Practical introduction to SimaPro

Table of contents

1. General

This document is a brief introduction to SimaPro for the exercice of the EPFL Environmental system analysis and assessment course. For more details you can consult the SimaPro tutorial document (http://www.pre-sustainability.com/simapro-tutorial).

SimaPro allows you to model a project in several ways that will give the same results. Here we propose one of the ways.

Note :

- This document describes linearly how to do an LCA with SimaPro. However, performing an LCA is an iterative process and the credibility of the results should be checked as you go along. This allows errors to be spotted earlier and the program to be better understood;
- Build up the reference material flows in kg, especially for PV modules so that the end of life is properly taken into account (chapter to come)

2. *Start-up*

2.1. Working on VDI (Virtual desktop infrastructure, in the classroom or on your computer)

1. **Open a VDI Session**: https://vdi.epfl.ch/ choose either the connection with the horizon client or the browser. Use your EPFL connexion information and an authenticator tool (for ex. Google authenticator)

2. **Open ENAC-SSIE-WIN**

3. **Preparing the database**

The database is quite big, too big for your z: account, therefore we will save your database on a specific server (s:).
To do that you have to connect this space is via a small script that I added in Application> APP-SSIE-HERUS> SimaPro>connexion-S-simaproj.

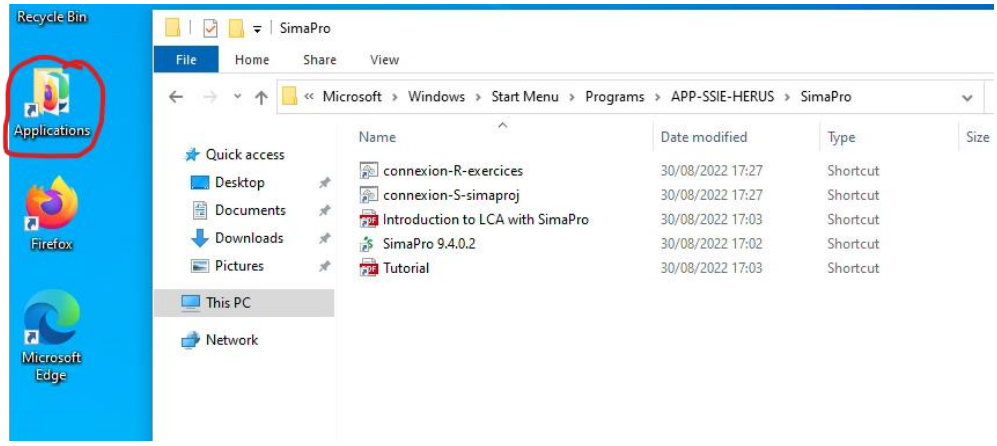


Figure 1 : script localization

And to download this database, you have to go on the R: space with this script: connexion-R-exercices.

The S: space is open for everyone. That mean that you can share the database in your project team (but only one access at the same time)

CAUTION: this space (S:) is not protected and there is no backup, therefore you have to make your own back up.

Create a folder in your name on the disk S:\SIMAPROvotrenom

Copy the SimaPro database from the location on the server: (R: \IIE-LCA\DB_professional) and paste it on your S: \SIMAPROvotrenom

Unzip your new database on the S: server.

4. **Open SimaPro**

Open the software in start menu > APP-SSIE-HERUS.

5. **Open the database: go to File \ Open SimaPro Database**

   - Click on location and select the previously created directory (S:\SIMAPROvotrenom)
   - Select Professional in the Database name window, click OK.

6. **Create a new project in your name: (File > open project) then click on New and enter the name of your project.**

Choose as library "Ecoinvent 3 - allocation, cut-off by classification - unit" and "Methods".

Only one project is created, regardless of the number of scenarios to be compared. Your project is integrated into the database used by SimaPro. If you make a backup of your database, you automatically make a backup of your project. One of the advantages of SimaPro is that it automatically saves every time a model is modified, so even if the computer crashes, your project is saved.

If you use your database directly from a USB stick, the calculation time may be important and transcription error can occur. It is advisable to load the database onto the T: drive at the beginning of the exercise and to retrieve it at the end of the exercise, this will save you time when saving and calculating.

Go to chapter 3

2.2. Working on a personal computer (Microsoft only)

Download SimaPro version 9.6.0 to be consistent with the version used on EPFL server and tutorial material. (https://pre-support.sharefile.com/share/view/sf7a1b1e6309b4741920d33b2af1f98fa).

1. **Install and activate the software according to the user code (Faculty Version)**

   License SimaPro

Year : 2025

ATTENTION: this license can only be used for academic projects, and only by ENAC teachers and students.
The school will acquire other licenses for academic projects from other faculties.

Registration name: ENAC 01
Registration code: 3JoCAMuPmScbmwAIAAAA#
AMJDJ/pG0hweIkaVReSRwfe6K1KUpiPEAMvDf7SliLTFyqwXTv
oDXVhu6pckYyW/HfZpXdlyWlhzVvfAyIjZHed5LNO40tiiwHh/
BCU1rzwchaSAy96exJ+e4Cyptn11t8w2xMkW1fgNfX+D2dMCO/
f9Tt6D7xB/X4+8xXiICd75

2. **Open the database: go to File \ Open SimaPro Database**

   - Click on Browse and select the database which should be here: C:\Documents and Settings\All Users\Documents\SimaPro\Database

   - Select Professional in the Database name window, click OK**.**

3. **Create a new project in your name: (File > open project) then click on New and enter the name of your project.**

Choose as library "Ecoinvent 3 - allocation, cut-off by classification - unit" and "Methods".

Only one project is created, regardless of the number of scenarios to be compared. Your project is integrated into the database used by SimaPro. If you make a backup of your database, you automatically make a backup of your project. One of the advantages of SimaPro is that it automatically saves every time a model is modified, so even if the computer crashes, your project is saved.

3. *The SimaPro interface*

Once you have chosen your libraries, select Process (in the inventory part, frame 2). You arrive at the place below (Figure 2). The main part of SimaPro (frame 1) is the explorer, on the left we have the windows that allow us to move through the different steps of the LCA (2) and within these steps (3). The right side (4) allows us to perform different actions such as creating processes, assemblies, modifying them, copying them, etc.

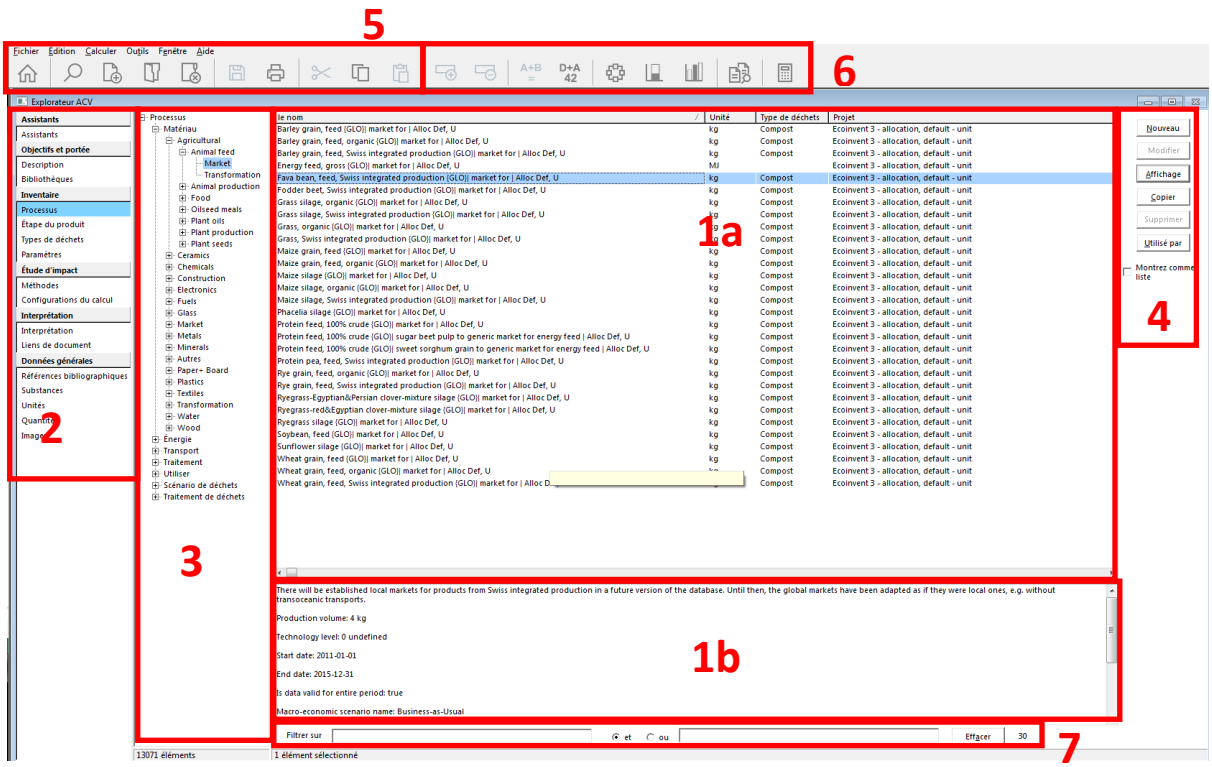


Figure 2 - project opening

At the top, we have the taskbar with the usual menus (5) as well as SimaPro specific buttons (6) and at the bottom (7), a bar that allows us to search in the processes.

In the left window (frame 2, Figure 2), we have in order the different steps that make up the LCA:

1. Goal and Scope: You can define the authors, the purpose of the study, etc. It may be useful to fill in the ***Author*** and ***How*** fields. In "Libraries" you can select the data libraries you want to work with (Figure 3).

2. **Inventory** : This is the part where we work the most. This is where the reference flows are entered and where the house is modelled in this way.

3. **Impact Assessment**: Part where you define the impact method (Impact 2002+, Ecological Scarcity 2013, ILCD 2011 Midpoint+,...) and where you find the calculation configurations you have saved. By going to methods, you can select a method (e.g. ILCD 2011 Midpoint+) as the default method.

4. **Interpretation**: Comments on the interpretation phase of the study can be entered and computerized support for the data and methods can be found.

It is easier to write the introduction with goals, etc., and the interpretation of the results directly in the paper you are going to hand in.

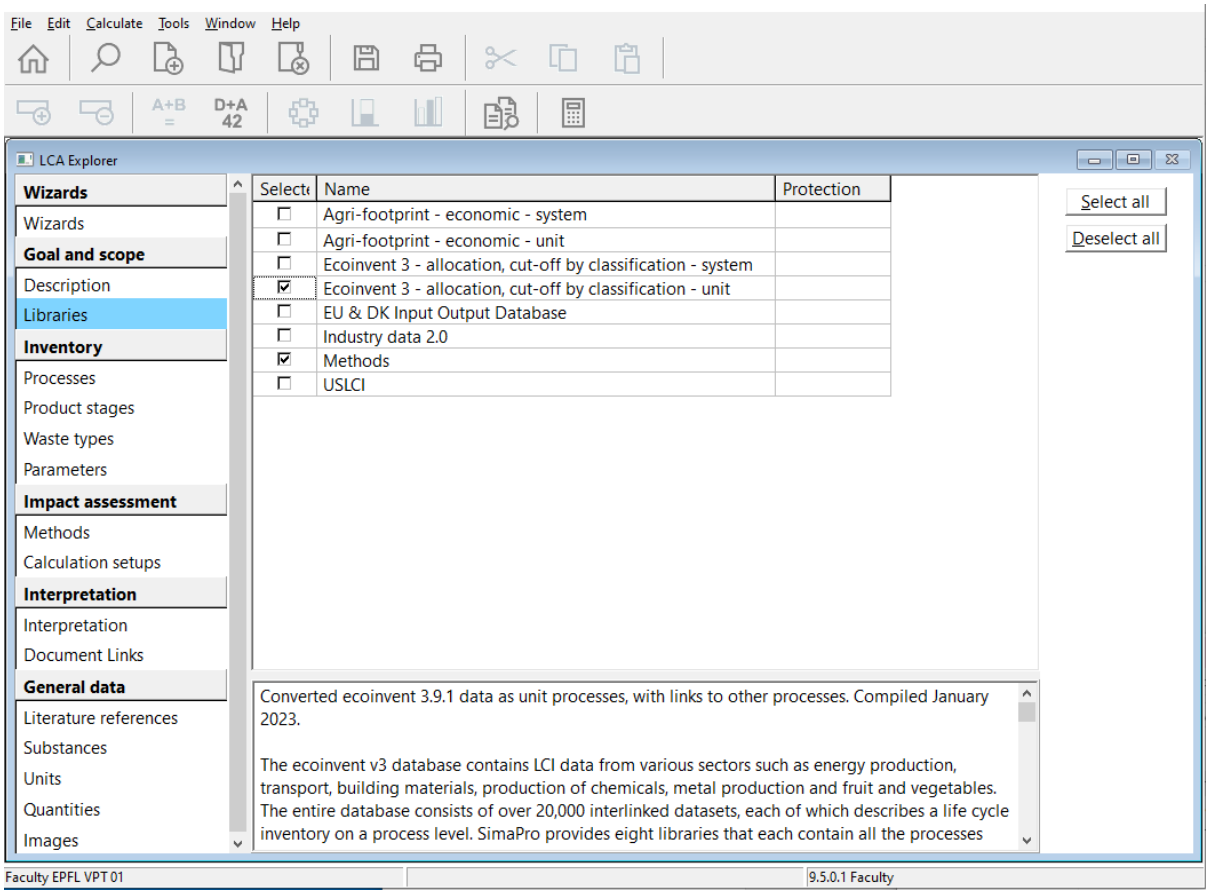


Figure 3 - Libraries

SimaPro toolbar

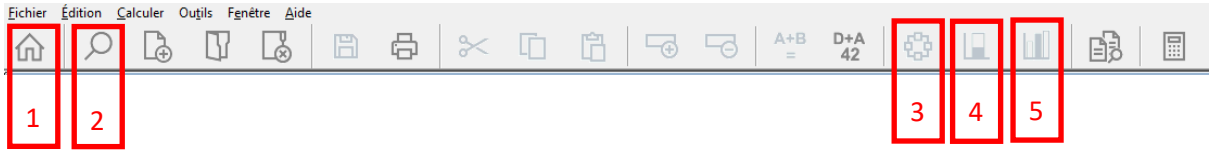


Figure 4 - toolbar

In the toolbar, the most important buttons of SimaPro are "bring me home" (1), the search tool (2) which is very efficient to find a product or a substance as well as the created elements that you might have lost and the buttons that allow you to launch the calculations (3-5):

- Compare (5): allows you to compare the selected processes (multiple selection = ctrl + click)
- Analysis (4): allows you to analyse the selected process
- Network (3): displays the process tree of the selected assembly

More details are given in chapter 5 " *Impact assessment: results"* of this document.

4. Ecoinvent

As we can see in frame 1a (Figure 2), SimaPro is provided with several data libraries (Ecoinvent, ELCD, IDEMAT,...). The different libraries are not necessarily consistent with each other on different parameters: regionalization, temporal limits, assumptions, system limits... . For this project we will use the Ecoinvent database that you have seen in class.

The database is structured in different ways. First, there is the allocation (point of substitution, cut-off or consequential), there is the modeling of processes (unit or system) and finally then there is the modeling of activities (transformation or market).

4.1. Unit and system processes

Unit process:

Modelling that links processes together, so you can follow the steps that lead to the final process (for example: a plank of wood > the sawmill > the transport > the log > the tree). The advantage is a very good traceability during the analysis, the disadvantages are a more important calculation time and this modelling does not allow to keep the confidentiality of the production processes.

System processes

Calculation of emission and resource consumption values without links between processes in the SimaPro model. The emission and resource consumption values are the same as for the unit processes, but only the values are kept, without being able to go back in the production chain. The advantages are lower computing time and guaranteed confidentiality of production processes.

4.2. Activity modelling

Processing (transformation) activity:

- Modeling of human activity, with modification of inputs (not necessarily all) to arrive at the final product
- No transport
- Regionalisation

Market activity

- No processing of products
- Transport
- Globalization according to the world distribution of production

- Globalization according to the distribution of production processes

Processing activity

Market activity

5. *Modelling of the BIPV and the conventional roof*

The modeling is done in the "inventory" step, which is composed of the following parts:

Figure 5 - inventory menu

1. Processes is the place to explore the databases selected in "libraries". The processes are classified by type (materials, energy, transport ...). A process consists of the quantitative set of inputs and outputs related to the realization of a unit of service or element. For example 1MJ of Swiss electricity, 1m² of solar module or the drying of 1kg of corn starch. A process can be composed of other processes, and does not necessarily refer to a functional unit.

2. **Product Stages : This is the place where we enter the reference flows**

3. Waste type: allows you to see which waste category the materials in the database belong to. The waste category is important for end-of-life modelling.

6.1. Process

Example of a process:

When you click on a process (Figure 6), e.g. primary aluminium ingot, the window opens in principle with the inputs/outputs of the process (2), i.e. everything that goes in and everything that comes out. This information is important for choosing a process during modelling and, at the end, for interpreting the results. The documentation tab (1) allows us to access the process metadata: how the data was collected, by whom, where, and details of the product (composition, density, etc.).
In input/output, we have in the first box (3) the name of the product followed by the box in which the avoided products will be listed (4). Part 5 lists the inputs, whether raw materials (resources), processed materials or energy. Then come the direct emissions (6), into the air, water, soil.... Finally, we have the different waste treatments for this process (7).

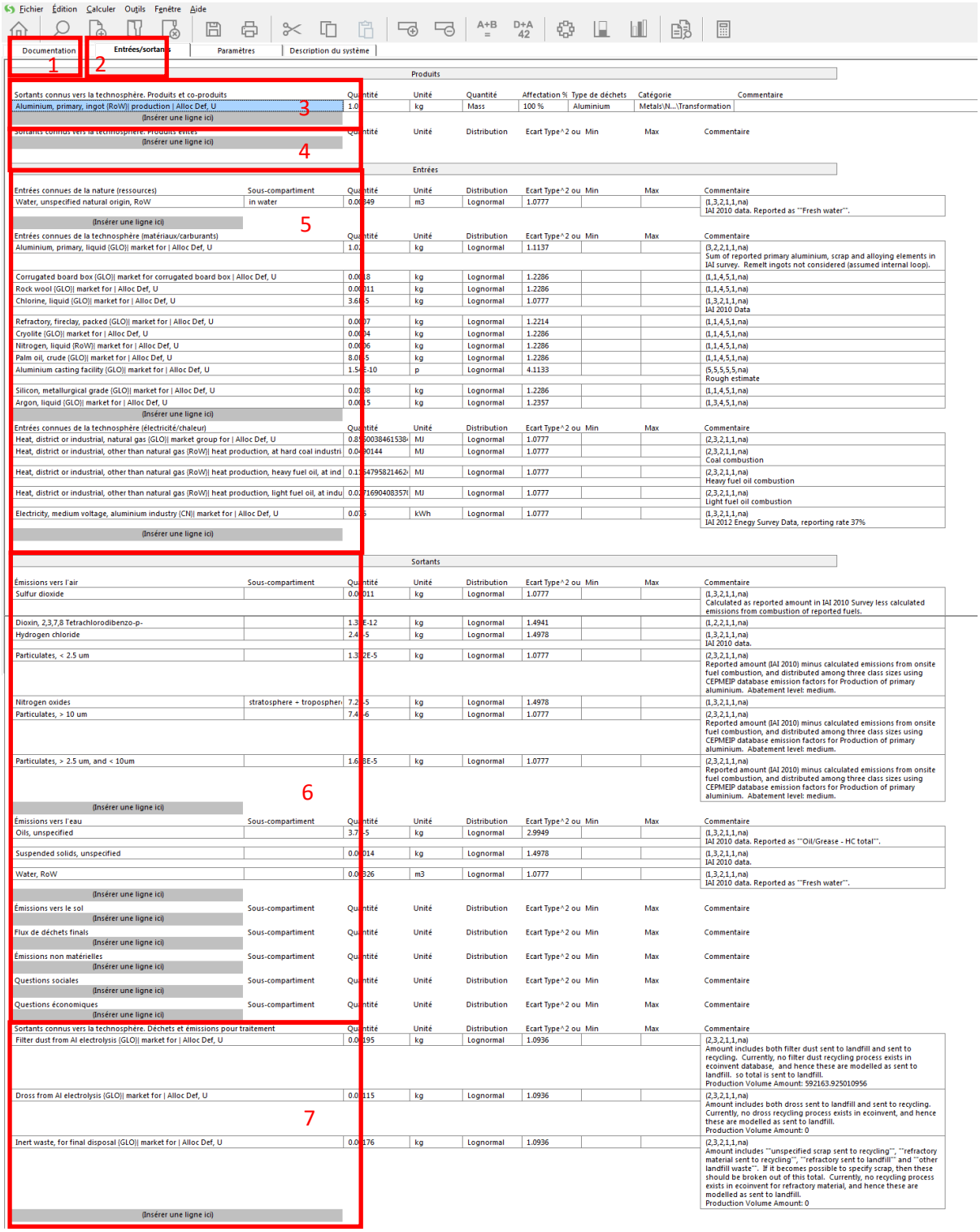


Figure 6 - process example

Did you know? You cannot directly modify a process in SimaPro, to modify it, you must first make a copy of it:

1. Select the process
2. Click on "Copy".
3. Change the name of the process to find it quickly

4. Modify the process as needed
5. Save and close
6. Move if necessary

This allows us, for example, to transform a material counted by volume into a material counted by mass. This is very important, as SimaPro only manages the end of life in kg. It uses the numerical value that it considers in mass to calculate the end of life. If you put 3.5m^3 of concrete, it will treat as 3.5 kg of concrete, instead of about 7700kg! To avoid this problem, the concrete process must be modified (Figure 7). Go to the exercise data to find the density of the concrete and replace 1m^3 with the weight of the concrete. In order to change the unit, you must first change the quantity (1) to "mass".

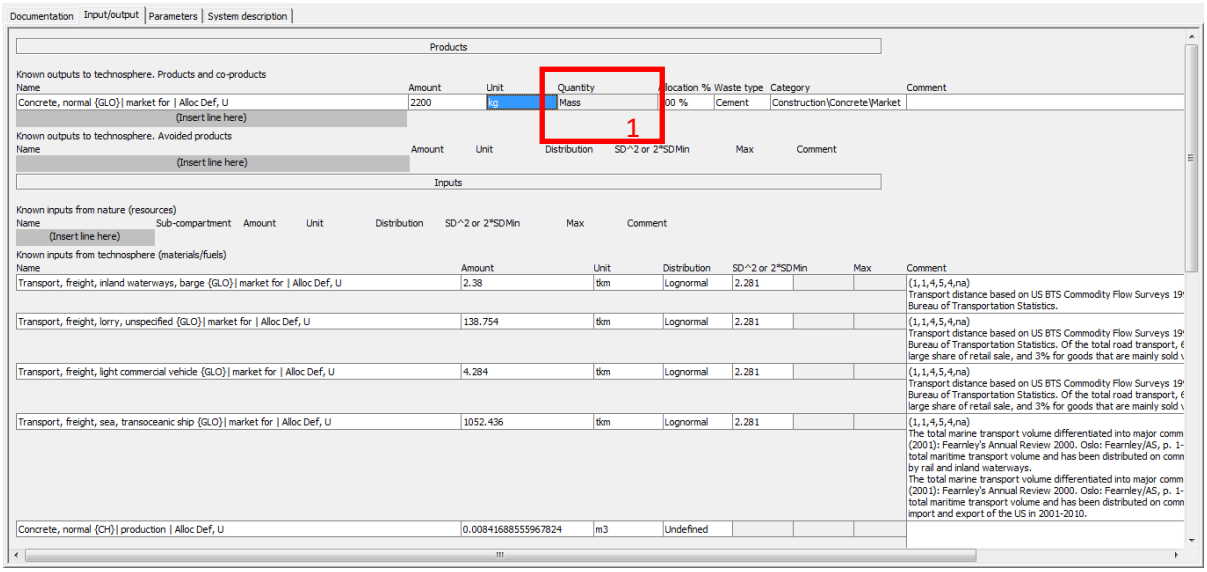


Figure 7 - Illustration of the process that takes data in kg from an existing process in volume

The most used part is "product stages". It models the different scenarios:

- The production phase is modelled in "assembly
- The life cycle part groups the three phases of the life cycle. We'll model it after we do the end of life.
- The end of life phase can be modelled in "disposal scenario", for simplicity, we will take directly the waste scenario that we have modelled in "waste scenario".

The other product stages will not be used.

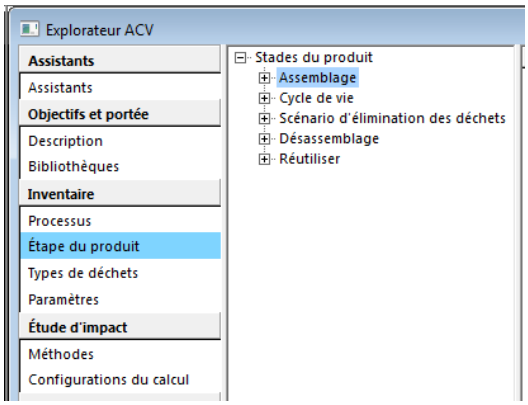


Figure 8 - product stages

6.2. Production phase: assembly

An assembly represents a studied system, a scenario; it always refers to ONE functional unit and is accounted for as a "part". To model the production phase, assemblies and sub-assemblies are created in the product stage assembly. For different installations, we will have a main assembly referring to sub-assemblies, Figure 9:

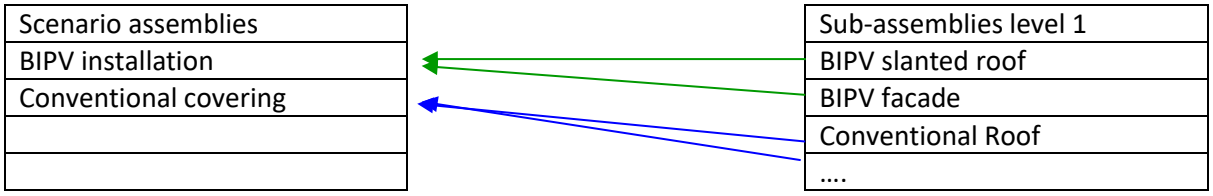


Figure 9 - Example of modelling in assemblies and sub-assemblies

It is practical to structure the assemblies in this way, as 2 different scenarios can have the same piece (assembly).

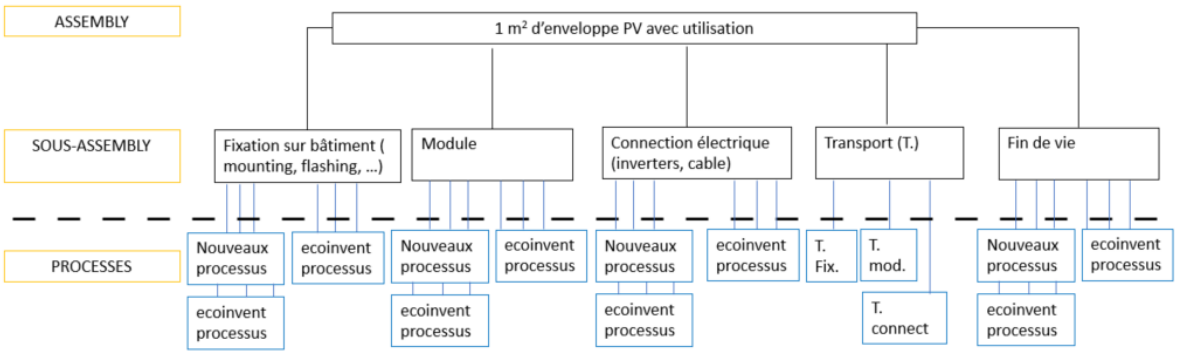


Figure 10 - Assemblies strucutre for the BIPV

6.3. End of life

There are several ways to deal with end of life in SimaPro, one quite simple and convenient way is to create the end of life as an assembly. So we create an assembly that is called end of life and that is composed of waste treatment processes like material recycling, waste incineration and/or landfill.

For this project, we will at least recycle the aluminium and the photovoltaic modules. The inverter will be considered as landfill in a sanitary landfill.

For aluminium recycling you can create a fairly simple process consisting of aluminium scrap and heat and produce an aluminium wrought alloy.

For PV recycling you can also create a fairly simple process consisting of waste glass sorting and sanitary landfill. The output product will be solar glass with a 60% grade loss. Note that sorting glass also has a loss, so this must be taken into account in the mass balance.

For the conventional scenario, another assembly is made for the end of life.

6. Impact analysis: Results

Before performing the analysis, you can select the default method, so that you don't have to reselect it every time. To do this, go to the Methods step (card 2, Figure 2), select the desired method (here, IMPACT World+ Midpoint, in the Global methods) and click on "set as default" on the right.

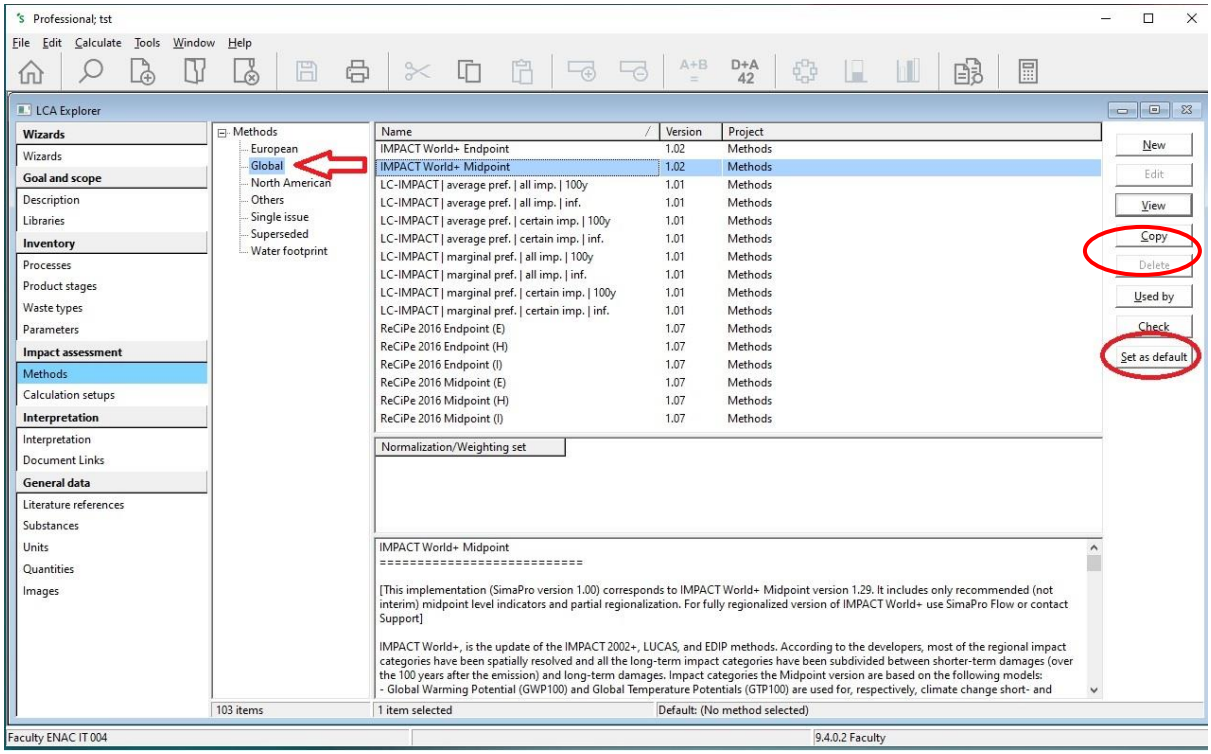


Figure 11: selection of the default method

To do an analysis, we can either:

- Compare different life cycles or assemblies. To do this, select them while holding down the ctrl key and click on the "Calculate \ compare" menu (or on the 4 button, Figure 4)

- Analyze a life cycle or an assembly. This makes it possible to have the impacts by details of the life cycle, respectively of the assembly. **In particular, the details per phase of the life cycle**. Select and click on the menu " Calculate \ analysis " (or on the button 3 Figure 4)

In both cases, we end up with a similar window where we have to select the impact method, Figure 12:

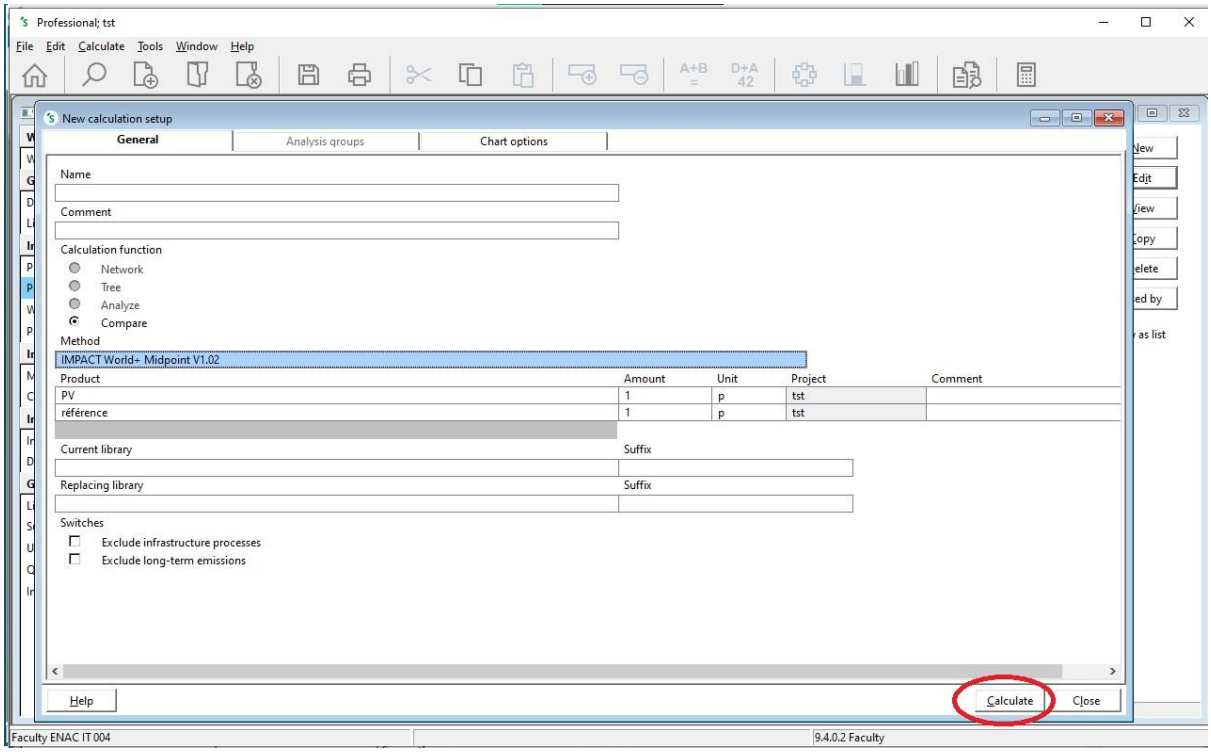


Figure 12 - example of an impact assessment comparing the life cycles of the three scenarios. You can change the impact method by clicking on the "method" field

After clicking on "calculate" (bottom right), the software compiles the data and you get a window with different options, Figure 13.

If you have been searching for multiple assemblies or processes, you can save the calculation configuration. This saves you having to go looking for them when you need to recalculate. The calculations are saved under "impact assessment\calculation setups" (frame2, Figure 2) in the left part of your software.

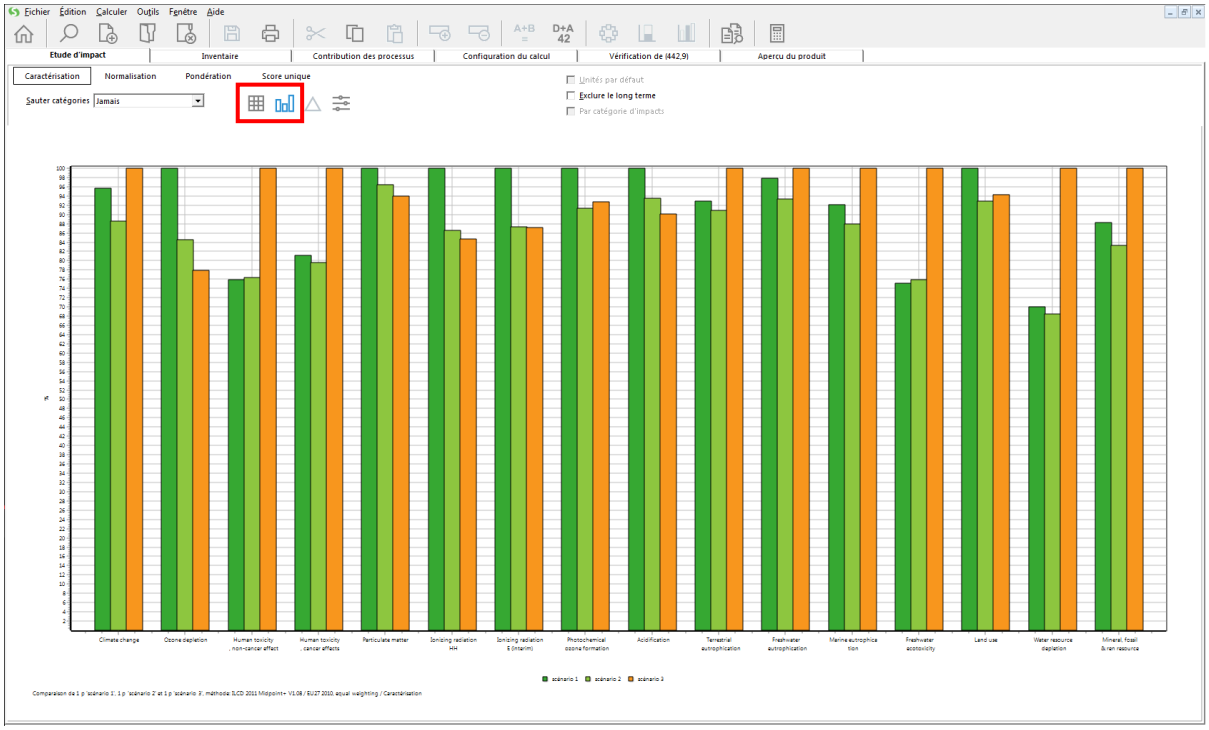
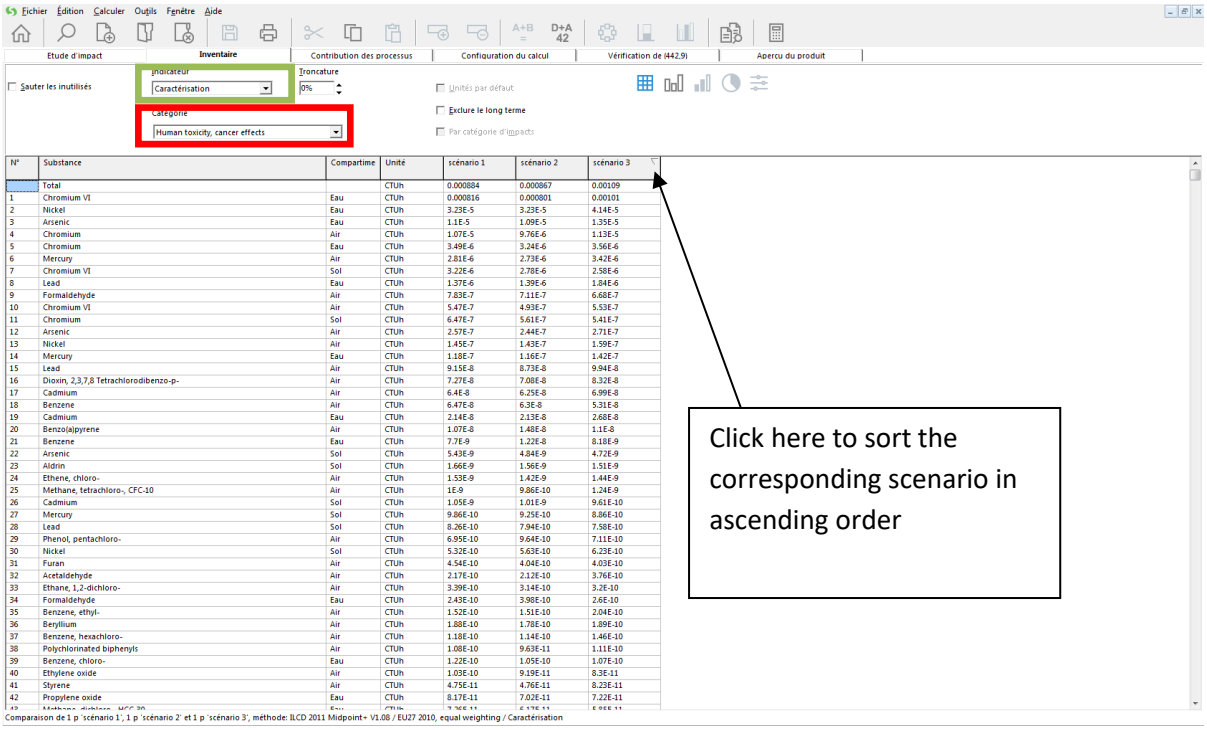


Figure 13 - Example of results obtained with "compare" by selecting 3 scenarios.

The options available in the "Impact assessment" tab (Characterisation, Normalization, Weighting) depend on the selected impact method. For IMPACT World+ Midpoint, only characterization is available. That corresponds to the midpoint results.

The results can be obtained in the form of graphs or tables (red frame, Figure 13). It is possible to export the results in the current form via the "file export" menu or to copy the table and paste it into Excel.

The "inventory" and "process contribution" tabs allow you to obtain the substances and processes that contribute the most to the gross inventory or the impact analysis. Simply change the "indicator" option and click on the column titles to perform an ascending/descending order. An example is given in Figure 14.



N°	Substance	Compartime	Unité	scénario 1	scénario 2	scénario 3
	Total		CTUh	0.000884	0.000867	0.00109
1	Chromium VI	Eau	CTUh	0.000816	0.000801	0.00101
2	Nickel	Eau	CTUh	3.23E-5	3.23E-5	4.14E-5
3	Arsenic	Eau	CTUh	1.1E-5	1.09E-5	1.35E-5
4	Chromium	Air	CTUh	1.07E-5	9.76E-6	1.13E-5
5	Chromium	Eau	CTUh	3.49E-6	3.24E-6	3.56E-6
6	Mercury	Air	CTUh	2.81E-6	2.73E-6	3.42E-6
7	Chromium VI	Sol	CTUh	3.22E-6	2.78E-6	2.58E-6
8	Lead	Eau	CTUh	1.37E-6	1.39E-6	1.84E-6
9	Formaldehyde	Air	CTUh	7.83E-7	7.11E-7	6.68E-7
10	Chromium VI	Air	CTUh	5.47E-7	4.93E-7	5.53E-7
11	Chromium	Sol	CTUh	6.47E-7	5.61E-7	5.41E-7
12	Arsenic	Air	CTUh	2.57E-7	2.44E-7	2.71E-7
13	Nickel	Air	CTUh	1.45E-7	1.43E-7	1.59E-7
14	Mercury	Eau	CTUh	1.18E-7	1.16E-7	1.42E-7
15	Lead	Air	CTUh	9.15E-8	8.73E-8	9.94E-8
16	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	CTUh	7.27E-8	7.08E-8	8.32E-8
17	Cadmium	Air	CTUh	6.4E-8	6.25E-8	6.99E-8
18	Benzene	Air	CTUh	6.47E-8	6.3E-8	5.31E-8
19	Cadmium	Eau	CTUh	2.14E-8	2.13E-8	2.68E-8
20	Benzo(a)pyrene	Air	CTUh	1.07E-8	1.48E-8	1.1E-8
21	Benzene	Eau	CTUh	7.7E-9	1.22E-8	8.18E-9
22	Arsenic	Sol	CTUh	5.43E-9	4.84E-9	4.72E-9
23	Aldrin	Sol	CTUh	1.66E-9	1.56E-9	1.51E-9
24	Ethene, chloro-	Air	CTUh	1.53E-9	1.42E-9	1.44E-9
25	Methane, tetrachloro-, CFC-10	Air	CTUh	1E-9	9.86E-10	1.24E-9
26	Cadmium	Sol	CTUh	1.05E-9	1.01E-9	9.61E-10
27	Mercury	Sol	CTUh	9.86E-10	9.25E-10	8.86E-10
28	Lead	Sol	CTUh	8.26E-10	7.94E-10	7.58E-10
29	Phenol, pentachloro-	Air	CTUh	6.95E-10	9.64E-10	7.11E-10
30	Nickel	Sol	CTUh	5.32E-10	5.63E-10	6.23E-10
31	Furan	Air	CTUh	4.54E-10	4.04E-10	4.03E-10
32	Acetaldehyde	Air	CTUh	2.17E-10	2.12E-10	3.76E-10
33	Ethane, 1,2-dichloro-	Air	CTUh	3.39E-10	3.14E-10	3.2E-10
34	Formaldehyde	Eau	CTUh	2.43E-10	3.98E-10	2.6E-10
35	Benzene, ethyl-	Air	CTUh	1.52E-10	1.51E-10	2.04E-10
36	Beryllium	Air	CTUh	1.88E-10	1.78E-10	1.89E-10
37	Benzene, hexachloro-	Air	CTUh	1.18E-10	1.14E-10	1.46E-10
38	Polychlorinated biphenyls	Air	CTUh	1.08E-10	9.63E-11	1.11E-10
39	Benzene, chloro-	Eau	CTUh	1.22E-10	1.05E-10	1.07E-10
40	Ethylene oxide	Air	CTUh	1.03E-10	9.19E-11	8.3E-11
41	Styrene	Air	CTUh	4.75E-11	4.76E-11	8.23E-11
42	Propylene oxide	Eau	CTUh	8.17E-11	7.02E-11	7.22E-11

Comparaison de 1 p 'scénario 1', 1 p 'scénario 2' et 1 p 'scénario 3', méthode: ILCD 2011 Midpoint+ V1.08 / EU27 2010, equal weighting / Caractérisation

Figure 14 - Results of the comparison of the three scenarios at the characterization inventory level (red box) for impacts on human health (green box)

When doing an analysis (but not a comparison) the network tab appears. It allows you to view impacts by midpoint category, by process or by substance. In Network, you can also limit the number of visible elements. For example, you can display only the elements that contribute to more than 10.2 % of the impacts (Figure 15) (cut-off). Cut-off are also possible for the inventory or process contribution. In Figure 16, for example, we can see all processes contributing to 3% or more of the particulate emissions (in kg PM2.5 eq.).)

The inventory, contribution process and network tables are extremely useful in interpreting the results.

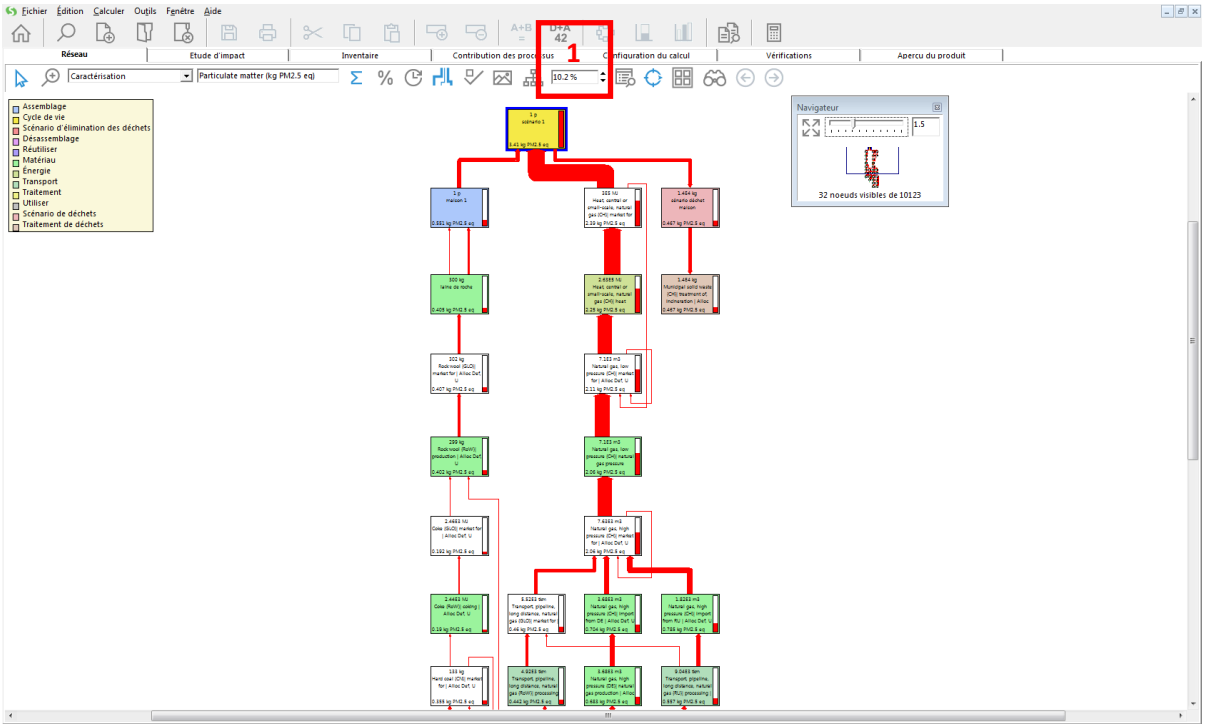
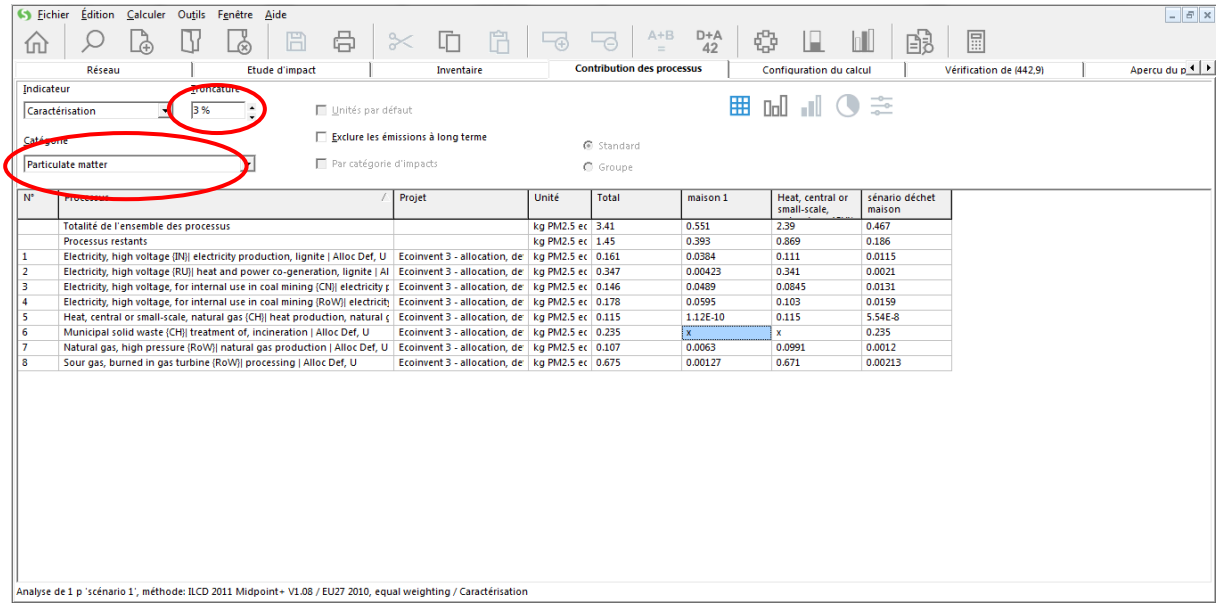


Figure 15 - network



N°	Processus	Projet	Unité	Total	maison 1	Heat, central or small-scale,	sénario déchet maison
	Totalité de l'ensemble des processus		kg PM2.5 ec	3.41	0.551	2.39	0.467
	Processus restants		kg PM2.5 ec	1.45	0.393	0.869	0.186
1	Electricity, high voltage {IN}| electricity production, lignite | Alloc Def, U	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.161	0.0384	0.111	0.0115
2	Electricity, high voltage {RU}| heat and power co-generation, lignite | Al	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.347	0.00423	0.341	0.0021
3	Electricity, high voltage, for internal use in coal mining {CN}| electricity p	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.146	0.0489	0.0845	0.0131
4	Electricity, high voltage, for internal use in coal mining {RoW}| electricit	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.178	0.0595	0.103	0.0159
5	Heat, central or small-scale, natural gas {CH}| heat production, natural g	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.115	1.12E-10	0.115	5.54E-8
6	Municipal solid waste {CH}| treatment of, incineration | Alloc Def, U	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.235	x	x	0.235
7	Natural gas, high pressure {RoW}| natural gas production | Alloc Def, U	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.107	0.0063	0.0991	0.0012
8	Sour gas, burned in gas turbine {RoW}| processing | Alloc Def, U	Ecoinvent 3 - allocation, de	kg PM2.5 ec	0.675	0.00127	0.671	0.00213

Figure 16 - contribution of particulate processes (cut-off 3%)

7. Payback time and sensitivity analysis

8.1. Carbon payback time

Calculate the annual production of the complete system, including losses and calculate the total CO2eq impact of the PV modules.
Calculate the CO2eq impact of 1kWh of the energy mix of the country where the installation is built, derive the annual amount of CO2eq avoided by the electricity production of the PV panels.

Define from which time the avoided impact equals the total impact of the system.

8.2. Energy payback time

For the energy payback time, do the same as for the carbon payback time, but to get the amount of energy we have to use a network analysis. It allows us to find the amount of energy used to create the photovoltaic modules.

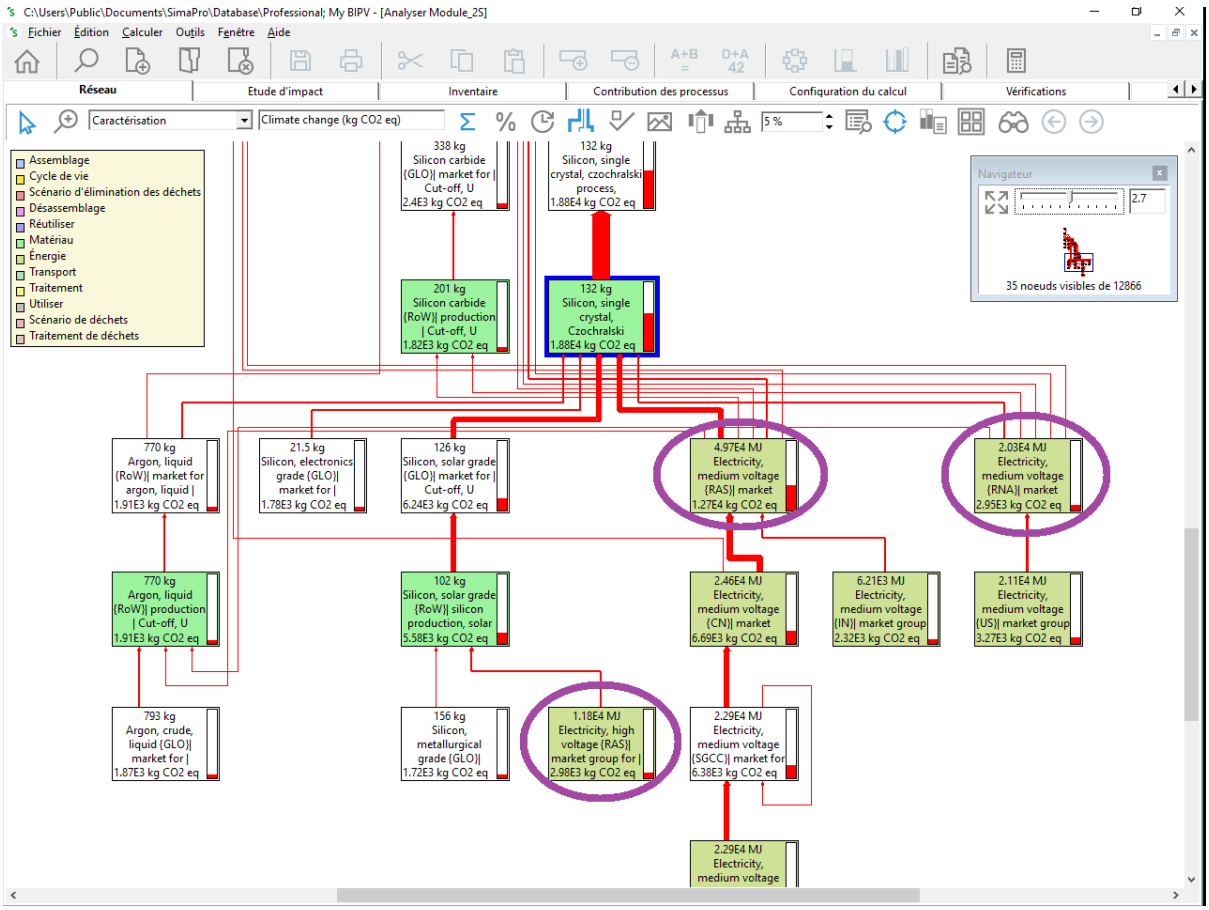


Figure 17 : example of quantity needed for photovoltaic modules

8.3. Sensitivity analysis on PV cleaning.

To perform sensitivity analyses on PV cleaning, create PV cleaning assemblies based on the number of times the panels will be cleaned over the lifetime. Cleaning is composed of water and transport of the persons who will clean the PV.

Make a comparison between the impact of cleaning and the amount of energy induced by yield loss.