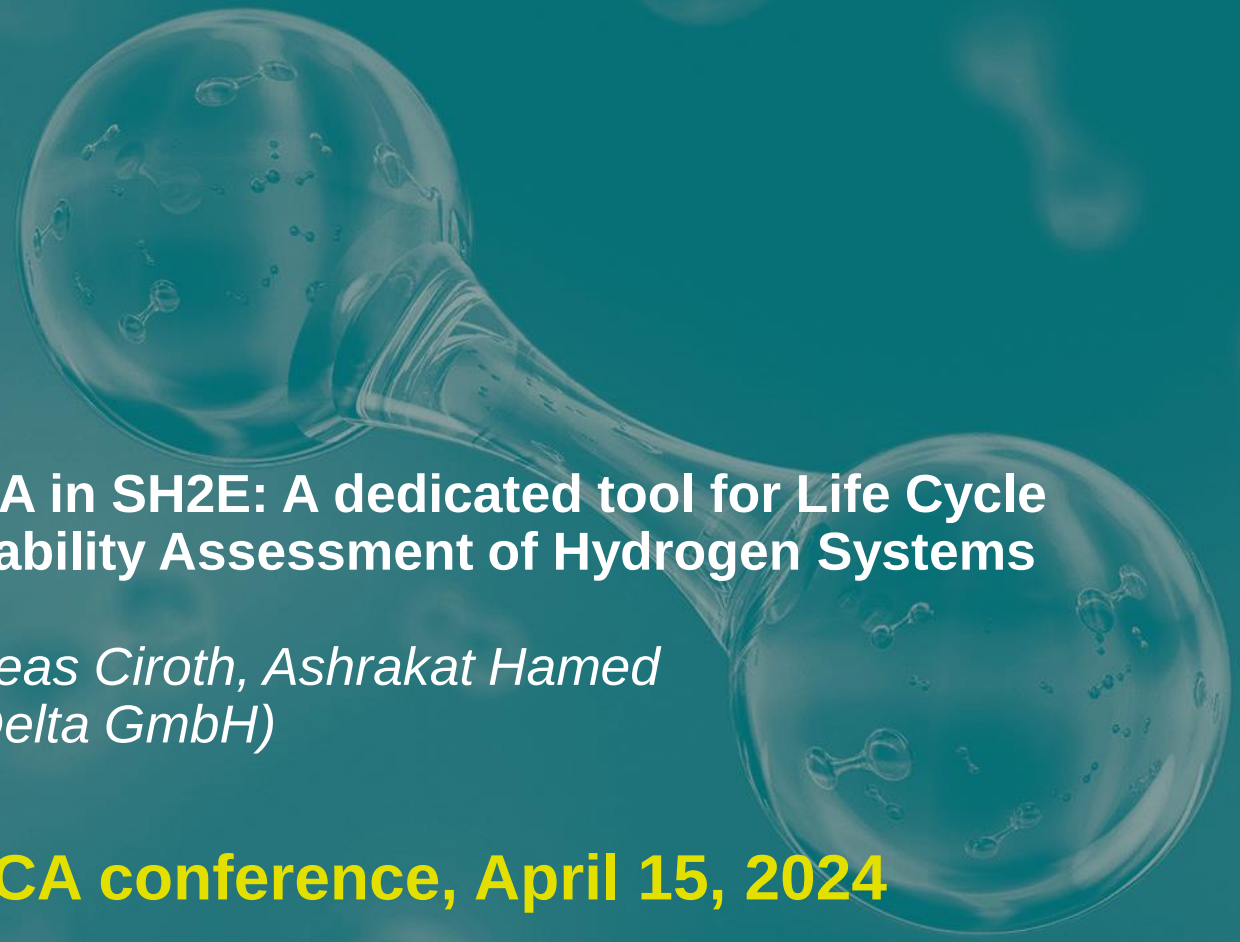

openLCA in SH2E: A dedicated tool for Life Cycle Sustainability Assessment of Hydrogen Systems

Dr. Andreas Ciroth, Ashrakat Hamed
(GreenDelta GmbH)

openLCA conference, April 15, 2024

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007163. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

TOOL DEMONSTRATION

1. The FCH-LCA tool
2. LCA modeling and assessment with the FCA-LCA tool
3. Specific features of the FCA-LCA tool
    1. Wizard templates
    2. Social LCA calculation
    3. Time for support of discounting and prospective modeling
4. Conclusions

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SH2E

About the FCH-LCA tool

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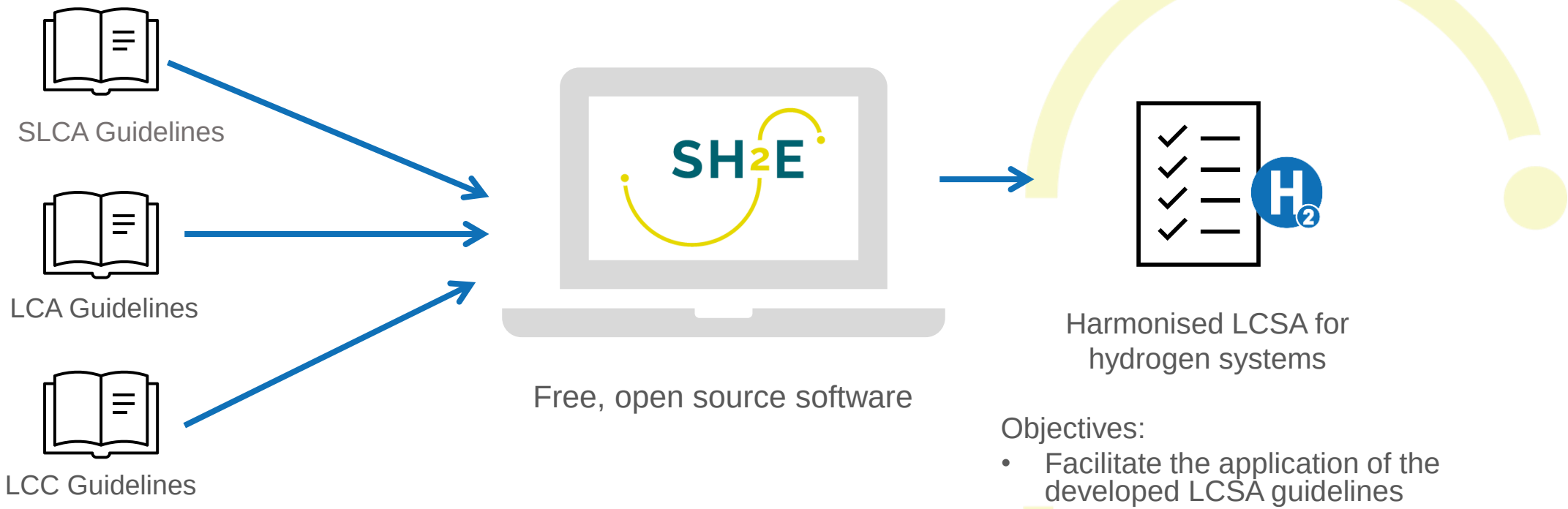
Welcome to the FCH-LCA tool



Objectives:

- Facilitate the application of the developed LCSA guidelines
- Ensuring the production of consistent and reliable results

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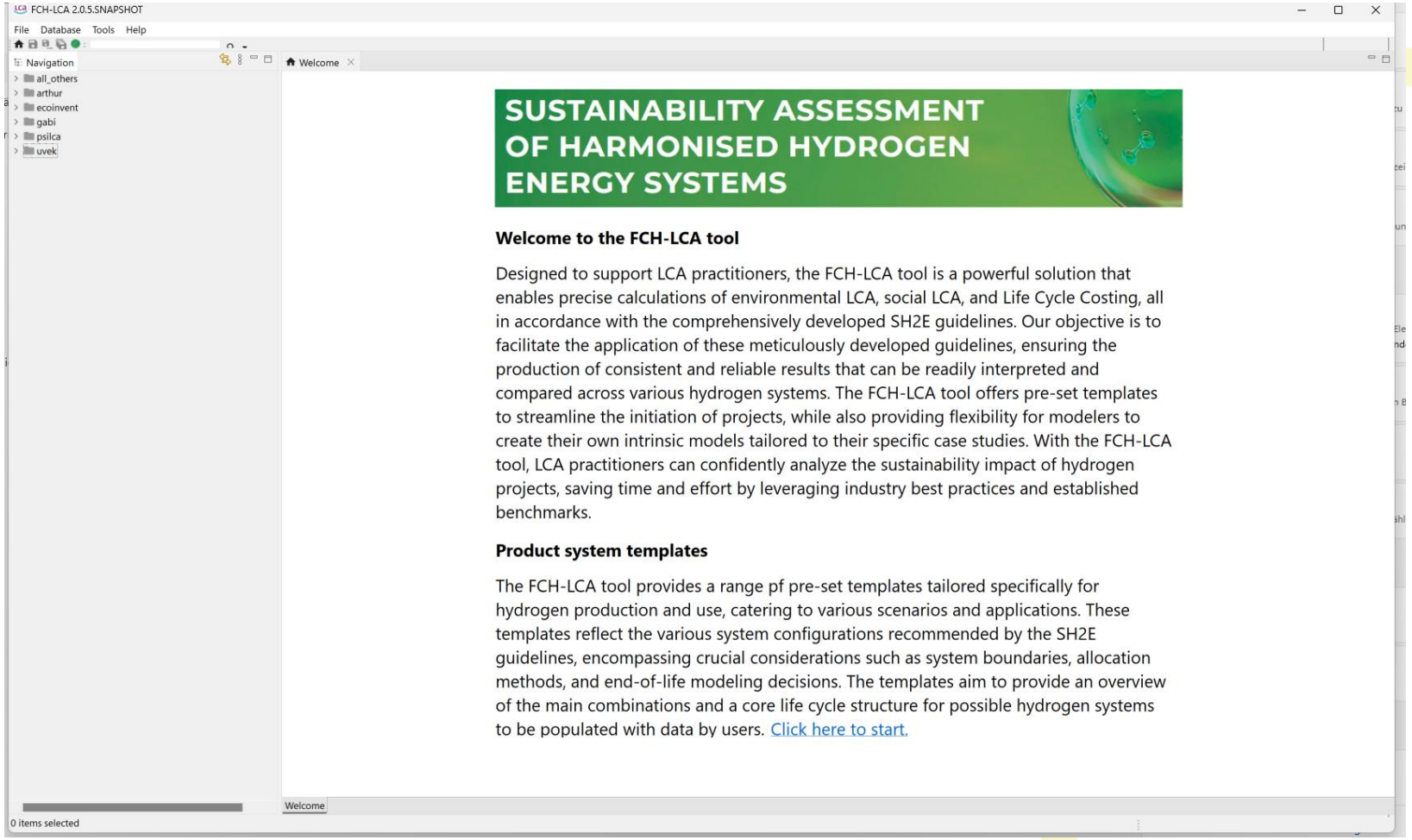

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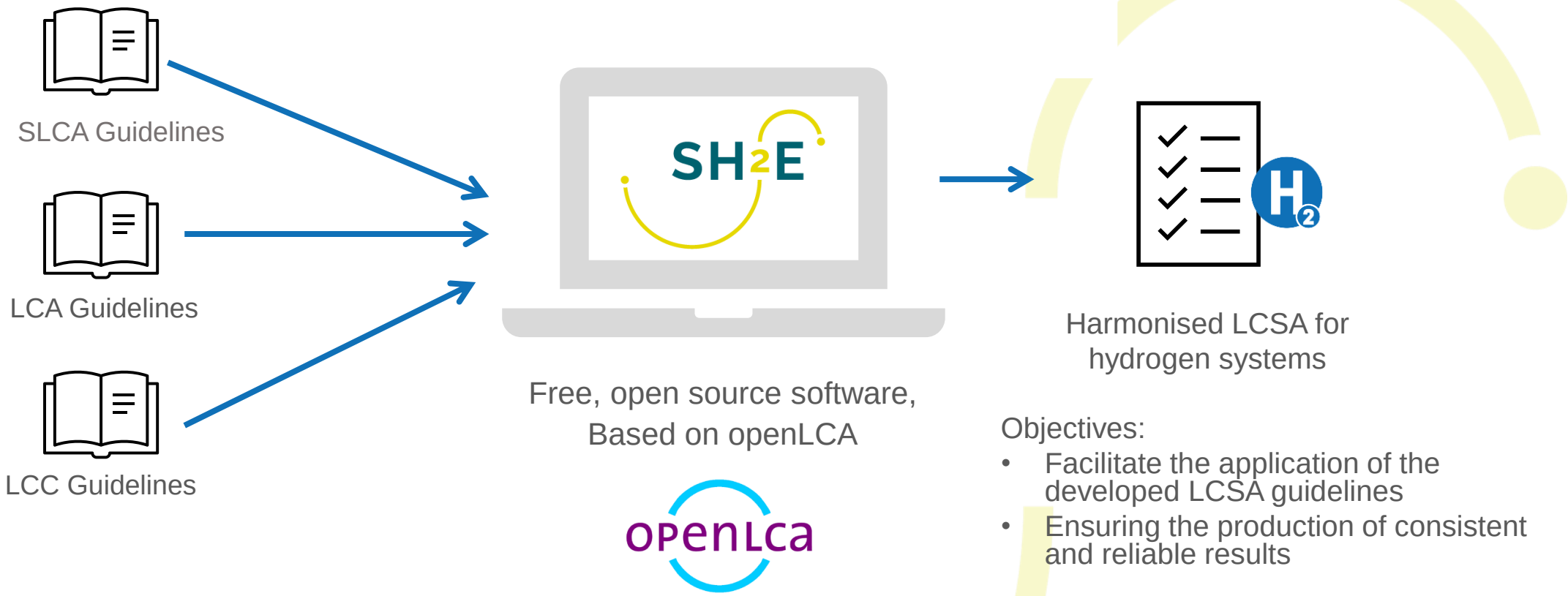
Welcome to the FCH-LCA tool



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About the openLCA software

- A free and (yet) professional approach to Life Cycle Assessment: powerful, feature-rich, (comparatively) easy to use, technically up-to-date, in active development; last version 2.1 released in January 2024
- 100,000 users worldwide
- Broad support for LCA databases and methods, in openLCA Nexus: > 300,000 datasets available
- Developed by GreenDelta since 2006
- Completely Open Source (Mozilla Public License)

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SH2E

Specific features of the FCA-LCA tool

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Templates to guide through methodological choices

SH2E guidelines foresee quite some methodological choices that are difficult to follow by practitioners

Creating “templates” that adhere to the guidelines supports users in following the guidelines (and in the end creates more consistent, comparable models)

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Tool Wizard: Guideline recommendations

Guidelines come with many recommendations and requirements

Box 1

The intended application must be considered for LCAs. The intended application is characterised by the intended reliability and the safeground level. The application situation must be coherent with it, by stating if the LCA study would be employed for decision support (yes/no) and the scale of the induced changes in the considered system (micro, meso or macro).

Box 2

An LCA that has only the purpose to describe a situation and is not meant for decision support must be modelled following the attributional LCI modelling approach.

An LCA that is meant for decision support needs to follow a change-oriented LCA modelling principle when the anticipated system change induced by the decision at stake is not minor compared to the existing system.

Box 7

If the LCA study is aimed at a macro-level decision (e.g., policy-making), a consequential approach has to be followed.

Box 4

To be prospective within the context of these guidelines, an LCA study must meet the following requisites:

1. The system must be modelled at a future time. ●●●●●
2. The foreground data for the technical/operating parameters and capital goods of the analysed product system must be prospective. ●●●●●

When performing a comparative study, it must be ensured that the FCH technologies under comparison are modelled at the same future time of implementation.

Box 5

1. The use of relevant prospective background data for processes directly linked to the foreground system (e.g., electricity production) is strongly recommended. ●●●●○
2. The use of prospective background data from dedicated databases (e.g., *premise*) is recommended. ●●●○○
3. It is recommended to state the Technology Readiness Level (TRL) and/or the Manufacturing Readiness Level (MRL) of the involved technology to facilitate comparability decisions.

To ensure users are applying the requirements/recommendations a tool wizard was created

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Tool Development: Wizards & templates

- Starting with the main 3 cases of hydrogen:
  1. Hydrogen production
  2. Hydrogen use
  3. Hydrogen production and use

  then breaking them down based on possible functional units.
  - Overall, 46 templates created

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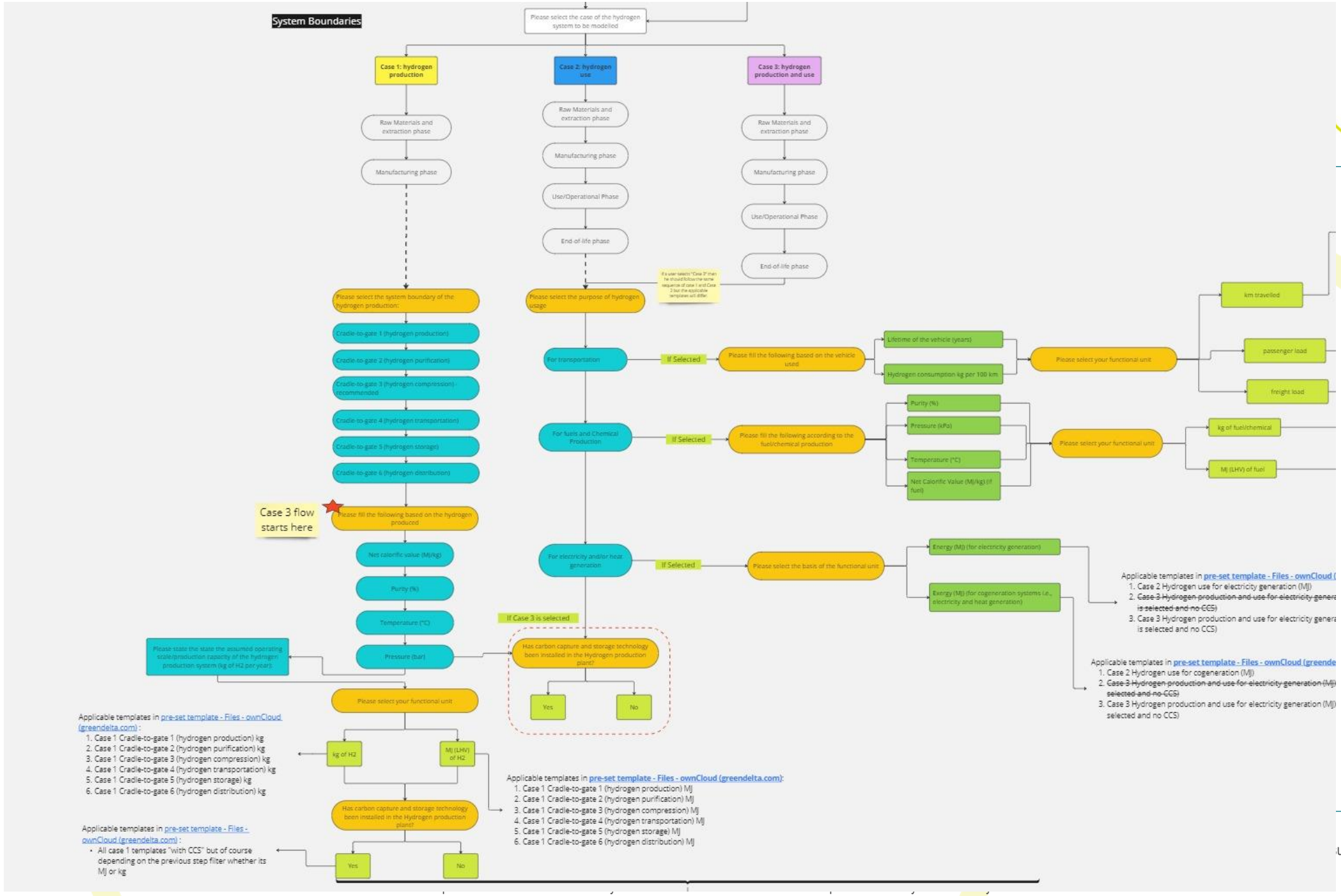
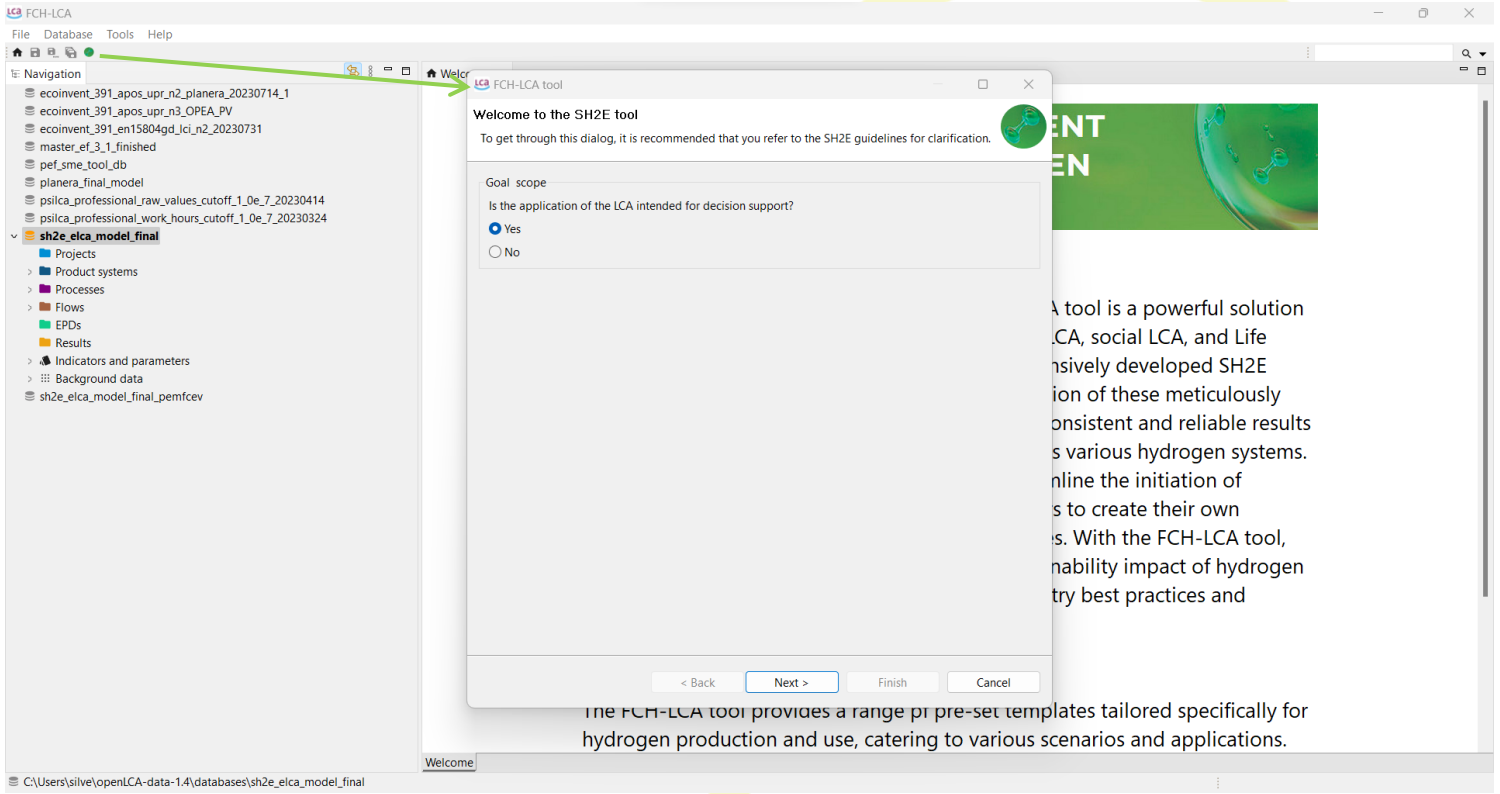


upport from the

Tool Wizard

SUSTAINABILITY ASSESSMENT OF HARMONISED HYDROGEN ENERGY SYSTEMS



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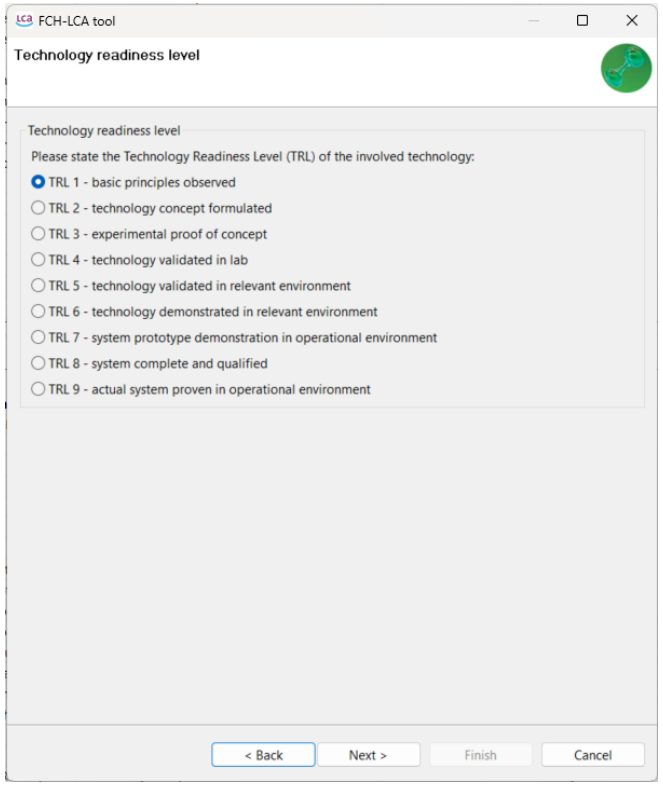
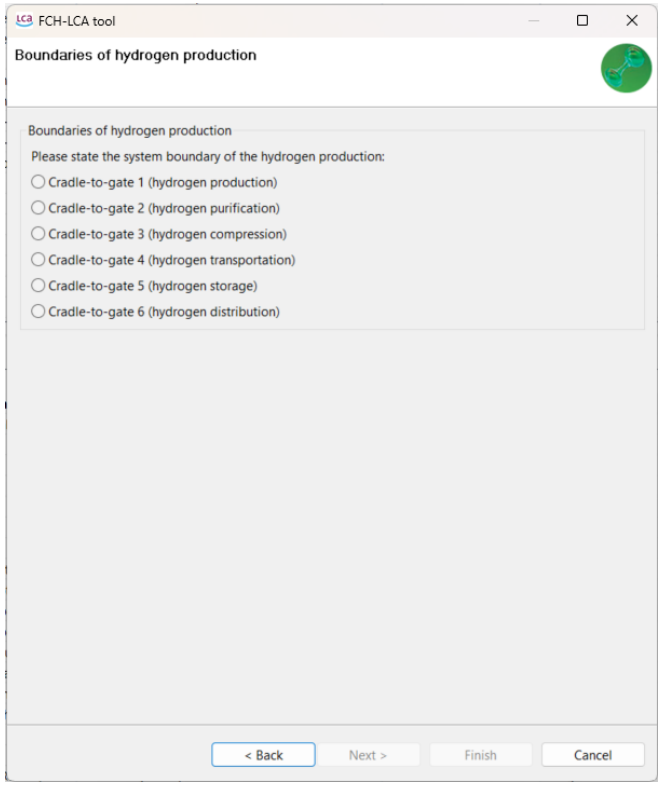
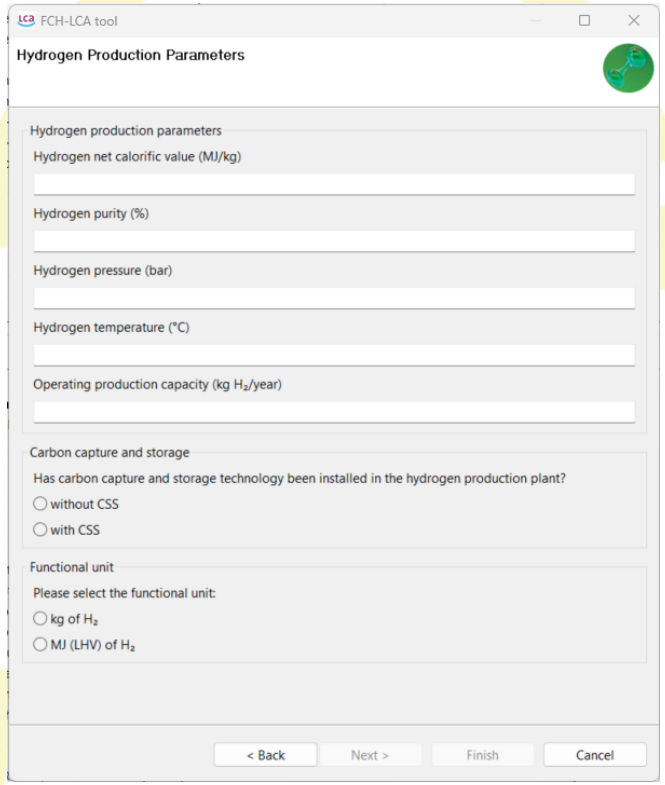
Tool Wizard







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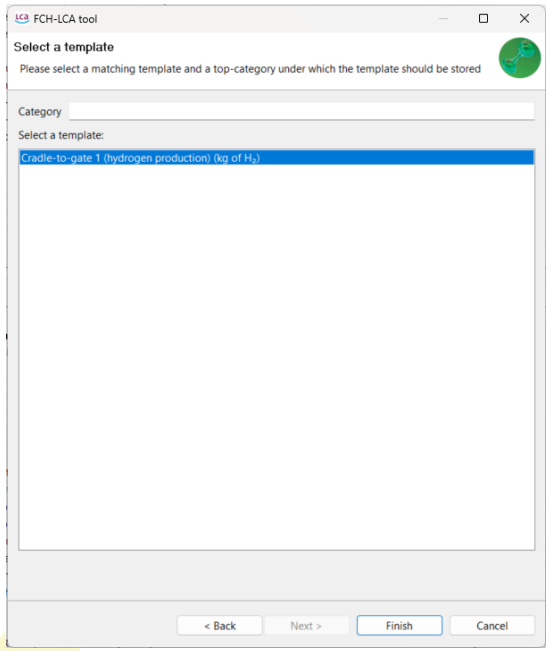
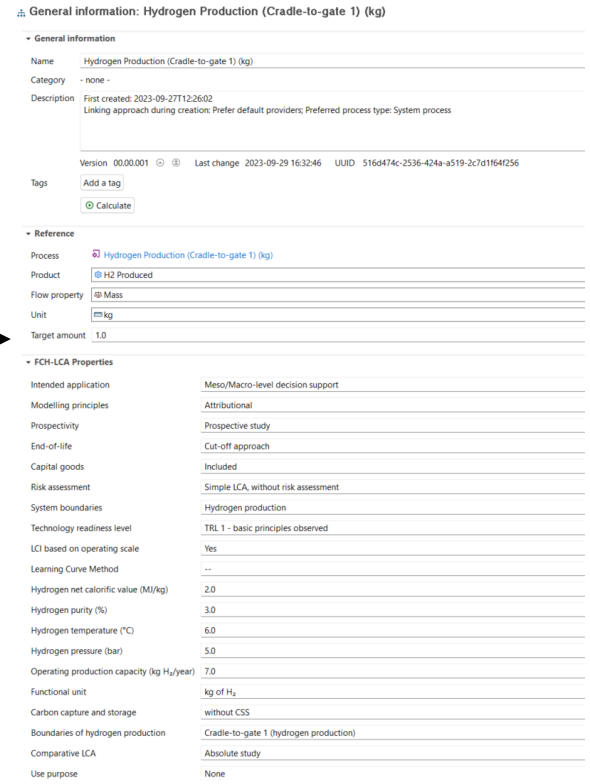
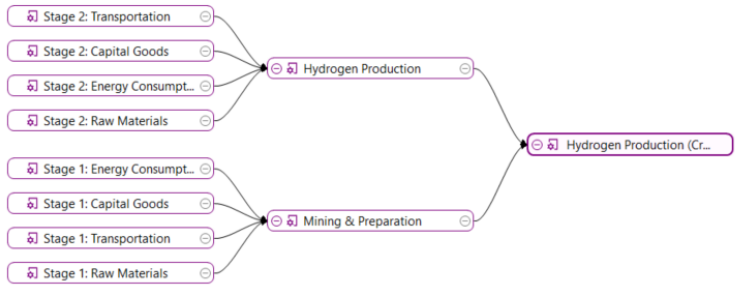
Tool Wizard filters the templates







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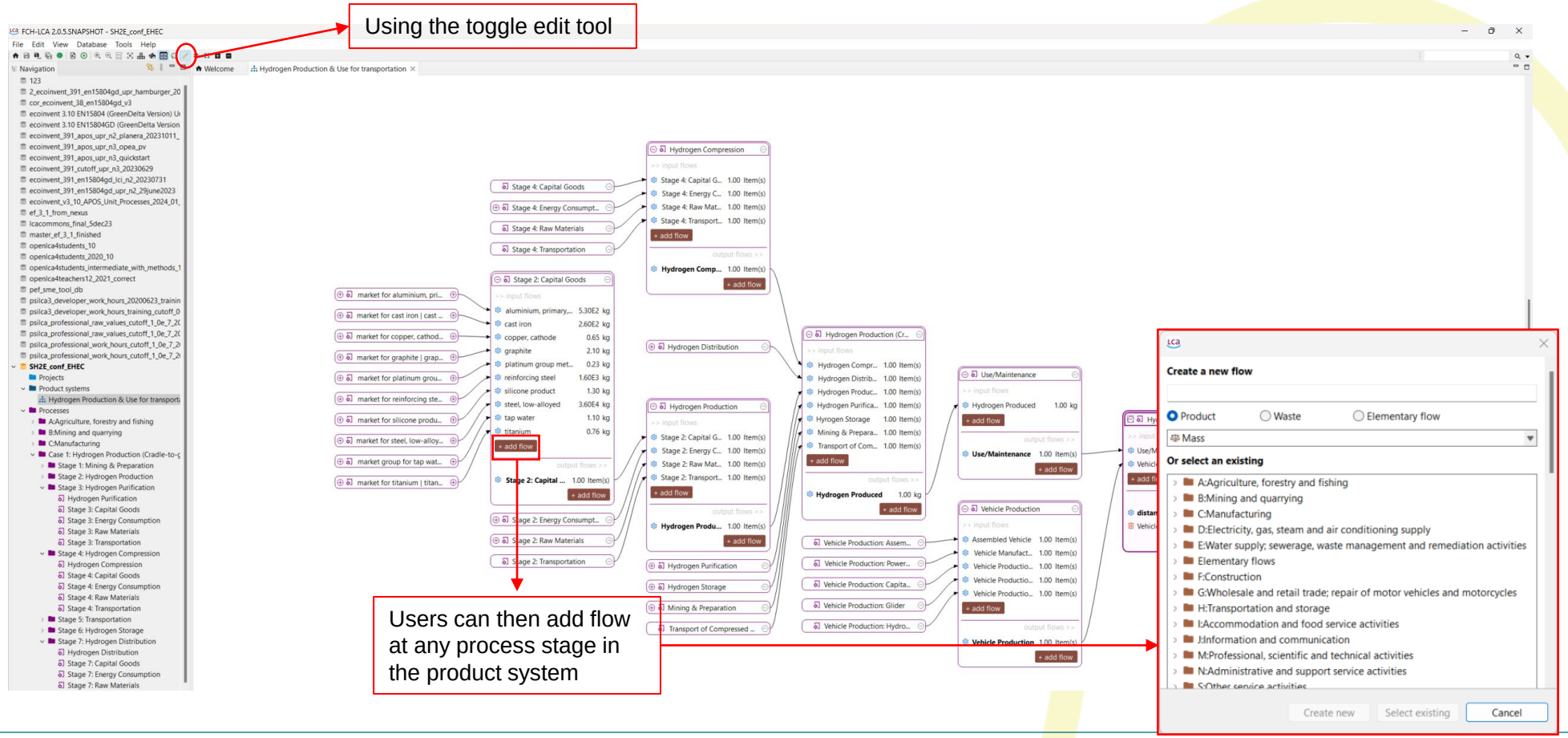
Users simply add the inputs and outputs in the model graph



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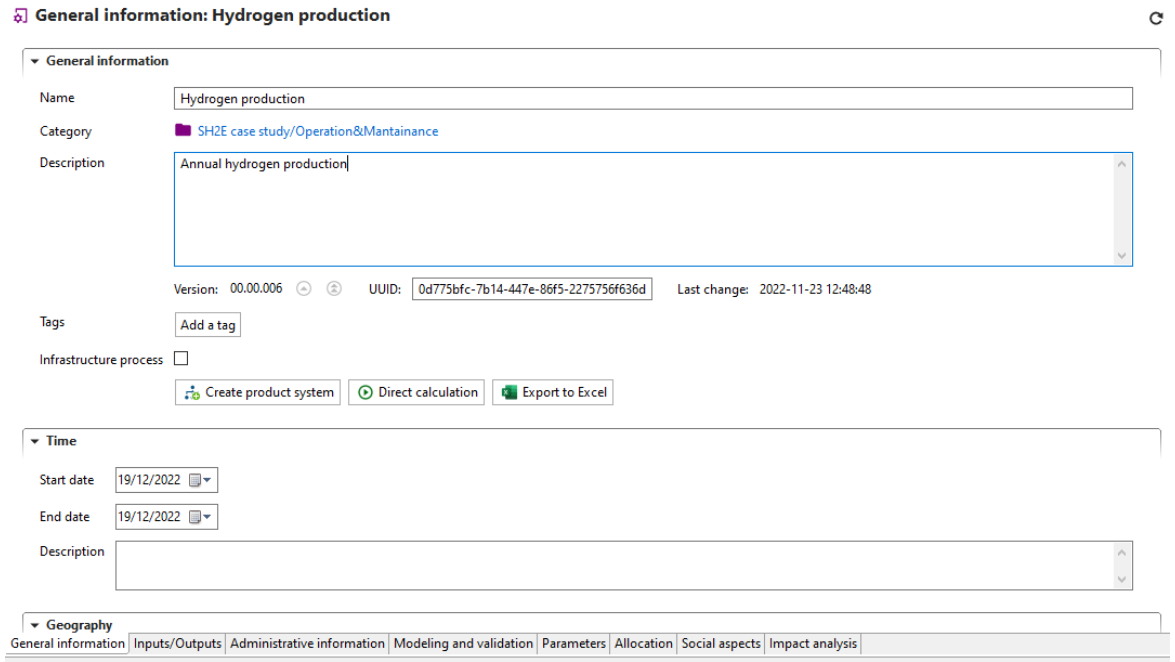
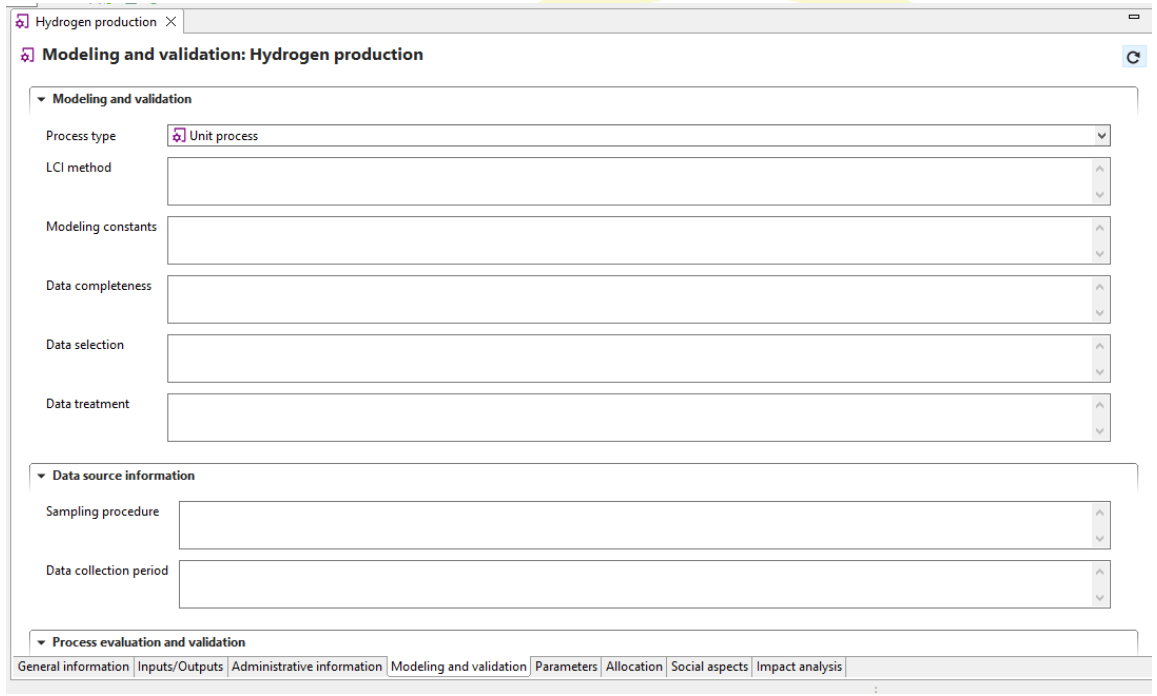
Support for documenting goal and scope and modelling choices





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Users use parameters to set up changeable inputs or create equations

Parameters: Vehicle Production: Hydrogen Tank

Global parameters

Name	Value	Uncertainty	Description
discount_rate	0.05	none	discount rate per period of time
time2	1.0	none	number of discount periods

Input parameters

Name	Value	Uncertainty	Description
density_naturalgas	0.65	none	kg/m3

Inputs

Flow	Category	Amount	Unit	Costs/Revenues
tap water	360:Water collection, treatment and supply/3600:Water co...	3.4200057	kg	10 / ((1 + discount_rate)^time2) USD
price		10 / ((1 + discount_rate)^time2)	USD 2002	

Inputs/Outputs: Vehicle Production: Hydrogen Tank

Inputs

Flow	Category	Amount	Unit
Composite material - carbon fiber		70.50000	kg
compressed air, 1000 kPa gauge	201:Manufacture of basic chemicals, fertilizers and n...	0.13836	m3
electricity, low voltage	351:Electric power generation, transmission and distr...	791.77800	MJ
electricity, low voltage	351:Electric power generation, transmission and distr...	1.60179	kWh
epoxy resin, liquid	201:Manufacture of basic chemicals, fertilizers and n...	24.20510	kg
injection moulding	222:Manufacture of plastics products/2220:Manufac...	7.00607	kg
metal working, average for metal product manufa...	25:Manufacture of fabricated metal products, except...	0.83571	kg
natural gas, high pressure	B:Mining and quarrying/06:Extraction of crude petro...	0.696/density_naturalgas	m3
polyethylene, high density, granulate	201:Manufacture of basic chemicals, fertilizers and n...	7.73779	kg
transport, freight, lorry 3.5-7.5 metric ton, EURO5	492:Other land transport/4923:Freight transport by r...	1.54793	t*km

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Multifunctionality in the SH2E FCH-LCA tool

Inputs/Outputs: SH2E Hydrogen production Germany (System expansion)

Inputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty	Avoided waste	Provider	Data quality entry	Location	Description
aluminium, primary, ingot	242:Manufacture of basic precious and oth...	3500.00000	kg		none		market for alumi...	(1; 2; 3; 4; 1)		
concrete, normal strength	239:Manufacture of non-metallic mineral p...	1300000/concrete_d...	m3		none		concrete, all typ...	(1; 2; 3; 4; 1)		
electricity, medium voltage	D:Electricity, gas, steam and air conditionin...	1.12500E8	kWh		none		market for electr...	(1; 2; 3; 1; 1)		
metal working, average for copper produ...	25:Manufacture of fabricated metal produc...	300.00000	kg		none		market for metal...	(1; 2; 3; 4; 2)		copper
natural gas, high pressure	B:Mining and quarrying/06:Extraction of cr...	88875000000/NG_h...	m3		none		market for natur...	(1; 1; 3; 1; 1)		
nickel, class 1	242:Manufacture of basic precious and oth...	300.00000	kg		none		market for nickel...	(1; 2; 3; 4; 1)		
steel, chromium steel 18/8	241:Manufacture of basic iron and steel/24...	6.00000E4	kg		none		market for steel, ...	(1; 2; 3; 4; 3)		steel, high alloy
steel, low-alloyed	241:Manufacture of basic iron and steel/24...	1.00000E5	kg		none		market for steel, ...	(1; 2; 3; 4; 1)		
steel, unalloyed	241:Manufacture of basic iron and steel/24...	2.40000E5	kg		none		market for steel, ...	(1; 2; 3; 4; 1)		
tap water	360:Water collection, treatment and supply...	8.10000E9	kg		none		market for tap w...	(1; 2; 3; 2; 1)		
zinc	242:Manufacture of basic precious and oth...	300.00000	kg		none		market for zinc | ...	(1; 2; 3; 4; 2)		

Outputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty	Avoided product	Provider	Data quality entry	Location	Description
SH2E Hydrogen (to conditionning and ...		**5.62500E8**	**kg**	**1.08000E9 EUR**	**none**					
steam, in chemical industry	*201:Manufacture of basic chemicals, fertiliz...*	*2.98125E9*	*kg*	*4.47000E7 EUR*	*none*	☑	*market for steam...*	*(1; 2; 3; 3; 2)*		
Carbon dioxide, fossil	Emission to air/unspecified	4.80938E9	kg		none			(1; 2; 5; 5; 1)		
Carbon monoxide, fossil	Emission to air/unspecified	6.18750E5	kg		none			(1; 2; 5; 5; 1)		
Methane, fossil	Emission to air/unspecified	1.02375E6	kg		none			(1; 2; 5; 5; 1)		
Nitrogen oxides	Emission to air/unspecified	1.29375E6	kg		none			(1; 2; 5; 5; 1)		
NMVOC, non-methane volatile organic c...	Emission to air/unspecified	1.91250E6	kg		none			(1; 2; 5; 5; 2)		NMHC Proxy
Particulate Matter, < 2.5 um	Emission to air/unspecified	1.23750E4	kg		none			(1; 2; 5; 5; 1)		
Sulfur oxides	Emission to air/unspecified	6.18750E4	kg		none			(1; 2; 5; 5; 1)		

When there is more than one product output

Users can do allocation based on physical, economic, energy

Users can also do system expansion

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Multifunctionality in the SH2E FCH-LCA tool

Users can see the allocation factors in the allocation tab

Allocation: SH2E Hydrogen production Germany

Default method: Causal — Calculate factors

Physical & economic allocation

Product	Physical	Economic
SH2E Hydrogen (to conditionning and dispensing) [562500000.00 kg]	0.15873015873015872	0.9602560682848761
steam, in chemical industry [2981250000.00 kg]	0.8412698412698413	0.03974393171512403
Σ	**1.00000**	**1.00000**

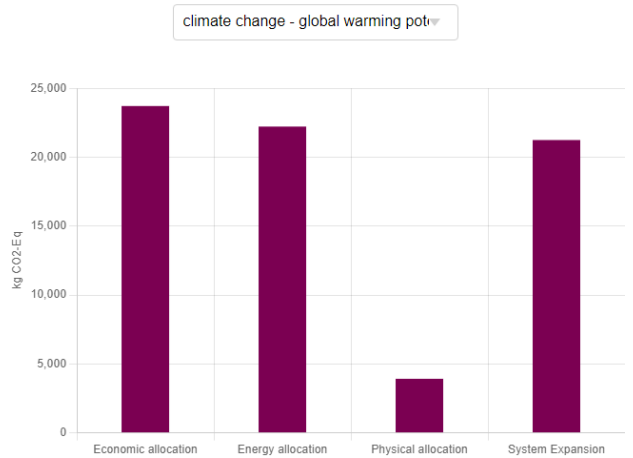
Causal allocation

Flow	Direction	Category	Amount	SH2E Hydr...	steam, in c...	Σ
natural gas, high pressure	Input	B:Mining and quarrying/06...	2.46875E9 m3	0.89987978...	0.10012021...	**1.00000**
steel, unalloyed	Input	241:Manufacture of basic ir...	2.40000E5 kg	0.89987978...	0.10012021...	**1.00000**
steel, low-alloyed	Input	241:Manufacture of basic ir...	1.00000E5 kg	0.89987978...	0.10012021...	**1.00000**
tap water	Input	360:Water collection, treat...	8.10000E9 kg	0.89987978...	0.10012021...	**1.00000**
electricity, medium voltage	Input	D:Electricity, gas, steam an...	1.12500E8 kWh	0.89987978...	0.10012021...	**1.00000**
concrete, normal strength	Input	239:Manufacture of non-m...	5.41667E5 m3	0.89987978...	0.10012021...	**1.00000**
metal working, average for copper product manufacturing	Input	25:Manufacture of fabricat...	300.00000 kg	0.89987978...	0.10012021...	**1.00000**
steel, chromium steel 18/8	Input	241:Manufacture of basic ir...	6.00000E4 kg	0.89987978...	0.10012021...	**1.00000**
zinc	Input	242:Manufacture of basic p...	300.00000 kg	0.89987978...	0.10012021...	**1.00000**
nickel, class 1	Input	242:Manufacture of basic p...	300.00000 kg	0.89987978...	0.10012021...	**1.00000**
aluminium, primary, ingot	Input	242:Manufacture of basic p...	3500.00000 kg	0.89987978...	0.10012021...	**1.00000**
Carbon dioxide, fossil	Output	Emission to air/unspecified	4.80938E9 kg	0.89987978...	0.10012021...	**1.00000**
NMVOC, non-methane volatile organic compounds	Output	Emission to air/unspecified	1.91250E6 kg	0.89987978...	0.10012021...	**1.00000**
Carbon monoxide, fossil	Output	Emission to air/unspecified	6.18750E5 kg	0.89987978...	0.10012021...	**1.00000**
Particulate Matter, < 2.5 um	Output	Emission to air/unspecified	1.23750E4 kg	0.89987978...	0.10012021...	**1.00000**
Methane, fossil	Output	Emission to air/unspecified	1.02375E6 kg	0.89987978...	0.10012021...	**1.00000**
Nitrogen oxides	Output	Emission to air/unspecified	1.29375E6 kg	0.89987978...	0.10012021...	**1.00000**
Sulfur oxides	Output	Emission to air/unspecified	6.18750E4 kg	0.89987978...	0.10012021...	**1.00000**

Compare the different allocations using Project-report feature

Variant comparison

The chart below compares the results of the different project variant for the selected indicator. You can change the selection and the chart is dynamically updated.



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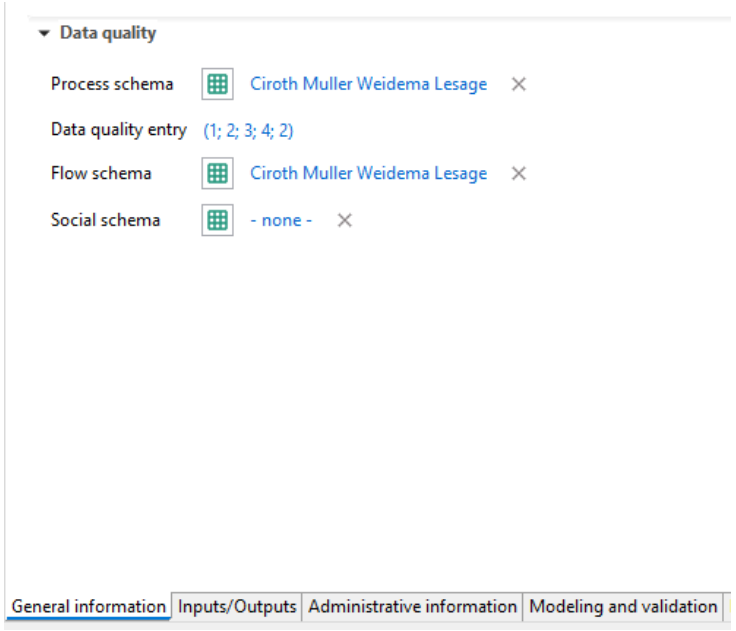
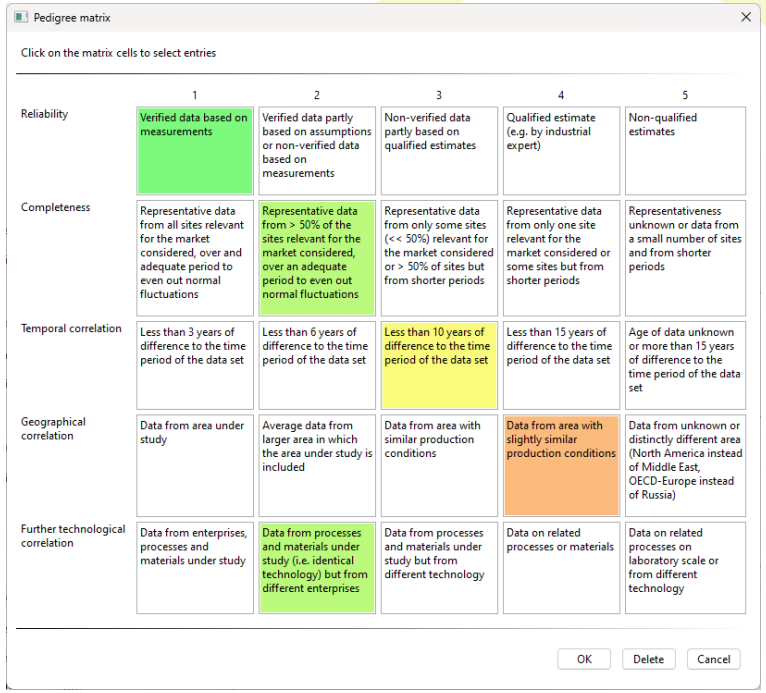
Data quality documentation and assessment





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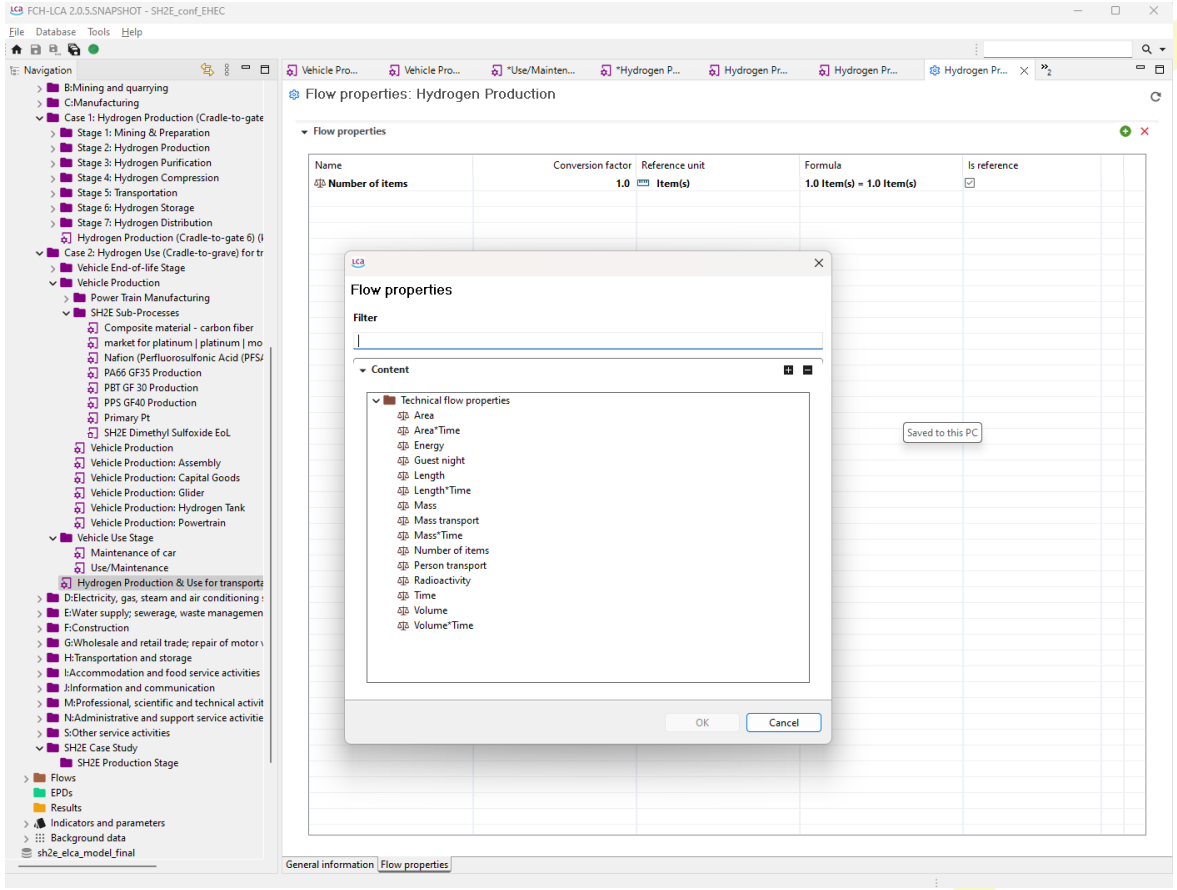
Users can also alter the defined Flow properties of the processes



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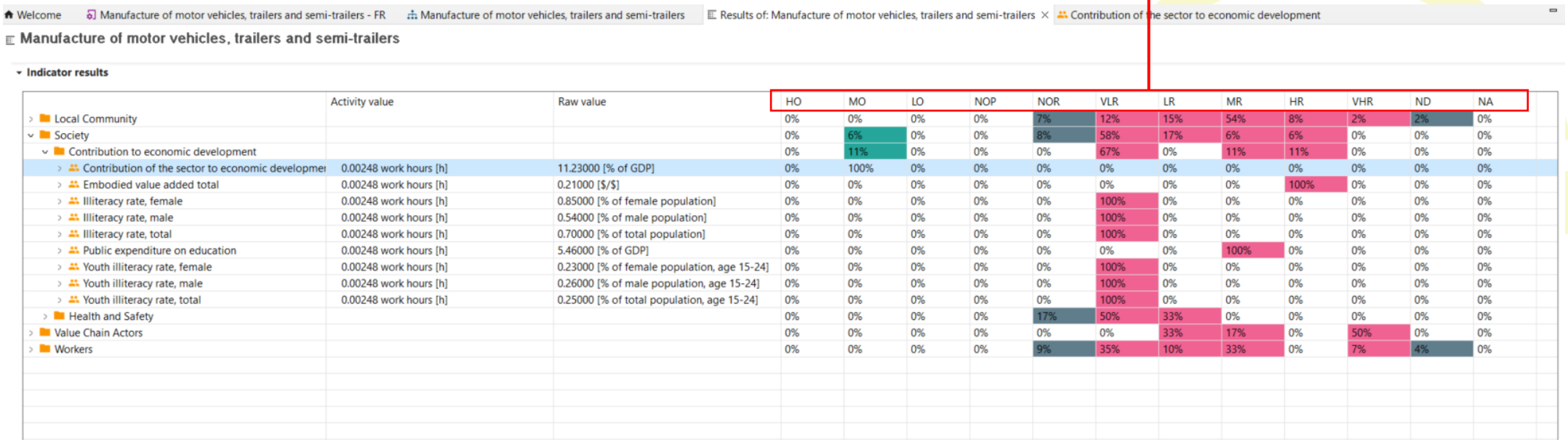
Special features: Social Assessment

Risk Level Scale



Welcome | Manufacture of motor vehicles, trailers and semi-trailers - FR | Manufacture of motor vehicles, trailers and semi-trailers | Results of: Manufacture of motor vehicles, trailers and semi-trailers | Contribution of the sector to economic development

Manufacture of motor vehicles, trailers and semi-trailers

Indicator results

	Activity value	Raw value	HO	MO	LO	NOP	NOR	VLR	LR	MR	HR	VHR	ND	NA
Local Community			0%	0%	0%	0%	7%	12%	15%	54%	8%	2%	2%	0%
Society			0%	6%	0%	0%	8%	58%	17%	6%	6%	0%	0%	0%
Contribution to economic development			0%	11%	0%	0%	0%	67%	0%	11%	11%	0%	0%	0%
Contribution of the sector to economic developmer	0.00248 work hours [h]	11.23000 [% of GDP]	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Embodied value added total	0.00248 work hours [h]	0.21000 [$/$]	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
Illiteracy rate, female	0.00248 work hours [h]	0.85000 [% of female population]	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Illiteracy rate, male	0.00248 work hours [h]	0.54000 [% of male population]	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Illiteracy rate, total	0.00248 work hours [h]	0.70000 [% of total population]	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Public expenditure on education	0.00248 work hours [h]	5.46000 [% of GDP]	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%
Youth illiteracy rate, female	0.00248 work hours [h]	0.23000 [% of female population, age 15-24]	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Youth illiteracy rate, male	0.00248 work hours [h]	0.26000 [% of male population, age 15-24]	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Youth illiteracy rate, total	0.00248 work hours [h]	0.25000 [% of total population, age 15-24]	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Health and Safety			0%	0%	0%	0%	17%	50%	33%	0%	0%	0%	0%	0%
Value Chain Actors			0%	0%	0%	0%	0%	0%	33%	17%	0%	50%	0%	0%
Workers			0%	0%	0%	0%	9%	35%	10%	33%	0%	7%	4%	0%

HO – High opportunity
MO – Medium opportunity
LO – Low opportunity
NOP - No Opportunity

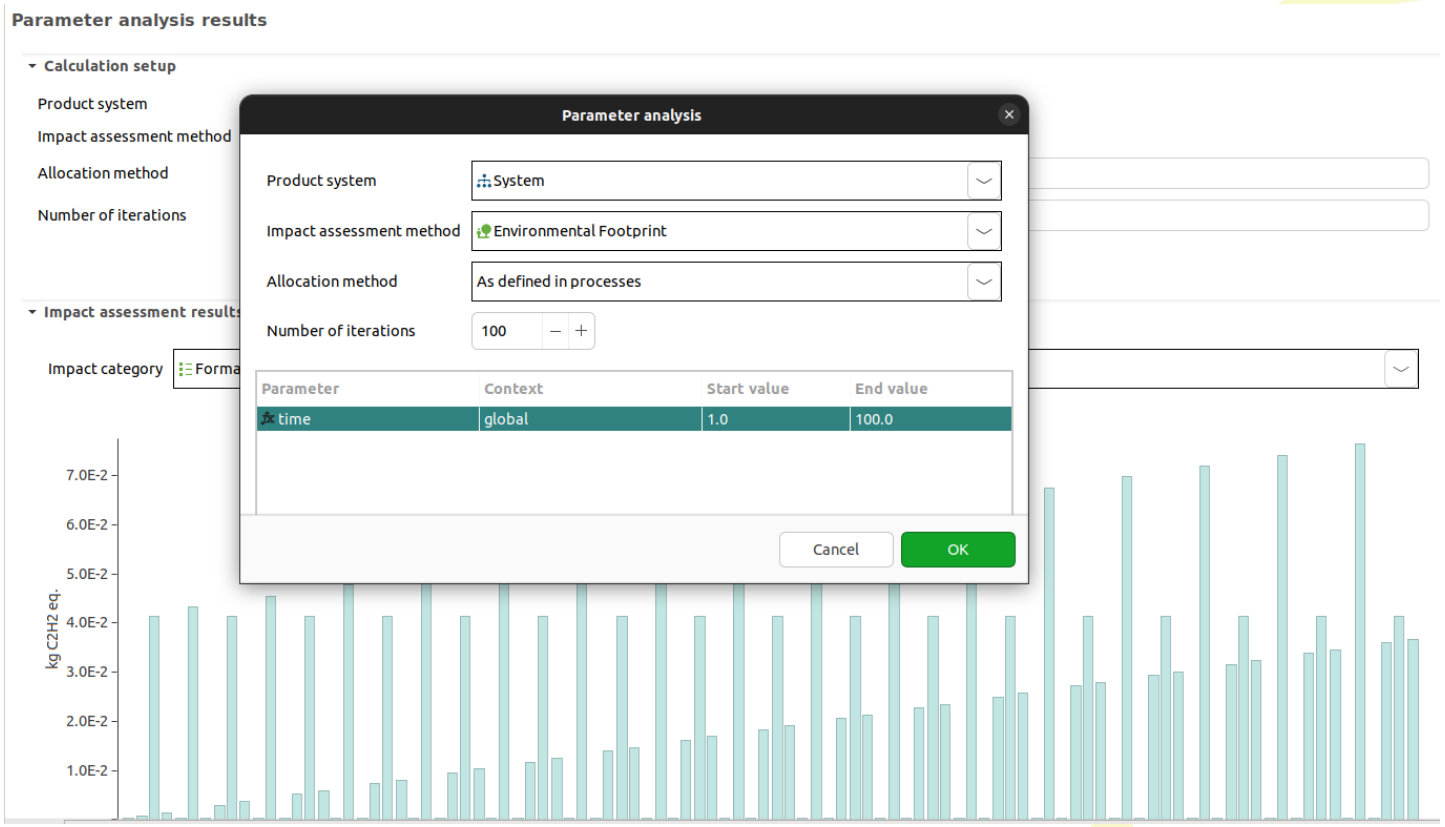
NOR– No Risk
VLR – Very Low Risk
LR – Low risk
MR - Medium Risk
HR – High Risk

VHR– Very High Risk
ND – No Data
NA – Not applicable

Co-funded by the European Union
Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007163. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Special features: Time variable



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SH2E

Conclusions

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Conclusions

Based on openLCA, a powerful tool has been created, open source and free to use, with the aim to fully reflect the SH2E guidelines and to support users in applying them.

We hope this is useful for the community. Feedback welcome.

Some of the implemented features are already integrated in the latest openLCA release as well (social calculation), some will come (time), and some are probably interesting also beyond openLCA (templates), in the context of EPDs and Environmental Footprint.

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SH2E

SUSTAINABILITY ASSESSMENT OF HARMONISED HYDROGEN ENERGY SYSTEMS

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