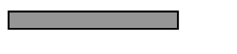
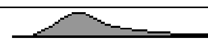
The Monte Carlo method

The Monte Carlo method is named after the famous Monte Carlo casino (see above) in Monaco. The statistical principle is simple. A calculation is repeated many times. Each time a random value is chosen for each flow, for example an emission or raw material input. The resulting range of all calculation results form a distribution from which uncertainty information can be derived with basic statistical methods.

The values chosen in the Monte Carlo analysis are within a specified distribution. In SimaPro, you can specify the uncertainty on the inputs and outputs of a process or product stage, and even on the parameters if you use parameterized modeling, using one of the 4 types of distributions:

Distribution	**Presentation**
Range	
Triangular	
Normal distribution	
Log normal distribution	

Currently, only the ecoinvent database supplies uncertainty data with the inventory data.

In SimaPro 7.1 versions that support parameterized modeling, you can add uncertainty to the parameters used to build your model. This allows you to consistently calculate uncertainty in your model. Additionally, you can set different uncertainty ranges or distributions in the scenario analysis for ultimate flexibility in calculating your uncertainty results.

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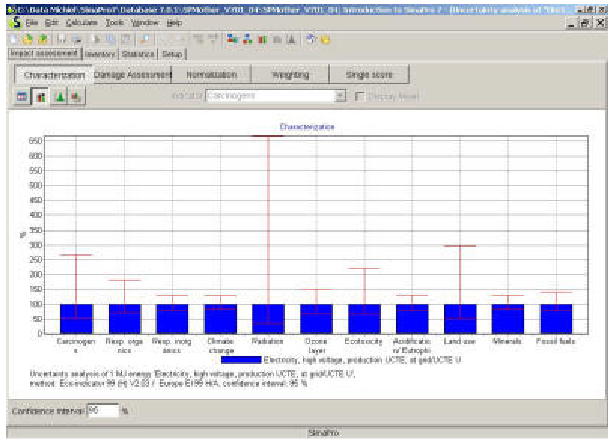
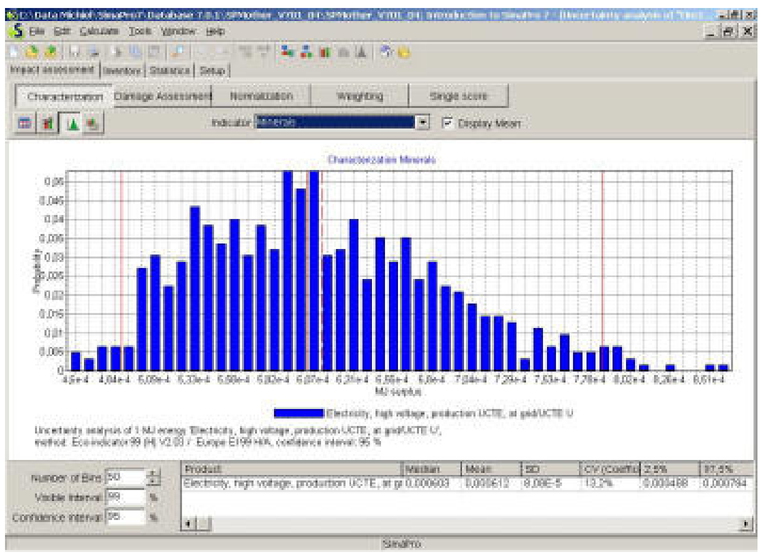
Monte Carlo Results

The uncertainty results in SimaPro can be presented in various ways.

In the image below the 95% interval is shown per impact category.

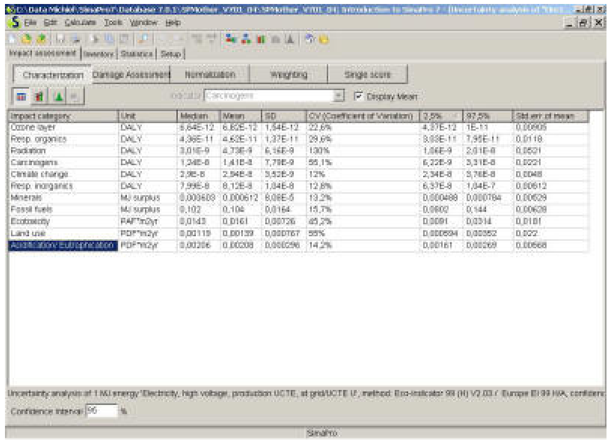


As SimaPro stores the outcomes of each calculation, these results form a distribution themselves. In the graph below, you see the distribution for impact category minerals for the production of high voltage electricity in Europe (UCTE).



Distribution of a characterization result

SimaPro can display such ranges for every impact category and even for every emission, both as graph and as tabular results. Further, you will find a range of statistical information plus display options with each graph and table.



Detailed statistical results overview

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Comparing products and dealing with correlations

SimaPro uses advanced process coupled sampling techniques when comparing the uncertainty in two LCA models. This means that if a certain process exists in both models, the same variation for this process is used in a single Monte Carlo sample for both models.

Correlations

When products are compared, we must observe the important issue of correlation. There is a real danger that Monte Carlo calculations overestimate uncertainty if products are compared where correlations are not observed. A simple example will illustrate this:

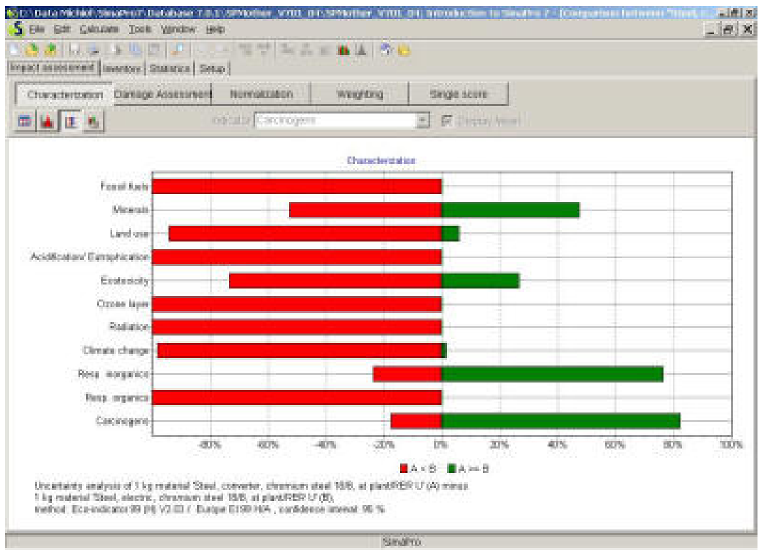
Suppose we have two products. Product A is made of 20 kg of steel, while product B is made of 21 kg of (the same type of) steel. Also suppose in this thought experimement that the uncertainty in the CO_2 output of steel production is extremely high, +/- 100%.

If we would calculate the Monte Carlo distributions for the CO_2 emissions of product A and B, we would conclude that we cannot say product A is better than B as both uncertainty ranges would be overlapping.

However, since both products use the same steel, the uncertainty is completely correlated. In order to determine the difference in CO_2 output, the uncertainty is not relevant. We can conclude the obvious fact that product A will have a 5% lower CO2 production than product B, because it simply uses 5% less of the same steel.

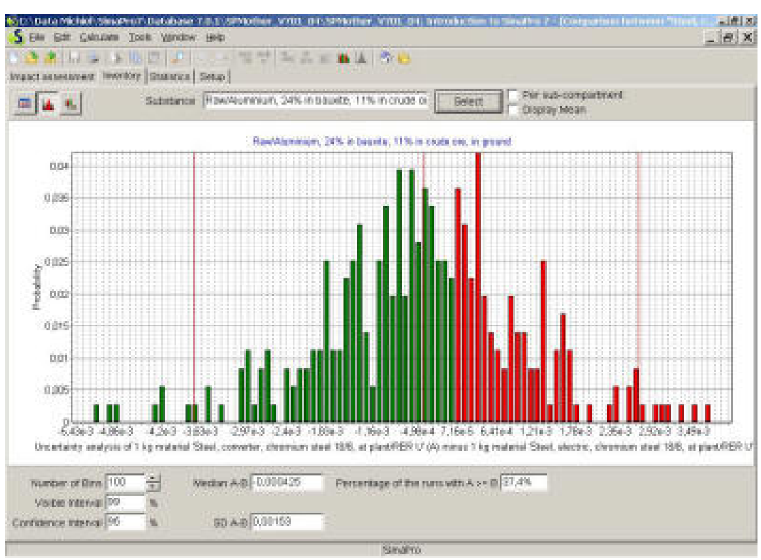
SimaPro considers correlations in a very sophisticated way. Contrary to what you expect, SimaPro will *not* show two overlapping distributions as this can easily give way to a wrong interpretation.

Instead, SimaPro shows in how many calculations product A scored lower than product B on a certain indicator or LCI result. The figures below displays such a distribution.



Comparative Monte Carlo shows the percentage of the samples where A<B and A>=B

Even though the results are a little more difficult to interpret, we feel that this is the only way to correctly present comparative results.



Comparative results on inventory (substance) level