

Welcome to the Life Cycle Assessment (LCA) Learning Module Series

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ACKNOWLEDGEMENTS:

CESTiCC

WASHINGTON STATE UNIVERSITY

FULBRIGHT



LCA Module Series Groups

Group A: ISO Compliant LCA Overview Modules

Group α : ISO Compliant LCA Detailed Modules

Group B: Environmental Impact Categories Overview Modules

Group β : Environmental Impact Categories Detailed Modules

Group G: General LCA Tools Overview Modules

Group γ : General LCA Tools Detailed Modules

Group T: Transportation-Related LCA Overview Modules

Group τ : Transportation-Related LCA Detailed Modules



General Paid LCA Software Tools

MODULE G1

It is suggested to review Modules A1 and A2 prior to this module



Why Use Software to Handle LCA?

With even moderately large systems, data handling and calculation can be complex and software will help:

- Reduce time needed for assessments
- Prevent errors
- Assisted conversion of data to functional unit basis
- Increase capabilities (e.g. monte carlo simulations, sensitivity analyses)
- Organize systems and data
- Automate creation of graphs and tables
- Provide process and flow information through databases only available in the software package

However, some software/database packages can:

- Be fairly expensive
- Require a learning curve to use effectively



Example of Data Complexity (Output Inventory for Crude Oil from NREL LCI)

Outputs			
2-Hexanone	water/unspecified	ELEMENTARY_FLOW kg	2.32e-08
Acetone	water/unspecified	ELEMENTARY_FLOW kg	3.55e-08
Aluminium	water/unspecified	ELEMENTARY_FLOW kg	3.19e-04
Ammonia	water/unspecified	ELEMENTARY_FLOW kg	5.32e-05
Antimony	water/unspecified	ELEMENTARY_FLOW kg	1.99e-07
Arsenic, ion	water/unspecified	ELEMENTARY_FLOW kg	9.83e-07
BOD5, Biological Oxygen Demand	water/unspecified	ELEMENTARY_FLOW kg	6.19e-04
Barium	water/unspecified	ELEMENTARY_FLOW kg	4.36e-03
Benzene	water/unspecified	ELEMENTARY_FLOW kg	5.96e-06
Benzene, 1-methyl-4-(1-methylethyl)-	water/unspecified	ELEMENTARY_FLOW kg	3.55e-10
Benzene, ethyl-	water/unspecified	ELEMENTARY_FLOW kg	3.35e-07
Benzene, pentamethyl-	water/unspecified	ELEMENTARY_FLOW kg	2.66e-10
Benzenes, alkylated, unspecified	water/unspecified	ELEMENTARY_FLOW kg	1.75e-07
Benzoic acid	water/unspecified	ELEMENTARY_FLOW kg	3.61e-06
Beryllium	water/unspecified	ELEMENTARY_FLOW kg	5.52e-08
Biphenyl	water/unspecified	ELEMENTARY_FLOW kg	1.13e-08
Boron	water/unspecified	ELEMENTARY_FLOW kg	1.12e-05
Bromide	water/unspecified	ELEMENTARY_FLOW kg	7.62e-04
COD, Chemical Oxygen Demand	water/unspecified	ELEMENTARY_FLOW kg	1.02e-03
Cadmium, ion	water/unspecified	ELEMENTARY_FLOW kg	1.45e-07
Calcium, ion	water/unspecified	ELEMENTARY_FLOW kg	1.14e-02
Chloride	water/unspecified	ELEMENTARY_FLOW kg	1.28e-01
Chromium	water/unspecified	ELEMENTARY_FLOW kg	8.50e-06
Cobalt	water/unspecified	ELEMENTARY_FLOW kg	7.88e-08
Copper, ion	water/unspecified	ELEMENTARY_FLOW kg	1.02e-06

Cresol, o-	water/unspecified	ELEMENTARY_FLOW kg	1.02e-07
Cresol, p-	water/unspecified	ELEMENTARY_FLOW kg	1.10e-07
Crude oil, at production	none	PRODUCT_FLOW kg	1.00e+00
Cyanide	water/unspecified	ELEMENTARY_FLOW kg	2.57e-10
Decane	water/unspecified	ELEMENTARY_FLOW kg	1.04e-07
Detergents, oil	water/unspecified	ELEMENTARY_FLOW kg	2.96e-06
Dibenzofuran	water/unspecified	ELEMENTARY_FLOW kg	6.76e-10
Dibenzothiophene	water/unspecified	ELEMENTARY_FLOW kg	3.49e-11
Dibenzothiophene	water/unspecified	ELEMENTARY_FLOW kg	5.48e-10
Dissolved solids	water/unspecified	ELEMENTARY_FLOW kg	1.58e-01
Docosane	water/unspecified	ELEMENTARY_FLOW kg	3.80e-09
Dodecane	water/unspecified	ELEMENTARY_FLOW kg	1.97e-07
Fluorene, 1-methyl-	water/unspecified	ELEMENTARY_FLOW kg	4.05e-10
Fluorenes, alkylated, unspecified	water/unspecified	ELEMENTARY_FLOW kg	1.01e-08
Fluorine	water/unspecified	ELEMENTARY_FLOW kg	4.98e-09
Hexacosane	water/unspecified	ELEMENTARY_FLOW kg	2.37e-09
Hexadecane	water/unspecified	ELEMENTARY_FLOW kg	2.15e-07
Hexanoic acid	water/unspecified	ELEMENTARY_FLOW kg	7.47e-07
Icosane	water/unspecified	ELEMENTARY_FLOW kg	5.41e-08
Iron	water/unspecified	ELEMENTARY_FLOW kg	6.31e-04
Lead	water/unspecified	ELEMENTARY_FLOW kg	2.09e-06
Lead-210/kg	water/unspecified	ELEMENTARY_FLOW kg	3.69e-16
Lithium, ion	water/unspecified	ELEMENTARY_FLOW kg	3.82e-06
Magnesium	water/unspecified	ELEMENTARY_FLOW kg	2.23e-03
Manganese	water/unspecified	ELEMENTARY_FLOW kg	3.56e-06
Mercury	water/unspecified	ELEMENTARY_FLOW kg	3.49e-09

Methane	air/unspecified	ELEMENTARY_FLOW kg	3.53e-03
Methane, monochloro-, R-40	water/unspecified	ELEMENTARY_FLOW kg	1.43e-10
Methyl ethyl ketone	water/unspecified	ELEMENTARY_FLOW kg	2.86e-10
Molybdenum	water/unspecified	ELEMENTARY_FLOW kg	8.17e-08
Naphthalene	water/unspecified	ELEMENTARY_FLOW kg	6.48e-08
Naphthalene, 2-methyl-	water/unspecified	ELEMENTARY_FLOW kg	5.63e-08
Naphthalenes, alkylated, unspecified	water/unspecified	ELEMENTARY_FLOW kg	2.86e-09
Nickel	water/unspecified	ELEMENTARY_FLOW kg	9.77e-07
Octadecane	water/unspecified	ELEMENTARY_FLOW kg	5.30e-08
Oils, unspecified	water/unspecified	ELEMENTARY_FLOW kg	7.20e-05
Pentanone, methyl-	water/unspecified	ELEMENTARY_FLOW kg	1.49e-08
Phenanthrene	water/unspecified	ELEMENTARY_FLOW kg	1.01e-09
Phenanthrenes, alkylated, unspecified	water/unspecified	ELEMENTARY_FLOW kg	1.19e-09
Phenol	water/unspecified	ELEMENTARY_FLOW kg	1.58e-06
Phenol, 2,4-dimethyl-	water/unspecified	ELEMENTARY_FLOW kg	9.96e-08
Radium-226/kg	water/unspecified	ELEMENTARY_FLOW kg	1.28e-13
Radium-228/kg	water/unspecified	ELEMENTARY_FLOW kg	6.57e-16
Selenium	water/unspecified	ELEMENTARY_FLOW kg	3.86e-08
Silver	water/unspecified	ELEMENTARY_FLOW kg	7.47e-06
Sodium, ion	water/unspecified	ELEMENTARY_FLOW kg	3.62e-02
Strontium	water/unspecified	ELEMENTARY_FLOW kg	1.94e-04
Sulfate	water/unspecified	ELEMENTARY_FLOW kg	2.58e-04
Sulfur	water/unspecified	ELEMENTARY_FLOW kg	9.42e-06
Suspended solids, unspecified	water/unspecified	ELEMENTARY_FLOW kg	9.77e-03



Common General LCA Software Tools

General LCA Software Tools

- GaBi
 - SimaPro
 - Quantis Suite
 - Umberto
- } Most widely used

Generally fully featured with:

- Uncertainty analysis
- Parameterized models
- Graphical model and results capabilities
- More



GaBi

Ganzheitliche Bilanz, German for “holistic balance”

Paid software produced by PE International, free educational version available for students and teachers

GaBi has extensive database options including their own database and integration with external databases, such as ecoinvent, US LCI, etc.

- Most data includes background information, reviews, etc.

Can pay their data team to collect data if needed

Users draw the life cycle “plan” as a flowchart, then calculate impacts

Software calculates results using sequential modeling

Includes i-report feature to produce reports with results

Single computer licenses only (“Buy one, Install one”*)



* <http://www.gabi-software.com/america/support/gabi-faq/>

GaBi Input

The screenshot displays the GaBi software interface for a gate-to-gate (AF&PA) process. The main window shows a process flow diagram for 'Containerboard (gate-to-gate) AF&PA'. The diagram includes various input flows such as 'US: West: Electricity grid mix (production mix)', 'Natural gas, at extraction site', 'Gasoline, at refinery', 'Diesel, at refinery', 'Pulp chips, at sawmill, US SE', 'Bituminous coal, at mine', 'US: Propane at refinery PE', 'US: Process steam from natural gas 90% (eGrid) PE', 'US: Heavy fuel oil at refinery (0.3wt.% S) PE', 'US: Light fuel oil at refinery PE', and 'Wood fuel, unspecified [p-egg]'. The process is connected to a 'Ferry Engine <u-so>' and a 'US: Truck - Medium Heavy-duty Diesel Truck / 17,333 lb payload - 6 PE <u-so>', which in turn connects to a 'US: Truck - Heavy Heavy-duty Diesel Truck / 53,333 lb payload - 8b PE <u-so>' and finally to 'Lube Oil to MDO Dummy <u-so>'.

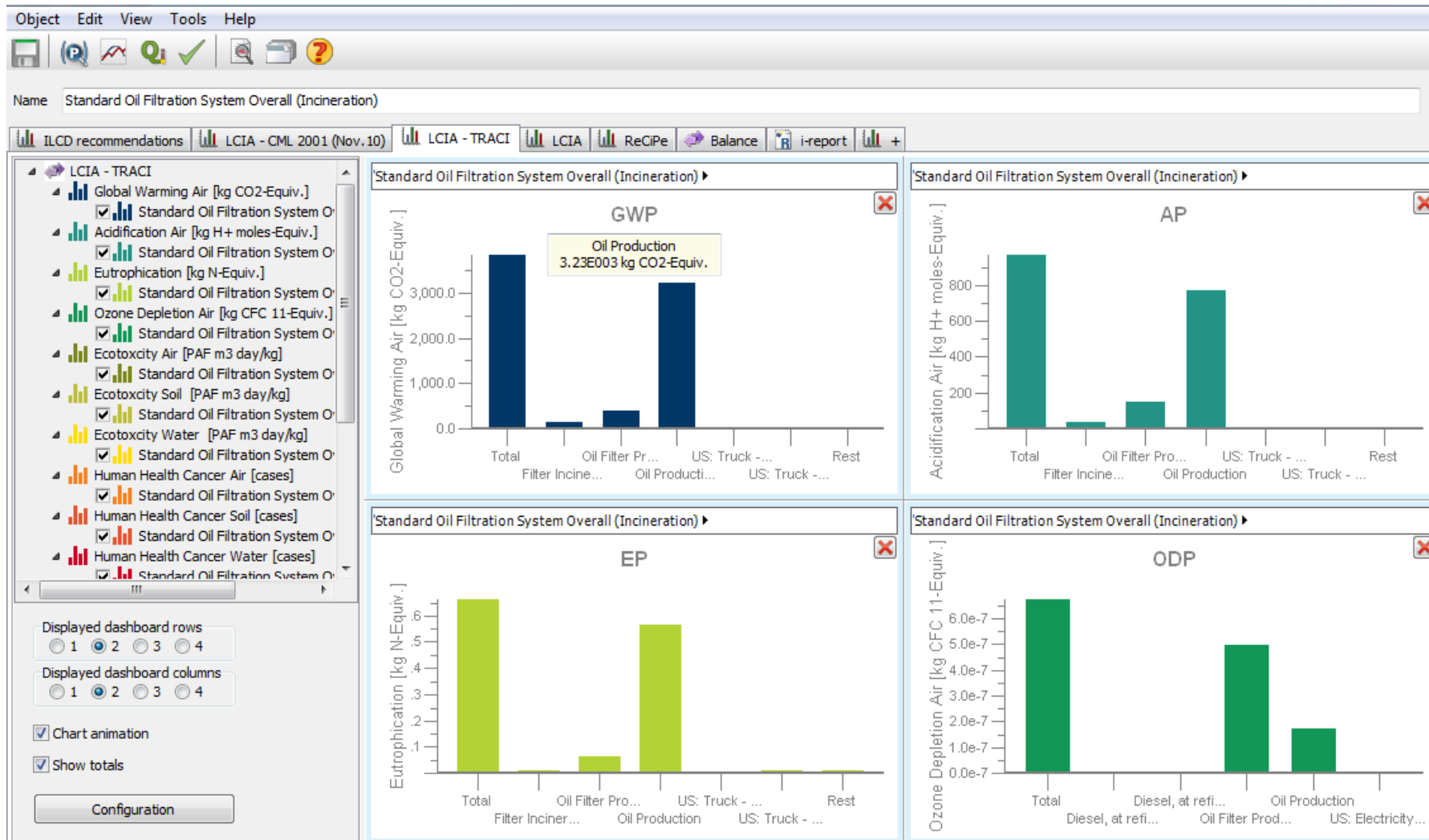
The 'Parameter' window shows the following inputs and outputs:

Flow	Quantity	Amount	Unit	Trz	Standard	Origin	Comment
Biomass (solid) [Biomass fuels]	Mass	0.034	kg	X	0 %	(No statement)	
Diesel [Refinery products]	Mass	0.0006	kg	X	0 %	(No statement)	
Electricity [Electric power]	Energy (net ca	0.017	MJ	X	0 %	(No statement)	
Electricity from hydro power [Sy	Energy (net ca	0.00000	MJ	X	0 %	(No statement)	
Gasoline (regular) [Refinery pro	Mass	0.00000	kg	X	0 %	(No statement)	
Hard coal USA [Hard coal, at pro	Mass	0.00075	kg	X	0 %	(No statement)	
Heavy fuel oil [Crude oil product	Mass	0.00075	kg	X	0 %	(No statement)	
Light fuel oil (0.2 wt.% S) [Refin	Mass	0.00075	kg	X	0 %	(No statement)	

The 'DB Plan' window shows a search for 'wood' with the following results:

Nation	Name	Type / Sh	QA	Source	Object group
US	Bark, at plywood plant, US PN1 agg		✓	USLCI/PE	Fuel producti
US	Bark, at plywood plant, US SE agg		✓	USLCI/PE	Fuel producti
US	Bark, at rough green lumber sa agg		✓	USLCI/PE	Fuel producti
US	Composite wood I-joint, at plar agg		✓	USLCI/PE	Products
US	Composite wood I-joint, at plar agg		✓	USLCI/PE	Products
US	Conditioned log, at plywood pl: agg		✓	USLCI/PE	Products

GaBi Output



SimaPro

Produced by PRé Consultants

Integrates with US LCI, ELCD, ecoinvent, and LCA food databases

Uses a more text/menu approach to modelling, rather than graphical approach

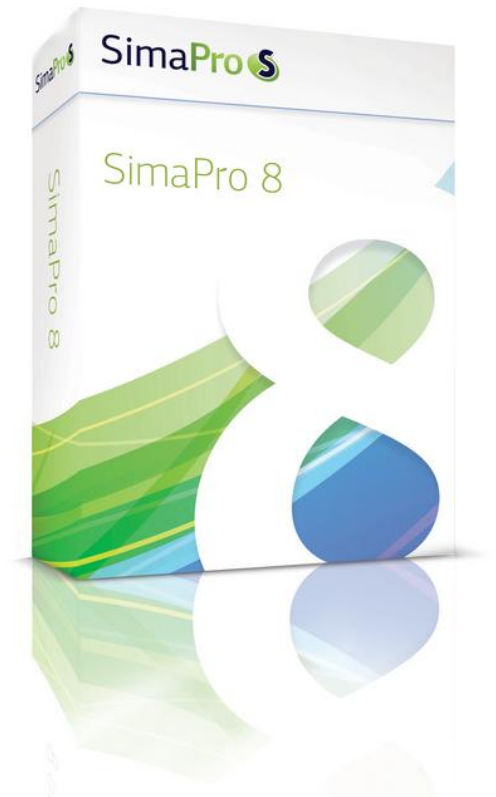
- Though graphical flowcharts can be viewed following data input

Calculates results using matrix inversion

For use by professionals at two levels (Analyst or Developer)

Server based, convenient for multiple users and for remote connection

Appears to be more commonly used, and hence easier to share with others and find tutorial type information



SimaPro Input

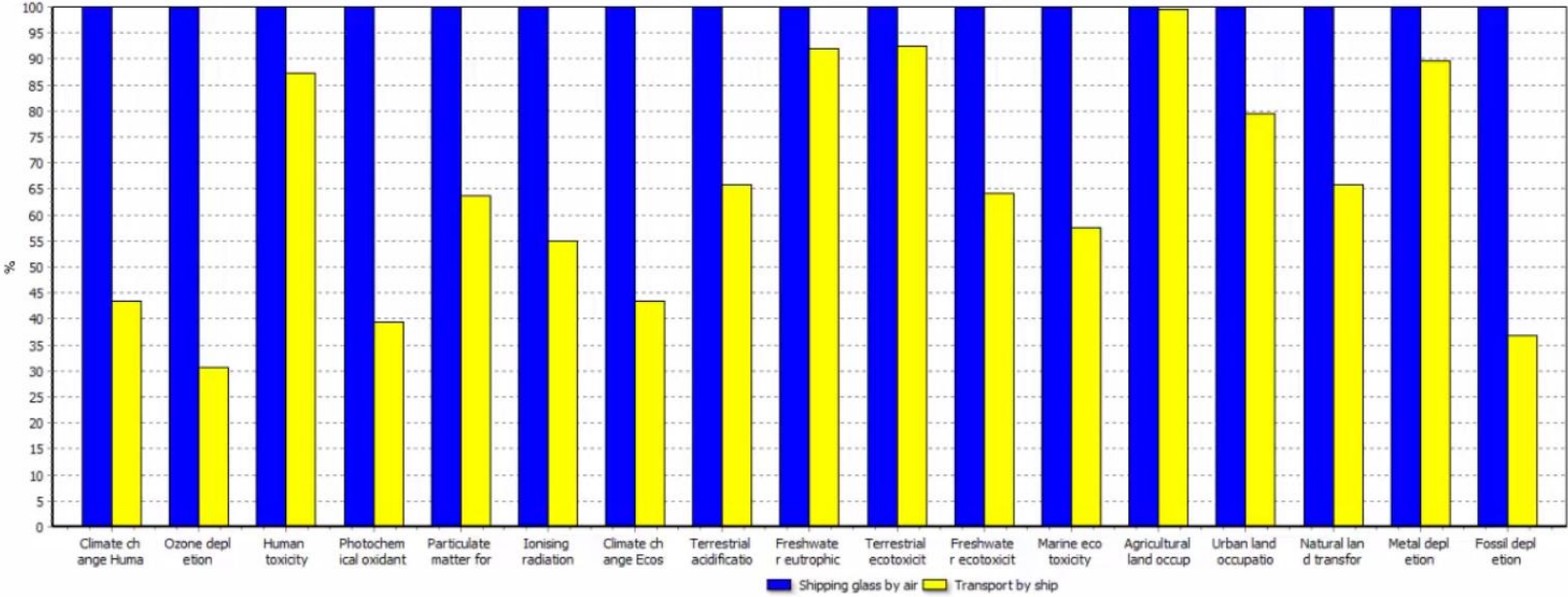
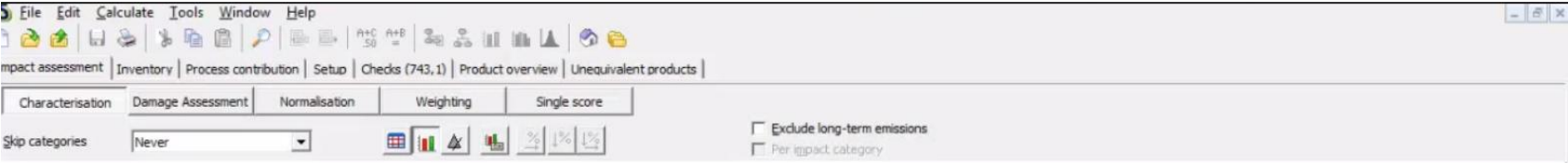
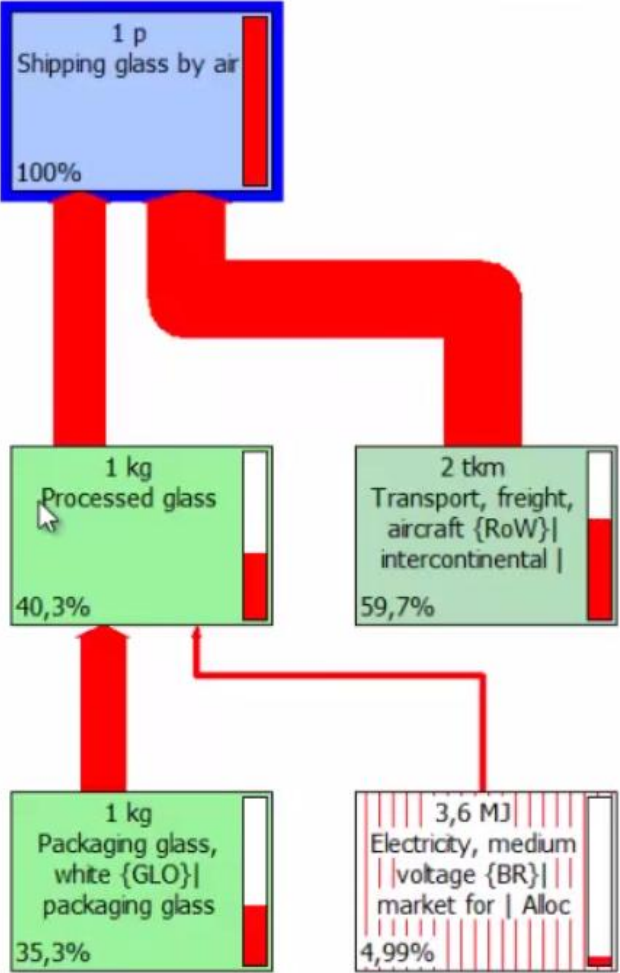
The screenshot displays the SimaPro software interface. A 'Select a product' dialog box is open, showing a list of products. The selected product is 'Electricity, medium voltage (BR) | market for | Alloc Def, U'. The dialog box has a table with the following columns: Name, Unit, Waste type, and Project. Below the table, there is a description of the dataset and a filter section.

Name	Unit	Waste type	Project
Electricity, medium voltage (ASCC) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (AT) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (AU) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (BA) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (BE) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (BG) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (BR) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-AB) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-BC) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-NB) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-NF) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-NS) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-NT) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-NU) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-ON) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc
Electricity, medium voltage (CA-PE) market for Alloc Def, U	kWh		Ecoinvent 3 - alloc

Filter on: and or Clear 74
10168 items 1 item selected

Davies, P. (2014). "LCA with SimaPro8: Tutorial 2" YouTube, <https://www.youtube.com/watch?v=czqbCs6hwuI>

SimaPro Output



Comparing 1 p 'Shipping glass by air' with 1 p 'Transport by ship';
Method: ReCiPe Endpoint (H) V1.08 / World ReCiPe H/H / Characterisation

Davies, P. (2014). "LCA with SimaPro8: Tutorial 3" YouTube, <https://www.youtube.com/watch?v=yFFXumd4M6Y>

Smaller Packages within GaBi and SimaPro

SimaPro

- **EarthSmart** is for evaluating the environmental impacts of a Product or Service life cycle
- **e-Dea** is software that allows everyone to design with environmental awareness
- **PackageSmart** is an LCA tool focused on packaging
- **LENS™** is a combined technology, software and expert services solution that allows organisations to manage their utility and environmental compliance costs
- **Superpac** is a Pack design and Pallet loading software.
- **3Pillars** is a Sustainability ROI (Return on Investment) evaluating your triple bottom line

GaBi

- **GaBi Envision** is the dedicated tool to design sustainable products and processes
- **GaBi Server** supports LCA collaboration and is ideal for organisations with two or more LCA practitioners.
- **GaBi DfX** is the professional software for compliance and sustainable product development with a view to the end of life phase



Quantis Suite

Web-based application

Integrates with ecoinvent 2.2 database

Model by phases, drag and drop inputs and processes to the stages. Manually choose quantities.

Free trial version available, must purchase full version

- Includes ~400 of the total 4000 processes in ecoinvent
- Includes IMPACT 2002+ impact methodology for five impact categories

Has partnered with SimaPro on some tools to expand distribution reach and resources

A few versions of the software available

- **Quantis Suite Product – LCAs according to ISO 14040 and carbon footprint**
- Quantis Suite Corporate – Carbon footprint focused, other environmental aspect tools
- Quantis Impulsio – Ecodesign software

User-friendly
LCA software



Your first steps in LCA and
carbon footprint

Easy-to-use tool to perform
Life Cycle Assessments and
carbon footprints

Dynamic analysis of results
and drag-and-drop
modeling

FREE VERSION

Use the free version and
upgrade when needed!



Quantis Suite Input

The screenshot shows the Quantis Suite 2.0 web interface. The main window displays the input for a PET bottle of juice, organized into three main sections: Raw materials (Supply chain), Packaging: sourcing, and Plastic bottle. The right sidebar shows the 'PROPERTIES' panel for the selected item, 'Concentrated coconut water'.

Raw materials (Supply chain) (1.02 x)

- Ingredients: sourcing** (1 x)
- Concentrated coconut water: 5 g
- Fruit juice, standard, concentrated, very rough 2 [kg]: 3 g
- Concentrated fruit juice (Central America): 3 g
- Fruit juice, standard, concentrated, very rough 2 [kg]: 3 g
- Concentrated fruit juice (Europe): 3 g
- Fruit juice, standard, concentrated, very rough 2 [kg]: 3 g
- Sugar: 6 g
- Sugar, from sugar beet, at sugar refinery, heavy metals back to soil 2 [kg]: 244 g
- Water (demineralised): 244 g
- water, deionised, at plant [kg] - CH (Ecoinvent 2.2: 2292): 244 g

Packaging: sourcing (1 x)

- Primary packaging** (1 x)
- Screw cap** (1 x)
- HDPE cap: 2.5 g
- polyethylene, HDPE, granulate, at plant [kg] - RER (Ecoinvent 2.2: 1829): 2.5 g
- Manufacturing: screw cap: 2.5 g
- injection moulding [kg] - RER (Ecoinvent 2.2: 1853): 2.5 g

Plastic bottle (1 x)

- Bottle: PET: 30 g
- polyethylene terephthalate, granulate, bottle grade, at plant [kg] - RER (Ecoinvent 2.2: 1828): 30 g
- Bottle: MXD-6 (Nylon) (3%): 1 g

PROPERTIES

1 PET bottle of juice | Element | Flow | EF

GENERAL

Name: Concentrated coconut water

Quantity: 5

Formula: [empty]

Unit type: Mass

Unit: g

Cost: 0 | CHF

Category: Agro-based

ENTER PARAMETERS

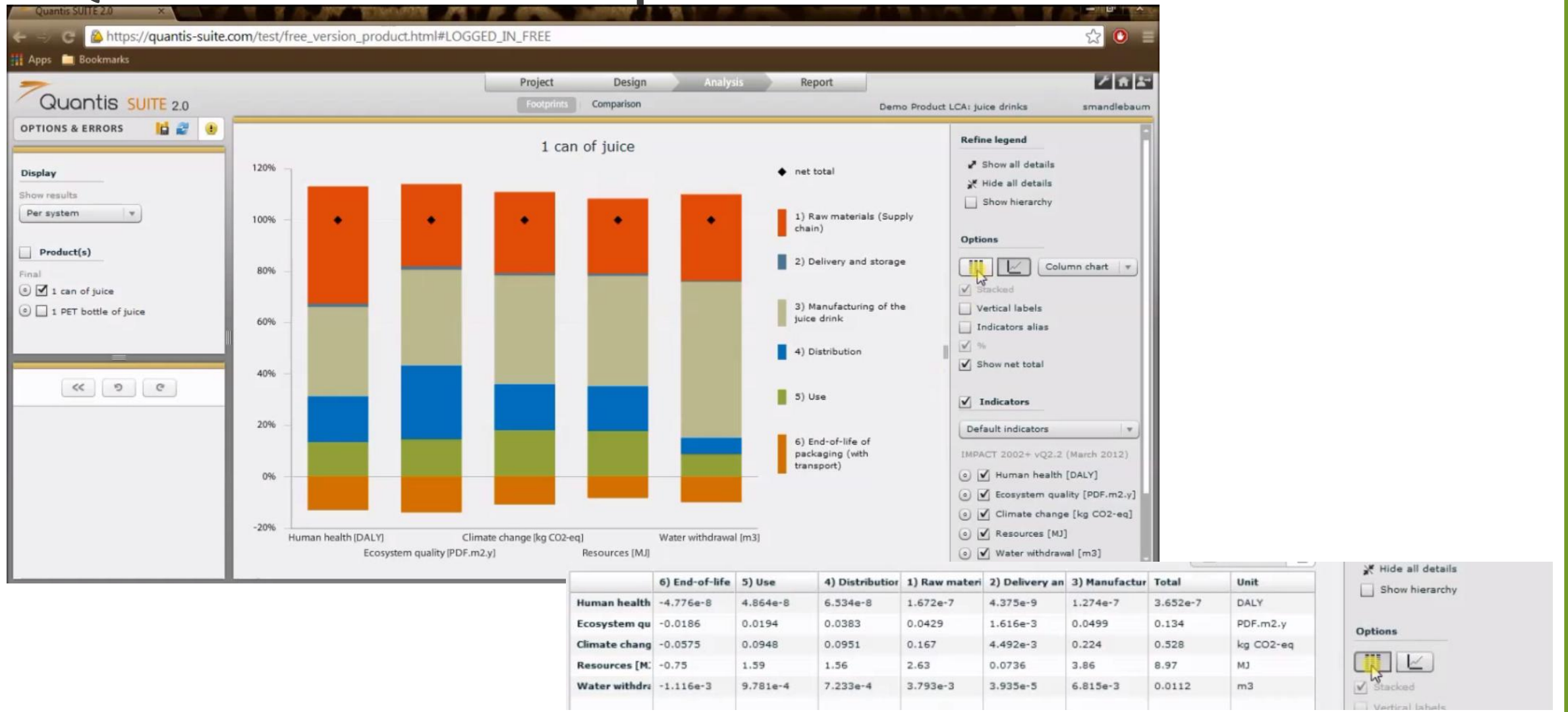
Name	Alias	Value	Unit

DESCRIPTION

[empty text area]

Quantis (2013). "QS Product Free 1 intro tour" YouTube, <https://www.youtube.com/watch?v=QRHaD91rxwA>

Quantis Suite Output



Quantis (2013). "QS Product Free 1 intro tour" YouTube, <https://www.youtube.com/watch?v=QRHaD91rxwA>

Umberto

Produced by ifu Hamburg

Integrate with ecoinvent 3 (included with software) and GaBi (separate purchase) databases

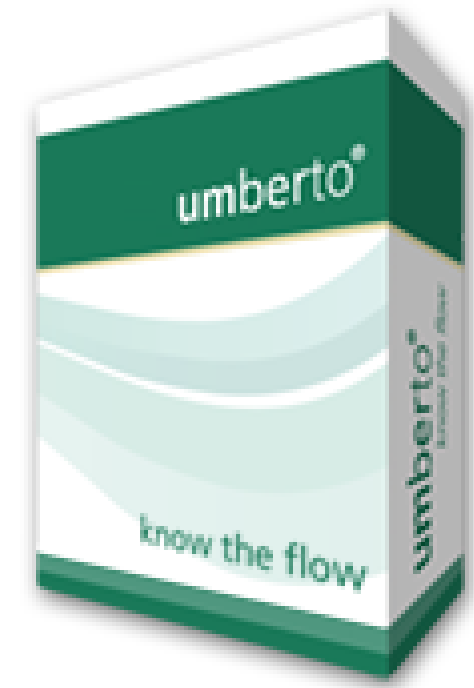
Frequent online web demos

Graphically oriented modelling approach featuring Sankey diagrams

Interfaces with Microsoft Excel and other Office programs

Multiple versions depending on needs

- NXT Efficiency: Costs, materials, and energy
- NXT LCA: Life cycle assessment
- NXT CO₂: Carbon footprint only
- NXT Universal: Combines environmental with cost and efficiency

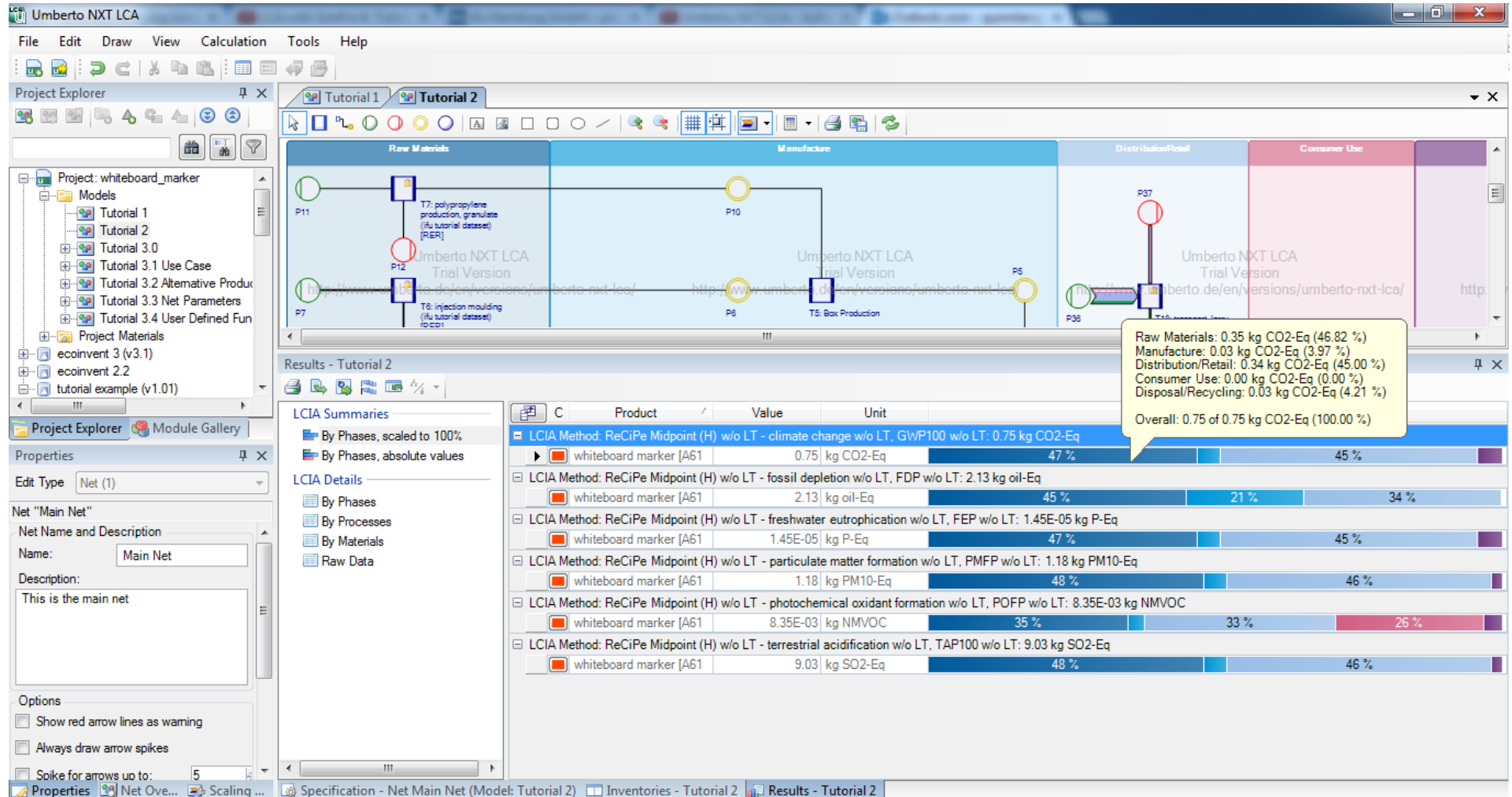


Umberto Input

The screenshot displays the Umberto NXT LCA software interface. The top menu includes File, Edit, Draw, View, Calculation, Tools, and Help. The Project Explorer on the left shows a project named 'whiteboard_marker' with various tutorial subnets and material databases. The main workspace shows a process flow diagram with nodes and connections. Below the diagram, a specification window for 'Process T18: transport, lorry 16-32 ton, EURO5 (fu tutorial dataset) [PER]' is open, displaying a table of input and output materials.

Input / Output				Generic Materials				Parameters				Allocations			
	Material	Place	Material Type	Coefficient		Material	Place	Material Type	Coefficient		Material	Place	Material Type	Coefficient	
	Copper, 0.99% in sulfide, Cu 0	P36	▲ Good	0		transport, freight, lorry 16-32	P35	▲ Good			Ammonia [air/unspecified]	P37	▲ Bad		
	Gas, natural, in ground [natural reso	P36	▲ Good	30		Carbon dioxide, fossil [air/uns	P37	▲ Bad	3,		Carbon dioxide, non-fossil [air/	P37	▲ Bad		
	Gravel, in ground [natural reso	P36	▲ Good	285		Carbon monoxide, fossil [air/u	P37	▲ Bad	4,		Dinitrogen monoxide [air/unsp	P37	▲ Bad		
	Oil, crude, in ground [natural r	P36	▲ Good	16		Methane [air/urban air close to	P37	▲ Bad			Methane, fossil [unspecified]	P37	▲ Bad		
	Sibnite, in ground [natural res	P36	▲ Good	30											
	Water, cooling, unspecified na	P36	▲ Good	255											
	Zinc, 9.0% in sulfide, Zn 5.3%	P36	▲ Good	104											

Umberto Output



Conclusion

Free Trial Links [GaBi](#) [SimaPro](#) [Quantis](#) [Umberto](#)

Most of these software options have similar features

Most have the ability to use data from multiple databases including ecoinvent and GaBi databases

Main differences seem to be in the user interfaces

- Free trial versions are available for each to get a feel for their input and output style

There are a few differences in specific extra features such as ability to generate reports within the software, be used remotely, export to other programs, and have add-ons for specific goals

Cost of each software may vary and most require requesting a quote to see pricing structure

Bottom Line:

Each one accomplishes the main functionality of simplifying the process of a life cycle assessment, but may differ slightly in specialized capabilities and style of use



Thank you for completing Module G1!

Group A: ISO Compliant LCA Overview Modules

Group α : ISO Compliant LCA Detailed Modules

Group B: Environmental Impact Categories Overview Modules

Group β : Environmental Impact Categories Detailed Modules

Group G: General LCA Tools Overview Modules

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Self-Assessment Quiz

MODULE G1: General Paid LCA Tools

A solid green horizontal bar at the bottom of the slide.

Which of these can be an advantage of using software to handle an LCA over doing one by hand?

- Prevent computational errors
- Increase capabilities
- Reduce time needed to carry out the assessment
- All of the above

Correct!

There are many advantages of using software to help compute LCA results, though those covered here must be purchased and may require a learning curve.

Which software tool produces and features their own database for their tool?



GaBi



SimaPro



Quantis Suite



Umberto

Correct!

PE international produces its own databases for GaBi while the other tools tend to rely more on third-party data sources. All of the softwares can use data from other sources like ecoinvent and the US LCI.

Which software tool operates exclusively as an online platform?



GaBi



SimaPro



Quantis Suite



Umberto

Correct!

Quantis Suite is the only tool covered that operates as a web-based tool. The other software options have various ways to connect over the internet, but are based on a computer or server.

Is there only one version of each software or multiple options to choose from?

Only one version of each

Multiple options

Correct!

Each tool has either different versions or add-on packages for specific tasks and goals, depending on the needs of the assessment (e.g. CO₂ only, costs in addition to LCA, etc.)

Which software tool offers a free trial version?

- GaBi
- SimaPro
- Quantis Suite
- Umberto
- All of the above

Correct!

All of these offer free trial versions so you can explore the interface and features of each tool for yourself. Links to the free trial pages are on the conclusion slide (slide 20).