Checks (573) Product overview

Characterization Damage Assessment Normalization Weighting Single score

Skip categories: Never

☐ Standard ☐ Default units
☒ Group ☐ Exclude long-term emissions
☒ Per impact category

Sel	Impact category /	Unit	Total	Aluminium frame	Aluminium, primary, ingot (AI Area, EU27 & EFTA) market for	Powder coat, aluminium sheet (GLO) market for	Impact extrusion of aluminium, 3 strokes	Welding, arc, aluminium (GLO) market for	Electricity, medium voltage, aluminium	Aluminium (waste treatment) (GLO)
<input checked="" type="checkbox"/>	Global warming, Hu		0,000976	x	0,000613	4,61E-5	9,2E-5	9,17E-6	0,000216	x
<input checked="" type="checkbox"/>	Global warming, Te		4,78E-5	x	3E-5	2,26E-6	4,5E-6	4,48E-7	1,05E-5	x
<input checked="" type="checkbox"/>	Global warming, Fre		1,3E-9	x	8,2E-10	6,16E-11	1,23E-10	1,22E-11	2,88E-10	x
<input checked="" type="checkbox"/>	Stratospheric ozone		1,89E-7	x	9,38E-8	1,08E-8	1,76E-8	1,19E-9	6,59E-8	x
<input checked="" type="checkbox"/>	Ionizing radiation		2,01E-6	x	6E-7	2,29E-8	1,52E-7	3,58E-9	1,23E-6	x
<input checked="" type="checkbox"/>	Ozone formation, H		2E-6	x	1,39E-6	8,31E-8	1,78E-7	2,3E-8	3,31E-7	x
<input checked="" type="checkbox"/>	Fine particulate mat		0,00115	x	0,000794	3,9E-5	0,000101	1,51E-5	0,000206	x
<input checked="" type="checkbox"/>	Ozone formation, Tr		4,75E-6	x	3,29E-6	2,05E-7	4,23E-7	5,37E-8	7,79E-7	x
<input checked="" type="checkbox"/>	Terrestrial acidificati		1,58E-5	x	1,12E-5	4,25E-7	1,03E-6	1,46E-7	2,97E-6	x
<input checked="" type="checkbox"/>	Freshwater eutrophication		8,1E-6	x	3,67E-6	2,11E-7	1,1E-6	4,21E-8	3,07E-6	x
<input checked="" type="checkbox"/>	Marine eutrophication		1,58E-9	x	6,91E-10	3,32E-11	3,02E-10	6,98E-12	5,49E-10	x
<input checked="" type="checkbox"/>	Terrestrial ecotoxicity		3,56E-7	x	1,47E-7	2,26E-8	6,56E-8	3,64E-8	8,4E-8	x
<input checked="" type="checkbox"/>	Freshwater ecotoxicity		5,65E-7	x	2,85E-7	2,04E-8	1,05E-7	8,19E-9	1,47E-7	x
<input checked="" type="checkbox"/>	Marine ecotoxicity		1,15E-7	x	5,95E-8	4,12E-9	2,06E-8	1,82E-9	2,93E-8	x
<input checked="" type="checkbox"/>	Human carcinogenicity		0,000843	x	0,000696	6,04E-5	1,88E-5	5,55E-6	6,25E-5	x
<input checked="" type="checkbox"/>	Human non-carcinogenicity		0,000306	x	0,00017	8,02E-6	4,03E-5	4,63E-6	8,37E-5	x
<input checked="" type="checkbox"/>	Land use		1,66E-6	x	8,34E-7	1,48E-7	4,77E-7	1,78E-8	1,8E-7	x
<input checked="" type="checkbox"/>	Mineral resource scarcity		3,13E-6	x	2,84E-6	1,22E-7	4,81E-8	2E-8	9,44E-8	x
<input checked="" type="checkbox"/>	Fossil resource scarcity		5,12E-5	x	3,58E-5	3,54E-6	4,4E-6	3,25E-7	7,16E-6	x
<input checked="" type="checkbox"/>	Water consumption		3,56E-5	x	1,34E-5	4,63E-7	-5,03E-7	6,44E-8	2,23E-5	x
<input checked="" type="checkbox"/>	Water consumption		1,3E-6	x	8,22E-7	5,01E-8	-5,33E-8	6,7E-9	4,75E-7	x
<input checked="" type="checkbox"/>	Water consumption		8,28E-11	x	5,86E-11	5,89E-12	6,69E-12	1,16E-12	1,04E-11	x

Analyzing 1,5 kg 'Aluminium frame'; Method: ReCiPe 2016 Endpoint (H) V1.08 / World (2010) H/A / Normalization

Figure 3.11 Analyze Aluminium frame, Normalization results (impact category, table)

When you click on the **Weighting** tab, **Show chart** and deselecting Per impact category again, you will see Figure 3.12.

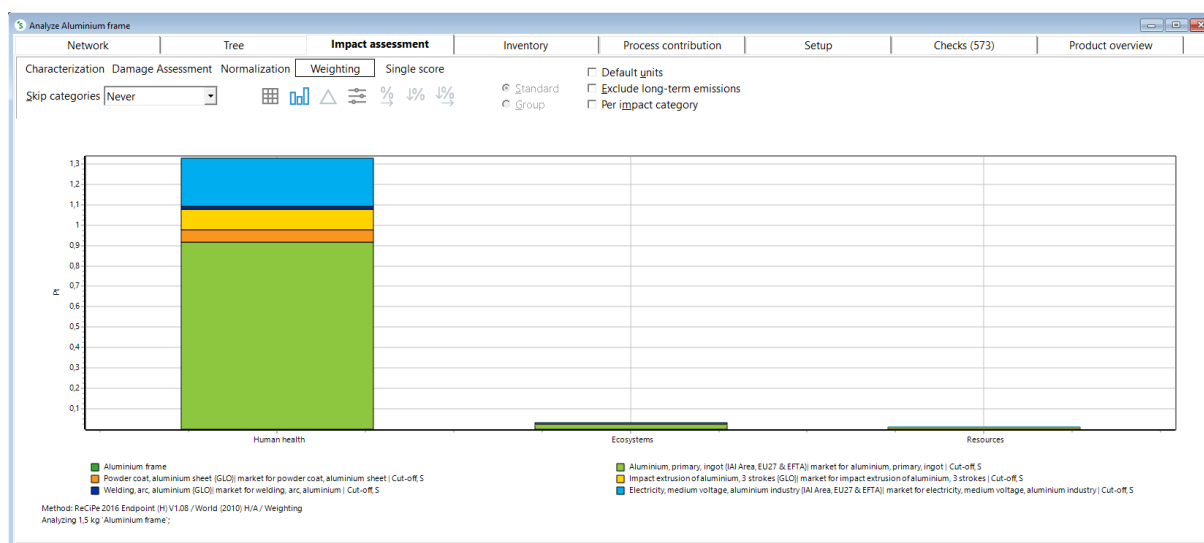


Figure 3.12 Analyze Aluminium frame, Weighting results

The figure above shows the weighted results for the production of the aluminium frame. Weighting multiplies the normalized results of the different midpoint impact/damage (endpoint) categories with a weighting factor that shows the relative importance of the impact/damage category.

Weighting

Weighting is the fourth (optional) step in the Life Cycle Impact Assessment (LCIA). It involves the multiplication of the normalized results of the different impact categories with a weighting factor which expresses the relative importance of each impact category. Weighting is considered as a controversial subject in LCA since in many cases, you will need to make trade-offs between different impact categories. Therefore, the outcome of your LCA studies can change depending on the weights assigned to the impact categories. More explanation about weighting can be found in the [Introduction to LCA](#) manual.

How to interpret the weighting results?

This is similar to interpreting the normalized scores. For instance, in this case the production of 1.5 kg of the aluminium frame has an overall weighted score of 1.37 Pt (click on **Show table** icon at the top to see this value) which means that the production impact of 1.5 kg of the aluminium frame is equivalent to that of the impact caused by an average of 1.37 persons in the world per year. The unit used for expressing the environmental impact is **Pt (Points)**.

When you click on the **Single score** tab, you will see Figure 3.13.

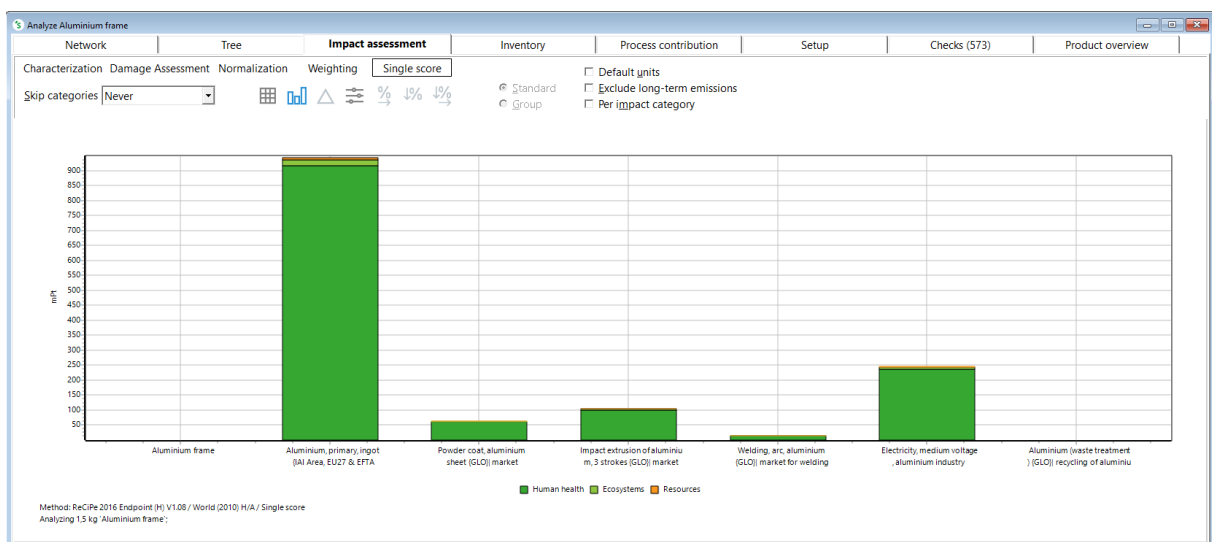


Figure 3.13 Analyze Aluminium frame, Single score results

This figure shows the single score results for the production of the aluminium frame. This method gives the environmental impacts of the different materials and processes used for the aluminium frame production in a single score.

How to interpret the single score results?

It is the same as the weighting scores interpretation. In this case, the single score results are expressed in **mPt (millipoints)** which is equivalent to 1/1000th of a point. Select the **Default units** box at the top to express the results in Points (Pt).

To see the environmental impacts caused by the different inventory substances for the different materials and processes involved in the production of the aluminium frame click on **Inventory** tab. You will see a window similar to Figure 3.14.

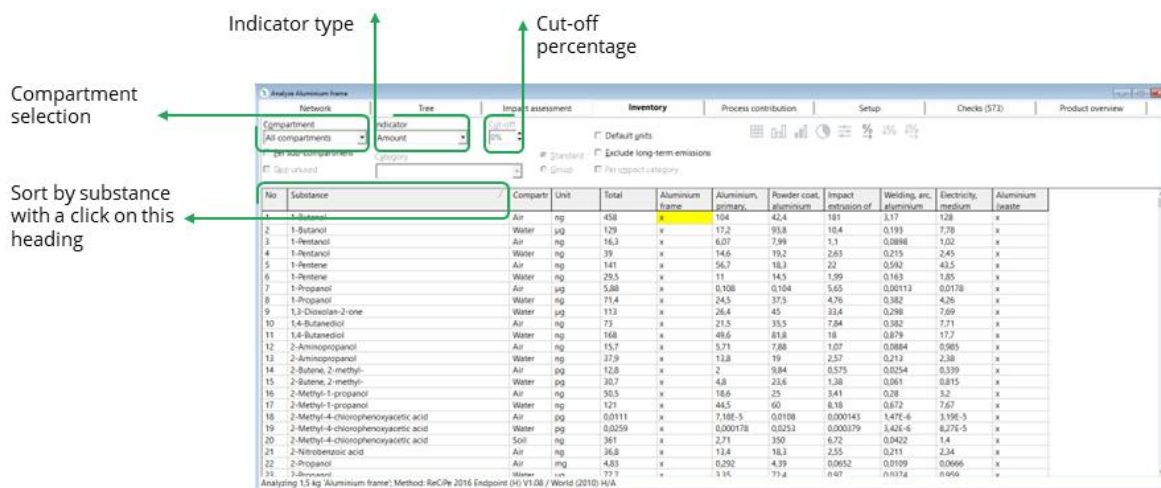


Figure 3.14 Analyze Aluminium frame, tab Inventory

This inventory window has many different features.

- 1) You can sort the order of the substances with a click on the Substance heading (shown in Figure 3.14).
- 2) You can select the drop-down box of **Compartment** option to view the environmental impacts of different inventory substances according to their compartments (raw material, air borne emission, water borne emission, etc.).
- 3) Select the **Indicator** drop down box to view the characterized results, the damage assessment, the normalized results, the weighted results or the single score. Select Single score before continuing.
- 4) Adjust the **Cut-off** percentage at the top (next to Indicator drop down box), to adjust the number of inventory substances shown in the table. For example, if the cut-off is adjusted to 2%, this analysis will show all the inventory substances in the network that contribute more than 2% of the total environmental impact (Single score).

Using threshold in the contribution analysis

Using the cut-off feature in the contribution analysis gives you the relative contribution per **process** in a list of processes. A process **that** is used more than once may have a small contribution in each instance, but the total contribution of all instances can still be significant. Contribution analysis **shows** this total contribution.

Right-click on the selected values to explore more options to specify the results.

To see the environmental impact contribution of each material/process to the production of the aluminium frame, click on **Process contribution** tab. You will see a similar window like Figure 3.15.

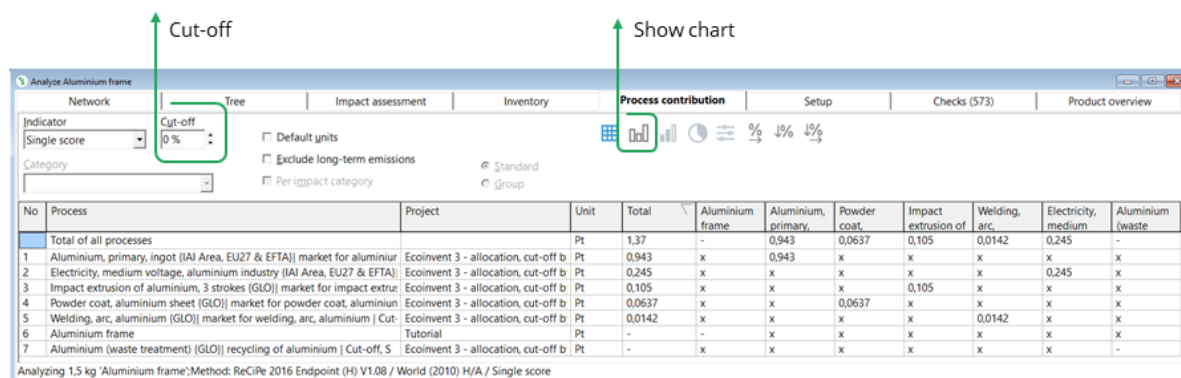


Figure 3.15 Analyze Aluminium frame, tab Process contribution

Click on the **Show chart** icon to view these results in the form of a graph. You will see the results similar Figure 3.16 when single score is selected, and the cut-off is set to 2%.

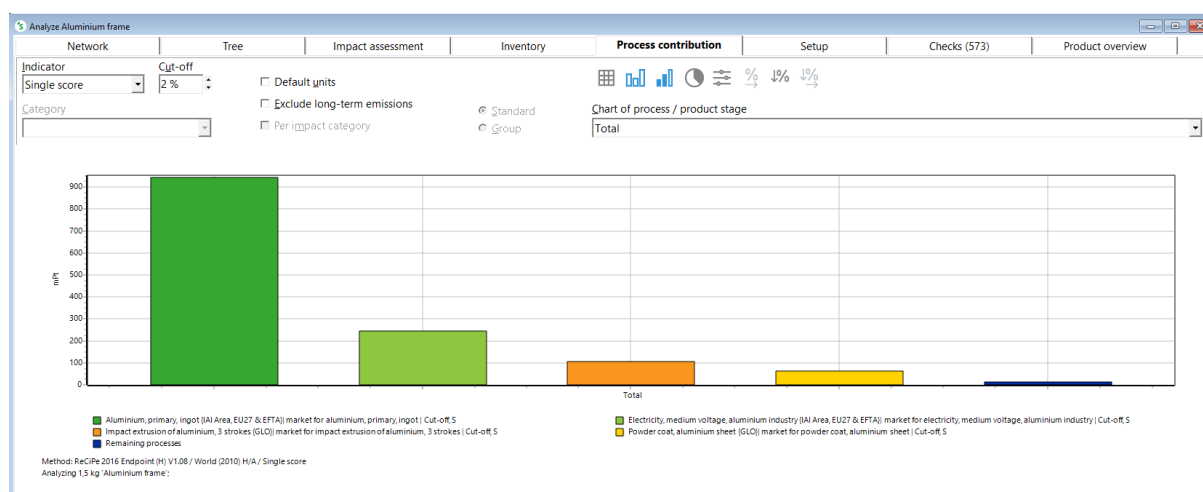


Figure 3.16 Analyze Aluminium frame, tab Process contribution (chart)

From Figure 3.16, you can see that use of the aluminium primary ingot material is the main contributor to the environmental impact of the aluminium frame production.

When you click on the **Setup** tab, on the first tab (General) you can view the impact assessment method and model details you entered for determining the impacts (as earlier shown in Figure 3.5).

The **Checks** tab (Figure 3.17) allows you to check which (and how many) substances in your model do not have a characterization factor in the used method (here: ReCiPe 2016 Endpoint (H)).

No	Substance	Compartment	Unit	Aluminium frame	Aluminium, primary, ingot (IAI Area, EU27 & ...)	Powder coat, aluminium sheet (GLO) market for	Impact extrusion of aluminium, 3 strokes	Welding, arc, aluminium (GLO) market for	Electricity, medium voltage, aluminium	Aluminium (waste treatment) (GLO)
1	1-Pentene	Water	ng	x	11	14,5	1,99	0,163	1,85	x
2	1,3-Dioxolan-2-one	Water	µg	x	26,4	45	33,4	0,298	7,69	x
3	1,4-Butanediol	Air	ng	x	21,5	35,5	7,84	0,382	7,71	x
4	1,4-Butanediol	Water	ng	x	49,6	81,8	18	0,879	17,7	x
5	2-Aminopropanol	Air	ng	x	5,71	7,88	1,07	0,0884	0,985	x
6	2-Aminopropanol	Water	ng	x	13,8	19	2,57	0,213	2,38	x
7	2-Butene, 2-methyl-	Water	pg	x	4,8	23,6	1,38	0,061	0,815	x
8	2-Nitrobenzoic acid	Air	ng	x	13,4	18,3	2,55	0,211	2,34	x
9	2,4-D ester	Air	pg	x	1,87E-5	0,0626	2,46E-5	7,15E-7	5,18E-6	x
10	2,4-D ester	Water	pg	x	6,93E-5	0,00743	8,87E-5	1,91E-6	2,35E-5	x
11	2,4-D ester	Soil	pg	x	0,00223	0,29	0,00285	6,16E-5	0,000754	x
12	Abamectin	Air	ng	x	6,27	7,17	1,19	0,131	1,26	x
13	Abamectin	Water	ng	x	0,487	0,558	0,0923	0,0102	0,0981	x
14	Abamectin	Soil	ng	x	57,5	60,6	11,6	1,18	11,9	x
15	Acenaphthylene	Air	ng	x	49,2	2,62	6,99	0,546	3,06	x
16	Acenaphthylene	Water	µg	x	2,08	0,068	0,183	0,0165	1,28	x
17	Acetamidrid	Air	ng	x	120	137	22,7	2,51	24,1	x
18	Acetamidrid	Water	pg	x	113	130	21,5	2,38	22,8	x
19	Acetamidrid	Soil	ng	x	137	126	29,6	2,73	29,4	x

Figure 3.17 Analyze Aluminium frame, tab Checks - Check on missing characterization factors

In this case, 573 substances are not defined. This is not unusual since we strive for inventories to be complete regardless of the presence of characterization factors.

Flows without characterization factor

When there is no characterization factor available in a method this can mean two things: there is no environmental impact of a certain substance according to that method, or there is simply no characterization factor determined within this method. You can assume that in the methods of the standard database characterization factors for the most relevant substances are included, but it might be good to check the list of substances not defined in used methods. If you for instance create a new process with an airborne emission called “CO₂” this will not be characterized with the present methods because they refer to this substance as “Carbon dioxide”.

The **Product overview** tab (Figure 3.18) gives you an overview of the library you have chosen, the project you are working on and the materials/processes used in your model.

Nr.	Name	Unit	Waste type	Type	Category	Referenced in project
1	Aluminium (waste treatment) (GLO) recycling of aluminium Cut-off, S	kg	Aluminium	Waste treat	Recycling/Transform	*
2	Aluminium, primary, ingot (IAI Area, EU27 & EFTA) market for aluminium, primary, ingot Cut-off, S	kg	Aluminium	Material	Metals/Non ferro/Ma	*
3	Electricity, medium voltage, aluminium industry (IAI Area, EU27 & EFTA) market for electricity, medium voltage, aluminium industry Cut-off, S	MJ		Energy	Electricity country mi	*
4	Impact extrusion of aluminium, 3 strokes (GLO) market for impact extrusion of aluminium, 3 strokes Cut-off, S	kg		Processing	Metals/Chipless shap	*
5	Powder coat, aluminium sheet (GLO) market for powder coat, aluminium sheet Cut-off, S	m2		Processing	Metals/Coating/Mark	*
6	Welding, arc, aluminium (GLO) market for welding, arc, aluminium Cut-off, S	m		Processing	Metals/Welding/Mark	*

Figure 3.18 Analyze Aluminium frame, tab Product overview

3.3 Exercises

This section contains exercises to let you model the rest of the frames directly in SimaPro.

- 1) The functional unit of the bike model (cycling 100,000 kilometer over a lifetime of 15 years) was chosen since we are doing a cradle-to-grave modelling of the bike. What would be the functional unit if you only want to model the manufacturing stage impacts (cradle-to-gate modelling) of the bike?
- 2) Model the remaining titanium, carbon fiber and steel frames similar to how we modelled the aluminium frame. Create a new process for these frames under "Processes>Material>_Different types of bike frames" category, enter the corresponding frame details and save them {CTRL + S} using the names "Titanium frame", "PAN carbon fiber frame" and "Steel frame" respectively. Choose the waste types as "Non-Ferro", "Others" and "Steel" for the titanium, PAN carbon fiber and Steel frames respectively. Similar to the above example, the environmental impacts of the frames are allocated to 100% of their mass.

The titanium, carbon fiber and steel frame production inventory details are shown in

Table 3.5 to Table 3.7.

Table 3.5 Inventory data for the production of 1.36 kg of titanium frame

Materials input			
Data	SimaPro category	Amount	Comment
Titanium {GLO}	Processes > Material > Metals > Non-Ferro > Market	1.43 kg	5% production losses estimated
Tap water {Europe without Switzerland}	Processes > Material > Water > Drinking water > Market	0.408 kg	-
Processes input			
Data	SimaPro category	Amount	Comment
Powder coat, aluminium sheet {GLO}	Processes > Processing > Metals > Coating > Market	0.34 m ²	Aluminium assumed, since processes for titanium aren't available.
Welding, arc, aluminium {GLO}	Processes > Processing > Metals > Welding > Market	0.68 m	-
Output			
Outputs to technosphere: Waste treatment			
Steel and iron (waste treatment) {GLO} recycling	Waste treatment > Recycling > Transformation	0,07 kg	Steel and iron (this is an empty process) chosen as proxy to reach

			input/output balance (coating ignored).
Wastewater, average {Europe without Switzerland}	Waste treatment > Waste water Treatment > Market	0.408 l	assuming all 0.408 kg input needs to be treated and that the water is moderately polluted

Table 3.6 Inventory data for the production of 1 kg of PAN carbon fiber frame

Materials input			
Data	SimaPro category	Amount	Comment
Acrylonitrile-butadiene-styrene copolymer {GLO}	Processes > Material > Chemicals > Organic > Market	2.25 kg	-
Dimethylacetamide {GLO}	Processes > Material > Chemicals > Organic > Market	0.0306 kg	
Injection moulding {GLO}	Processes > Processing > Plastics > Market	1 kg	-
Processes input			
Data	SimaPro category	Amount	Comment
Electricity, low voltage {GLO}	Processes > Energy > Electricity country mix > Low voltage > Market	58 kWh	-
Heat, district or industrial, other than natural gas {GLO}	Processes > Energy > Heat > Others > Market	237,3 MJ	
Output			
Data	SimaPro category	Amount	Comment
Carbon dioxide, fossil	Airborne emission	1,06 kg	
Outputs to technosphere: Waste treatment			
Waste asphalt {RoW}	Waste treatment > Others > Market	0,22	Proxy for carbon fiber waste

Table 3.7 Inventory data for the production of 1.8 kg of Steel frame

Materials input			
Data	SimaPro category	Amount	Comment
Chromium steel pipe {GLO}	Processes > Material > Metals > Ferro > Market	1.894 kg	5% production losses estimated
Tap water {Europe without Switzerland}	Processes > Material > Water > Drinking water > Market	0.54 kg	-
Processes input			
Data	SimaPro category	Amount	Comment
Powder coat, steel {GLO}	Processes > Processing > Metals > Coating > Market	0.45 m ²	-
Welding, arc, steel {GLO}	Processes > Processing > Metals > Welding > Market	0.9 m	-
Output			
Outputs to technosphere: Waste treatment			
Steel and iron (waste treatment) {GLO} recycling	Waste treatment > Recycling > Transformation	0,094 kg	To reach input/output balance (coating ignored)
Wastewater, average {Europe without Switzerland}	Waste treatment > Waste water Treatment > Market	0.54 l	Assuming all 0.54 kg input needs to be treated and that the water is moderately polluted

3.4 Comparison of the frames

When you finish entering all the frame details and save them, click on **Compare** icon at the top. Enter the following details in the calculation setup window which opens after clicking the Compare icon:

- 1) Enter "Comparison of bike frames" in the Name field. Under Method, the ReCiPe impact assessment method is already selected by default (please refer to [section 3.2.4](#) to see how to select a default method).
- 2) Select the models of which you want to compare the impacts in the Product field. In this case, select the four frames and enter their weight and unit in the Amount and Unit fields.

The window looks like Figure 3.19 after entering all the details.

New calculation setup

General | Parameter sets | Analyze groups | Chart options

Name:

Comment:

Calculation function

- ☐ Network
- ☐ Tree
- ☐ Analyze
- ☒ Compare
- ☐ Uncertainty analysis

Method:

Product	Amount	Unit	Project	Comment
Frame aluminium	1	p	Tutorial	
Frame PAN carbon fiber	1	p	Tutorial	
Frame steel	1	p	Tutorial	
Frame titanium	1	p	Tutorial	

Current library: Suffix:

Replacing library: Suffix:

Switches

- ☐ Inventory per sub-compartment
- ☐ Exclude infrastructure processes
- ☐ Exclude long-term emissions

Monte Carlo stop criterion

- ☒ Fixed number of runs:
- ☐ Use stop factor: Value:
- ☐ Seed value:

Figure 3.19 Calculation setup for comparison of the four frames

3) Click **Calculate** at the bottom.

You will see a window similar to Figure 3.20 (if you have entered all the relevant frame details and followed the steps above) when you click on **Single score** on the **Impact assessment** tab.

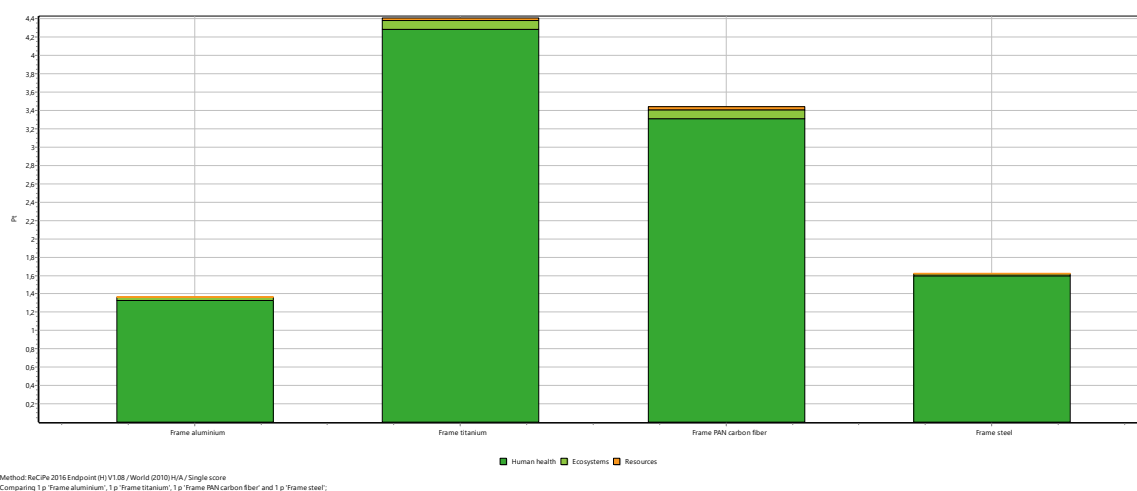
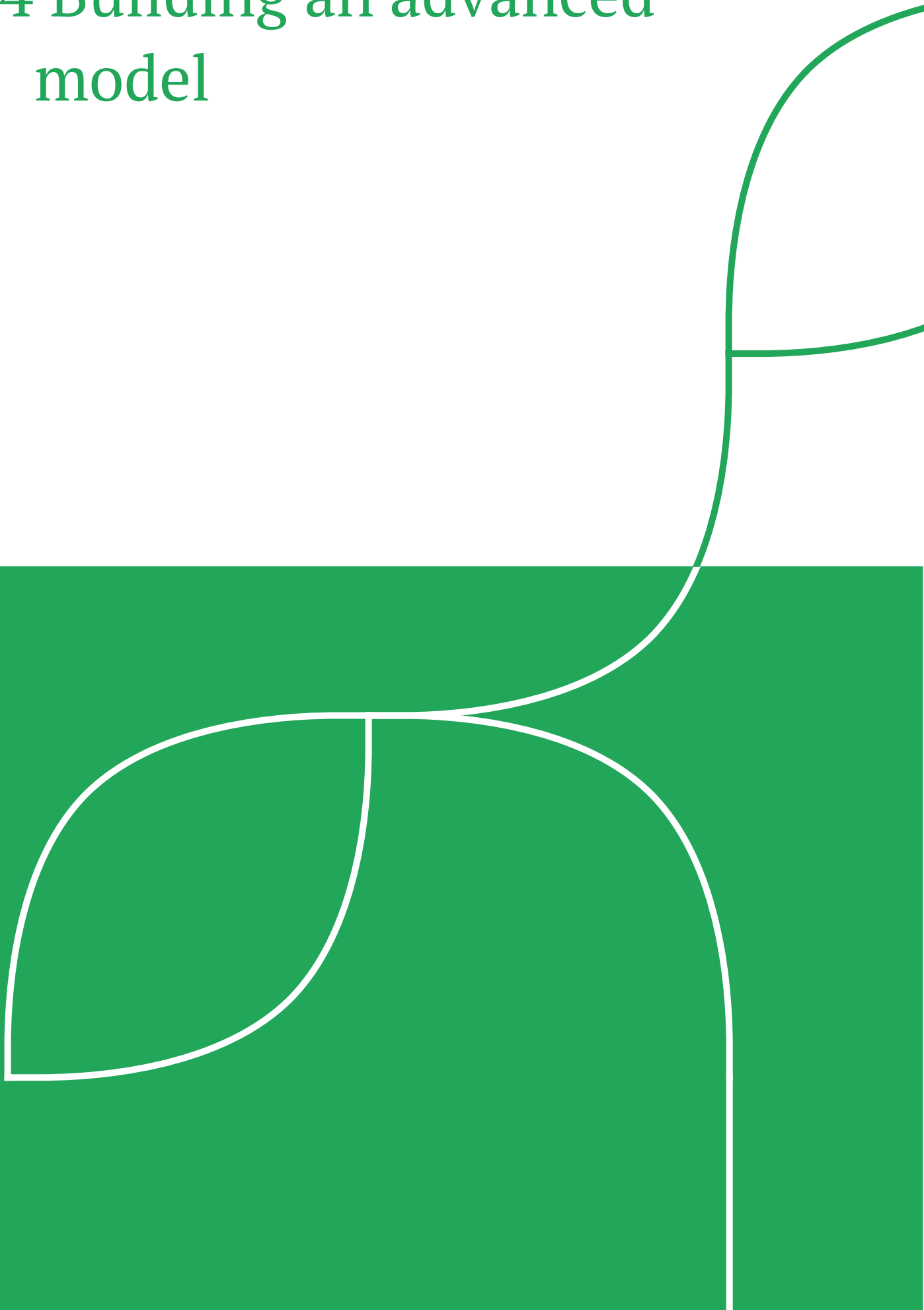


Figure 3.20 Comparison of the different types of bike frame impacts

In this figure you can see that the production of a steel frame has the lowest impact, whilst the production of the PAN carbon fiber frame has the highest impact.

You can check the different options and features mentioned above for better understanding and interpretation of the factors influencing the impacts. You can use different impact assessment methods to verify your results.

4 Building an advanced model



4 Building an advanced model

What you will do	Model bicycle components, compare the life cycle impacts of bikes using different frames and interpret the results
Required Entry level	Chapter 2 and 3 should be completed first
Recommended reading	'Introduction to LCA with SimaPro' Chapters 2, 3, 4 and 5
SimaPro license type	SimaPro Classroom/Faculty/PhD/Analyst/Developer Please note that the 'Tree' feature is not available in the Classroom and Faculty licenses of SimaPro

In the previous chapter, you learned to model the different types of racing bike frames. In this chapter, you will learn to model the racing bike components and bike packaging in addition to the use and disposal stage processes of the bike. This will be done under the **Inventory > Product stages** category in SimaPro.

4.1 Saddle sub-assembly

In this section, we will model the saddle of the bike. We will also provide some data on the other components of a road bike. You can use this data to model the remaining components of the bike. The production details for these components are mentioned below.

Objective: A saddle of weight 280 grams is to be modelled.

Given: The inventory data to produce a saddle is presented in Table 4.1.

Modelling bike components and packaging

We model the bike components and bike packaging as an assembly (in product stages). This allows us to make use of waste scenarios to model the end-of-life. You can refer to [section 2.5.2](#) for further explanation between modelling in processes and in product stages.

Table 4.1 Production details for the bike saddle (280 grams)

Materials input			
Data	SimaPro category	Amount	Comment
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	100 g	Saddle mounting rails

Ethylene vinyl acetate copolymer {RER}	Assemblies and materials > Material > Plastics > Thermoplasts > Market	30 g	Saddle cover
Polyethylene, high density, granulate {GLO}	Assemblies and materials > Material > Plastics > Thermoplasts > Market	100 g	Plastic saddle shell
Polyurethane, flexible foam {RER}	Assemblies and materials > Material > Plastics > Thermosets > Market	50 g	Foam
Processes input			
Data	SimaPro category	Amount	Comment
Injection moulding {GLO}	Processes > Processing > Plastics > Market	100 g	Moulding the plastic shell

Steps:

- 1) Open the existing project "Tutorial", where you modelled the different bike frames.
- 2) In Inventory on the left, select Product stages. Go to Product stages > Assembly > Others and click on *New* on the right side. Type *Saddle* in the name field to create a new assembly for the saddle.
- 3) Enter the materials and process used for the assembling the saddle as listed in Table 4.1.
- 4) Once you finish entering all the materials and process details, save the saddle assembly. The saddle assembly window will look like Figure 4.1.

Figure 4.1 Assembly of saddle

4.1.1 Exercise

Model the remaining bike components and the bike packaging in product stages as new assemblies: the handlebar, groupset (chain, cassette, crankset, derailleurs, shifters, and other moving parts of the bike), a pair of brakes and wheels.

You can find the inventory details for these components in Table 4.2 to Table 4.6. Create separate sub-assemblies for each of these components under the product stages, name them as "Handlebar", "Groupset", "Brakes", "Wheels", "Packaging of the bike (cardboard)". Do not forget to save the part sub-assemblies after entering all details.

Table 4.2 Inventory data for the handlebar (350 grams)

Materials input			
Data	SimaPro category	Amount	Comment
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	300 g	Handlebar material
Polyurethane, flexible foam {RER}	Assemblies and materials > Material > Plastics > Thermosets > Market	50 g	Handlebar tape
Processes input			
Data	SimaPro category	Amount	Comment
Section bar extrusion, aluminium {GLO}	Processes > Processing > Metals > Chipless shaping > Market	300 g	Aluminium processing (this process includes 1,3% aluminium input and waste treatment to compensate for production losses)

Table 4.3 Inventory data for the groupset (1676 grams)

Materials input			
Data	SimaPro category	Amount	Comment
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	378 g	Crankset
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	225 g	Derailleur (back)
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	95 g	Derailleur (front)
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals>Alloys>Market	47 g	Bottom bracket


Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	160 g	Shifters
Glass fibre reinforced plastic, polyamide, injection moulded {GLO}	Assemblies and materials > Material > Plastics > Thermoplasts > Market	30 g	Bottom bracket
Glass fibre reinforced plastic, polyamide {GLO} 	Assemblies and materials > Material > Plastics > Thermoplasts > Market	40 g	Shifters
Iron-nickel-chromium alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	294 g	Cassette
Steel, chromium steel 18/8 {GLO}	Assemblies and materials > Material > Metals > Ferro > Market	257 g	Chain
Steel, chromium steel 18/8 {GLO}	Assemblies and materials > Material > Metals > Ferro > Market	100 g	Cable for shifters
Synthetic rubber {GLO}	Assemblies and materials > Material > Plastics > Rubber > Market	50 g	Shifters
Processes input			
Data	SimaPro category	Amount	Comment
Wire drawing, steel {GLO}	Processes > Processing > Metals > Chipless shaping > Market	100 g	For shaping the shifter cables (This process includes 4,3% production waste and the associated additional steel production and waste treatment.)

Table 4.4 Inventory data for the brakes (679 grams)

Materials input			
Data	SimaPro category	Amount	Comment
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	379 g	Brake mounts
Synthetic rubber {GLO}	Assemblies and materials > Material > Plastics > Rubbers > Market	200 g	Blocks (4 pieces)

Steel, chromium steel 18/8 {GLO}	Assemblies and materials > Material > Metals > Ferro > Market	100 g	Brake cables
Processes input			
Data	SimaPro category	Amount	Comment
Wire drawing, steel {GLO}	Processes > Processing > Metals > Chipless shaping > Market	100 g	For shaping brake cables

Table 4.5 Inventory data for a pair of wheels (together 2800 grams)

Materials input			
Data	Simapro category	Amount	Comment
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	1880 g	Rim
Aluminium, wrought alloy {GLO}	Assemblies and materials > Material > Metals > Alloys > Market	150 g	Spokes
Synthetic rubber {GLO}	Assemblies and materials > Material > Plastics > Rubber > Market	270 g	Inner tire
Synthetic rubber {GLO}	Assemblies and materials > Material > Plastics > Rubber > Market	450 g	Outer tire
Nylon 6 {RER}	Assemblies and materials > Material > Plastics > Thermoplasts > Market	50 g	Rim type
Processes input			
Data	Simapro category	Amount	Comment
Welding, arc, aluminium {GLO}	Processes > Processing > Metals > Welding > Market	0.10 m	Welding the aluminium materials

Table 4.6 Packaging for the bike (cardboard; 3 kg)

Materials input			
Data	SimaPro category	Amount	Comment
Corrugated board box {RER}	Assemblies and materials > Material > Paper + Board > Corrugated board > Market	3000 g	-

4.2 Final bike assembly

Once you have entered the details for all the components and saved them, you have to link these components with the different bike frames (which we already modelled in the last chapter) in order to create the final bike assembly.

Before we model the final bike assemblies for the bikes using different frames, we have to create separate assemblies for the different frames (aluminium, titanium, PAN Carbon Fiber and Steel) under Product stages > Assembly > Others. This way, we can link them as sub-assemblies in the corresponding final bike assemblies. Follow this step to create a separate assembly for the aluminium frame:

- 1) Double-click on Product stages > Assembly > Others and click on *New* on the right side. Under Name, enter *Frame aluminium* and under Materials/Assemblies field, double-click the *Add* line and select the Aluminium frame under the corresponding Materials category on the left (which we modelled in [Chapter 3](#)). In this case, it was under Assemblies and materials > Material > _Different types of bike frames category. Under the Amount field, enter *1.5* and under Unit, choose *kg* since we modelled 1.5 kg of aluminium frame. After you enter the details, the window should look like in Figure 4.2.

Figure 4.2 Assembly of frame aluminium

Follow the same steps to create separate assemblies for the remaining frames you modelled as Processes and enter corresponding details. The weights of the frames already mentioned in Table 3.1 in Chapter 3. Don't start the exercises unless you finish creating these assembly models for the remaining frames.

The next step is then to model four separate final bike assemblies using the four different bike frames (aluminium, titanium, PAN carbon fiber and steel). You then link them with these frames and components assemblies since you have to compare the environmental impacts of the bikes using these four different frames. Follow these steps to model the aluminium frame final bike assembly:

- 2) Create a new assembly in Product stages (click on *Assembly > Others* and click on *New* on the right side). Name it *Bike Assembly (Aluminium frame)*.
- 3) Double-click Add line under Materials/Assemblies and select the Frame Aluminium assembly you have modelled above (*Assembly > Others > Frame Aluminium*). Enter 1 as amount (the unit is p from 'piece').

Unit “p” in SimaPro

In SimaPro, with amount as quantity, the unit p is most often used as an abbreviation for ‘piece’. Other occurring uses in SimaPro are ‘guestnight’ (used in ecoinvent processes) and ‘person’.

- 4) Now add another line under Materials/Assemblies, and choose the Groupset part you have modelled in the Assembly category. Enter 1 as amount.
- 5) Follow the above step for the remaining components you modelled. The amount is the same for every assembly: 1 p.
- 6) In the processes field, select Transport > Road > Market > Infrastructure and select Road vehicle factory {GLO} | market for road vehicle factory | Cut-off, S and enter the value 9.3693E-10 as the amount. This road vehicle factory process reflects the bike assembly hall needed to assemble the bike. This value was obtained from the ecoinvent database for the average production of one bike.

You will see (Figure 4.3) once you have followed the steps above.

Edit assembly 'Bike Assembly (Aluminium frame)'

Input/output | Parameters

Name	Status	Comment
Bike Assembly (Aluminium frame)	None	The aluminium frame weighs 1,5 kg.

Materials/Assemblies	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Frame aluminium	1	p	Undefined				
Saddle	1	p	Undefined				
Handlebar	1	p	Undefined				
Groupset	1	p	Undefined				
Pair of wheels	1	p	Undefined				
Set of brakes	1	p	Undefined				
Packaging for the bike (cardboard)	1	p	Undefined				

Add line

Processes	Amount	Unit	Distribution	SD2	Min	Max	Comment
Road vehicle factory {GLO} market for road vehicle factory Cut-off, S	9,3693E-10	p	Undefined				This road vehicle factory process reflects the bike assembly

Add line

Image

Figure 4.3 Assembly of bike (aluminium frame)

4.2.1 Exercise

Similar to the example we modelled above, create the bike assemblies for the remaining bike frames (Titanium, PAN carbon fiber and Steel) using the “Copy” function. To do that, click *Bike Assembly (Aluminium Frame)* model you just created under Product stages > Assembly > Others and select *Copy* on the right. Enter the name of the corresponding bike frame assembly and swap the aluminium frame with the corresponding bike frame (Titanium/PAN carbon fiber/Steel frame). Enter the names as Bike Assembly (Titanium frame), Bike Assembly (PAN carbon fiber frame), Bike Assembly (Steel frame) for the Titanium, PAN carbon fiber and Steel frames respectively.

4.3 Use stage of the bike

Once the production of the bikes is modelled in SimaPro, model its use stage processes under Product stages > Life cycle option. In this section we will explain how to model the use stage processes of the bike using the aluminium frame.

Objective: To model the use stage processes of the bike using the aluminium frame.

Given: The modelling information ([section 3.1.1](#)), gives us the following details:

- The entire lifetime of each bike for all the frames is 15 years.
- The bike is transported 500 km from the manufacturing plant to the store location in a EURO5 truck. Use Transport, freight, lorry 3.5-7.5 metric ton, euro5 {RER}, market for this transportation process.
- For maintenance of the bikes assume three times a year. This involves transport to the maintenance center in a medium-sized EURO5 diesel fueled passenger car for an average distance of 10 km per round trip (i.e., 30 km per year corresponding to 450 km over total lifetime of the bike).

The total weight of each bike was calculated by adding up the weights of the components (5.785 kg), the different frames and its packaging (3 kg). The weights of the different bike frames are mentioned in Table 3.1 in Chapter 3. See Table 4.7 for the total weight of the bikes, including packaging.

Table 4.7 Total weight of the bike for different frames and including 3 kg packaging

Type of bike frame	Total bike weight (kg)
Aluminium	10.285
Titanium	10.145
PAN carbon fiber	9.785
Steel	10.585

Steps:

- 1) Create a new life cycle model for the bike using the aluminium frame by clicking on Life cycle > Others under Product stages and click on *New* on the right side. Name it as Bike life cycle (Aluminium frame) under the Name field.
- 2) Double-click the line under Assembly field. Select the *Bike Assembly (Aluminium frame)* from the Assembly category and enter 1 as the amount (unit is p) since you have to model the use-stage impact for one piece of aluminium bike.
- 3) Enter the bike transportation details from the manufacturing to use location. To do this, double-click the line below Processes field, click on category Transport > Road > Market and then choose Transport, freight, lorry 3.5-7.5 metric ton, euro5 {RER} | market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 | Cut-off, S, since we assume this truck type is used to transport the bike from the manufacturing to use location. Using the formula in the [Background data](#) for freight transport, the transport needed to transport 10.285 kg of bike over 500 km distance is 5142.5 kgkm. Thus, enter 5142.5 as amount and select kgkm as unit.

- 4) In a new line, enter the transportation values involved for the bike maintenance (transportation to the maintenance center).

Since a medium-sized diesel fuel powered EURO5 car is used for taking the bike to the maintenance center, double-click *Processes* field, double-click category Transport > Road > Market and then choose Transport, passenger car, medium size, diesel, EURO 5 {GLO} | market for transport, passenger car, medium size, diesel, EURO 5 | Cut-off, S, and enter the Amount as 450 with its unit as km, since that is the total distance travelled to the maintenance center over the entire bike lifetime.

- 5) Under Waste/Disposal scenario, double-click the line, click on *New* on the right side in the ensuing window and enter Name as "Disposal of bike (aluminium frame)". We will see how to enter details for this disposal scenario in the next section.
- 6) Save the life cycle model.

After all these details are entered, the window will look like Figure 4.4.

Name	Status	Comment
Bike life cycle (Aluminium frame)	None	The bike weighs 5.785 kg excluding frame and excluding 3 kg packaging.

Assembly	Amount	Unit	Distribution: SD2 or 2SD	Min	Max	Comment
Bike Assembly (Aluminium frame)	1	p	Undefined			

Processes	Amount	Unit	Distr	SD2	Min	Max	Comment
Transport, freight, lorry 3.5-7.5 metric ton, EURO5 (RER) market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 Cut-off, S	5142.5	kgkm	Undr				Distribution: 10.285 kg; 500 km.
Transport, passenger car, medium size, diesel, EURO 5 (RER) transport, passenger car, medium size, diesel, EURO 5 Cut-off, S	450	km					Maintenance: thrice per year; 10 km per round trip; 15 years.

Waste/Disposal scenario

Additional life cycles	Number	Distribution: SD2 or 2SD	Min	Max	Comment
Disposal of bike (aluminium frame)					

Figure 4.4 Lifecycle of bike (aluminium frame)

4.3.1 Exercise

Similar to the example above, model the use stage impacts for the remaining bike frames titanium, carbon fiber, and steel and save them under the names Bike life cycle (Titanium frame), Bike life cycle (Carbon fiber frame), Bike life cycle (Steel frame) respectively. The transportation details for the bikes using these frames is similar to the bike using aluminium frame as well. The total weights of the bikes using different frames can be found in Table 4.7 Under Waste/Disposal scenario, create disposal scenarios for these frames and name them as Disposal of bike (titanium frame), Disposal of bike (PAN carbon fiber frame), Disposal of bike (steel frame) for the titanium, PAN carbon fiber and Steel frames respectively as we did for the aluminium frame bike.

4.4 Disposal of the bike

Enter the disposal details of the bike after entering its production and use stage processes under Product stages > Disposal scenario > Others category. Similar to the pattern followed above, we will explain how to model the disposal process of the bikes using aluminium frames. From this you will model the disposal processes for the remaining bike frames as part of the exercises.

Objective: To model the disposal stage of the bike using aluminium frame.

Given: We assume (from [section 3.1.1](#)) for the bike's end of life that:

- 30% is reused completely
- 65% is collected as bulky waste for further processing, with some components being reused
- 5% ends up directly as municipal solid waste

Assumptions: We make the following additional assumptions with respect to the different types of bike disposal:

- The 30% of the bikes that will be reused are transported in a EURO 5 truck over a distance of 2000 km in order to reuse it in a different country.
- The 65% bikes collected as bulky waste for processing, are transported to a waste management service company over a distance of 200 km in a EURO5 truck. Use Market type {RER} for this transportation process. At the waste management service company the bike is disassembled.
 - A part of the different bike frames and components will be disassembled for reuse. The disassembly percentages and the actual reuse percentages (%) thereof are mentioned in Table 4.8.
 - The remaining percentage per component is assumed to be treated as municipal solid waste in the Netherlands through "Municipal solid waste (waste scenario) {NL}| Treatment of waste | Cut-off, S", which entails different percentages per material/waste type separated from the waste stream for material recycling. Take a look at this process in SimaPro (Processes > Waste scenario > Municipal > Municipal solid waste (waste scenario) {NL}| Treatment of waste | Cut-off, S) for details (Figure 4.5).

Edit waste scenario process 'Municipal solid waste (waste scenario) {NL}| Treatment of waste | Cut-off, S'

Documentation | **Input/output** | Parameters | System description

Products

Waste specification	Amount	Unit	Category	Comment
Municipal solid waste (waste scenario) {NL} Treatment of waste Cut-off, S	1	kg	Municipal	Netherlands

Inputs

Inputs from technosphere: materials/fuels

Amount	Unit	Distribution	SD2	Min	Max	Comment
Add line						

Inputs from technosphere: electricity/heat

Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line						

Outputs

Materials and/or waste types separated from waste stream	Material / Waste type	Percentage	Comment
Core board (waste treatment) {GLO} recycling of core board Cut-off, S	Cardboard	91 %	
Paper (waste treatment) {GLO} recycling of paper Cut-off, S	Packaging paper	91 %	
Packaging glass, white (waste treatment) {GLO} recycling of packaging glass, white Cut-off, S	Glass	86,6 %	
Steel and iron (waste treatment) {GLO} recycling of steel and iron Cut-off, S	Ferro metals	95,6 %	
Aluminium (waste treatment) {GLO} recycling of aluminium Cut-off, S	Aluminium	95,6 %	
Steel and iron (waste treatment) {GLO} recycling of steel and iron Cut-off, S	Steel	95,6 %	
Mixed plastics (waste treatment) {GLO} recycling of mixed plastics Cut-off, S	Plastics	57,2 %	
PE (waste treatment) {GLO} recycling of PE Cut-off, S	PE	57,2 %	
PET (waste treatment) {GLO} recycling of PET Cut-off, S	PET	57,2 %	
PP (waste treatment) {GLO} recycling of PP Cut-off, S	PP	57,2 %	
PS (waste treatment) {GLO} recycling of PS Cut-off, S	PS	57,2 %	
PVC (waste treatment) {GLO} recycling of PVC Cut-off, S	PVC	57,2 %	
Paper (waste treatment) {GLO} recycling of paper Cut-off, S	Paper	91 %	
Paper (waste treatment) {GLO} recycling of paper Cut-off, S	Newspaper	91 %	
Biowaste (RoW) treatment of biowaste, industrial composting Cut-off, S	Compost	66,3 %	
Add line			

Waste streams remaining after separation	Percentage	Comment
Municipal solid waste (waste scenario) {Europe without Switzerland} Treatment of municipal solid waste, landfill Cut-off, S	3,3 %	
Municipal solid waste (waste scenario) {Europe without Switzerland} Treatment of municipal solid waste, incineration Cut-off, S	96,7 %	

Figure 4.5 Municipal solid waste process in SimaPro

Table 4.8 Disassembly and Reuse percentages of different bike components collected as bulky waste

Components	Disassembly percentage (%)	Names of the disposal scenarios for components	Reuse percentage (%)
Aluminium frame	50	Disposal of aluminium frame	20
Titanium frame	50	Disposal of titanium frame	20
Carbon fiber frame	50	Disposal of carbon fiber frame	20
Steel frame	50	Disposal of steel frame	20
Saddle	40	Disposal of the saddle	25
Handlebar	30	Disposal of handlebar	5
Groupset	0	Disposal of groupset	0
Wheels	35	Disposal of the wheels	25
Set of brakes	0	Disposal of the brakes	0
Cardboard packaging	0	Packaging disposal of the bike	0

- The 5% that ends up as municipal solid waste is assumed to be treated as municipal solid waste in the Netherlands through "Municipal solid waste (waste scenario) {NL}| Treatment of waste | Cut-off, S".

Steps:

- 1) You have already created a disposal scenario for the bike with the aluminium frame in the previous section. You can find it under Product stages > Disposal scenario > Others and select *Disposal of bike (aluminium frame)*. Now enter the corresponding details under this model by following the next few steps.

Referring to Assembly field

The corresponding bike assembly 'Bike Assembly (Aluminium Frame)' is already linked under the Referring to assembly field for this disposal scenario.

- 2) Leave the Processes field empty since there is no separate waste associated with the bike except for its packaging which is assumed to be separated by the consumer itself.
- 3) Since 5% of the bikes after its lifetime directly ends up as municipal solid waste in the Netherlands, double-click the line under Waste scenarios field, select Municipal category and then select "Municipal solid waste (waste scenario) {NL} | Treatment of waste | Cut-off, S" and enter 5% in the percentage field.
- 4) Since 65% of the bikes are collected for processing, double-click the line under Disassemblies field and create a new disassembly model for the bike using aluminium frame. Click *New* on the right side and enter the name of your model as 'Disassembly of bike (aluminium frame)' and click OK. In the percentage field, enter 65%.
- 5) Since 30% of the bikes are assumed to be reused, double-click the line under Reuses field and similar to the above step, create a reuse model for the bike using aluminium frame. Click *New* on the right side and enter the name of your model as 'Reuse of bike (aluminium frame)' and click OK. In the percentage field, enter 30%.
- 6) Save this disposal scenario.

After all the details are entered the disposal scenario window will look like Figure 4.6.

Edit disposal scenario 'Disposal of bike (aluminium frame)'

Input/output | Parameters

Name	Status	Comment
Disposal of bike (aluminium frame)	None	

Referring to assembly	Amount	Unit	Comment
Bike Assembly (Aluminium frame)	1	p	

Processes

Processes	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line							

Waste scenarios

Waste scenarios	Percentage	Comment
Municipal solid waste (waste scenario) {NL}	5 %	
Add line		

Disassemblies

Disassemblies	Percentage	Comment
Disassembly of bike (aluminium frame)	65 %	
Add line		

Reuses

Reuses	Percentage	Comment
Reuse of bike (aluminium frame)	30 %	
Add line		

Figure 4.6 Disposal scenario of bike (aluminium frame)

4.4.1 Exercise

Enter the details for the corresponding disposal scenarios of the bikes using “Titanium”, “PAN carbon fiber” and “Steel” frames. You already created the (still empty) disposal scenarios for these bike frames in the previous exercise in [section 4.3.1](#).

4.5 Disassembly

In the previous step, you created a new disassembly for the bike with aluminium frame named as Disassembly of bike (aluminium frame). You can find this disassembly by clicking on *Disassembly* > *Others* under Product stages. This disassembly is empty, and it needs to be filled. Enter the relevant details for this disassembly by following these steps:

Referring to assembly field

The corresponding bike assembly ‘Bike Assembly (Aluminium Frame)’ is already linked under the Referring to assembly field for this disassembly.

- 1) Under Processes field, enter the transportation details involved with the respect to the dismantling of the bike: Double-click the line below Processes field, click category Transport > Road > Market and then choose Transport, freight, lorry 3.5-7.5 metric ton, euro5 {RER}| market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 | Cut-off, S, assuming that this type of truck is used to transport the bike to the waste service company for disassembling it. The amount is 1457 kgkm.
- 2) Create disposal scenarios for the disposal of an aluminium frame and the components used for assembling the Bike Assembly (Aluminium Frame) by double-clicking the empty line next to each correspondence sub-assembly. Click on *New* on the right side. In the ensuing window, enter the names of the disposal scenarios for the aluminium frame and the different components as mentioned in Table 4.8 above. You can skip the groupset, set of brakes and cardboard packaging since we assume that they are not separated as sub-assemblies but are directly treated as municipal solid waste.

Separation of sub-assemblies field

The sub-assemblies used for this disassembly will already be linked under the Sub-assembly field.

- 3) Enter the disassembly percentages of the bike frame and other components from Table 4.8 in the *Percentage* field.
- 4) In the Waste scenarios field, Select *Municipal* category and then choose “Municipal solid waste (waste scenario) {NL}| Treatment of waste” and then enter 100% under the Percentage field, since the components which aren't separated are assumed to be processed as municipal solid waste in the Netherlands. The Waste scenarios field should always be equal to 100%. If not equal to 100%, SimaPro will show an error, since these remaining components have to be disposed of completely.

After all the details are entered, the disassembly model window will look similar to Figure 4.7.

Edit disassembly 'Disassembly of bike (aluminium frame)'

Input/output | Parameters

Name: Disassembly of bike (aluminium frame) | Status: None | Comment: This disassembly of bike concerns the 65% that is collected for further processing. The disposal scenarios (here in this example) concern separation of sub-assemblies that are partly reused in the end. The remainder follows the Municipal solid waste scenario which includes material recycling.

Referring to assembly: Bike Assembly (Aluminium frame) | Amount: 1 | Unit: p | Comment:

Processes

	Amount	Unit	Di	St	M	M	Comment
Transport, freight, lorry 3.5-7.5 metric ton, EURO5 (RER) market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 Cut-off, S	7,285*200	kgkm					10.285 kg minus 3 kg packaging

Add line

Separation of sub-assemblies

Disposal scenarios	Sub-assembly	Percentage	Comment
Disposal of frame aluminium	Frame aluminium	50 %	
Disposal scenario (saddle)	Saddle	40 %	
Disposal scenario (handlebar)	Handlebar	30 %	
	Groupset	0 %	
Disposal scenario (pair of wheels)	Pair of wheels	35 %	
	Set of brakes	0 %	
	Packaging for the bike (cardboard)	0 %	

Add line

Treatment of remaining waste

Waste scenarios	Percentage	Comment
Municipal solid waste (waste scenario) {NL} Treatment of waste Cut-off, S	100 %	

Add line

Figure 4.7 Disassembly scenario of bike (aluminium frame)

Note that the “Set of brakes”, “Groupset” and “Packaging of the bike (cardboard)” sub-assemblies are visible in this disassembly. Because the associated percentages are 0 it is fine to leave the disposal scenario empty. Alternatively you might want to give these disposal scenarios a name. By doing so (empty) scenarios are created but it will not be used because of the percentage being 0.

4.5.1 Components disposal scenario's

In the previous section, we created disposal scenarios for the frames and bike components. You can find these models by double-clicking on *Disposal scenario > Others* under Product stages. These disposal scenarios are still empty. We already mentioned (under section 4.4) that the separated bike frames and components are partly reused. Follow the steps below to enter the disposal scenarios of the different frames and components concerned. In this case, we enter the details for the **Disposal of aluminium frame** model:

- 1) Select Product stages > Disposal scenario > Others to the left and select 'Disposal of frame aluminium' model on the right.
- 2) In this disposal scenario, under Waste scenarios field, double-click the line and select “Municipal solid waste (waste scenario) {NL} | Treatment of waste | Cut-off, S” and enter 80% under Percentage, since 80% of the frames are assumed to be discarded as municipal solid waste.
- 3) Under the Reuses field, double-click Add line and select New. Give this reuse product stage a name like “Reuse of frame (aluminium)”. Enter 20% under Percentage. The window now looks like Figure 4.8:

The screenshot shows the 'Edit disposal scenario' window for 'Disposal of frame aluminium'. The window has two tabs: 'Input/output' and 'Parameters'. The 'Input/output' tab is active.

Name: Disposal of frame aluminium
Status: None
Comment: (empty field)

Referring to assembly: Frame aluminium
Amount: 1
Unit: p
Comment: (empty field)

Processes: (empty table with columns: Amount, Unit, Distribution, SD2 or 2SD, Min, Max, Comment)

Waste scenarios: (empty table with columns: Percentage, Comment)

Disassemblies: (empty table with columns: Percentage, Comment)

Reuses: (empty table with columns: Percentage, Comment)

Reuse of frame (aluminium): 20 %
Comment: (empty field)

Figure 4.8 Disposal scenario of aluminium frame

- 4) Save this Disposal of frame aluminium model.

Do not forget to enter the details for the remaining bike components (saddle, handlebar, set of wheels) disposal scenarios using the reuse percentages as stated in Table 4.8 before you start solving 4.5.2 Exercise.

4.5.2 Exercise

Create disassembly models for the bikes using Titanium, PAN carbon fiber and Steel frames similar to how we built the disassembly model for the bike using Aluminium frame as above. Name them as Disassembly of bike (Titanium frame), Disassembly of bike (PAN carbon fiber frame) and Disassembly of bike (Steel frame) respectively. Create disposal scenarios for the corresponding frames (as we did for the aluminium frame above) and enter the corresponding details. Link the already created disposal scenarios for the components (under the Disposal scenarios field) to the respective Disassembly models of bikes using Titanium, PAN carbon fiber and Steel frames.

4.6 Reuse

While creating the bike disposal scenario ([section 4.4](#)), we already built a reuse model "Reuse of bike (aluminium frame)" for the bike using aluminium frame. This model is empty now. You can find this model by double-clicking on Product stages > Reuse > Others. Enter the relevant details under this model by following these steps:

Referring to assembly field

Similar to the disassembly model, the corresponding bike assembly 'Bike Assembly (Aluminium Frame)' is already linked under the *Referring to assembly* field for this reuse model.

- 1) Under Processes field, enter the transportation details involved for the bike reuse:
Double-click the line below Processes field, double-click category Transport > Road > Market and then choose Transport, freight, lorry 7.5-16 metric ton, euro5 {RER} | market for transport, freight, lorry 7.5-16 metric ton, EURO5 | Cut-off, S, since we assume this type of truck is used to transport the bike to its reuse location. Enter the transportation Amount as 14570, Unit as kgkm.
- 2) Save this reuse model.

After entering all these details, the reuse model window looks like Figure 4.9.

Name	Status	Comment
Reuse of bike (aluminium frame)	None	

Referring to assembly	Amount	Unit	Comment
Bike Assembly (Aluminium frame)	1	p	

Processes	Amount	Unit	Distr	SD2	Min	Max	Comment
Transport, freight, lorry 7.5-16 metric ton, EURO5 {RER} market for transport, freight, lorry 7.5-16 metric ton, EURO5 Cut-off, S	14570	kgkm					

Add line

Figure 4.9 Reuse scenario of bike (aluminium frame)

4.6.1 Exercise

Enter the details for the reuse models of the bikes using Titanium, PAN carbon fiber and Steel frames similar to how we entered the details for the Reuse of bike (aluminium frame) model above.

4.7 Environmental impacts of aluminium frame bike life cycle

4.7.1 Network and Tree diagram

To get an overview of the whole model you have just built, click on the Bike life cycle (Aluminium frame) (under the Product stages > Life cycle > Others) and choose the *Network icon* at the toolbar. If you didn't yet [select a default method](#), choose ReCiPe 2016 Endpoint (H) impact assessment with World (2010) H/A Normalization/Weighting set as the method and click Calculate. You will get a warning: "Not all products of this network are currently visible (11 of 66)." Click OK and select "show indicator as percentage". You will then see the network diagram as seen in Figure 4.10. You can play around with different cut-off percentages to increase/decrease the number of nodes shown in this diagram.

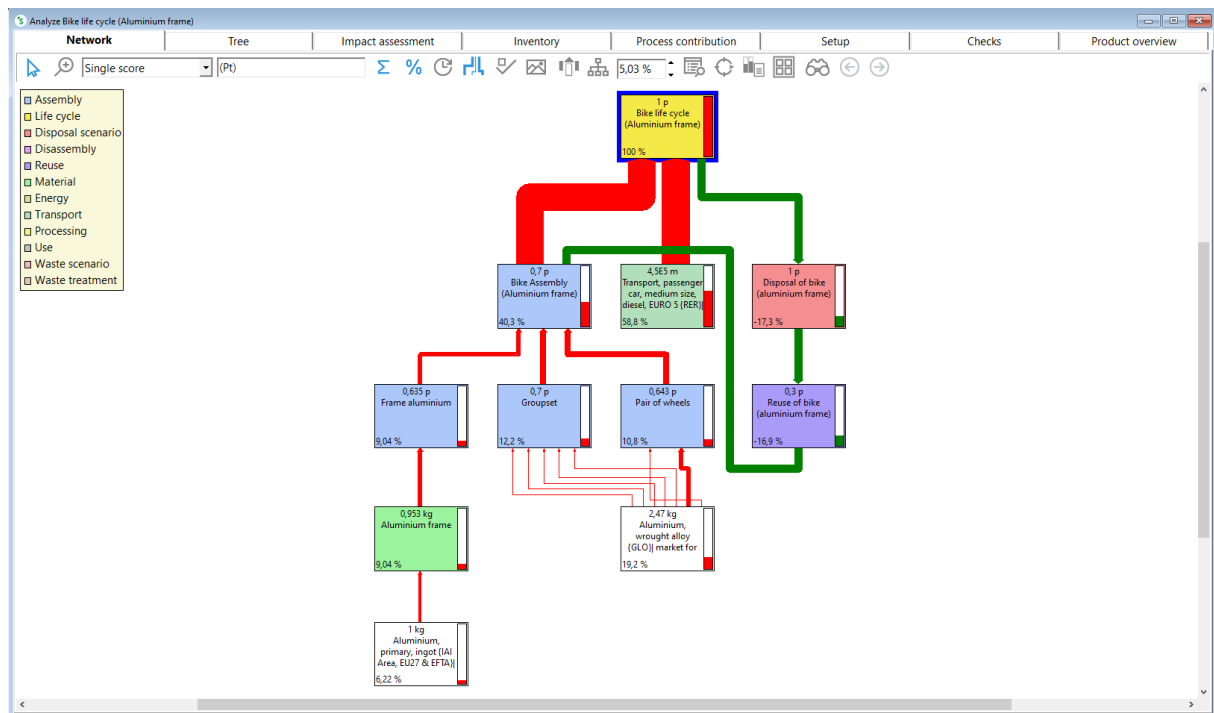


Figure 4.10 Network diagram of aluminium frame bike life cycle

From Figure 4.10 we can see that transport using a passenger car (i.e., transportation involved for the bike maintenance) causes 58.8% of the total impact caused during the entire life cycle of the bike using aluminium frame. The bike assembling causes about 40,3% of the impact, with its main source of impact (12.2%) coming from the groupset assembly.

By clicking on the *Tree* tab you will see the tree view as in Figure 4.11.

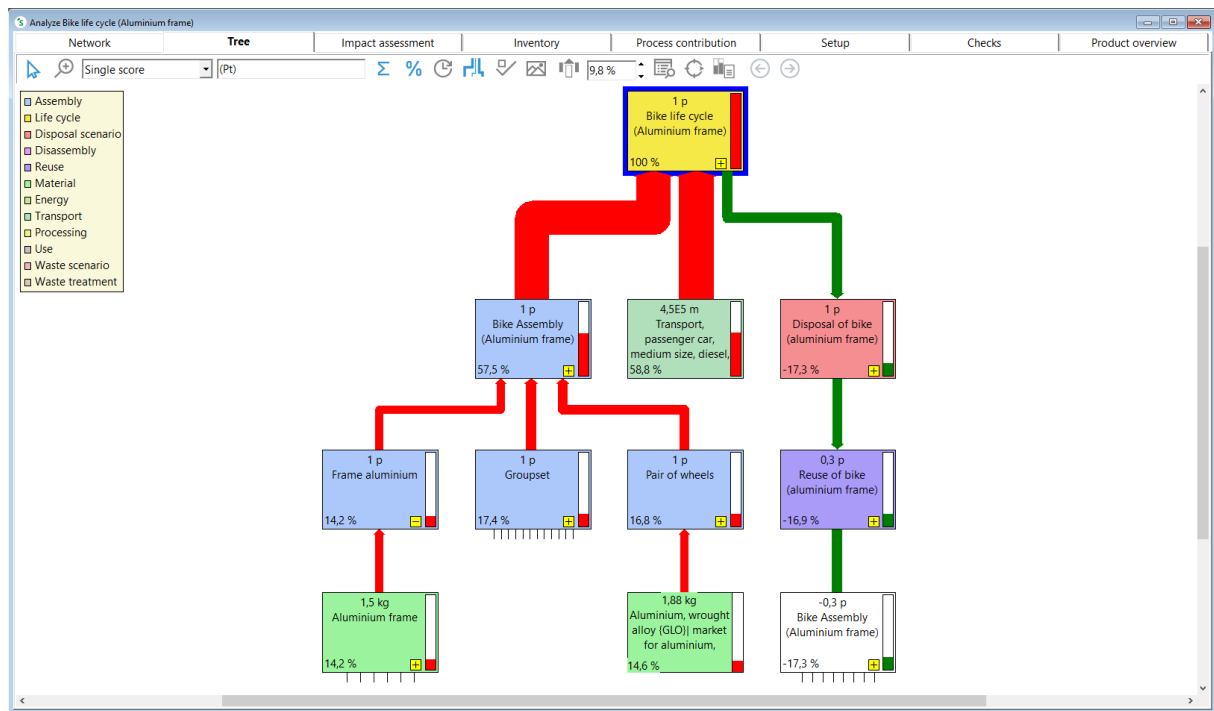


Figure 4.11 Tree diagram of aluminium frame bike life cycle

From Figure 4.10 and Figure 4.11, it is clear that transport in a passenger car (i.e., transportation involved for the bike maintenance) has a larger impact during the entire life cycle of the bike compared to the total impact of production and assembly of the bike with aluminium frame.

Show input and output flows: This option shows the input and output flows according to the corresponding node you select.

Show analysis groups: This option allows you to view the results grouped by its functions (for example, production, energy, transport, waste) rather than the standard view per process or product stage. To learn more about this option please refer to [this video](#) on the SimaPro Help Center.

Tree cannot be shown and not all products are visible

When you choose to display your calculation in Tree mode, you may get a warning that it is not possible to display it as a tree because it contains loops. This simply means that you might accidentally choose ecoinvent unit processes in your model and it is only possible to view loops in the Network view. You can go through your model again and make sure that you choose system process data, and not the unit process.

Furthermore, it is also possible to see the warning stating that not all products of your network are currently visible. This simply tells you that not all nodes are displayed in the Network/Tree as there are too many to fit the screen to keep it legible. It calculates a cut-off level in such a way that only some of the most important processes are displayed. You can play with the cut-off percentage to explore and view more processes.

4.7.2 Analysis diagram

To see the environmental impacts of the life cycle of the bike, click on the Bike life cycle (Aluminium frame) (under the Product stages > Life cycle > Others) and select the *Analyze icon* at the toolbar. Select ReCiPe 2016 Endpoint (H) with World (2010) H/A Normalization/Weighting set as the impact assessment method and click on the *Single score* tab. You will see a window as in Figure 4.12.

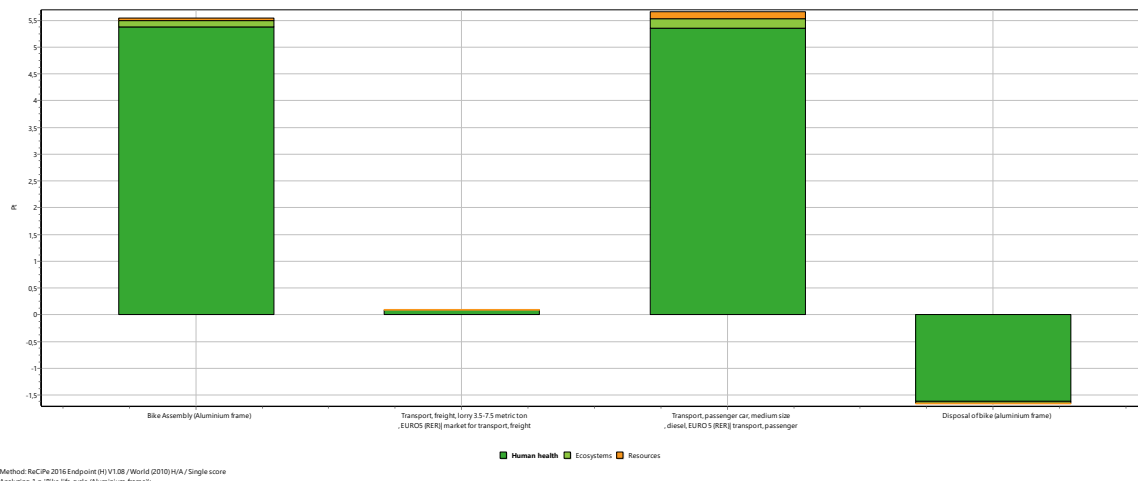


Figure 4.12 Analysis of environmental impacts over the entire bike life cycle using aluminium frame

Try exploring other tabs and options (as we discussed in Chapter 3) to get a more detailed analysis of the results.

4.8 Comparison of bike life cycle using different frames

Once you finish entering all the bike life cycle details for the different frames it would be interesting to compare their impacts. Select all these life cycle models from top to bottom (by clicking while holding down the CTRL key) and click on *Compare icon* at the toolbar. Select ReCiPe 2016 Endpoint (H) with World (2010) H/A Normalization/Weighting set impact assessment method and then click *Calculate*. Go to the *Single score* tab and you should the following window as seen in Figure 4.13 (provided you entered all the details correctly).

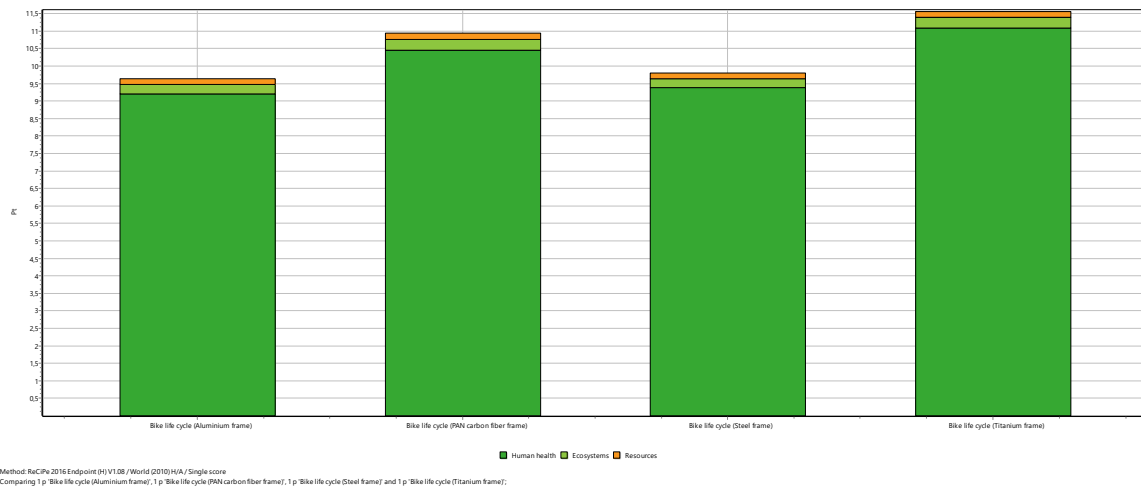
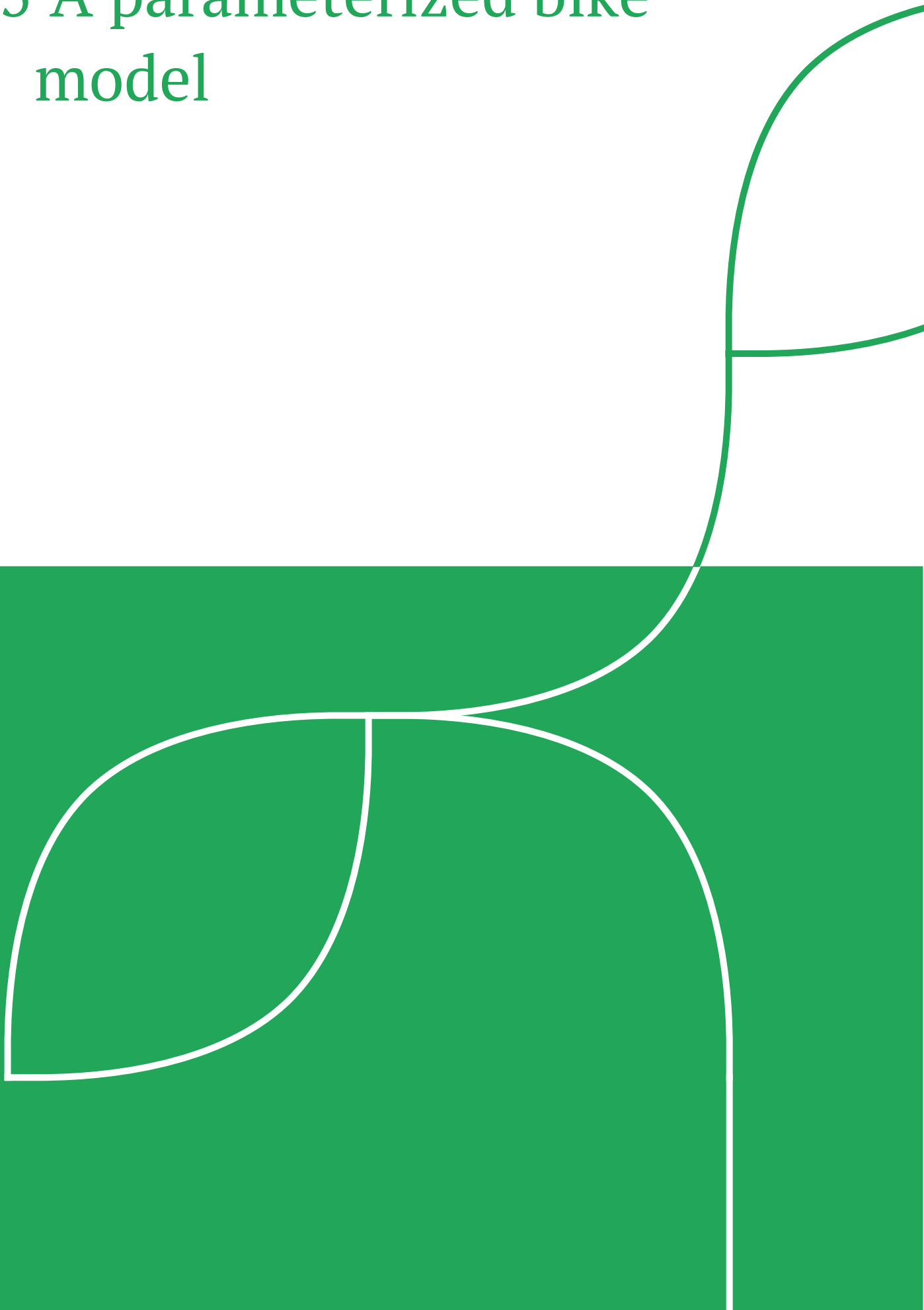


Figure 4.13 Environmental impacts over the entire bike life cycle using different frames

Figure 4.13 shows that using bikes with aluminium or steel frame will have a lower impact over its life cycle when compared to using bikes with carbon fiber or titanium frames.

You can also explore other different tabs and options (which we discussed in the previous chapter) to get a more clear and detailed analysis of these results.

5 A parameterized bike model



5 A parameterized bike model

What you will do	Perform a sensitivity analysis for the bike model using parameters
Required Entry level	Chapter 2, 3 and 4 should be completed first (including the exercises)
Recommended reading	'Introduction to LCA with SimaPro' Chapters 1, 2, 3, 4 and 5
SimaPro license type	SimaPro PhD/Analyst/Developer Please note that the feature parameters with scenario analysis (the "Parameter sets" tab) is not available in the Classroom and Faculty license of SimaPro.

5.1 Introduction

While performing the Life Cycle Assessment of systems, you have to make various input data assumptions. This was the case with your bike model as well. Thus, you should perform a sensitivity analysis to obtain more robust LCA results. The sensitivity analysis allows you to identify the parameters which influence your results. The theory behind a sensitivity analysis is simple: play around with the input values and processes, recalculate the LCA results and check their influence on the results. You can use the **Parameters** in SimaPro to perform a sensitivity analysis, by changing the input values and processes of your model and checking the results.

In SimaPro, parameters can be defined on the database, project or process level. Parameters will be discussed in detail in the next sections.

Different parameter levels in SimaPro

Parameters can be defined on three different levels in SimaPro:

Database parameters: are parameters that are defined on the database level (under *Inventory* -> *Parameters*, tab *Database*). Once you create this parameter, you can use it in all libraries and projects within this SimaPro database.

Project parameters: are parameters that have meaning only in the project you are working in. You can define different parameters per project (under *Inventory* > *Parameters*, tab *Project*). These parameters are independent of one another and can be under the same name while having a different meaning per project

Process parameters: are parameters that refer to a process or product stage level. You can define process parameters in many different processes (under *Inventory* > *Processes* or *Product stages*, tab *Parameters*) and they all can have different meanings or purposes.

If they have the same name, process parameters overrule project parameters, and project parameters overrule database parameters.

Individual parameters can be used in formulas to form a *calculated parameter*. Calculated parameters can be specified below the parameters, so also on three levels.

In this tutorial, we will show you how to model the parameters on a process level (i.e., involving the bike model). We will analyze how the choices we made could potentially influence our results. Generally, the subject of this sensitivity analysis may be related to:

- assumptions we made, for example variation in the transport distance
- selection of library and process data, for instance using data from different regions or sources
- methodological choices, for instance comparing the type of allocation used
- selection of impact assessment methods

Uncertainty analysis

While the outcome of the LCA can depend quite heavily on the assumptions made, LCA data is, inevitably, full of uncertain numbers. These uncertainties can have different causes, like uncertain measurements or uncertainty about how representative a figure is for the actual case we are studying. This means we must ask ourselves how certain or uncertain our results are, especially when we are comparing data. Read more about how to deal with uncertainty and Monte Carlo analysis in [this](#) article or in the [Introduction to LCA](#) manual. Please note that uncertainty calculations can only be made in SimaPro PhD, Analyst, and Developer licenses.

5.2 Variable transportation distances for bike maintenance

In Chapter 4 [section 4.7.2](#) we saw that the main source of impact during the entire life cycle of the aluminium frame bike was the transport involved for bike maintenance in a passenger car. Using **Parameters**, you can create scenarios and compare the environmental impacts for different distances involved during bike maintenance. In this case, we will compare the impacts for scenarios involving variable transportation distances for the aluminium frame bike.

Preview: For the baseline scenario we assumed a transportation distance of 450 km for bike maintenance over its total lifetime of 15 years (from [section 4.3](#)). In this example, we will compare the impacts for the following distances in addition to the baseline scenario:

Table 5.1 Transportation distance scenarios for maintenance for the aluminium frame bike

Baseline scenario	Scenario 1	Scenario 2
450 km	225 km	675 km

Steps:

- 1) Open the project "Tutorial" that you already created for modelling the road bike.
- 2) In the inventory column on the left, select Product stages. On the right side click Product stages > Life cycle > Others on the right and double-click on Bike life cycle (Aluminium frame).
- 3) Select *Parameters* tab at the top and create the necessary input parameters. In this case, we have to create the "distance" input parameter, since we are comparing the scenarios for variable transportation distances.
- 4) As input parameter, enter "distance" and enter "450". You can enter "km" in the comment field, since we are specifying the input parameter for the maintenance transportation distance of the aluminium frame bike which is expressed in km.

After you enter these details, the window looks like Figure 5.1.

Input parameters	Value	Distribution	SD2 or 2SD	Min	Max	Hide	Comment
distance	450	Undefined				<input type="checkbox"/>	km

Calculated parameter Expression Comment

No Error / Additional info

Figure 5.1 Life cycle bike, Parameters

- 5) Now select the *Input/output* tab, under Processes, select the corresponding process and add the parameter distance into the amount field. In this case type "distance" directly into the Amount field of the process Transport, passenger car, medium size, diesel, EURO 5 {GLO} | market for transport, passenger car, medium size, diesel, EURO 5 | Cut-off, S and press enter. Save this entry and the window will look like Figure 5.2 after you enter these details.

Input/output Parameters

Name: Bike life cycle (Aluminium frame) Status: None Comment: The bike weighs 5.785 kg excluding frame and excluding 3 kg packaging. The aluminium frame weighs 1.5 kg. All together including packaging: 10.285 kg.

Assembly	Amount	Unit	Distribution: SD2 or 2SD	Min	Max	Comment
Bike Assembly (Aluminium frame)	1	p	Undefined			

Processes

	Amount	Unit	Distr	SD2	Min	Max	Comment
Transport, freight, lorry 3.5-7.5 metric ton, EURO5 (RER) market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 Cut-off, S	5142.5	kgkm	Und				Distribution: 10.285 kg; 500 km.
Transport, passenger car, medium size, diesel, EURO 5 Cut-off, S	distance = 450	km					Maintenance: thrice per year; 10 km per round trip; 15 years. ==> default scenario = 3*10*15

Waste/Disposal scenario

Disposal of bike (aluminium frame)

Additional life cycles

Number Distribution: SD2 or 2SD Min Max Comment

Figure 5.2 Life cycle bike, Input/output, with parameters

- 6) Now click on the *Analyze* button at the top. Select *Parameter sets* tab in the ensuing Calculation setup window. Click on *Add* option below, under Parameter set on, double-click Set 1 and rename it as “baseline: 450 km”. Next, we need to specify the value per scenario. In this case we are modelling the scenarios for different transportation distances of 225 km, 450 km (baseline scenario) and 675 km as seen above in Table 5.1. Thus, click on *Add parameter* option, select “Scan Tree” option on the right and choose the distance parameter
- 7) Now you have to add the parameter sets for the remaining scenarios and specify the values per scenario. Click on *Add* option, rename Set 2 on the left as low: 225 km, double-click under the low: 225 km column on the right and enter 225. Now, again click on *Add* option, rename Set 3 as high: 675 km, double-click under the high: 675 km column on the right and enter 675. After entering these details, the window looks like Figure 5.3.

Parameter sets

Import from Excel sheet

No	Parameter set	No	Parameter	Defined in	Type	baseline: 450	low: 225 km	high: 675 km
1	baseline: 450 km	1	distance	Bike life cycle (Aluminium frame) PARAMETERISED	Product	450	225	675
2	low: 225 km							
3	high: 675 km							

km

Add Delete Add parameter Delete parameter ☐ Show uncertainty values View import log Refresh

Help Calculate Close

Figure 5.3 Calculation setup, Parameter sets, distance



Saving the parameter sets

After you define some parameters sets as scenario analysis, you can save this as a calculation setup for a quicker analysis in the future. To do that, go to the *General* tab next to the *Parameter sets*. Fill in the Name, Method, and Product. Once you are done, save the calculation set up by clicking File > Save or pressing CTRL + S. You can find the saved calculation set up in the LCA explorer screen > Impact assessment > Calculation setups.

Now click on *Calculate* button at the bottom. You will see Figure 5.4.

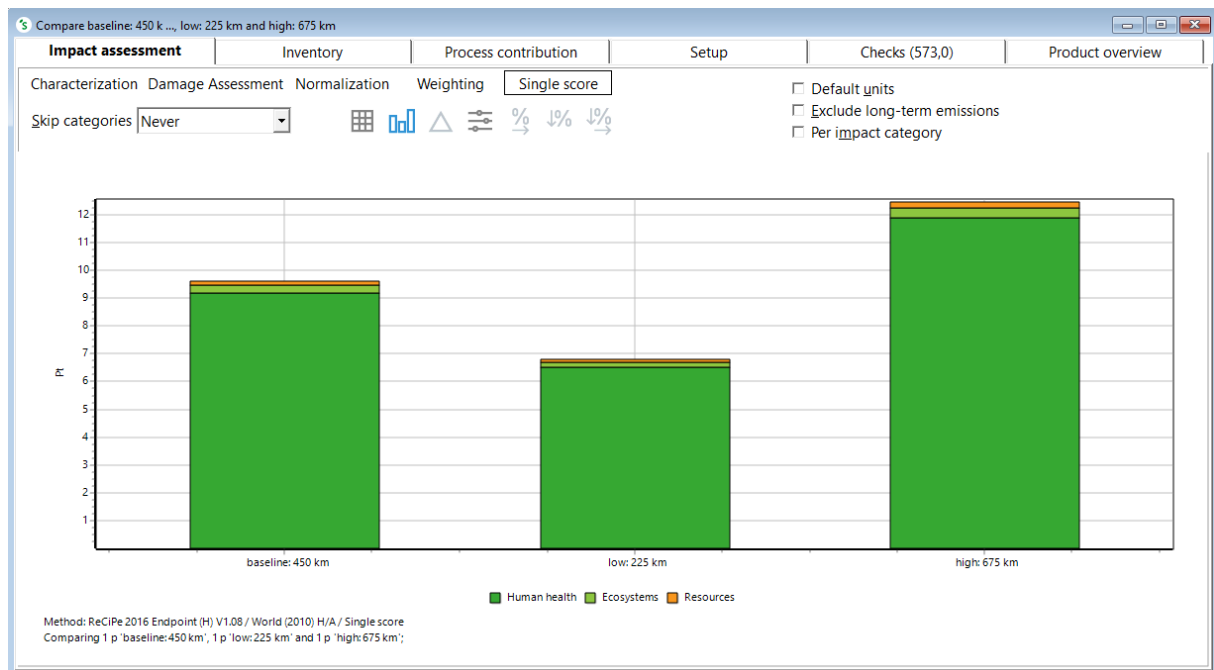


Figure 5.4 Comparison of variable maintenance transportation distances

From Figure 5.4, you can see that the environmental impact during the entire life cycle of the aluminium frame bike is lower when the transport distance for the maintenance is lower. The impact increases as the transport distance for the maintenance is higher.

5.2.1 Exercise

Similar to the example above, calculate the impacts involving these three scenarios with respect to different transportation distances involved for bike maintenance, for the titanium frame bike life cycle. See Table 5.2.

Table 5.2 Transportation distance scenarios for maintenance for the titanium frame bike

Baseline scenario	Scenario 1	Scenario 2
450 km	300 km	600 km

5.3 Compare aluminium from different regions

In [section 3.2.3 \(Chapter 3\)](#), we assumed that “Aluminium, primary, ingot {IAI Area, EU27 & EFTA}” type in SimaPro would be used for the primary aluminium ingot material used in the manufacture of the aluminium frame. Using **parameters**, you can compare the environmental impacts of aluminium from other regions.

Preview: For the baseline scenario we used “Aluminium, primary, ingot {IAI Area, EU27 & EFTA}” type for the primary aluminium ingot material in the production of aluminium frame for the road bike. In this case, we will compare the impacts when {RoW} and {CN} type of aluminium primary ingot material are used. {RoW} type includes inventory data modelled for production of aluminium primary ingot in Rest-of-World. {CN} type includes inventory data modelled for production of aluminium primary ingot in China.

Steps:

- 1) Open the project “Tutorial” you already created for this tutorial.
- 2) In the Inventory column on the left, select Processes, on the right side double-click Processes > Material > Different types of bike frames and double-click *Aluminium frame*.
- 3) Select *Input/output* tab in the ensuing window. Under Inputs from technosphere: materials/fuels add the alternative material types you want to compare with. In this case, add a new line, select Processes > Material > Metals > Non Ferro > Transformation and choose Aluminium, primary, ingot {CN}| aluminium production, primary, ingot | Cut-off, S. Enter “1.579” and use “kg” as a unit. This amount is entered, since 1.579 kg of primary aluminium ingot material was used in the production of the aluminium frame.
- 4) Similarly, add the aluminium from other regions. Under inputs from technosphere: materials/fuels, add a new line, select Processes > Material > Metals > Non Ferro > Market and choose Aluminium, primary, ingot {RoW}| market for aluminium, primary, ingot | Cut-off, S. Enter “1.579 kg”. You already added the Aluminium, primary, ingot {IAI Area, EU27 & EFTA}| market for aluminium, primary, ingot | Cut-off, S material when you modelled the Aluminium frame under Processes in Chapter 3. After entering these details, the window looks like Figure 5.5.

Products									
Outputs to technosphere: Products and co-products		Amount	Unit	Quantity	Allocation	Waste type	Category	Comment	
Aluminium frame		1.5	kg	Mass	100 %	Aluminium	„Different types of bi		
Add line									
Outputs to technosphere: Avoided products		Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment	
Add line									
Inputs									
Inputs from nature		Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add line									
Inputs from technosphere: materials/fuels			Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Aluminium, primary, ingot {CN} aluminium production, primary, ingot Cut-off, S			1.579	kg	Undefined				
Aluminium, primary, ingot {RoW} market for aluminium, primary, ingot Cut-off, S			1.579	kg	Undefined				
Aluminium, primary, ingot {IAI Area, EU27 & EFTA} market for aluminium, primary, ingot Cut-off, S			1.579	kg	Undefined				5% production losses estimated
Powder coat, aluminium sheet [GLO] market for powder coat, aluminium sheet Cut-off, S			0.375	m2	Undefined				
Impact extrusion of aluminium, 3 strokes [GLO] market for impact extrusion of aluminium, 3 strokes Cut-off, S			1.51	kg	Undefined				(This proces does not include possible losses.)
Welding, arc, aluminium [GLO] market for welding, arc, aluminium Cut-off, S			0.75	m	Undefined				
Add line									
Inputs from technosphere: electricity/heat			Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Electricity, medium voltage, aluminium industry [IAI Area, EU27 & EFTA] market for electricity, medium voltage,			31.5	kWh	Undefined				electricity is used for bending, hydroforming, furnace, quench tank and screwing processes during the frame

Figure 5.5 Material process for aluminium frame, with aluminium from three regions

- 5) Now, select the *Parameters* tab. Under Input parameters, add the parameters for the different types of primary aluminium ingot material you added previously. Double-click the line under Input parameters, enter “EU27_EFTA” and enter its value as “1” and under Comment enter “1=selected; 0=not selected”. Similarly, add the remaining parameters: Add a new line, enter “RoW”, value as “0” and under Comment enter “1=selected, 0=not

selected". Next, under Input parameters, add a new line, enter "CN", value as "0" and under Comment enter "1=selected; 0=not selected". The value "1" is used for the "EU27_EFTA" parameter because we use this parameter as baseline for the aluminium, primary, ingot material. Thus, the remaining input parameters are set to "0".

Input parameters	Value	Distribution	SD2 or 2SD	Min	Max	Hide	Comment
EU27_EFTA	1	Undefined				<input type="checkbox"/>	1=selected; 0=not selected
RoW	0	Undefined				<input type="checkbox"/>	1=selected; 0=not selected
CN	0	Undefined				<input type="checkbox"/>	1=selected; 0=not selected

Add line

Calculated parameter Expression Comment

Add line

No Error / Additional info

Figure 5.6 Material process for aluminium frame, Parameters

- 6) Now select the Input/output tab. Multiply the "Amount" for the corresponding materials you added in the Input/output tab (in Step 3) by the respective input parameters you created in the previous step. In this case, under the Amount field for Aluminium, primary, ingot {CN}| aluminium production, primary, ingot | Cut-off, S, enter "1.579*CN" and press Enter key. The "=0" value automatically appears to its right.
- 7) Now, do this for the remaining materials. Under the Amount field for Aluminium, primary, ingot {RoW}| market for aluminium, primary, ingot | Cut-off, S, enter "1.579*RoW" and press Enter key. The "=0" automatically appears to its right. Similarly, under the Amount field for Aluminium, primary, ingot {IAI Area, EU27 & EFTA}| market for aluminium, primary, ingot | Cut-off, S, enter "1.579* EU27_EFTA" and press Enter key. The "=1.58" value automatically appears to its right.

After you enter the details, click *Save*. The window will look like Figure 5.7.

Products									
Outputs to technosphere: Products and co-products									
	Amount	Unit	Quantity	Allocation	Waste type	Category	Comment		
Aluminium frame	1,5	kg	Mass	100 %	Aluminium	„Different types of bi			
Add line									
Outputs to technosphere: Avoided products									
Add line									
Inputs									
Inputs from nature									
Add line									
Inputs from technosphere: materials/fuels									
	Amount	Unit	Distribution	SD2	or 2SD	Min	Max	Comment	
Aluminium, primary, ingot (CN) aluminium production, primary, ingot Cut-off, S	1,579*CN = 0	kg							
Aluminium, primary, ingot (RoW) market for aluminium, primary, ingot Cut-off, S	1,579*RoW = 0	kg							
Aluminium, primary, ingot (IAI Area, EU27 & EFTA) market for aluminium, primary, ingot Cut-off, S	1,579*EU27_EFTA = 1,58	kg						5% production losses estimated	
Powder coat, aluminium sheet (GLO) market for powder coat, aluminium sheet Cut-off, S	0,375	m2	Undefined						
Impact extrusion of aluminium, 3 strokes (GLO) market for impact extrusion of aluminium, 3 strokes Cut-off, S	1,51	kg	Undefined					(This process does not include possible losses.)	
Welding, arc, aluminium (GLO) market for welding, arc, aluminium Cut-off, S	0,75	m	Undefined						
Add line									
Inputs from technosphere: electricity/heat									
Electricity, medium voltage, aluminium industry (IAI Area, EU27 & EFTA) market for electricity, medium voltage,	31,5	kWh	Undefined					electricity is used for bending, hydroforming, furnace, quench tank and screwing processes during the frame production	

Figure 5.7 Material process for aluminium frame, with aluminium from three regions, parameterized amounts



Tips for adding and moving your entry in SimaPro

There are several ways to move your entry up and down in SimaPro. The first way is by clicking *Add line* and adding the new entry as usual at the bottom of the list just above the *Add line* button. Then drag up and down to the preferred position. The second option is to right-click on the desired position and choose *Insert line*. A new line will be added directly above. Lastly, you can also copy the line by first selecting the whole line (single mouse click just before the line concerned as seen in the picture below) clicking **CTRL + C** or right click > Copy and then paste where you want to insert the copied entry.

Place your cursor between the left margin and before the process line to select the whole line. The whole line will then be blocked in Azure color

	Amount	Unit	Distribution	SD2	Min	Max	Comment
Aluminium, primary, ingot (CN) aluminium production, primary, ingot Cut-off, S	1,579*CN = 0	kg					
Aluminium, primary, ingot (RoW) market for aluminium, primary, ingot Cut-off, S	1,579*RoW = 0	kg					
Aluminium, primary, ingot (IAI Area, EU27 & EFTA) market for aluminium, primary, ingot Cut-off, S	1,579*EU27_EFTA = 1,58	kg					5% production losses estimated
Powder coat, aluminium sheet (GLO) market for powder coat, aluminium sheet Cut-off, S	0,375	m2	Undefined				
Impact extrusion of aluminium, 3 strokes (GLO) market for impact extrusion of aluminium, 3 strokes Cut-off, S	1,51	kg	Undefined				(This process does not include possible losses.)
Welding, arc, aluminium (GLO) market for welding, arc, aluminium Cut-off, S	0,75	m	Undefined				
Add line							

- 8) Now click on the *Analyze button* at the top. Select the *Parameter sets* tab in the calculation setup window. Now add the number of scenarios you want to model according to the input parameters you created in the previous step and name them. Click on *Add parameter* option below, select *Scan Tree* option on the right and choose all three input parameters (Single-click the first parameter, hold *Shift* key and press down arrow key) and click *Select* on the right side. Now you will see all the parameters appear on the right. Click *Add* to add the parameter sets and specify the values per scenario. To do that, under Parameter set on the left, double-click Set 1 and rename it as "CN". Now add the remaining parameter sets by clicking on *Add* button twice and rename Set 2 and Set 3 as "IAI area, EU27 & EFTA" and "RoW" respectively. The names were chosen according to the type of primary aluminium ingot material you chose with respect to their regions.
- 9) Now, enter the values for the parameters: For the "CN" parameter, enter the value "1" and the remaining parameters as "0". Do this for the remaining parameters as well. For the "IAI area" parameter, enter the value "1" and the remaining parameters as "0". For the

“ROW” parameter, enter the value “1” and the remaining parameters as “0”. The parameter sets should look similar to Figure 5.8.

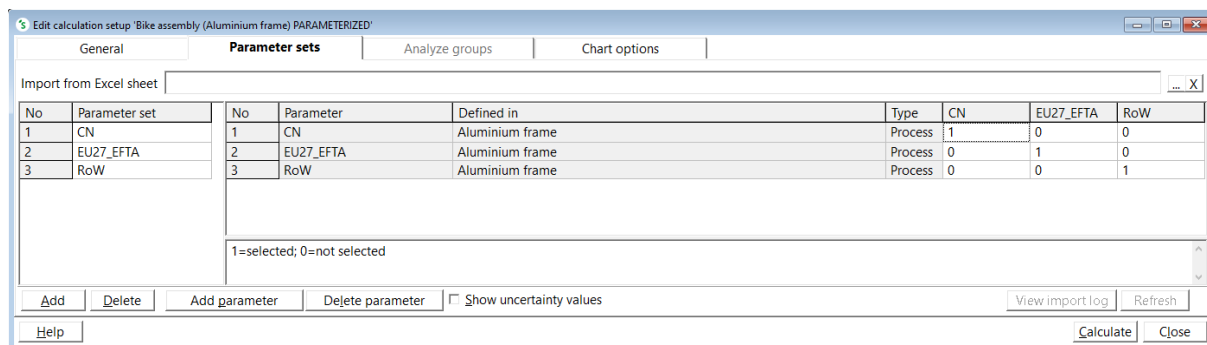


Figure 5.8 Calculation setup, Parameter sets, region

Now click on the *Calculate* button at the bottom and select the *Show chart* icon with Impact assessment and Single score selected. You will see a window similar to Figure 5.9.

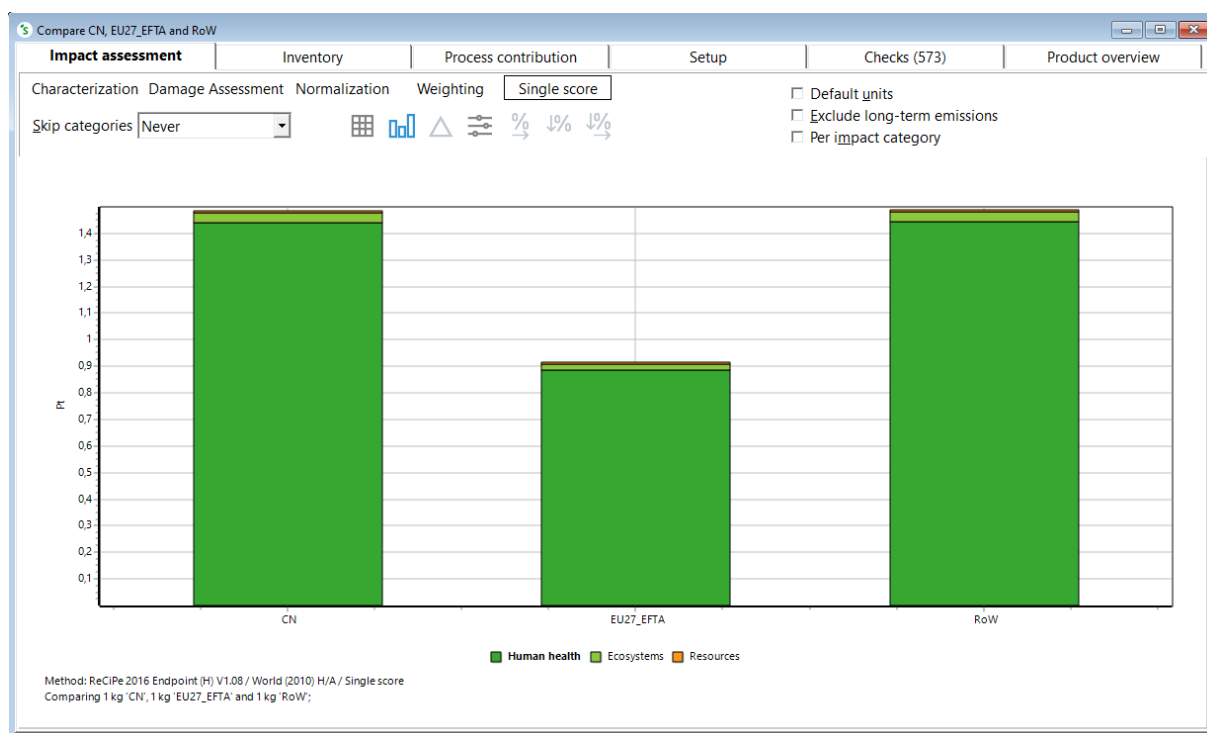


Figure 5.9 Comparison of aluminium frame assembly impacts for different types of aluminium material used its production

From Figure 5.9, you can see how the environmental impact changes, if the aluminium for the frame is produced in a different region. Aluminium manufactured in China and Rest-of-world (RoW) has a much higher impact than the aluminium produced in Europe (EU27 & EFTA).

Please take the time to explore the differences between the two processes with the highest impact. This is best done in a separate calculation. Select those two processes (Aluminium, primary, ingot {CN}| production and Aluminium, primary, ingot {RoW}| market for) in the LCA explorer and click the compare button. Switching from Single score to characterization already reveals differences per impact category (Figure 5.10) while their single score is almost identical.

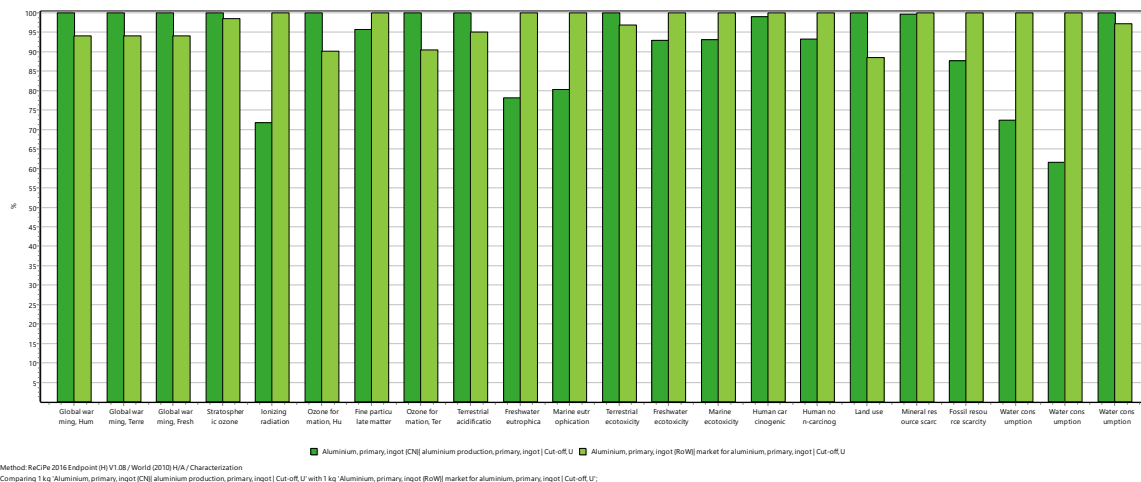


Figure 5.10 Comparing Aluminium, primary, ingot {CN}| production and Aluminium, primary, ingot {RoW}| market for

For further analysis you might want to use the unit processes rather than the system processes.

5.3.1 Exercise

For the PAN carbon fiber frame process you modelled in [Chapter 3](#) (Exercise 3.3) (baseline scenario), you used a global average dataset for the electricity production (Electricity low voltage {GLO}) for the “Fiber production step” process. Compare the environmental impacts when different electricity mixes Electricity, low voltage {NL}| market for electricity, low voltage | Cut-off, S and Electricity, low voltage {RER}| market group for electricity, low voltage | Cut-off, S are used in the “Fiber production step” process involved in the PAN carbon fiber frame process.

5.4 Different modes of transportation depending on distance

In the current (baseline) scenario, we assumed that the bikes are transported over a distance of 500 km in a 3.5-7.5 metric ton lorry from the manufacturing plant to the user location in the Netherlands. Now, we will calculate environmental impacts of scenarios with different modes of transport.

Preview: We are comparing the environmental impacts of the different modes of transportation for the steel frame bike life cycle model. As mentioned above, for the baseline scenario we assumed a transportation distance of 500 km from the manufacturing plant to final use location in a 3.5-7.5 metric ton EURO5 lorry (from [section 3.1.1](#)).

The modes of transport used for various transport distances are listed below in Table 5.3.

Table 5.3 Modes of transport used for various transport distances of the steel frame bike

Scenario	Condition for distance	Transport mode
Local (100 km)	Smaller or equal to 150 km	Light commercial vehicle {RER}
Regional (500 km)	Between 150 and 600 km	Lorry 3.5-7.5 metric ton, EURO5 {RER}
Abroad (1500 km)	Bigger or equal to 600 km	Container ship, freight sea {GLO}

You can use this “condition for distance” feature, if you want to compare the impacts of different modes of transport used when the transport distance varies. For the exercise we will model the following scenarios:

- If transportation distance (local) is less than or equal to 150 km, a light commercial vehicle {RER} will be used for transporting the steel frame bike from the manufacturing plant to the use location.
- If the transportation distance (regional) is between 150 and 600 km, a 3.5-7.5 metric ton euro5 lorry {RER} will be used.
- If the transportation distance (abroad) is greater than or equal to 600 km, a container ship, freight sea {GLO} will be used.

To model and compare the impacts of the transport scenarios, follow the steps below:

Steps:

- 1) In the inventory column on the left, select Product stages. On the right side double-click Product stages > Life cycle > Others on the right and double-click *Bike life cycle (Steel frame)*.
- 2) Select the *Input/output* tab in the ensuing window. Under Processes, insert a new line and add the alternative modes of transportation (see Table 5.3). Add a new line and select Processes > Transport > Road > Market and add “Transport, freight, light commercial vehicle {RER} | market group for transport, freight, light commercial vehicle | Cut-off, S” with 5292.5 kgkm. This value is entered, since that is the baseline amount calculated to transport the steel frame bike from the manufacturing plant to the use location.
- 3) Similarly, add the remaining modes of transportation. Add a new line, select Processes > Transport > Water > Market and add Transport, freight, sea, container ship {GLO} | market for transport, freight, sea, container ship | Cut-off, S, 5292.5 kgkm. The Transport, freight, lorry 3.5-7.5 metric ton, EURO5 {RER} | market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 | Cut-off, S was already added when you modelled the life cycle for the steel frame bike. After entering these details, the window looks like Figure 5.11.

Input/output Parameters

Name: Bike life cycle (Steel frame) PARAMETERIZED
 Status: None
 Comment: The bike weighs 5.785 kg excluding frame and excluding 3 kg packaging. The steel frame weighs 1.8 kg. All together including packaging: 10.585 kg.

Assembly	Amount	Unit	Distribution: SD2 or 2SD	Min	Max	Comment
Bike Assembly (Steel frame)	1	p	Undefined			

Processes

Processes	Amount	Unit	Distribution	SD2	Min	Max	Comment
Transport, freight, light commercial vehicle (RER) market group for transport, freight, light commercial vehicle Cut-off, S	5292,5	kgkm	Undefined				Distribution: 10.585 kg; 500 km.
Transport, freight, sea, container ship (GLO) market for transport, freight, sea, container ship Cut-off, S	5292,5	kgkm	Undefined				Distribution: 10.585 kg; 500 km.
Transport, freight, lorry 3.5-7.5 metric ton, EURO5 (RER) market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 Cut-off, S	5292,5	kgkm	Undefined				Distribution: 10.585 kg; 500 km.
Transport, passenger car, medium size, diesel, EURO 5 (RER) transport, passenger car, medium size, diesel, EURO 5 Cut-off, S	450	km					Maintenance: thrice per year; 10 km per round trip; 15 years.

Waste/Disposal scenario: Disposal of bike (steel frame)
 Comment:

Additional life cycles
 Number Distribution: SD2 or 2SD Min Max Comment

Figure 5.11 Life cycle bike (steel frame), Input/output, fixed amount for all 3 possible transport models

- 4) Select the *Parameters* tab at the top and create the required input parameters. In this case, we have to create the “distance” and “mass” input parameters, since the values for transportation by truck are calculated by multiplying the mass of transported goods with the transport distance (as we saw earlier in section 4.3).
- 5) Under input parameters, create the parameter “mass” and enter “10.585” as the default value. You can enter ‘kg’ in the comment field.
- 6) Under input parameters, create the parameter “distance”, with a value of “500”. You can enter ‘km’ in the comment field.
- 7) Under calculated parameters, add a line and create the parameter “transport”. Under Expression, enter $mass \cdot distance$ to calculate the transport needs in kgkm. The calculated value (5.29E3) will now be visible on the right.
- 8) In the next line, enter “local” and under Expression, enter $distance \leq 150$ and press Enter. The “=0” value appears automatically to the right. If the statement is true, the parameter will return a value of “1.” In this case, the value “=0” appears since the expression used is not true. The specified “distance” input parameter is 500, and this is not equal to or smaller than 150. In the comment field, you can enter “0 if not true, 1 if true”.
- 9) In the next line, enter “abroad” and under Expression, enter $distance \geq 600$ and press Enter. The “=0” value appears automatically to the right. The “=0” value appears since the expression used is not true. The specified “distance” input parameter is 500, and this is not equal to or larger than 600. In the comment field, you can enter “0 if not true, 1 if true”.
- 10) In the next line, enter “regional” and “ $distance > 150$ and $distance < 600$.” The “=1” value appears automatically to the right. The “=1” value appears because the specified “distance” input parameter is 500, and this is indeed larger than 150 and smaller than 600. In the comment field, you can enter “0 if not true, 1 if true”.

After you have entered all these details, the window looks like Figure 5.12.

Input/output	Parameters																					
Input parameters	<table border="1"> <thead> <tr> <th>Value</th> <th>Distribution</th> <th>SD2 or 2SD</th> <th>Min</th> <th>Max</th> <th>Hide</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>distance</td> <td>500</td> <td>Undefined</td> <td></td> <td></td> <td><input type="checkbox"/></td> <td>km</td> </tr> <tr> <td>mass</td> <td>10,585</td> <td>Undefined</td> <td></td> <td></td> <td><input type="checkbox"/></td> <td>kg</td> </tr> </tbody> </table>	Value	Distribution	SD2 or 2SD	Min	Max	Hide	Comment	distance	500	Undefined			<input type="checkbox"/>	km	mass	10,585	Undefined			<input type="checkbox"/>	kg
Value	Distribution	SD2 or 2SD	Min	Max	Hide	Comment																
distance	500	Undefined			<input type="checkbox"/>	km																
mass	10,585	Undefined			<input type="checkbox"/>	kg																
Add line																						
Calculated parameter	<table border="1"> <thead> <tr> <th>Expression</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>transport</td> <td>mass*distance = 5,29E3</td> </tr> <tr> <td>local</td> <td>distance <= 150 = 0</td> </tr> <tr> <td>abroad</td> <td>distance >= 600 = 0</td> </tr> <tr> <td>regional</td> <td>distance > 150 and distance < 600 = 1</td> </tr> </tbody> </table>	Expression	Comment	transport	mass*distance = 5,29E3	local	distance <= 150 = 0	abroad	distance >= 600 = 0	regional	distance > 150 and distance < 600 = 1											
Expression	Comment																					
transport	mass*distance = 5,29E3																					
local	distance <= 150 = 0																					
abroad	distance >= 600 = 0																					
regional	distance > 150 and distance < 600 = 1																					
Add line																						

No Error / Additional info

Figure 5.12 Life cycle bike (steel frame), parameters: input parameters and calculated parameters

- 11) Then select the *Input/output* tab. Multiply the amount for the corresponding processes you added in the input/output tab by the input parameters you have created in the previous steps. In this case, under the Amount field for "Transport, freight, light commercial vehicle {RER} | market group for transport, freight, light commercial vehicle | Cut-off, S", write "transport*local". The "=0" value automatically appears to its right.
- 12) Do this for the remaining processes. In the amount field for Transport, freight, sea, container ship {GLO} | market for transport, freight, sea, container ship | Cut-off, S, write "transport*abroad". Similarly in the amount field for Transport, freight, lorry 3.5-7.5 metric ton, euro5 {RER} | market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 | Cut-off, S, write "transport*regional". Save the changes you made to the steel life cycle. When you finish entering all these details, click *Save*. You will see a window like Figure 5.13.

Name	Status	Comment
Bike life cycle (Steel frame) PARAMETERIZED	None	The bike weighs 5.785 kg excluding frame and excluding 3 kg packaging. The steel frame weighs 1.8 kg. All together including packaging: 10.585 kg.

Assembly	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Bike Assembly (Steel frame)	1	p	Undefined				

Processes	Amount	Unit	Distribution	SD2	Min	Max	Comment
Transport, freight, light commercial vehicle {RER} market group for transport, freight, light commercial vehicle Cut-off, S	transport*local = 0	kgkm					Distribution: 10.585 kg; 500 km.
Transport, freight, sea, container ship {GLO} market for transport, freight, sea, container ship Cut-off, S	transport*abroad = 0	kgkm					Distribution: 10.585 kg; 500 km.
Transport, freight, lorry 3.5-7.5 metric ton, EURO5 {RER} market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 Cut-off, S	transport*regional = 5,29E3	kgkm					Distribution: 10.585 kg; 500 km.
Transport, passenger car, medium size, diesel, EURO 5 {RER} transport, passenger car, medium size, diesel, EURO 5 Cut-off, S	3*10*15 = 450	km					Maintenance: thrice per year; 10 km per round trip; 15 years.

Add line

Waste/Disposal scenario	Comment
Disposal of bike (steel frame)	

Additional life cycles	Number	Distribution	SD2 or 2SD	Min	Max	Comment
Add line						

Figure 5.13 Life cycle bike (steel frame), Input/output, parameterized

- 13) Next click on the *Analyze button*. Select the *Parameter sets* tab. Add the scenarios you want to model and name them. In this case we are modelling the mode-of-transportation scenarios for Local (100 km), Regional (500 km) and Abroad (1500 km) bike transportation distances (seen above in Table 5.3). Click on the *Add parameter* option, select *Scan Tree*

on the right and select the “distance” parameter, to create scenarios with different transportation distances. Click on *Add* and specify the values per scenario. To do that, under Parameter set on the left, double-click Set 1 and rename it to “Local”. Double-click under the “Local” column on the right and enter 100, since you have to specify a transportation distance of 100 km for the “Local” scenario.

- 14) Now you have to add the parameter sets for the remaining scenarios and specify the distances. Add the “Regional” scenario with 500 km, and the “Abroad” scenario with 1500 km. Once you have created the parameter sets, the calculation setup looks like Figure 5.14.

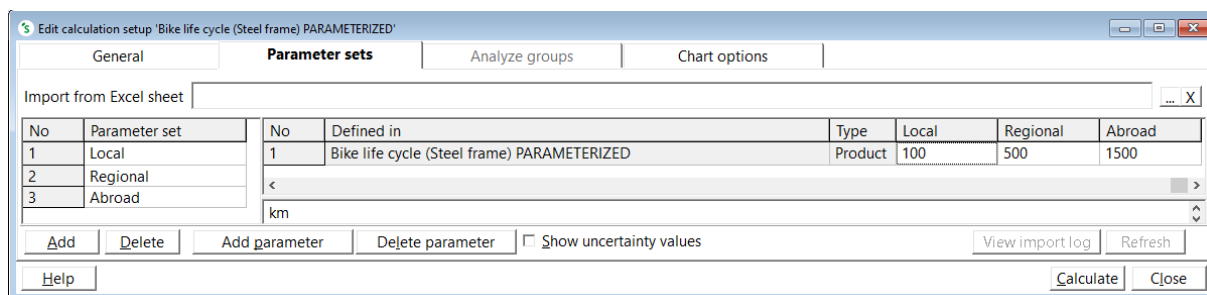


Figure 5.14 Calculation setup, with parameter sets

Click on *Calculate* to compare your scenarios:

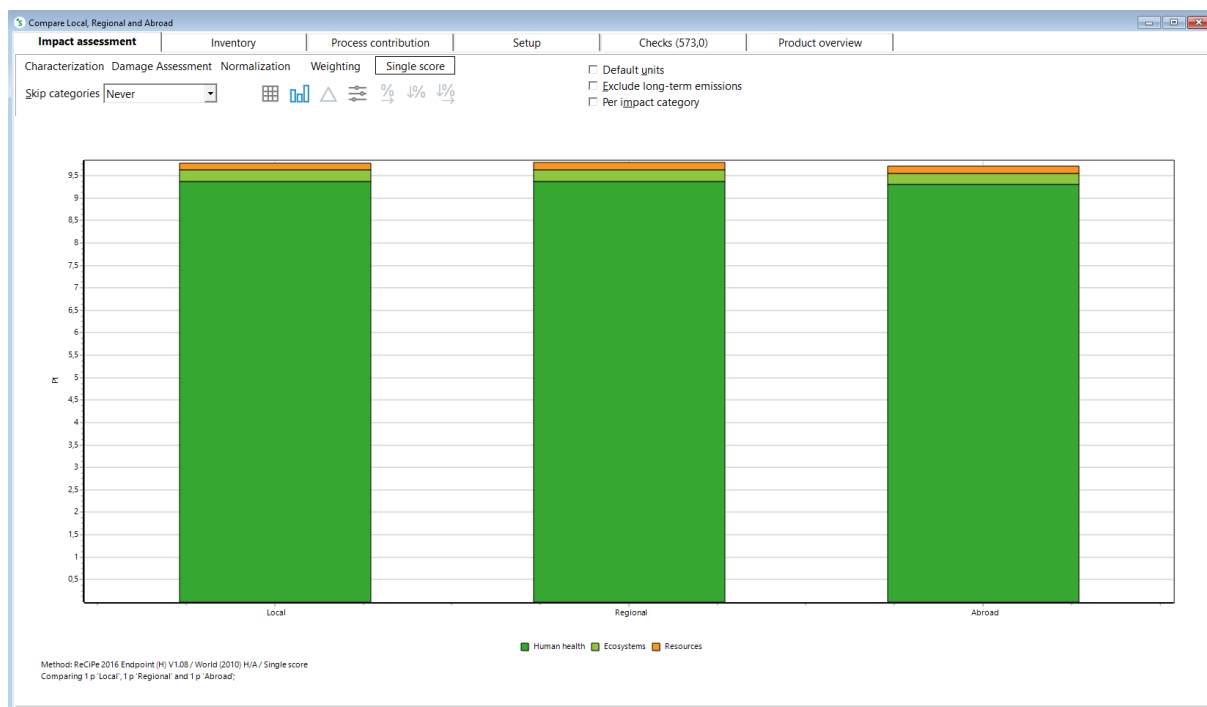


Figure 5.15 Comparison of impacts for different modes of transportation based on distances (single score)

From Figure 5.15, you can see the combined influence of different modes of transportation and distances on the life cycle impact of the steel frame bike. The difference in ReCiPe Pt between the three scenarios is very little in this case. The lower distance in the local scenario compared to the

regional scenario would mean lower impact, but the light commercial vehicle means more impact per km compared to the lorry resulting in about the same impact in the end. The same goes for the lorry compared to the container ship. The impact per km by truck is higher for the regional transportation (500 km) of the steel frame bike, while transportation by a transoceanic ship to abroad location (over a three times longer distance of 1500 km) has in the end a slightly lower impact in comparison.

5.5 Other features in Parameters

SimaPro offers additional features for parameters. To use them, select the parameters tab. In the *Calculated parameter section*, right-click under Expression. You will see the following options:

- Edit Expression
- Move Parameter
- Convert To Constants
- Insert External Link (only available in SimaPro Developer)
- Importing scenarios from Excel (only available in SimaPro Developer)

Edit expression: This option allows you to correct the expression you entered and shows the various functions, operators and parameters you defined in SimaPro.

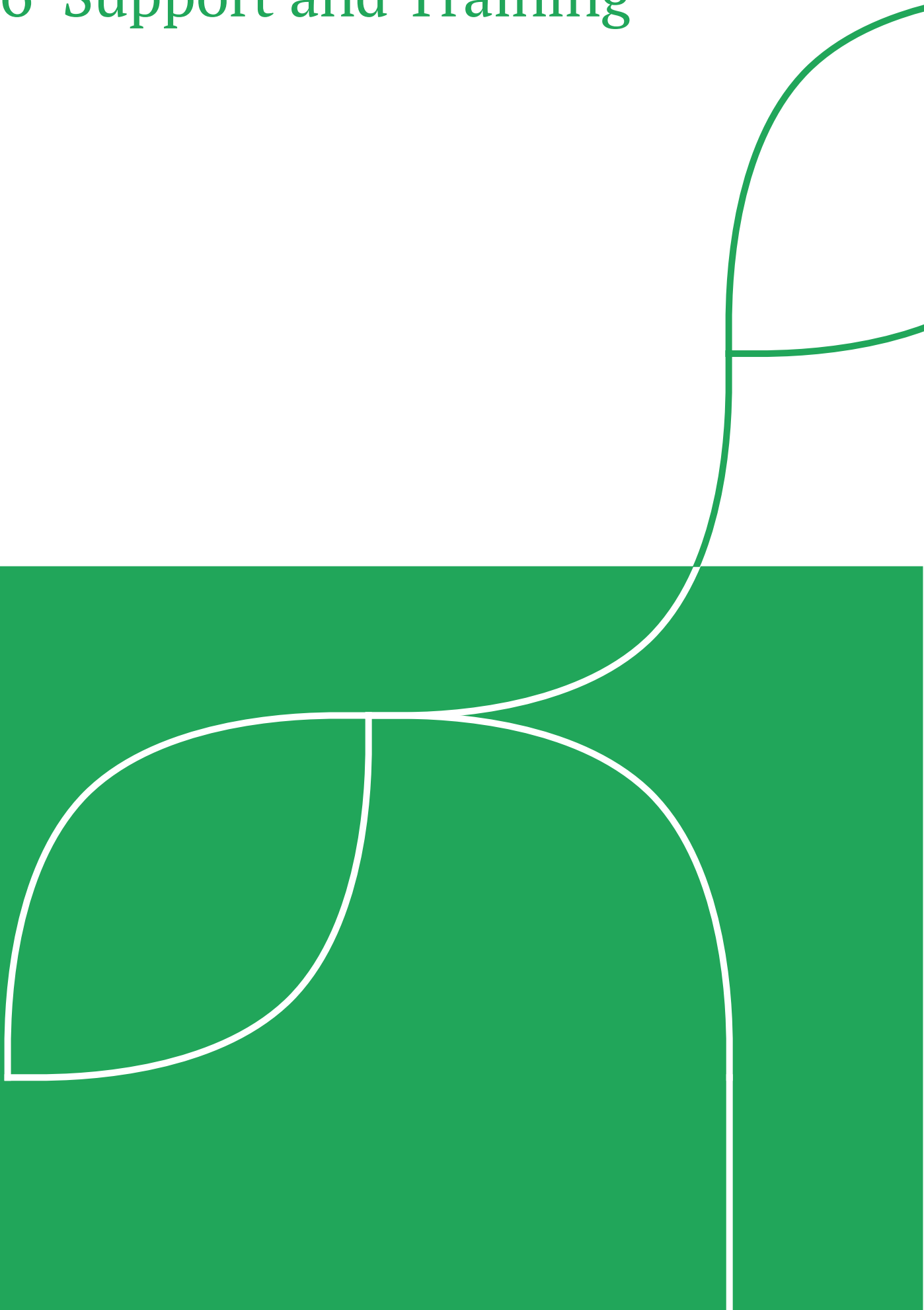
Move parameter: This option allows you to move the parameters defined in your process to the project or the database level (under the LCA Explorer menu > Inventory > Parameters).

Convert to constants: This option removes the formula you have entered to calculate your parameter and shows the result of your formula.

Insert external link: This option allows you to retrieve parameters from an Excel file or the database. Click on "Browse" to look for a file and select the cells you would like to use in your model. The file will be inserted as a link. When you change a cell value in the Excel file, it will be automatically updated in SimaPro. If you move the Excel file from its original location, SimaPro will remember the last value. If you change the location of your Excel file, you can replace the existing link by selecting Tools > External link Manager and find and replace the existing link with the new link. You can also check this [article](#) for more explanation about this feature. Please note that this feature is only available in the SimaPro Developer.

Importing scenarios from Excel: In addition to the above features, you can also import the different scenarios you want to use for your project from Excel. You can check this [article](#) to learn more about this option. Please note that this feature is only available if you have a SimaPro Developer license.

6 Support and Training



6 Support and training

We hope you enjoyed building your first model with this tutorial!

Feel free to [contact us](#) or your [local partner](#) if you have questions about this tutorial or any technical questions about using SimaPro. We suggest you also explore the [SimaPro Help Center](#) for more guides, FAQs and helpful tips to help you get the most out of SimaPro.

If you are interested in developing more advanced skills, PRé and its global partners provide dedicated SimaPro trainings. Please check [this](#) page for more information.