

**Grant No. 101007163**

Project start date: 01.01.2021  
Project duration: 42 months  
Project Coordinator: IMDEA Energy

# D4.3 Extended life-cycle tools

## WP4 Harmonised extension to Life Cycle Costing and Social Life Cycle Assessment User Manual

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<b>STATUS</b>	F
<b>DISSEMINATION LEVEL</b>	PU
<b>DELIVERABLE TYPE</b>	OTHER
<b>DUE DATE</b>	XX/XX/XX (MXX)

**DRAFT**



*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 programme, Hydrogen Europe and Hydrogen Europe Research.*

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## EXECUTIVE SUMMARY

Designed to support LCA practitioners, the FCH-LCA tool is a powerful solution that enables precise calculations of environmental LCA, social LCA, and Life Cycle Costing, all in accordance with the comprehensively developed SH2E guidelines. The objective is to facilitate the application of these meticulously developed guidelines, ensuring the production of consistent and reliable results that can be readily interpreted and compared across various hydrogen systems. The FCH-LCA tool offers pre-set templates to streamline the initiation of projects, while also providing flexibility for modelers to create their own intrinsic models tailored to their specific case studies. With the FCH-LCA tool, LCA practitioners can confidently analyze the sustainability impact of hydrogen projects, saving time and effort by leveraging industry best practices and established benchmarks. The FCH-LCA tool is an add-on to openLCA software. This document provides installation guidance and acts as a manual to the FCH-LCA tool. Users are strongly recommended to also check the openLCA manual for understanding openLCA software.

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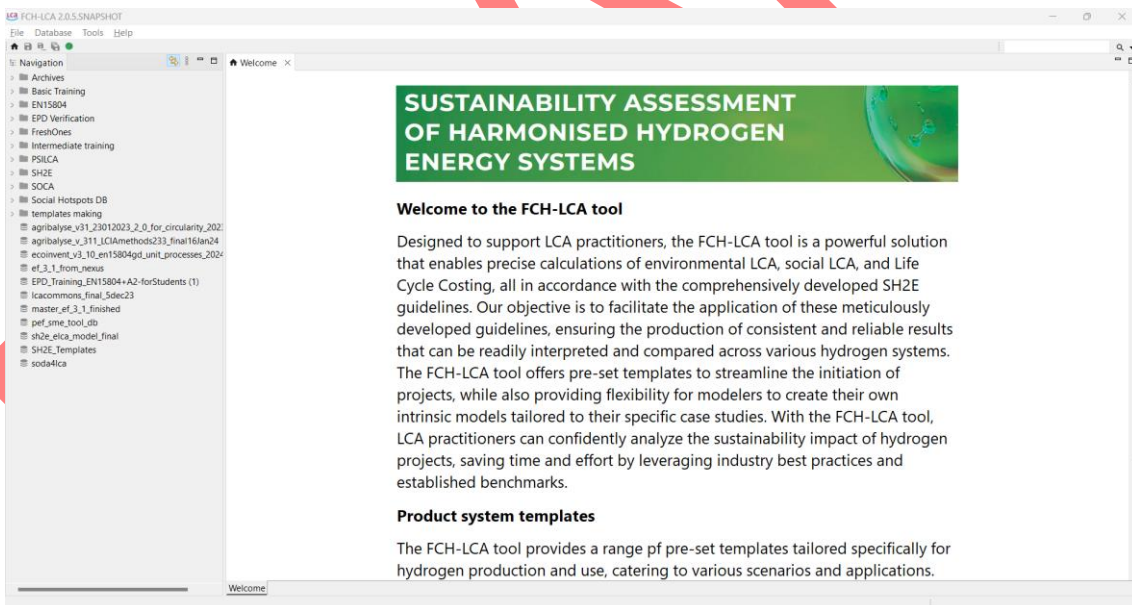
## Installing the FCH-LCA

The tool can be installed by unzipping the file and then running the execution file as seen in Figure 1 from this link: <https://share.greendelta.com/index.php/s/R3uc0nuziZt6cGV/download>.

Name	Date modified	Type	Size
bin	5/20/2024 6:09 AM	File folder	
configuration	5/28/2024 4:09 PM	File folder	
jre	5/20/2024 6:09 AM	File folder	
olca-mkl-x64_v1	5/20/2024 6:09 AM	File folder	
plugins	5/20/2024 6:11 AM	File folder	
.eclipseproduct	5/20/2024 6:09 AM	ECLIPSEPRODUCT ...	1 KB
about.html	5/20/2024 6:09 AM	Microsoft Edge HT...	436 KB
derby.log	6/14/2024 3:35 PM	Text Document	2 KB
<b>FCH-LCA.exe</b>	5/20/2024 6:09 AM	Application	521 KB
FCH-LCA.ini	5/28/2024 4:08 PM	Configuration setti...	1 KB
workbench.xml	5/28/2024 4:14 PM	XMI File	74 KB

Figure 1 Tool installing

Users will then be guided to the following welcome page - Figure 2.



**SUSTAINABILITY ASSESSMENT OF HARMONISED HYDROGEN ENERGY SYSTEMS**

**Welcome to the FCH-LCA tool**

Designed to support LCA practitioners, the FCH-LCA tool is a powerful solution that enables precise calculations of environmental LCA, social LCA, and Life Cycle Costing, all in accordance with the comprehensively developed SH2E guidelines. Our objective is to facilitate the application of these meticulously developed guidelines, ensuring the production of consistent and reliable results that can be readily interpreted and compared across various hydrogen systems. The FCH-LCA tool offers pre-set templates to streamline the initiation of projects, while also providing flexibility for modelers to create their own intrinsic models tailored to their specific case studies. With the FCH-LCA tool, LCA practitioners can confidently analyze the sustainability impact of hydrogen projects, saving time and effort by leveraging industry best practices and established benchmarks.

**Product system templates**

The FCH-LCA tool provides a range of pre-set templates tailored specifically for hydrogen production and use, catering to various scenarios and applications.

Figure 2 Welcome page FCH-LCA tool

## Completing the wizard

To access the wizard and the templates, users must have an active database as seen in Figure 3. It is important to understand the database elements and structure – to do so, it is recommended to refer back to the openLCA manual.

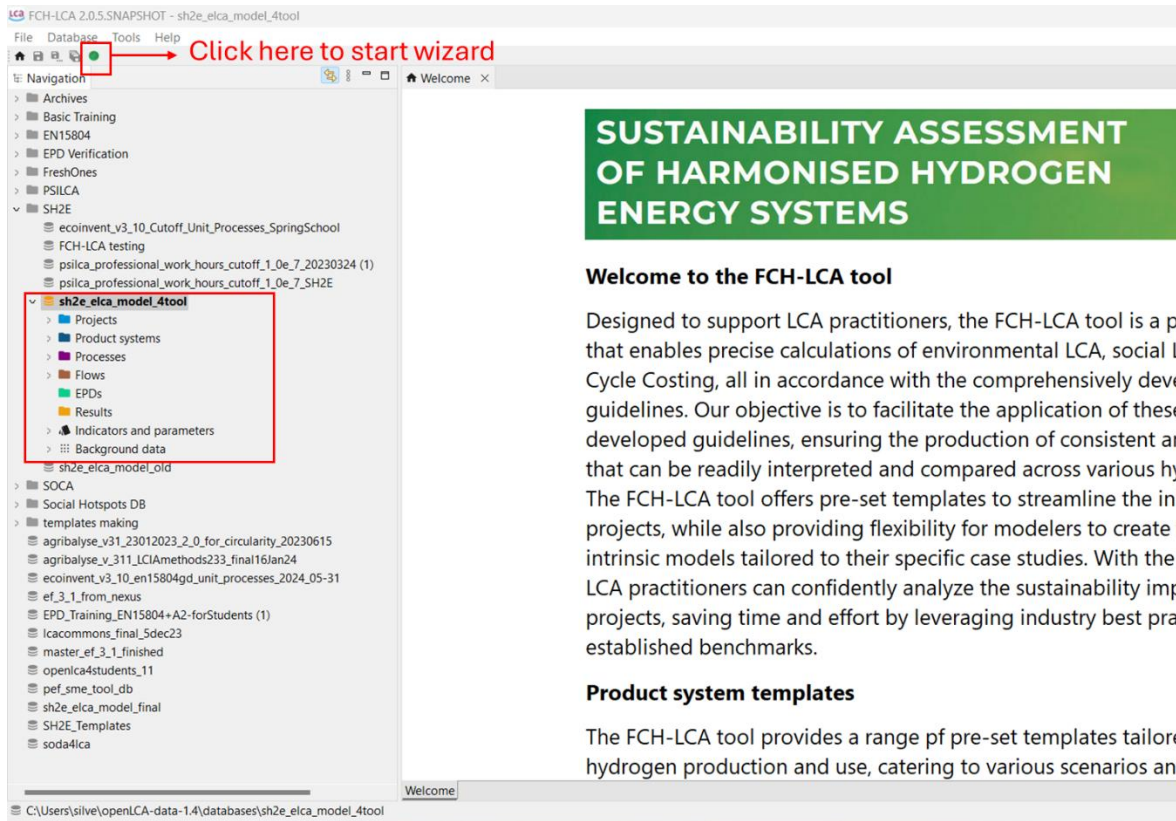


Figure 3 Starting the wizard

Once the user starts the wizard, a pop-up window shall appear (Figure 4) where users shall go through it by selecting the appropriate decision. It is recommended that users should refer to the FCH-LCA guidelines as they go through the wizard to better understand the questions posed.

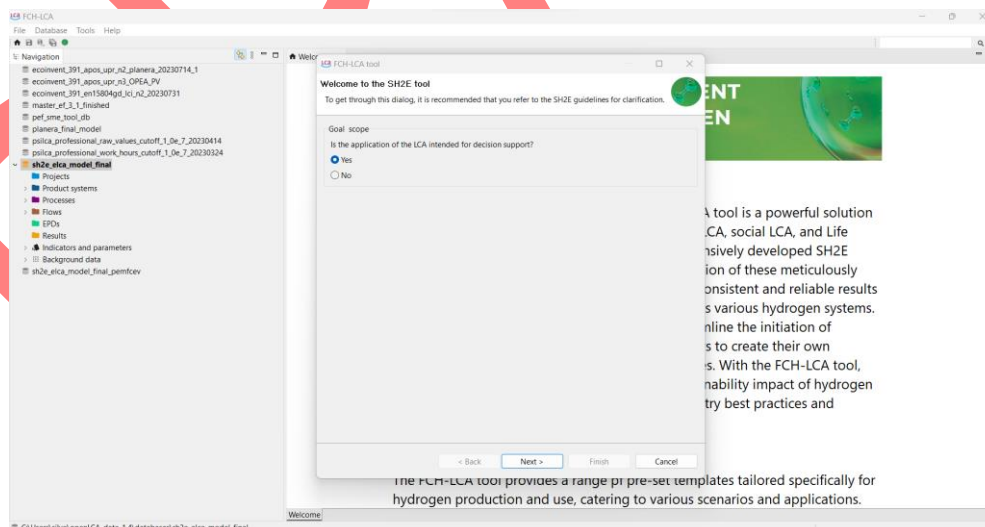


Figure 4 Wizard pop-up window

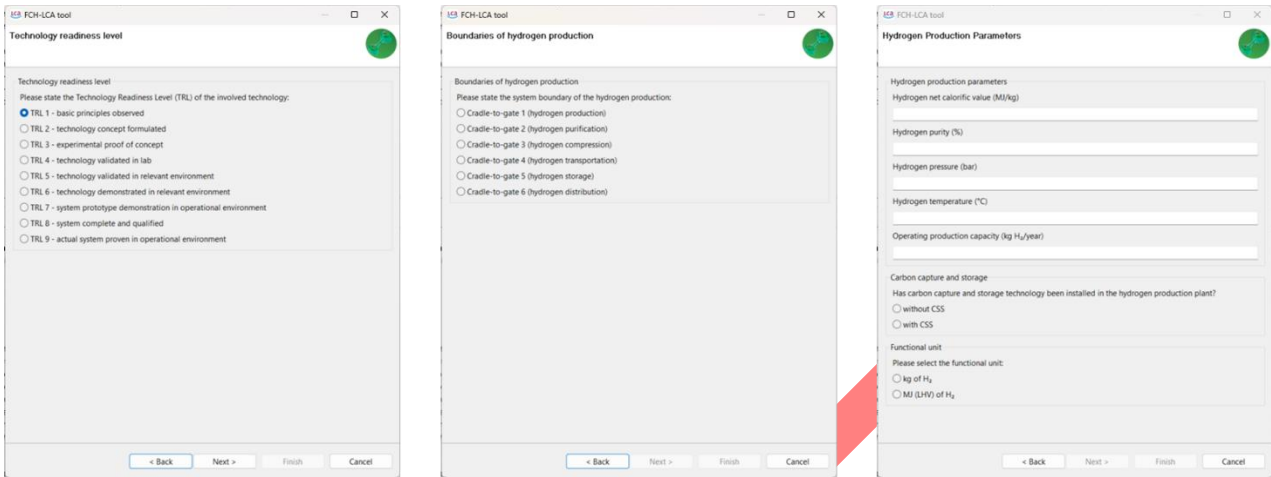


Figure 5 Wizard questions

Based on the selection made by the users, the users shall be guided to a certain template option as seen in Figure 6.

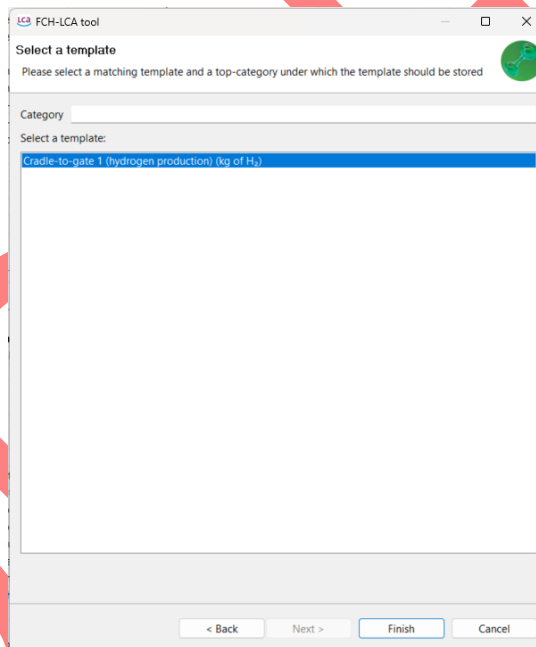


Figure 6 Template decision based on wizard selection

Once the template is selected and users click on 'Finish', a product system will be created based on the selected template. The user responses through the wizard can be seen under 'FCH-LCA Properties' in the 'General Information' tab as seen in Figure 7. Moving to the 'modal graph' the users will be able to see the overview of structure of the product system template.



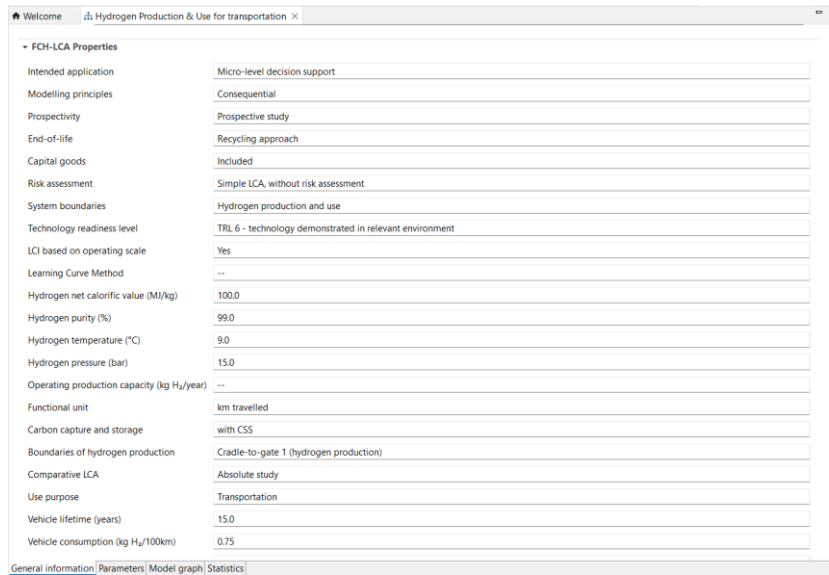


Figure 7 FCH-LCA Properties

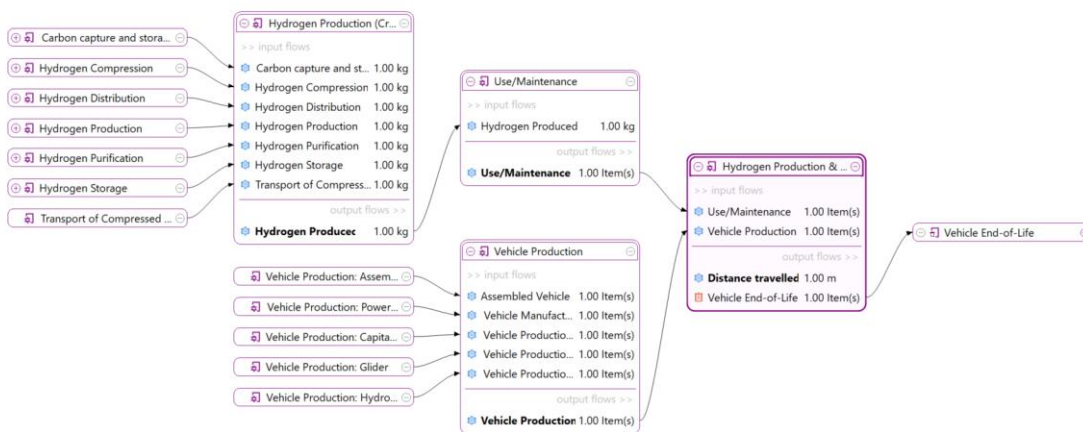


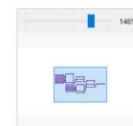
Figure 8 Product system of hydrogen production and use for vehicle

## Template structure

In general, the pre-set templates are split into three main categories:

1. Case 1: Hydrogen Production
2. Case 2: Hydrogen Use
3. Case 3: Hydrogen Production and Use

For Case 1: Hydrogen Production, there are up to 6 main stages, as seen in Figure 9:



1. Hydrogen Production
2. Hydrogen Purification
3. Hydrogen Compression
4. Hydrogen Transportation
5. Hydrogen Storage
6. Hydrogen Distribution

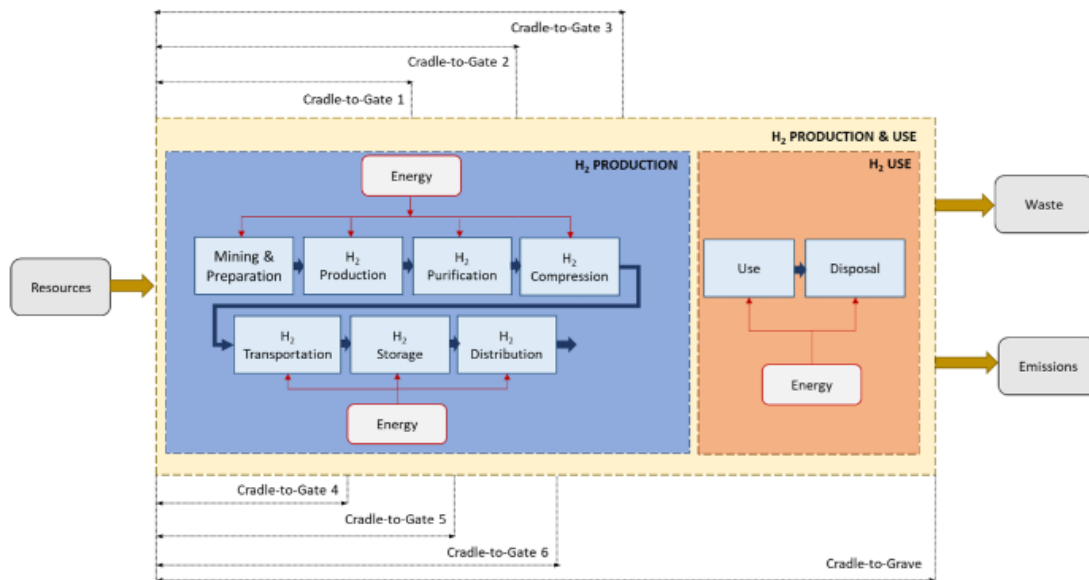


Figure 9 Foreground phases for studies assessing FCH systems

Accordingly, 6 main child categories are created, with each containing the following processes (1) Capital Goods, (2) Energy Consumption, (3) Raw Materials, and (4) Transportation. This can be seen in Figure 10. The point behind the classification is to later facilitate the interpretation of results and covering all LCA data requirements.

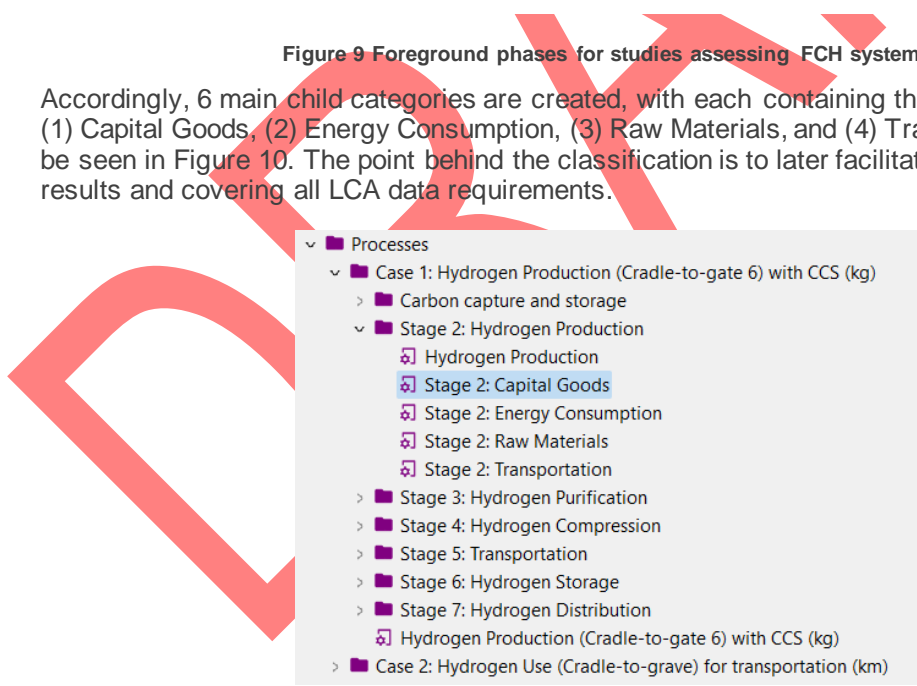
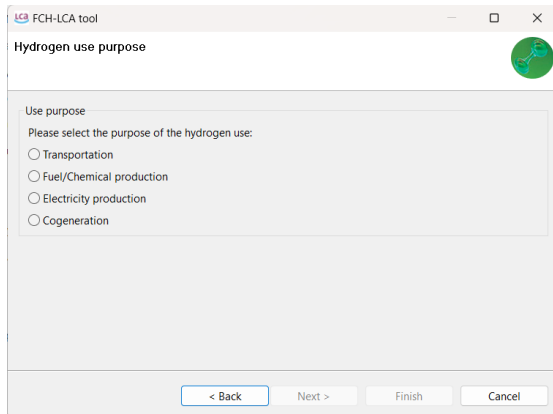


Figure 10 Breakdown of processes

### For Case 1: Hydrogen Production stages

As for case 2: Hydrogen use, there are 3 main uses identified in the manual (1) transportation (2) fuels and chemicals production and (3) electricity and/or heat generation. Accordingly, similar approach has been taken to divide the templates as seen Figure 11.



**Figure 11 Hydrogen use cases**

In the transportation use case, the template is split into the following main processes:

1. Vehicle Use/Maintenance
  - a. The hydrogen production from cradle-to-gate 6 is included
2. Vehicle Production
3. Vehicle End-of-Life

In the Fuel/chemical production use case, the template is split into the following main processes:

1. Upstream process including – raw materials, energy consumed by raw materials extraction (if any), transport to gate, capital goods
2. Core process including – auxiliary material, energy consumption, storage
3. Downstream process including distribution of the fuel/chemical produced and use

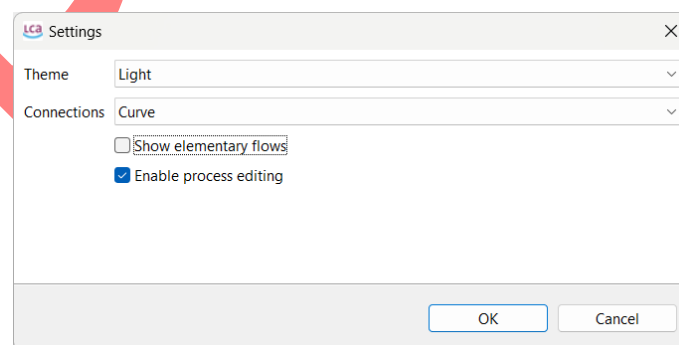
In the electricity generation/cogeneration use case, the template is split into the following main processes:

1. Manufacturing stage
2. Operation stage
3. End of life stage

In all production and use cases, users are free to adjust the processes they would prefer to see their overall results breakdown.

### Completing the pre-set template

Users then should complete the processes by inserting the required input/output flows. Adding/removing flows can be added directly through the model graph by right-clicking on the graph, click on "Settings" and then check "Enable process editing".



**Figure 12 Activated settings in the model graph.**

Then, by clicking on add flow, users can search the flows they wish to add in each process as well as the amount.

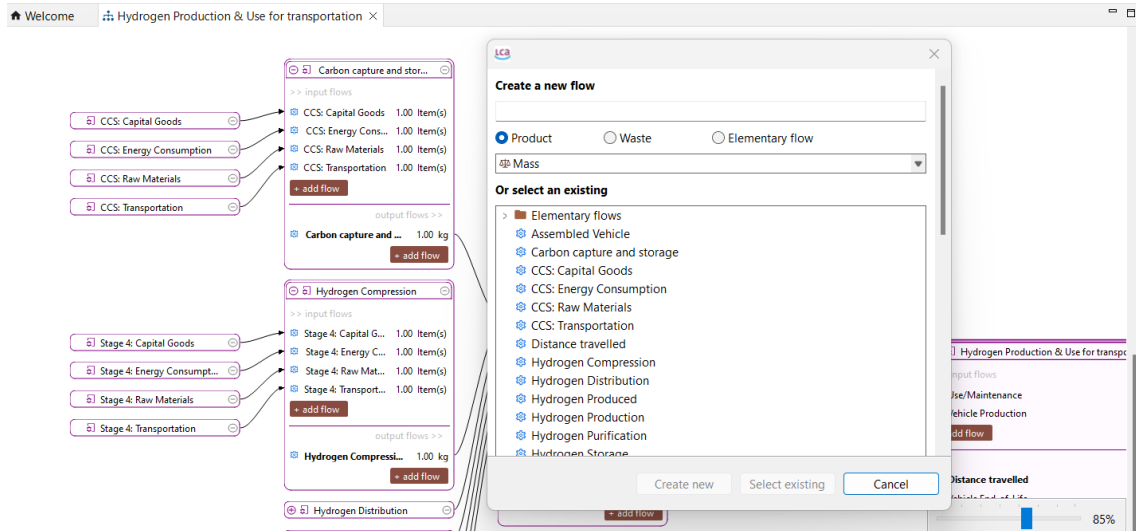


Figure 13 Adding of new flows in model graphs

However, after adding a new flow to a process, you need to add its provider. This can be done by right-clicking on the flow, then "Search providers".

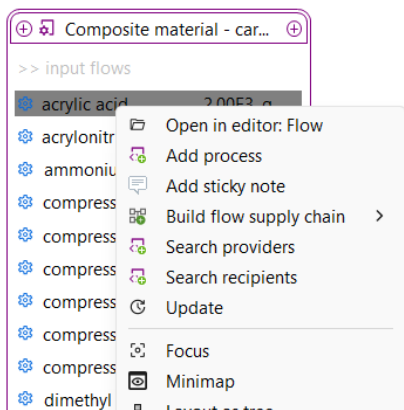


Figure 14 Searching for providers

Alternatively, users can go to the processes of the product system, which can be found under the 'processes' as seen in Figure 15.

After expanding the child category, users can open each process and insert the input/output flows directly by clicking on the green '+' sign on the top left corner. After inserting all the needed flows in each process, users must save their changes before moving on to the next process. Once adding a new flow, users must hover to the 'Provider' and select the convenient provider for the added flow.

**Tip:** users are recommended to close the 'product system' if they want to make changes on the process level – this so the changes in the product system can be also reflected over there.

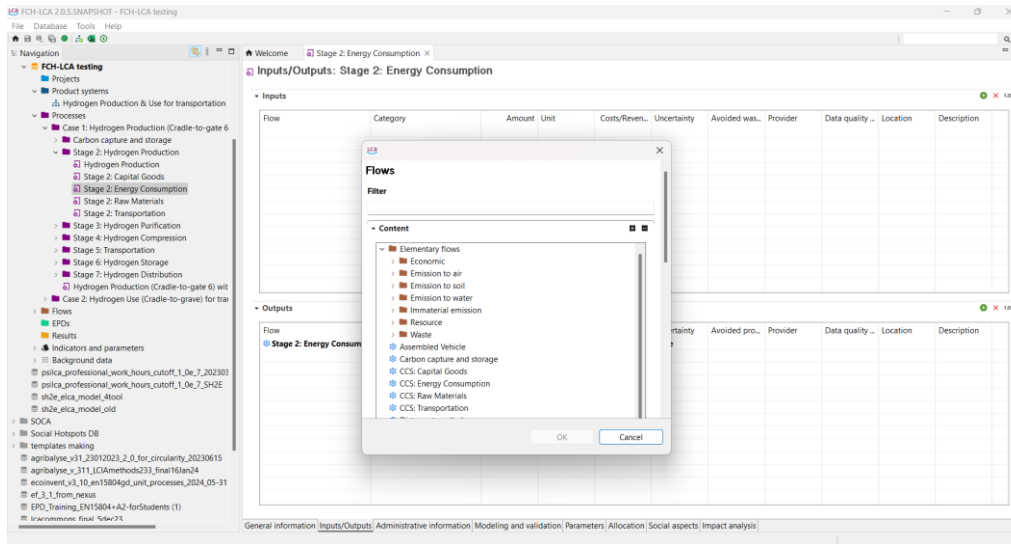


Figure 15 Adding of new flows in the process

## Calculating Results

After adding the new flows into the processes, if users did not do this in the product stage level, they must go back to the product stage, under 'general information' tab and click on calculate as seen Figure 16:

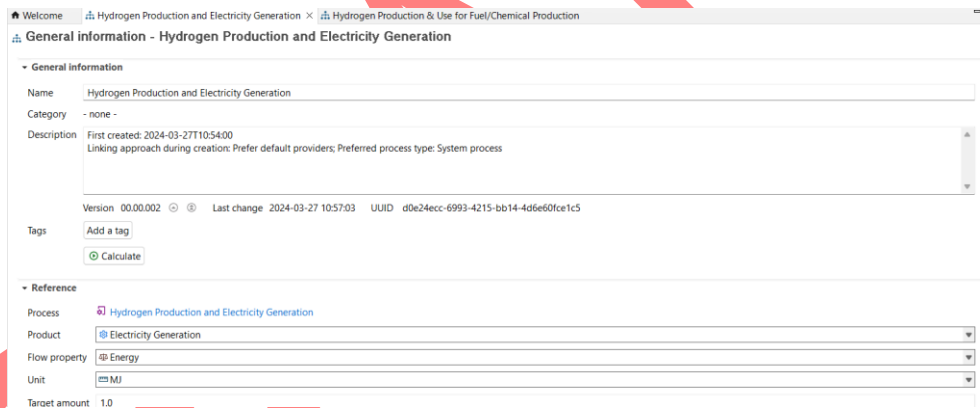


Figure 16 Calculating the results

Results will appear under the results tab seen in Figure 17. To understand the information conveyed in each tab, please refer to the openLCA manual:

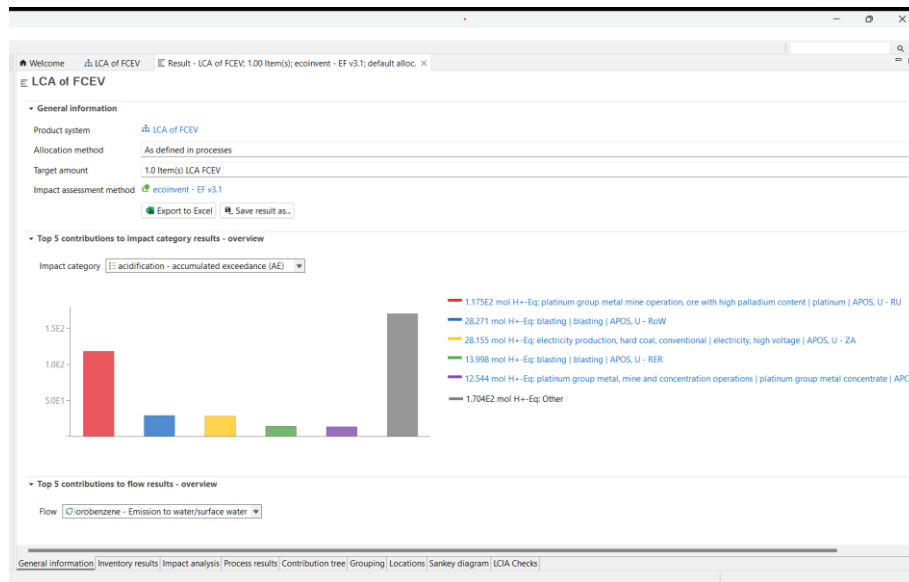


Figure 17 Results of a product system

### Special feature: parameter analysis

Part of the LCC of FCH is to evaluate equations that are time dependent. With this special feature of 'parameter analysis' this can be done. As an example to evaluate the discounting equations, users would follow the following steps:

Step 1: Create a new elementary flow

The 'New flow' dialog box contains the following fields:

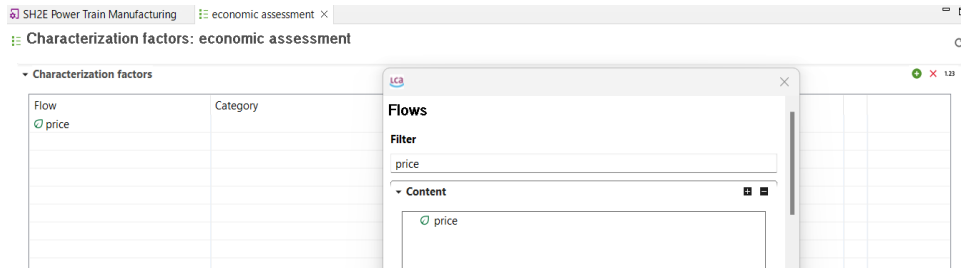
- Name: Present Value
- Description: (empty)
- Flow type: Elementary flow
- Reference flow property: Market value, bulk prices

Step 2: Create a new impact category

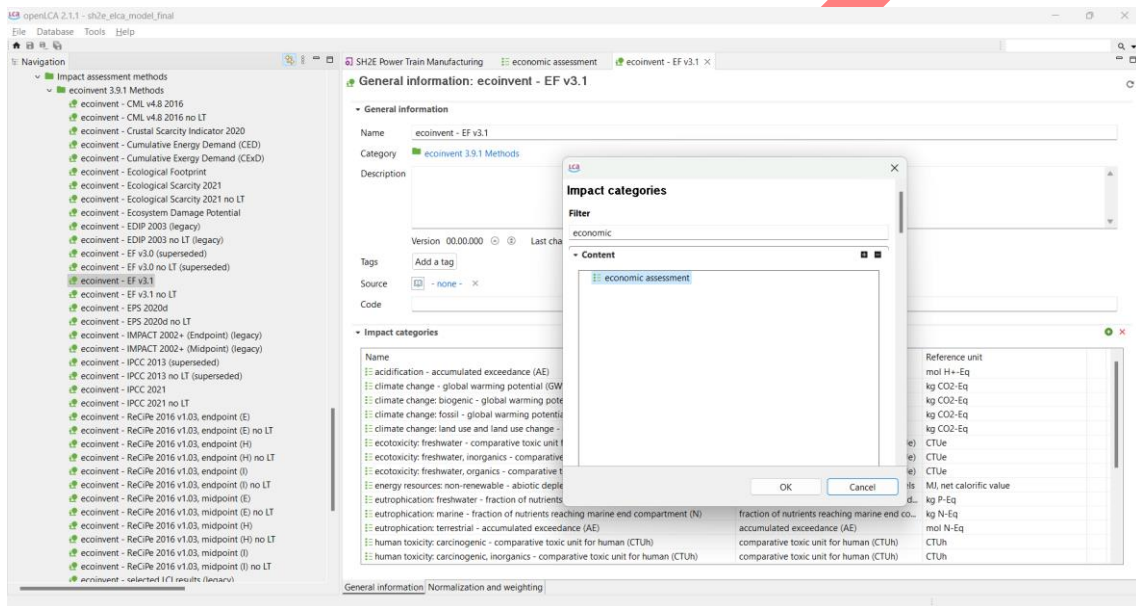
The 'New environmental indicator' dialog box contains the following fields:

- Name: Discounting
- Description: (empty)
- Reference unit: Euro

Step 3: Add the newly created flow into the new impact category:

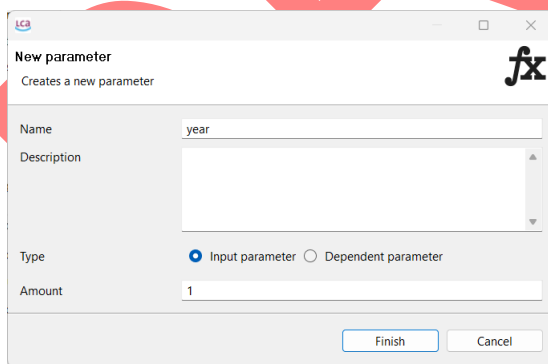


Step 4 Create a new method/add the created category in an existing method or in a new method.



Step 5 Create a new global parameter

Users then select the input parameter option and insert the value of 1 to represent the start year.



Step 6 Set up the equation in the selected process or new process

economic assessment | ecoinvent - EF v3.1 | rate | year | SH2E Hydrogen Production Spain | electricity production, photovoltaic, 570kWp open ground installati...

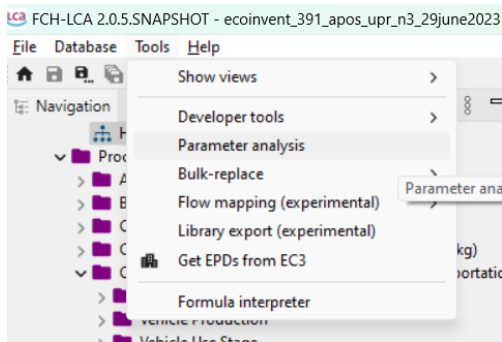
**Inputs/Outputs: SH2E Hydrogen Production Spain**

Inputs

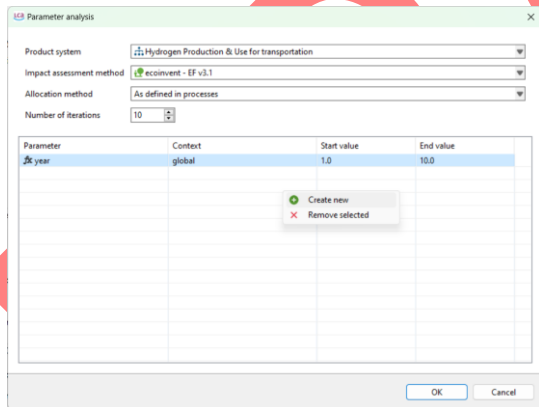
Flow	Category	Amount	Unit	Costs/Reve...	Uncertainty	Avoided w...	Provider	Data qualit...
copper, cathode	242:Manufacture of basic...	0.65000	kg		none		market f...	(1; 2; 3; 4; 2)
electricity, low voltage	351:Electric power gener...	9.00000E7	kWh		none		electricit...	
graphite	089:Mining and quarryin...	2.10000	kg		none		market f...	(1; 2; 3; 4; 1)
Nafion (Perfluorosulfon...		5.80000	kg		none		Nafion (...)	(1; 2; 3; 2; 2)
platinum group metal ...	072:Mining of non-ferrou...	0.23000	kg		none		market f...	(1; 3; 3; 4; 1)
reinforcing steel	241:Manufacture of basic...	1600.00000	kg		none		market f...	(1; 2; 3; 4; 1)
silicone product	201:Manufacture of basic...	1.30000	kg		none		market f...	(1; 2; 3; 4; 1)
steel, low-alloyed	241:Manufacture of basic...	3.60000E4	kg		none		market f...	(1; 2; 3; 3; 1)
tap water	360:Water collection, tre...	1.10000	kg		none		market ...	(1; 2; 3; 2; 3)
tap water	360:Water collection, tre...	3.42000E7	kg		none		market f...	(1; 2; 3; 2; 1)
titanium	242:Manufacture of basic...	0.76000	kg		none		market f...	(1; 2; 3; 3; 1)
price		9.0E7*0.017*(1+rate)^year	EUR 2000					

$$F = P(1 + r)^n$$

Step 6 Got to -> tools -> parameter analysis



Step 7 Add the parameter and adjust end value (eg. 10 iterations = 10 years)

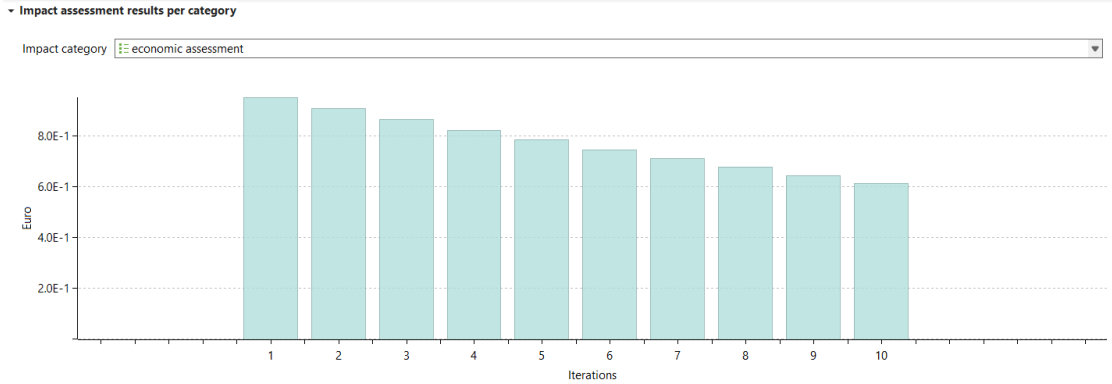


Results can then be seen in tabular and graphical form. The results can be exported via excel.



▼ Impact assessment results

Impact category	1	2	3	4	5	6	7	8
economic assessment (Euro)	0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67689



A full tutorial can be found on youtube on the openLCA channel!

### Direct approach SLCA on openLCA

In SLCA, results are usually viewed in the form of medium risk hours which is based on the social impact assessment method. The direct approach method<sup>2</sup> was previously implemented as a Python script to perform direct calculation of social indicators. Instead, you can now view this type of calculation directly under the “Social Assessment” tab after calculating your results. To activate this new feature, go to “File” → “Preferences” → “Experimental Features” → check “New Social Impact Assessment.” Then, restart your software for the changes to take effect. Results can also be exported by simply right-clicking anywhere in the page seen below and clicking on “export to excel”.

☰ Manufacture of food products and beverages; Manufacture of tobacco products - RU

▼ Indicator results

Indicator	Activity value	Raw value	HO	MO	LO	NOP	NOR	VLR	LR	MR	HR	VHR	ND	NA
Local Community			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Access to material resources			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Certified environmental management	0.08630 work hours [h]	17.79960 [# of CEMS per 10000 em...	0%	0%	0%	0%	0%	56%	15%	14%	2%	12%	2%	0%
Extraction of biomass (related to aree	0.08630 work hours [h]	67.01319 [annual t/km2]	0%	0%	0%	0%	0%	54%	17%	4%	9%	1%	15%	0%
Extraction of biomass (related to pop	0.08630 work hours [h]	4.48392 [annual t/cap]	0%	0%	0%	0%	0%	95%	2%	1%	1%	0%	0%	0%
Extraction of fossil fuels	0.08630 work hours [h]	8.77402 [annual t/cap]	0%	0%	0%	0%	0%	2%	55%	3%	1%	0%	0%	0%
Extraction of industrial and construct	0.08630 work hours [h]	5.67899 [annual t/cap]	0%	0%	0%	0%	0%	2%	2%	95%	0%	1%	0%	0%
Extraction of ores	0.08630 work hours [h]	1.75079 [annual t/cap]	0%	0%	0%	0%	0%	98%	0%	1%	0%	0%	0%	0%
Level of industrial water use (related t	0.08630 work hours [h]	1.17842 [% of total actual renewabl...	0%	0%	0%	0%	0%	95%	0%	3%	1%	0%	0%	0%
Level of industrial water use (related t	0.08630 work hours [h]	47.68259 [% of total water withdra...	0%	0%	0%	0%	0%	3%	1%	2%	0%	94%	0%	0%
Environmental Footprints			0%	0%	0%	0%	0%	31%	2%	32%	26%	8%	1%	0%
GHG Footprints			0%	0%	0%	0%	0%	2%	0%	0%	56%	42%	0%	0%
Local employment			0%	0%	0%	0%	0%	0%	93%	0%	0%	0%	6%	0%
Migration			0%	0%	0%	0%	0%	33%	1%	16%	0%	0%	50%	0%
Respect of indigenous rights			0%	0%	0%	0%	0%	2%	0%	1%	95%	1%	0%	2%
Safe and healthy living conditions			0%	0%	0%	0%	0%	1%	1%	0%	32%	65%	0%	0%
Society			0%	4%	1%	0%	0%	42%	10%	20%	14%	8%	0%	0%
Value Chain Actors			0%	0%	0%	0%	0%	6%	23%	11%	5%	23%	32%	0%
Workers			0%	0%	0%	0%	0%	89%	27%	8%	21%	16%	8%	118%
Child labour			0%	0%	0%	0%	0%	3%	78%	17%	1%	0%	0%	0%
Discrimination			0%	0%	0%	0%	0%	65%	1%	1%	1%	0%	32%	0%
Fair Salary			0%	0%	0%	0%	0%	2%	2%	63%	1%	33%	0%	0%
Living wage, per month (AV)	0.08630 work hours [h]	359.59740 [USD]	0%	0%	0%	0%	0%	1%	2%	95%	1%	1%	0%	0%
Minimum wage, per month	0.08630 work hours [h]	178.13004 [USD]	0%	0%	0%	0%	0%	0%	1%	2%	0%	97%	0%	0%
Sector average wage, per month	0.08630 work hours [h]	701.60971 [USD]	0%	0%	0%	0%	0%	4%	3%	91%	2%	0%	0%	0%
Forced Labour			0%	0%	0%	0%	0%	1%	36%	2%	5%	31%	25%	0%
Frequency of forced labour	0.08630 work hours [h]	5.41101 [Cases per 1.000 inhabitants]	0%	0%	0%	0%	0%	3%	97%	0%	0%	0%	0%	0%
Goods produced by forced labour	0.08630 work hours [h]	0.26032 [t]	0%	0%	0%	0%	0%	1%	3%	3%	15%	0%	74%	0%
Trafficking in persons	0.08630 work hours [h]	2.91291 [Tier1]	0%	0%	0%	0%	0%	0%	2%	4%	1%	93%	0%	0%

Figure 18 Direct approach method SLCA

End of document

<sup>1</sup> [https://www.youtube.com/watch?v=ocmWcnEGUxo&t=383s&ab\\_channel=openLCA](https://www.youtube.com/watch?v=ocmWcnEGUxo&t=383s&ab_channel=openLCA)

<sup>2</sup> Cirotto A, Di Noi C, Srocka M (2019) Revisiting the activity variable in social LCA, beyond worker hours. Presentation LCA XIX, Tucson. [https://www.greendelta.com/wp-content/uploads/2019/11/2019\\_LCA\\_XIX\\_Revisiting-the-activity-variable-in-SLCA.pdf](https://www.greendelta.com/wp-content/uploads/2019/11/2019_LCA_XIX_Revisiting-the-activity-variable-in-SLCA.pdf)