SH2E

Grant No. 101007163

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D4.3 Extended life-cycle tools

WP4 Harmonised extension to Life Cycle Costing and Social Life Cycle Assessment

User Manual

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DOCUMENT CHANGE CONTROL

VERSION NUMBER	DATE OF ISSUE	AUTHOR(S)	BRIEF DESCRIPTION OF CHANGES
1	06 Jun 2024	Ashrakat Hamed Andreas Ciroth	First version
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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.

This document provides a short manual for users of the tool. The tool itself is submitted separately, and publicly available for example from here, as open source tool: https://www.greendelta.com/project/sh2e/.

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A short manual for the FCH-LCA Tool

1 Installation, hardware and software requirements

The tool is installed by downloading and unzipping a zip archive provided at the GreenDelta SH2E project website: https://www.greendelta.com/project/sh2e/. Once the archive is extracted, start the tool by clicking on FCh-LCA.exe.

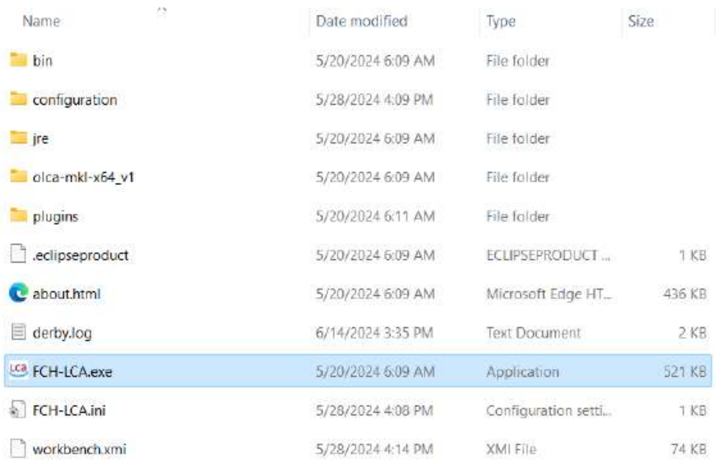

Figure 1 Downloaded and extracted zip file with program executable (exe)

The tool works in modern 64 bit windows operation systems. Hardware requirements are 12 GB RAM and about 500 MB storage space. Figure 1 shows the extracted content of the zip archive.

Once the tool has launched, users will see the following welcome page - Figure 2.

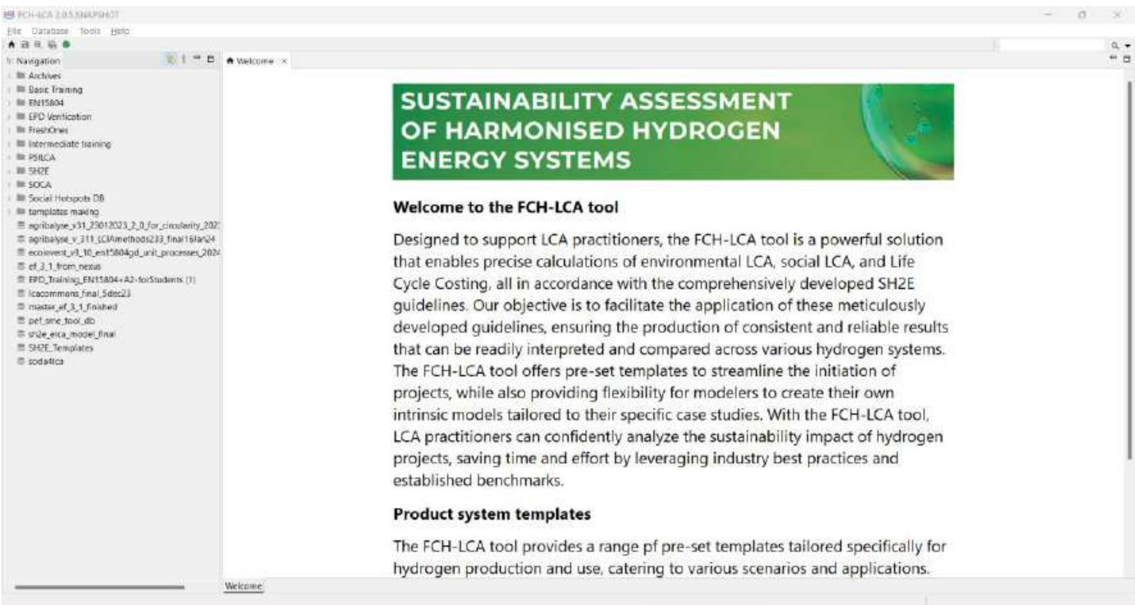

Figure 2 Welcome page FCH-LCA tool

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2 COMPLIANT PRODUCT SYSTEM CREATION USING THE FCH-LCA WIZARD

2.1 Completing a SH2E product system structure via the wizard

One of the two main new additions of the FCH-LCA tool compared to openLCA is the wizard. The wizard is designed to guide you through modeling questions for hydrogen systems, collects your answers, and builds a corresponding life cycle model, or product system, which can then be calculated afterwards. The wizard reflects the modeling methodology developed in SH2E.

To access the wizard and the templates, users must have an active database as seen in Figure 3. Either restore one, or create one from scratch, and complete it then with datasets. As this is basic openLCA functionality, please go to the openLCA manual, https://greendelta.github.io/openLCA2-manual/introduction/index.html.

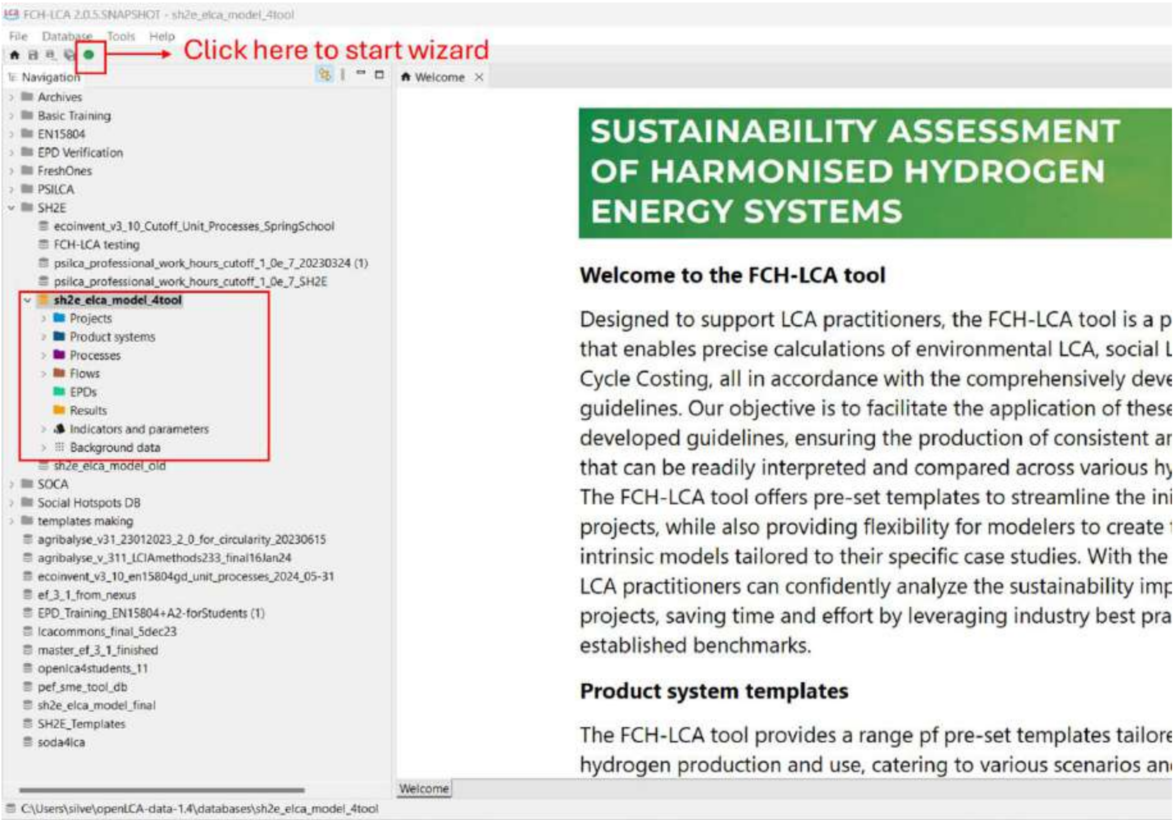

Figure 3 Starting the wizard

After the wizard is started, a pop-up window appears (Figure 4) where users are asked a series of questions and typically are presented a selection of possible answers. These answers reflect methodological recommendations for all kinds of hydrogen systems. Figure 5 shows some examples. For details and background, please go to the FCH-LCA guidelines.

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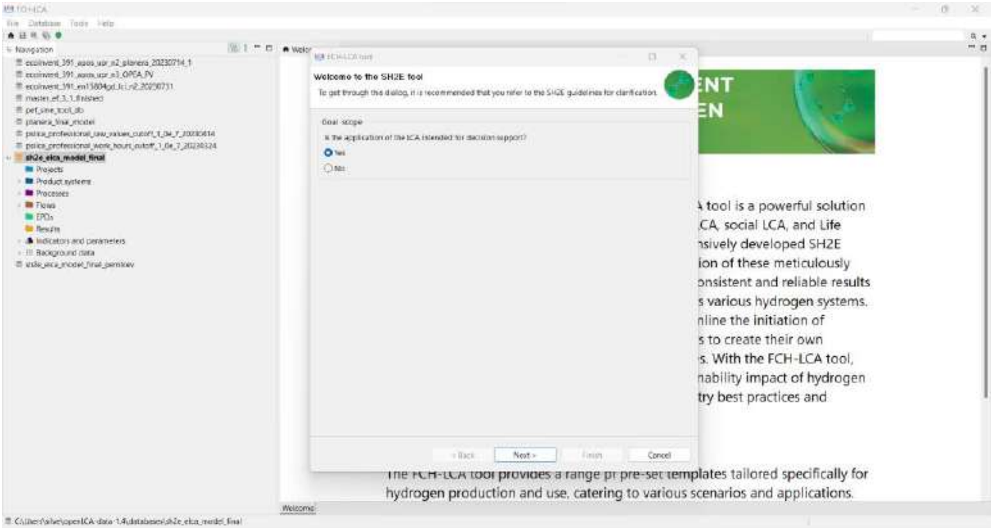

Figure 4 Wizard pop-up window

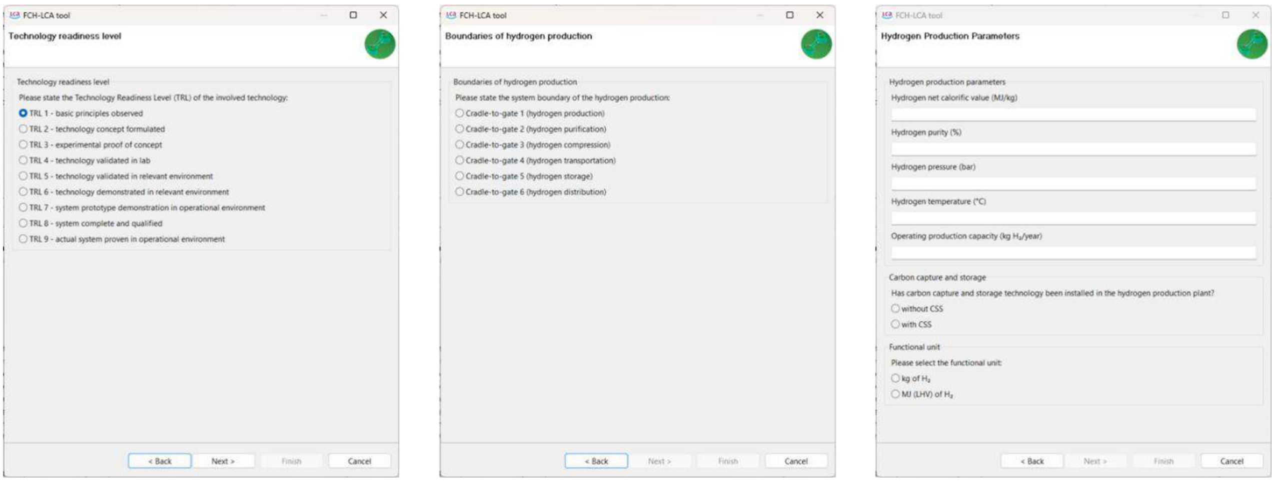

Figure 5 Wizard questions

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

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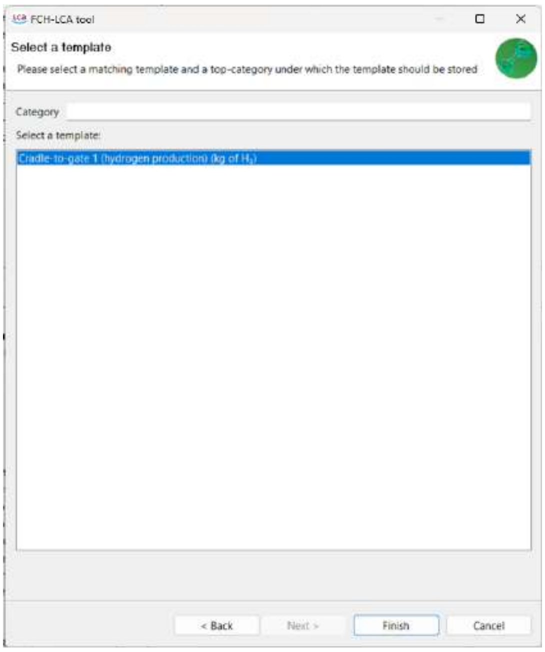

Figure 6 Template decision based on wizard selection

Once the template is selected and users click on ‘Finish’, a product system will be created based on the selected template and options. 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, see Figure 8.

Figure 7 FCH-LCA Properties

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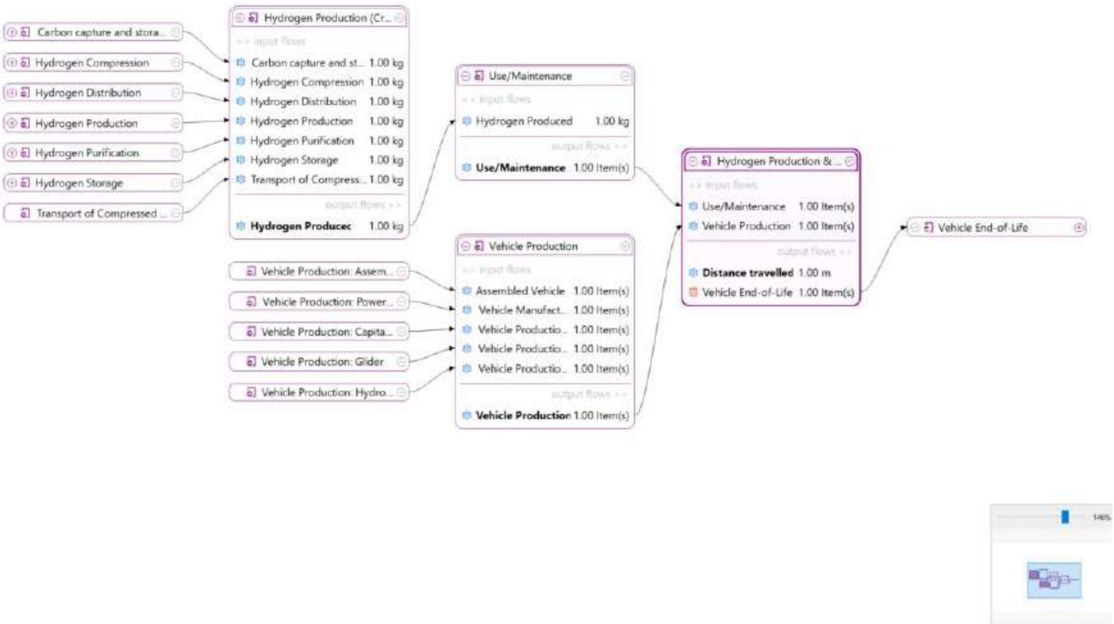

Figure 8 Product system of hydrogen production and use for vehicle

2.2 On the product system template structure

There are three different types or cases for hydrogen systems, each resulting in a different product system type:

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

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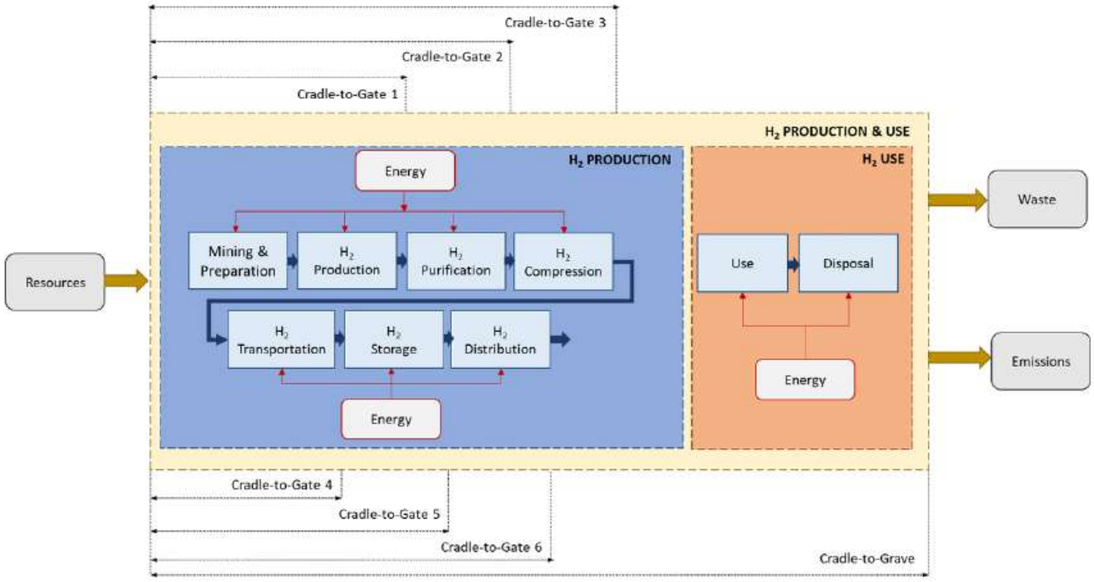

Figure 9 Foreground phases for studies assessing FCH systems

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.

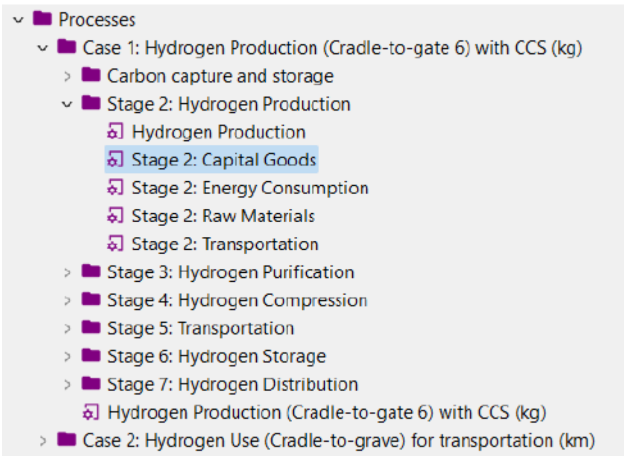

Figure 10 Breakdown of processes

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, a similar approach has been taken to divide the templates as seen in Figure 11.

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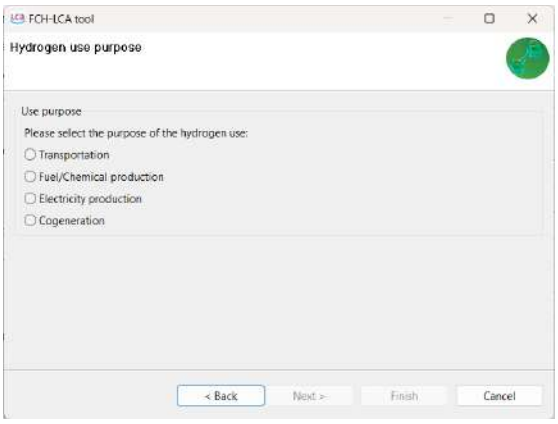

Figure 11 Hydrogen use cases

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 in their overall results breakdown.

2.3 Completing the pre-set template

After the product system template structure is set by the wizard (and the responses of the users in the wizard of course), users 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" (see Figure 12). More details are again explained in the openLCA manual, see above.

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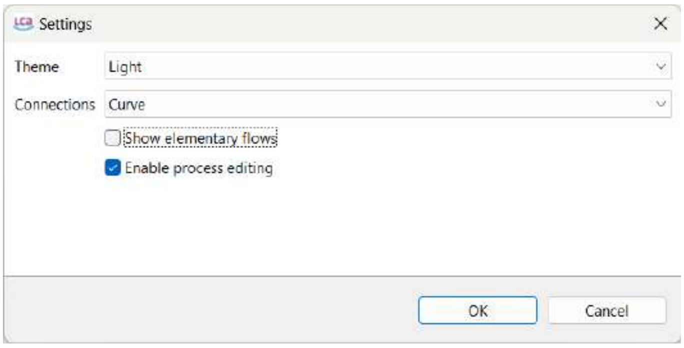

Figure 12 Activated settings in the model graph.

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).

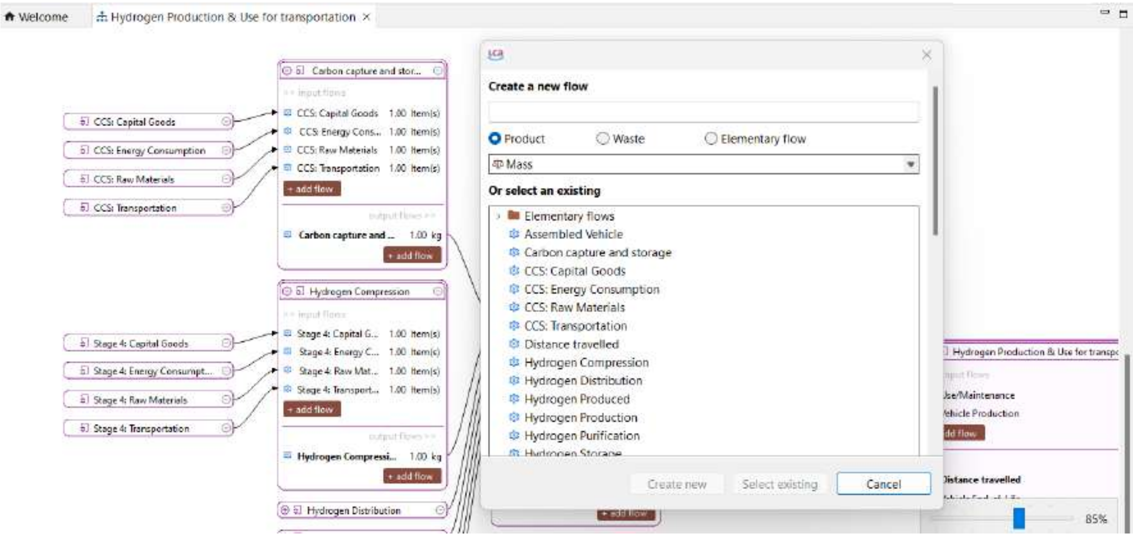

Figure 13 Adding of new flows in model graphs

However, after adding a new technoshpere flow (waste or product) to a process, you should add its provider to specify where the flow is provided from. This can be done by right-clicking on the flow, and then selecting "Search providers" (Figure 14).

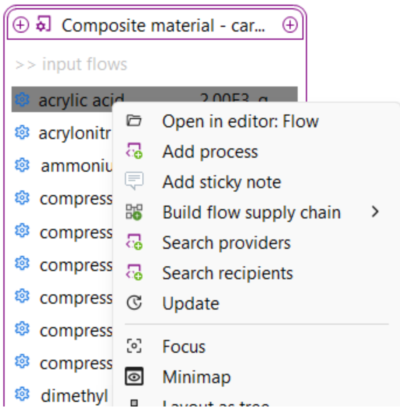

Figure 14 Searching for providers

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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. Updating the product system has the same effect. For details, please check again the openLCA manual.

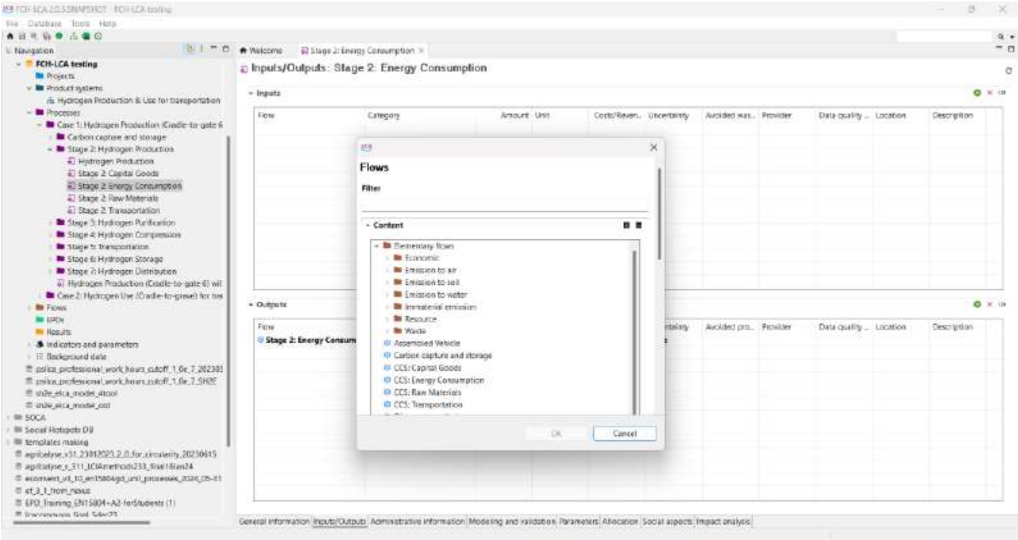

Figure 15 Adding of new flows in the process

2.4 Calculating Results

As a next step, the product system and thus life cycle model created for the hydrogen system can be calculated. To do so, go e.g. in the product system 'general information' tab and click on calculate as seen in Figure 16. There are again other options available, please check the openLCA handbook for these.

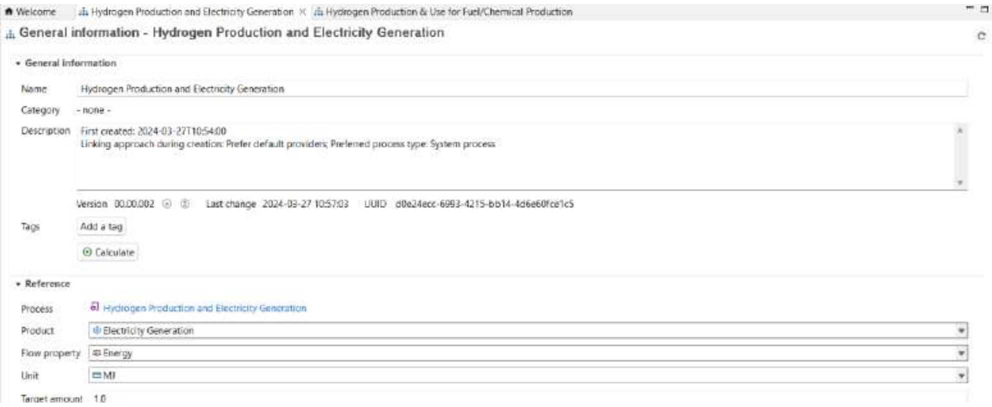

Figure 16 Calculating the results

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Results will appear under the results tab seen in Figure 17. Rich information is provided in several table, for overall results and also for hotspot analysis. For details, please again refer to the openLCA manual:

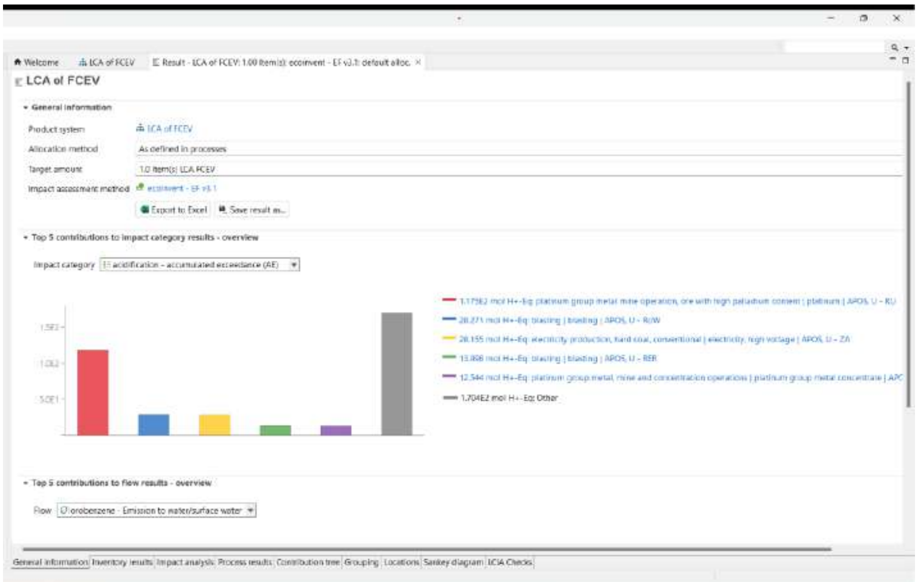


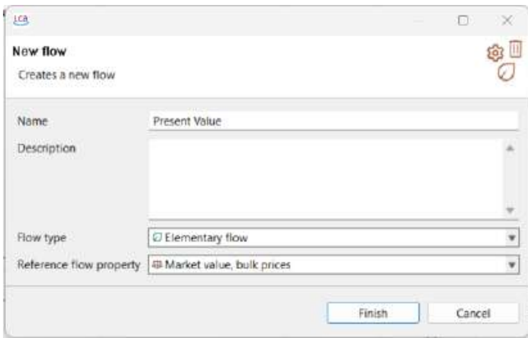
Figure 17 Results of a product system

3 NEW MODELING CAPABILITIES

3.1 Special feature: parameter analysis, simulating a system over time

Part of the LCC requirements of SH2E is to evaluate equations that are time-dependent, especially for discounting. To enable this, the FCH-LCA tool has a new modeling feature called 'parameter analysis'. Taking again the example to evaluate discounting equations, users would follow the following steps:

Step 1: Create a new elementary flow



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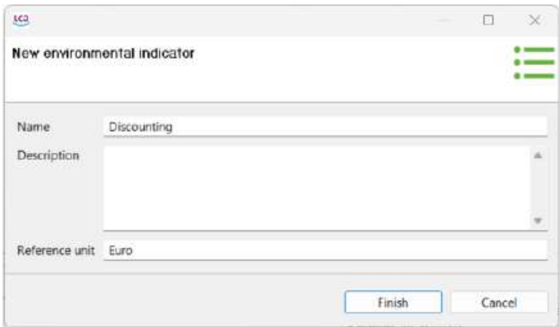
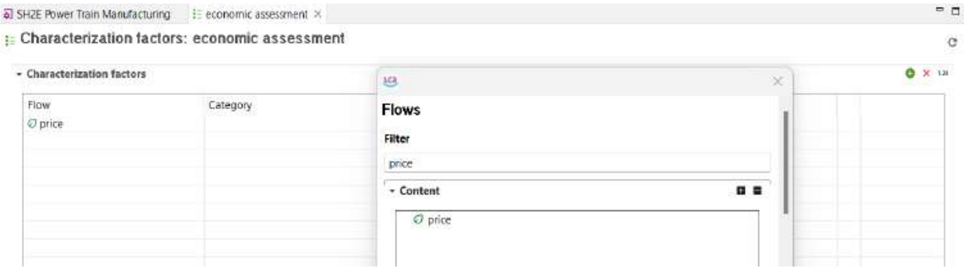
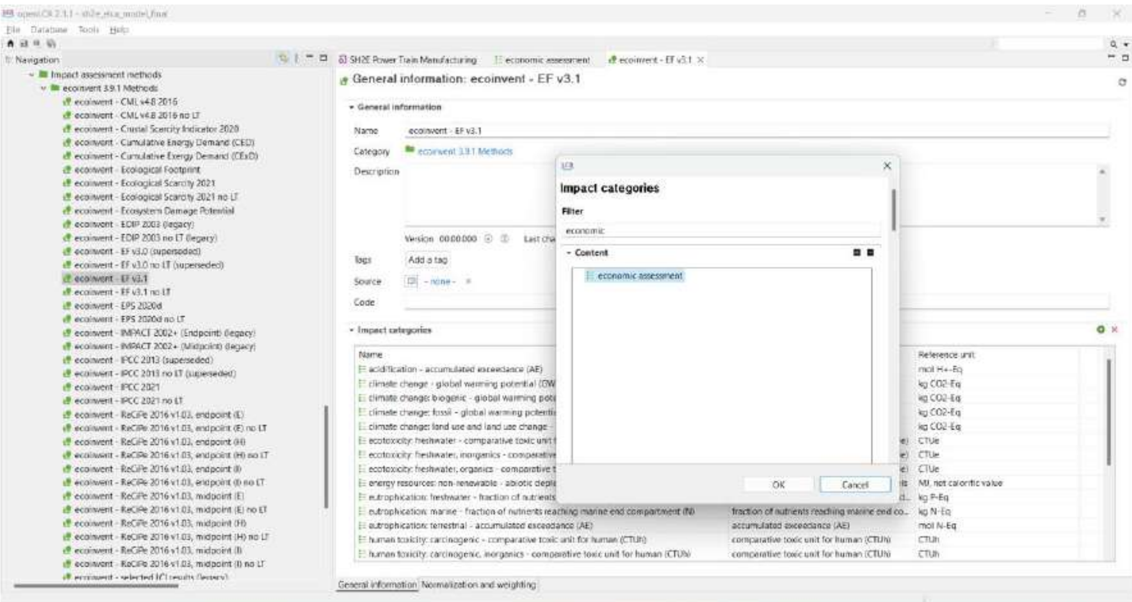
Step 2: Create a new impact category



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.

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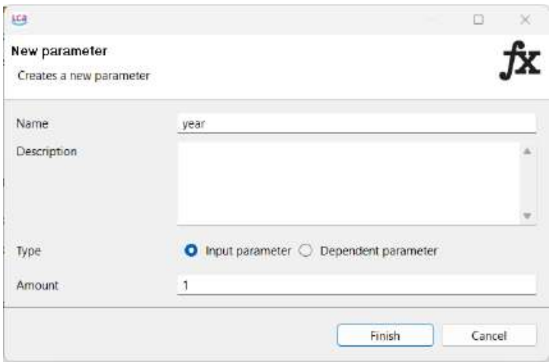
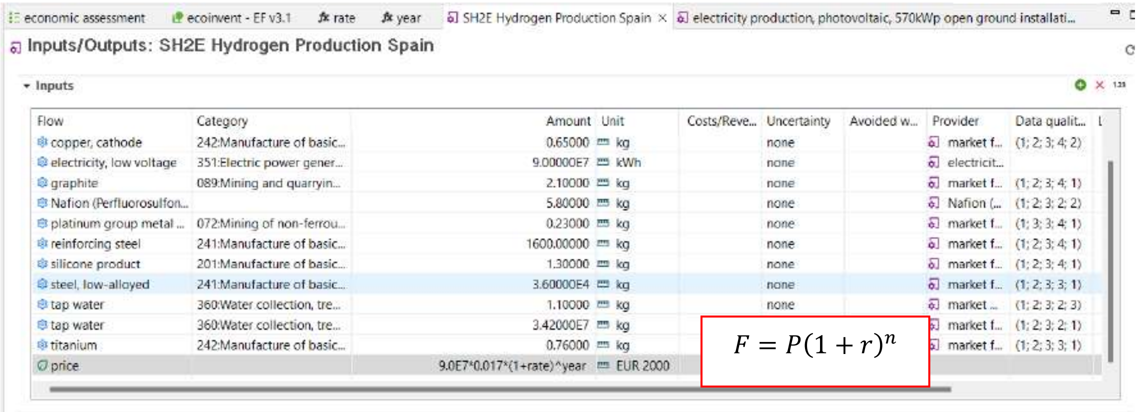
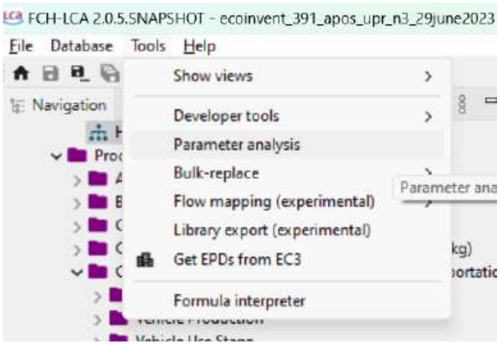


Step 6 Set up the equation in the selected process or new process



Step 6 Got to -> tools -> parameter analysis



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

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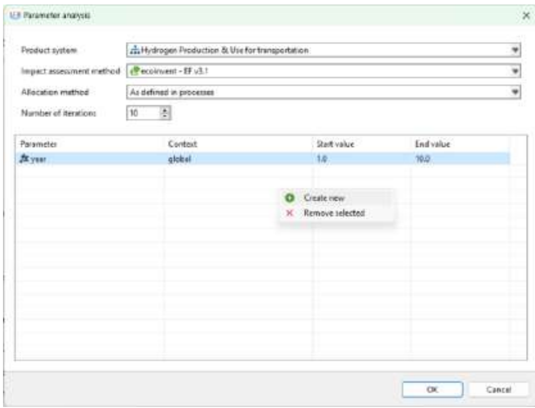

Results can then be seen in tabular and graphical form (Figure 18). The results can be exported to excel format for example, for further analysis.

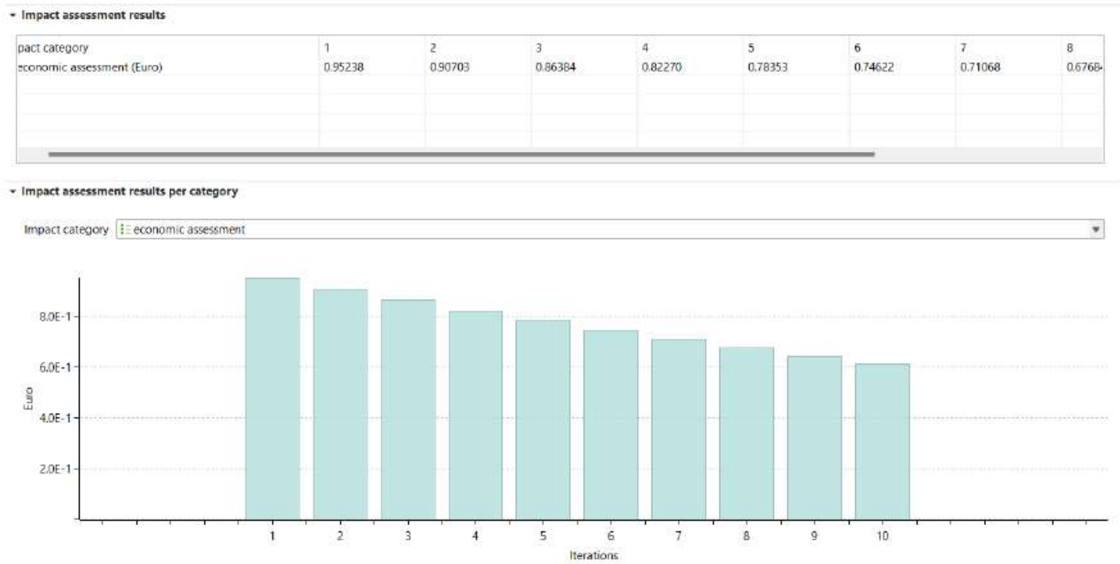

Figure 18 Results of a product system

A full tutorial for this feature can be found on youtube on the openLCA channel[1].

3.2 Direct SLCA calculation approach

The other new modeling capability implemented in the FCH-LCA tool is the calculation of SLCA, so social life cycle assessment, without need to use risk assessment and activity variable. In SLCA, results are usually viewed in the form of medium risk hours which are obtained by classifying the risk for an impact indicator and quantifying it with an activity variable, which is often worker hours. This is not perfect especially for social impact indicators not linked to the work environment. The direct approach method[2] was proposed as a way to overcome this, using a specific algorithm to scale indicators that do not scale with the system size and thus cannot be aggregated simply. Examples are unemployment rates, presence of indigenous populations, and others. This "direct calculation" in the FCH-LCA tool provides this direct calculation of SLCA, without the need to have an activity variable or risk assessment. The traditional SLCA calculation

[1] https://www.youtube.com/watch?v=ocmWcnEGUxo&t=383s&ab_channel=openLCA

[2] Ciroth 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

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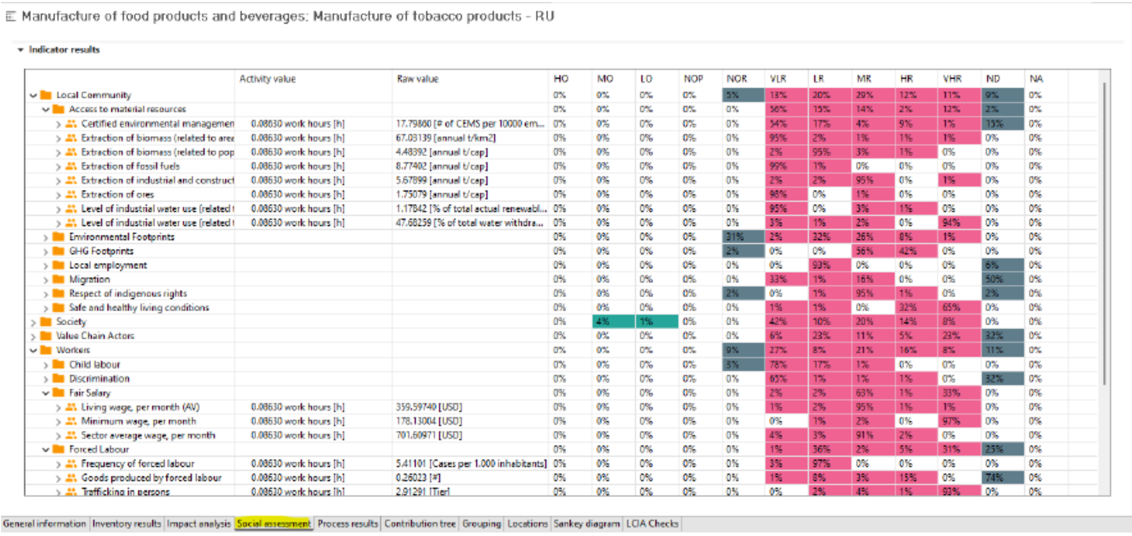
via risk assessment and activity variable is also performed, as long as both risk assessment and activity variable are available for the life cycle model processes. Both are performed when calculating a product system. It needs to be activated in the tool, however. To activate this new feature, go to "File" –> "Preferences" –> "Experimental Features" –> check "New Social Impact Assessment." Then, restart your software for the changes to take effect. See above or in the openLCA handbook for details on how to start a calculation.

Calculation results for SLCA are then provided under the "Social Assessment" tab (Figure 19).



	Activity value	Raw value	HO	MO	LO	NOP	NOR	VLR	LR	MR	HR	VHR	ND	NA
Local Community			0%	0%	0%	0%	5%	13%	20%	29%	12%	11%	9%	0%
Access to material resources			0%	0%	0%	0%	0%	56%	15%	14%	2%	12%	2%	0%
Certified environmental managemen	0.08630 work hours [h]	17.79860 [# of CEMS per 10000 em...	0%	0%	0%	0%	0%	54%	17%	4%	9%	1%	15%	0%
Extraction of biomass (related to area	0.08630 work hours [h]	67.03139 [annual t/km2]	0%	0%	0%	0%	0%	95%	2%	1%	1%	1%	0%	0%
Extraction of biomass (related to pop	0.08630 work hours [h]	4.48392 [annual t/cap]	0%	0%	0%	0%	0%	2%	95%	3%	1%	0%	0%	0%
Extraction of fossil fuels	0.08630 work hours [h]	8.77402 [annual t/cap]	0%	0%	0%	0%	0%	99%	1%	0%	0%	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%	31%	2%	32%	26%	8%	1%	0%	0%
GHG Footprints			0%	0%	0%	0%	2%	0%	0%	56%	42%	0%	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%	2%	0%	1%	95%	1%	0%	2%	0%
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%	9%	27%	8%	21%	16%	8%	11%	0%
Child labour			0%	0%	0%	0%	3%	78%	17%	1%	0%	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]	0.26023 [#]	0%	0%	0%	0%	0%	1%	8%	3%	15%	0%	74%	0%
Trafficking in persons	0.08630 work hours [h]	2.91291 [Tier]	0%	0%	0%	0%	0%	0%	2%	4%	1%	93%	0%	0%

Figure 19 Direct approach method SLCA

They show the social indicators, the selected activity variable and its quantitative amount (0.0863 work hours in the figure), the raw, direct value of the indicator (e.g. frequency of forced labour 5,41101 cases per 1000 inhabitants) for the entire calculated system, and on the right the risk levels for each indicator (HO, MO, LO high, middle, low opportunity; VLR very low risk etc.; ND no data, NA not available). This shows the spread of the indicator across different risk levels.

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