Zero Emission electric Vehicles enabled by haRmonised circularity

Deliverable 2.4

Digital database tool for design-based identification of CE value chains

30 June 2026 (M30)

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04.05.2026	V0	Initial draft of structure
05.06.2026	V1	Initial draft for review
15.06.2026	V2	First reviewed and revised version
30.06.2026	V3	First submission version

ZEvRA project abstract

ZEvRA's main objective is to improve the circularity of light-duty EVs throughout their entire value chain, from materials supply and manufacturing to end-of-life (EoL) processes, which aligns with the European Union's goal of achieving zero CO2e emissions by 2035, particularly in the EV value chain. To do so, ZEvRA will develop a Design for Circularity (DfC) methodology and a holistic circularity assessment aimed at improving the production of electric vehicles (EVs) based on the 9Rs. This methodology will be validated by developing zero emission solutions for the most important automotive materials, covering > 84% material mix: steel, three versions of aluminium (wrought, casting, and foam), thermoplastics composites (long and continuous fibre-reinforced), unfiled/short fibre plastics, glass, tyres and Rare Earth Elements (REE). These solutions will be supported by a set of digital tools to support the manufacturing of the use cases, the assessment of circularity, traceability, and the virtual integration of components into a full replicable vehicle.

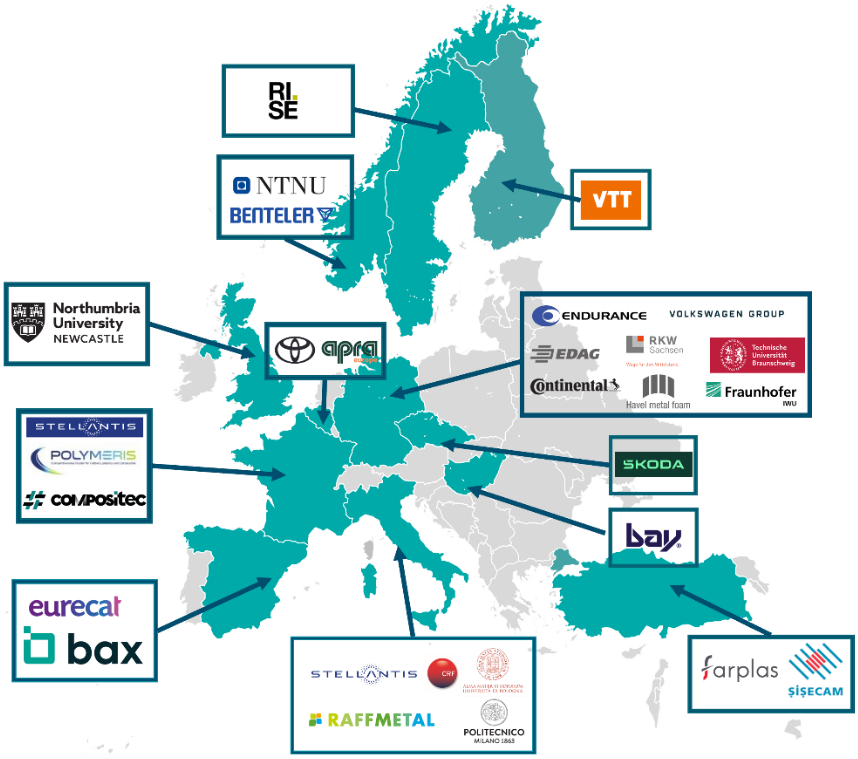

Figure 1: *ZEvRA Consortium*

To maximise the outreach of our methodology and zero emission solutions, ZEvRA will develop a dedicated training & upskilling programme for the automotive workforce and academia, together with activities aimed at increasing awareness & acceptability of the proposed zero emission solutions. Lastly, circular business models targeting EoL and logistics aimed at improving the economic feasibility of circularity in EVs are advanced. ZEvRA's innovations aim to improve zero emission approaches in the life cycle and value chain of at least 59% of European EVs by 2035 through the 5 OEMs and Tier 1's that are part of the consortium (Figure 1), which includes industry and academia covering the entire automotive value chain.

Table of Contents

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Index of Figures

Index of Tables

Abbrevations and Acronyms

Table 1: *Abbrevations and Acronyms*

Abbr.	Full name
AP-242	STEP Application Protocol 242 (managed model-based 3D engineering)
BPNL / BPNS	Business Partner Number – Legal entity / Site (Catena-X identifiers)
BPDM	Business Partner Data Management (Catena-X)
CAD	Computer-Aided Design
Catena-X	Automotive data-exchange ecosystem / network
CE	Circular Economy
DfC	Design for Circularity
DIN 8593	Standard family classifying joining (assembly) processes
DTR	Digital Twin Registry (Catena-X)
FRP	Fibre-Reinforced Plastic / Polymer
GA	Grant Agreement
GUI	Graphical User Interface
JSON	JavaScript Object Notation (data file format)
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCT	Life Cycle Thinking
PU	Public (dissemination level)
R0–R9	The ten R-strategy levels of the 9R framework (R0 Refuse … R9 Recover)
STEP	STandard for the Exchange of Product model data (ISO 10303)
WP	Work Package

Executive summary

This Deliverable is per the Grant Agreement the digital tool itself (Type: OTHER) and this document is the accompanying report that points to the tool and explains how to use it. The report has two parts:

- a link to the tool repository, and
- the user manual for operating the tool.

The tool helps designers assess the Design-for-Circularity (DfC) suitability of a component or product already during the design phase. It brings the circularity assessment for the individual R-strategies, developed in Task 1.2, into a digital environment. The tool itself, named Circular DESIGNer, is a stand-alone desktop application with a graphical user interface which is operated through a sequence of dialog windows. The assessment covers the ten R-strategies (R0 Refuse to R9 Recover) and addresses material, disassembly/assembly and logistics aspects. A product is described component-by-component through a structured profile, geometric and material data as well as additional attributes. The datasets are imported from a CAD STEP file and user input through guided forms. Each component is compared against a classification of typical vehicle parts that can be configured for the relevant domain, so that no second comparison variant must be modelled. The material database can be filled manually or e.g. imported from the Catena-X network. Each component design is added through projects, and the classification can be adapted to suit individual areas of application. The strategy evaluation is tuned via parameter-to-goal assignment and goal-to-strategy weighting. Results are presented as KPIs, charts of suitability per R-strategy and of goal achievement per life-cycle stage, with drill-down for the individual parameters.

This document refers to the tool version in the repository as of 30 June 2026. Due to bug fixes, new features and adjustments, newer versions may be available in the repository in future, and there may be differences from this manual.

1 Introduction

1.1 Purpose and scope of this manual

This document, and in particular the manual, explains how to operate and use the tool Circular DESIGNer. This is not a description of the development process or the methodological basis on which the tool was developed. The document covers access, input data and preparation, the step-by-step assessment workflow, the outputs and how to read them, and how to populate the databases. The detailed calculation rules and the weighting of parameters into individual R-strategies are out of scope of this document. The tool is developed for design engineers and circular economy analysts who wish to evaluate and optimise vehicle components during the early stages of product development.

1.2 Context within ZEvRA

The Circular DESIGNer is the public deliverable of Task T2.4 in Work Package WP2 (Lead Beneficiary Fraunhofer; Involved Partners: TU Braunschweig, Eurecat). It operationalises, at design time, the circularity assessment transferred from Task 1.2. The tool provides analysis results for a product's components design in relation to the respective R-strategies. This information can subsequently be used to carry out the Harmonised Circularity Assessment, which is being developed as the central focus of WP1.

2 User Manual

2.1 Tool overview and access

2.1.1 Repository

The repository contains the application, the reference database files (JSON), the license and the setup instructions referenced in Section 2.2. This repository is free software. It can be redistributed and/or modified under the terms of the GNU General Public License as published by the Free Software Foundation, either version 3 of the license, or any later version. This program is distributed in the hope that it will be useful, but without any warranty; without even the implied warranty of merchantability or fitness for a particular purpose. See the GNU General Public License in the repository for more details.

The repository can be accessed via the links below:

Zenodo: https://doi.org/10.5281/zenodo.21030411

GitHub: https://github.com/F-Digiser/Circular-DESIGNer

2.1.2 What the tool does

At the design stage, Circular DESIGNer uses CAD-derived and user-entered data to evaluate how well a design fits each of the ten R-strategies and where its circularity potential is greatest. For this, each component is compared against typical values for its category, taken from the classification, so a second variant is not required. The classification database therefore enables data to be put into context and compared. The tool does not compute a LCA. The life-cycle link is provided by grouping circularity goals into the stages Material Selection, Development, Production and Manufacturing, Logistics, Use, End of Life.

2.1.3 The start window

On start-up, the Circular DESIGNer opens the start window (see Figure 2) with the menu bar:

- File (new/open project),
- Materials (add/import/update materials),
- Parameter Assignment (assign parameters to goals) and
- Goals (edit goal weightings).

The name and version of the active project are shown in the upper-right corner. The central Start Analysis button begins the assessment.

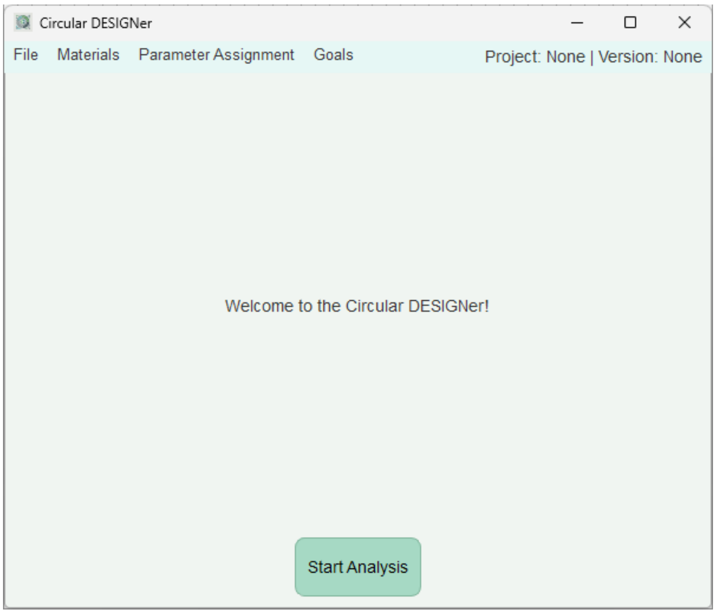


Figure 2: *Start window with the menu bar (File, Materials, Parameter Assignment, Goals) and Start Analysis*

2.1.4 Recommended order for first-time use

Because an assessment depends on reference data that must exist first, a user should proceed in the following order:

1. Install and start the tool (Section 2.2).
2. Prepare the classification database for the intended domain (Section 2.6.1). This is required prior to the first assessment in order to ensure that the calculated values are comparable within the domain.
3. Populate the material database with the materials you will use manually, via Catena-X, or let it grow during assessment (Section 2.6.2). The materials referenced by classification examples must already exist.
4. Optionally review the parameter-to-goal assignment (Section 2.6.3) and the goal-to-strategy weighting (Section 2.6.4). The defaults are expert-set and defined by the outcomes of the project ZEvRA.
5. Create a project and import the STEP file, then adjust the product tree (Section 2.4.1).
6. Assess every component and complete its profile, including “Assess Material” for each material, and tick “Assessed” (Section 2.4.3).
7. Run the calculation (Section 2.4.4) and read the results (Section 2.5).

2.2 System requirements and setup

The tool is a Python desktop application with a graphical user interface, designed to run on Windows 11. It uses the CadQuery module for processing the STEP file and JSON handling for data storage in addition to the GUI and charting libraries. The concrete setup details below are to be completed. There are two options for running the application: Either the packaged .exe file or the main Python file.

Steps for running the packaged .exe file:

No Python installation is required for the packaged application.

1. Download the repository from Zenodo or GitHub.
2. If it is distributed as a ZIP archive, extract the complete archive before starting it. The application reads and writes JSON files from the folder app_data. So, the file circular_designer.exe must be run next to the folder app_data containing the JSON files. Since the JSON files are also appended to and overwritten, the exe file must be run from a user-writable directory, not from a protected location.
3. Start circular_designer.exe by double-clicking.

Steps for running the main Python file from the root:

1. Download the repository from Zenodo or clone it from GitHub.
2. Create and activate a virtual environment and run the following from the repository root:

```
python -m pip install --upgrade pip setuptools wheel
python -m pip install -r requirements-lock.txt
python -m pip check
```

Figure 3: *Terminal commands for installing the dependencies of the application*

3. After installing all dependencies, the user can run the application from the repository root with the command in

```
python tool.py
```

Figure 4: *Terminal command for running the application*

Tested environment: Python 3.12 on Windows. Other operating systems have not been tested.

2.3 Input data and preparation

2.3.1 Prerequisite: a CAD model exported as STEP

Each project is created from CAD data. A CAD model exportable to STEP is therefore required. The import is based on the STEP file standard AP-242, which is exportable from virtually all 3D-CAD systems. The tool reads the product hierarchy and, per component, the volume. All other attributes (material, joining connections, life span, classification, qualitative questions) are entered manually during the assessment.

2.3.2 Reference databases that must exist before assessment

- Classification database (e.g. classification_validation.json): This is the reference catalogue of typical vehicle parts, which must be drawn up in advance. (Section 2.6.1)
- Material database: This is the catalogue of materials and their circularity attributes. It is filled/maintained per Section 2.6.2.

2.3.3 Component / part input fields

In Table 2 the input parameters are listed, along with the source from which they are taken.

Table 2: *Input parameters*

Field	Input type / values	Source
Volume [mm^3]	Number	CAD
Material (material name)	Text	User
Lifespan [a]	Number (years)	User
Hierarchy (product tree)	Structure	CAD
Classification	Tree selection	User
Standard Component	Yes / No	User
Joining component	Yes / No	User
Connected with	Component(s) via tree	User
Connected By (joining connection)	Selection per partner	User
Covered by	Component(s) via tree	User
Material reduction in areas of low stress	Yes / No	User
Use of recycling-friendly methods	Yes / No	User
Tracking of recycling strategies	Yes / No	User
Efficiency testing through simulation	Yes / No	User
Robustness for long lifespan	Yes / No	User
Long-term high-quality appearance	Yes / No	User
Product and material labeling	Yes / No	User
Recognizability of recycling	Yes / No	User
Accessibility of critical raw materials	Yes / No	User
Recognizability of disposal	Yes / No	User
Potential for remanufacturing	Yes / No	User
Potential for upcycling	Yes / No	User

2.3.4 Joining-connection input fields

In Table 3 the input parameters for each connection of a component are recorded.

Table 3: *Joining connection input parameters*

Field	Input type / values	Source
Type of joining connection	Selection from DIN 8593 tree	User
Amount of joining connections	Number	User
Joining connection Non-Destructive detachable	Yes / No	User
Joining connection(s) Aging	Yes / No	User
Tool used for joining connection(s)	Selection from tool list	User
Detachment Time (seconds)	Number (s)	User

2.3.5 Material input fields

In Table 4 the input parameters for each material are recorded which are stored in the material database.

Table 4: *Material input parameters*

Field	Input type / values	Source
Material (material name)	Text	User
Recycling percentage (%)	Number 0–100	User
Recyclate content (%)	Number 0–100	User
Recycling criticality	Yes / No	User
Environmental harmfulness	Yes / No	User
Health harmfulness	Yes / No	User
Monomaterial	Yes / No	User
Additives and Fillers	Yes / No	User
Surface coatings	Yes / No	User
Availability	Regionally / Nationally / Same continent / Other continent	User
Density [kg/mm^3]	Number	User

Materials can be entered manually, imported from the Catena-X network, or updated (see Section 2.6.2.).

2.4 Step-by-step usage workflow

The assessment follows the proposed sequence. Each step corresponds to a dialog window in the tool.

2.4.1 Step 1 – Create or open a project

Create a new project and import the STEP file

Choose “File” and then “New Project” to open the project window (see Figure 5).

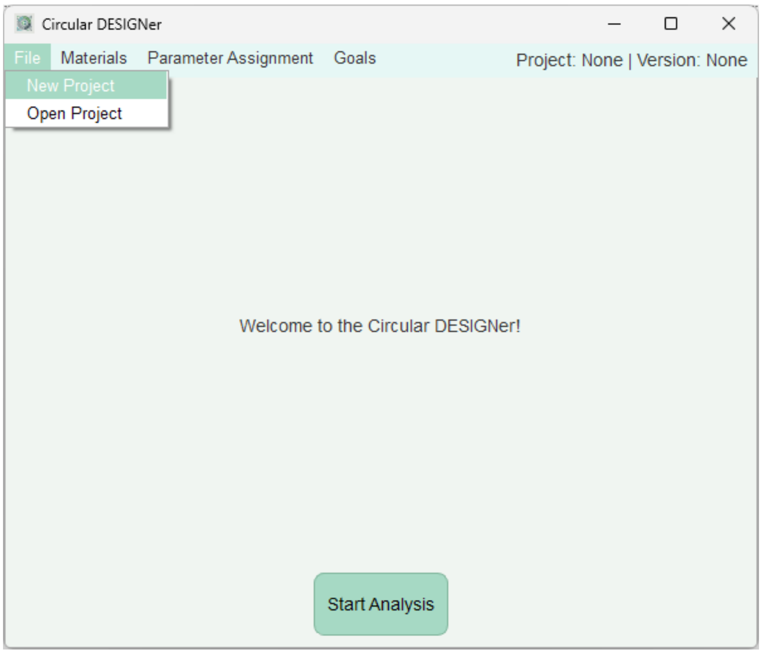


Figure 5: *File menu → New Project*

Enter the project name, version, and then use “Load STEP File” to open a file browser and select the STEP file. After that, the path of the selected file is shown. (see Figure 6 and Figure 7)

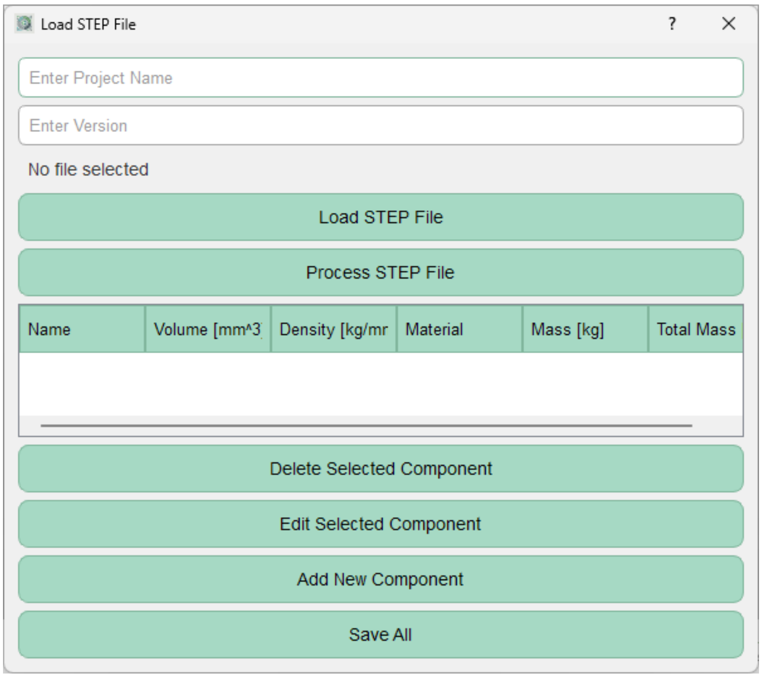


Figure 6: *Enter project name and version*

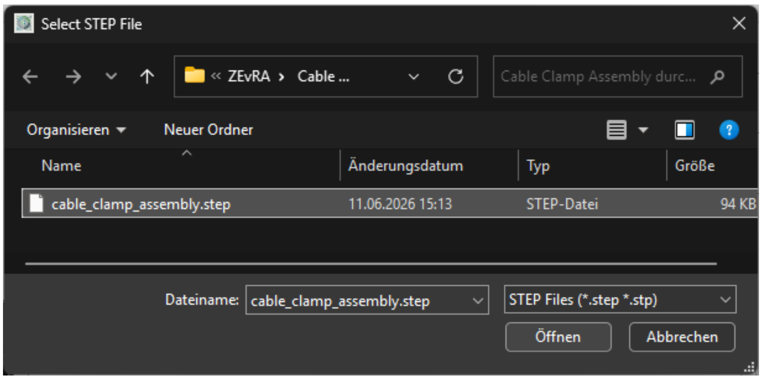


Figure 7: *Load STEP File → select the STEP file in the file browser*

Use "Process STEP File" to process it and the product structure appears as a tree with Name, Volume, Density, Material, Mass and Total Mass. (see Figure 8).

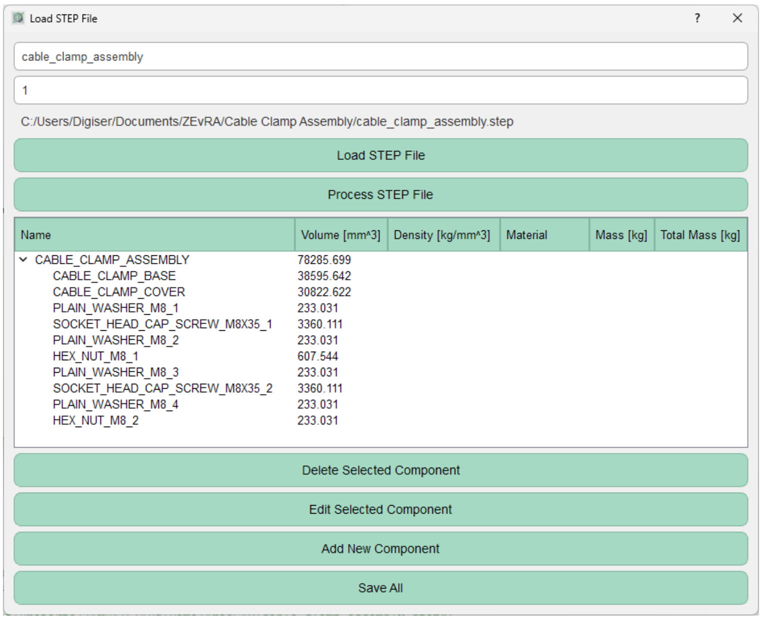


Figure 8: *Process STEP File: the product structure shown as a tree*

Adjust the product tree

"Delete Selected Component" removes a component after a confirmation dialog. A success message follows (see Figure 9) and the tree updates.

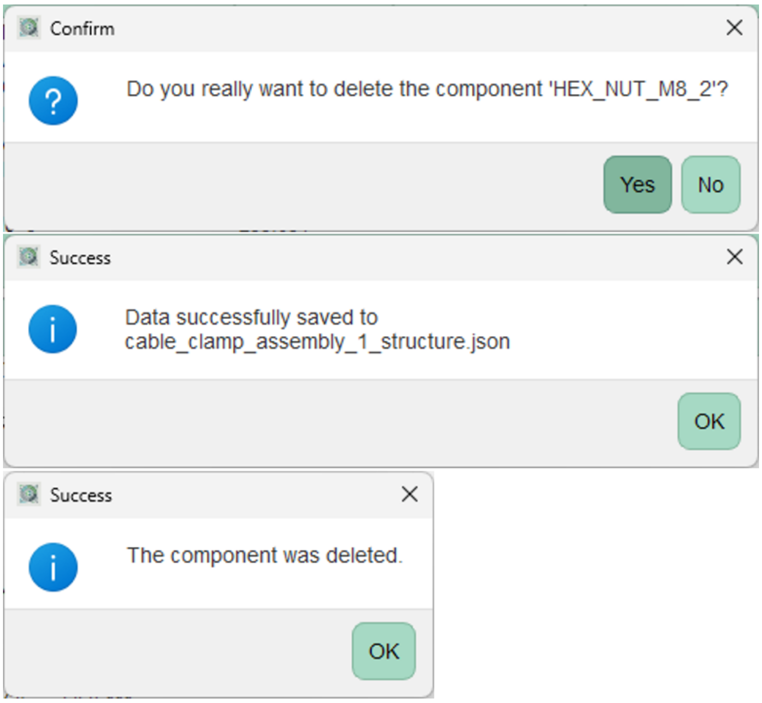


Figure 9: *Delete Selected Component: confirmation and success windows*

"Edit Selected Component" lets you change the name and select a material. Confirm changes with "OK" (see Figure 10).

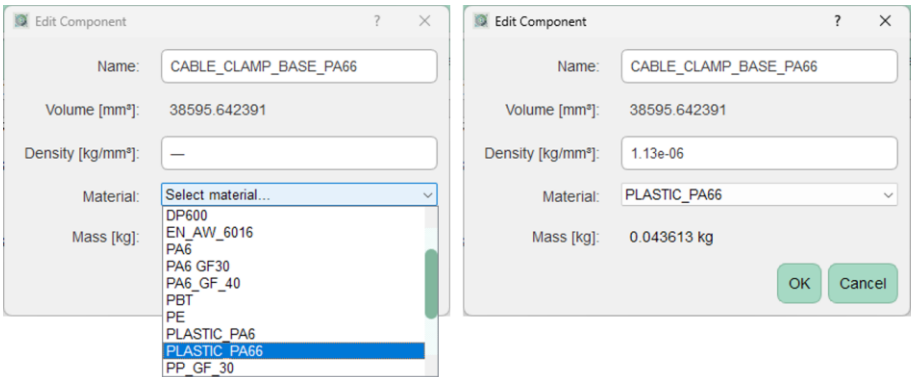


Figure 10: *Edit Selected Component: selecting a material*

Once all components have been finalised, the relevant dimensions are calculated in the product overview (see Figure 11).

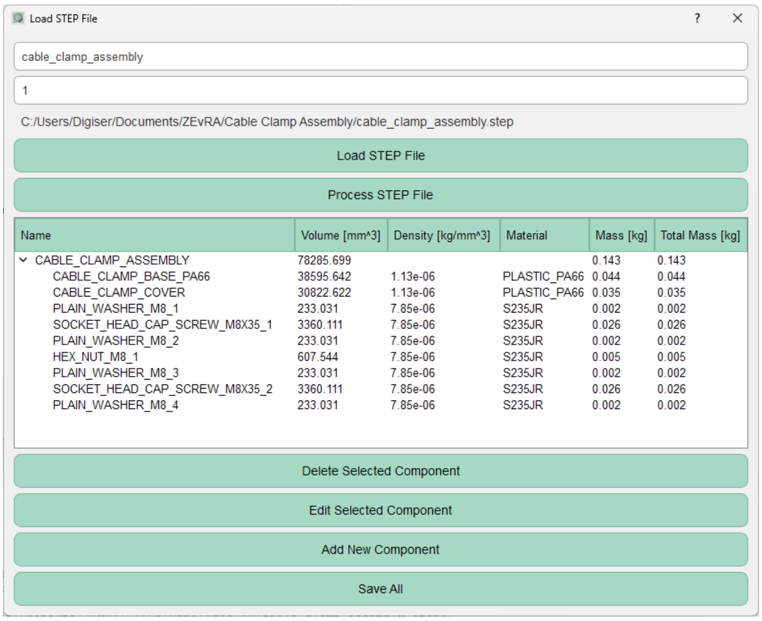


Figure 11: *New project: Result after editing components*

After clicking "Add New Component" you can fill in name, volume and select a material and an assembly. Confirm with "OK" and the tree updates (see Figure 12).

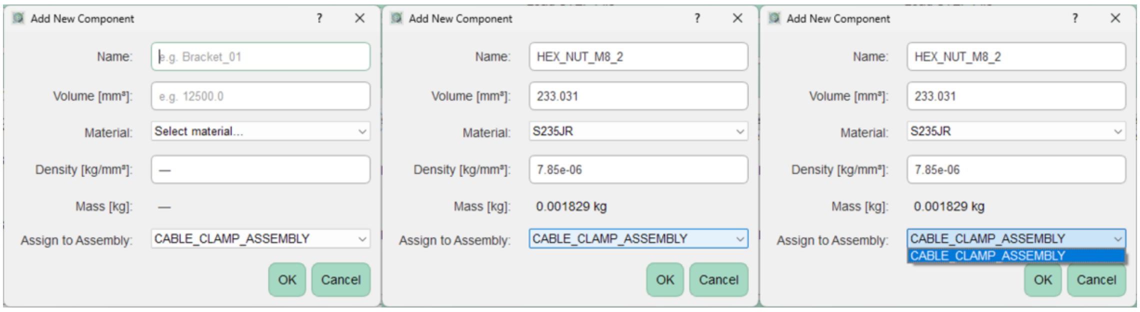


Figure 12: *Add New Component: name, volume, material and assembly*

"Save All" writes the project file and makes it the active project (shown in the upper-right corner). You receive a confirmation (see Figure 13)

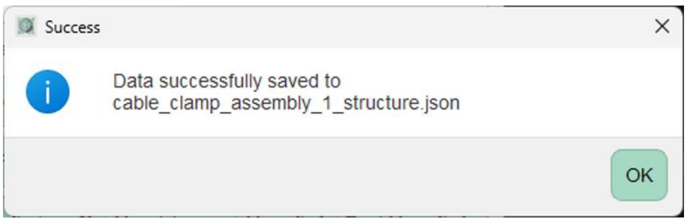


Figure 13: *Save All: success message*

Open an existing project

Alternatively you can choose "File" → "Open Project" and select an already created project structure (see Figure 14), this will then be loaded and displayed in the top right-hand corner as the active project (see Figure 15).

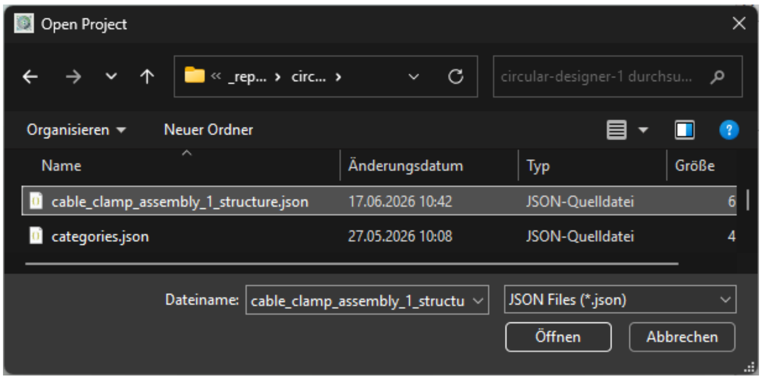


Figure 14: *Open Project: select the existing structure to open*

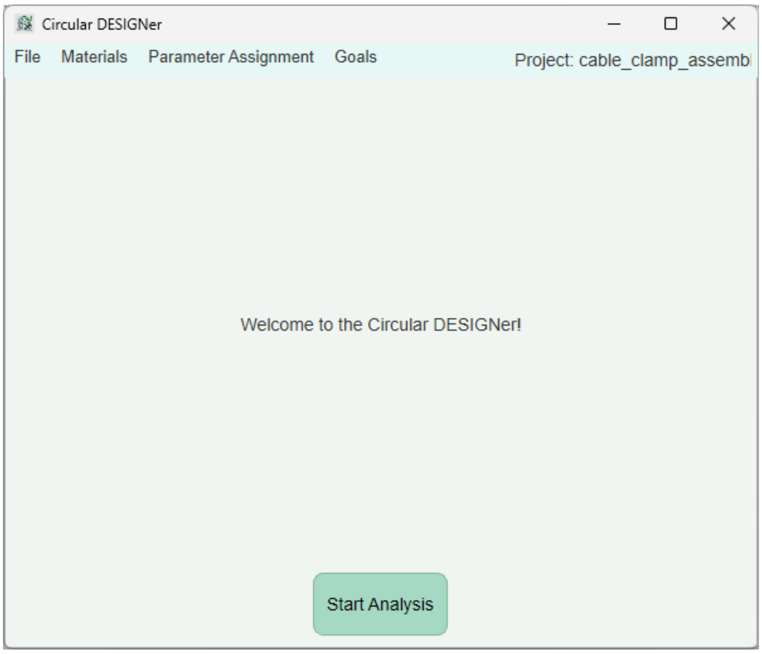


Figure 15: *Open Project: the loaded project shown in the upper-right corner*

2.4.2 Step 2 – Start the analysis and select a component

After Step 1, Press "Start Analysis" in the start window to open the "Select Component for Analysis" window. Select the component from the product tree to assess it. (see Figure 16)

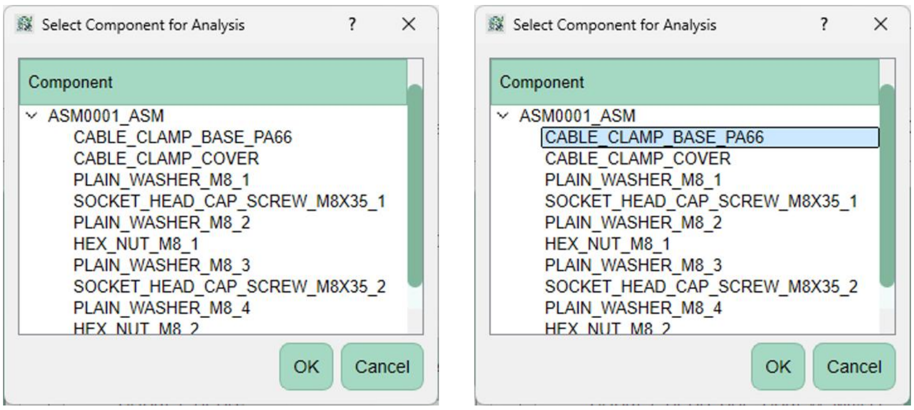


Figure 16: *Start Analysis → Select Component for Analysis*

2.4.3 Step 3 – Complete the component profile

The component dialog is divided into Basic Parameters, Disassembly, Material and Development. To reach all groups scroll through the dialog window (see Figure 17).

Basic Parameters

The CAD-derived values are read-only. Enter the life span, choose the category in the Classification tree, and state whether the component is a standard/normed part (see Figure 17).

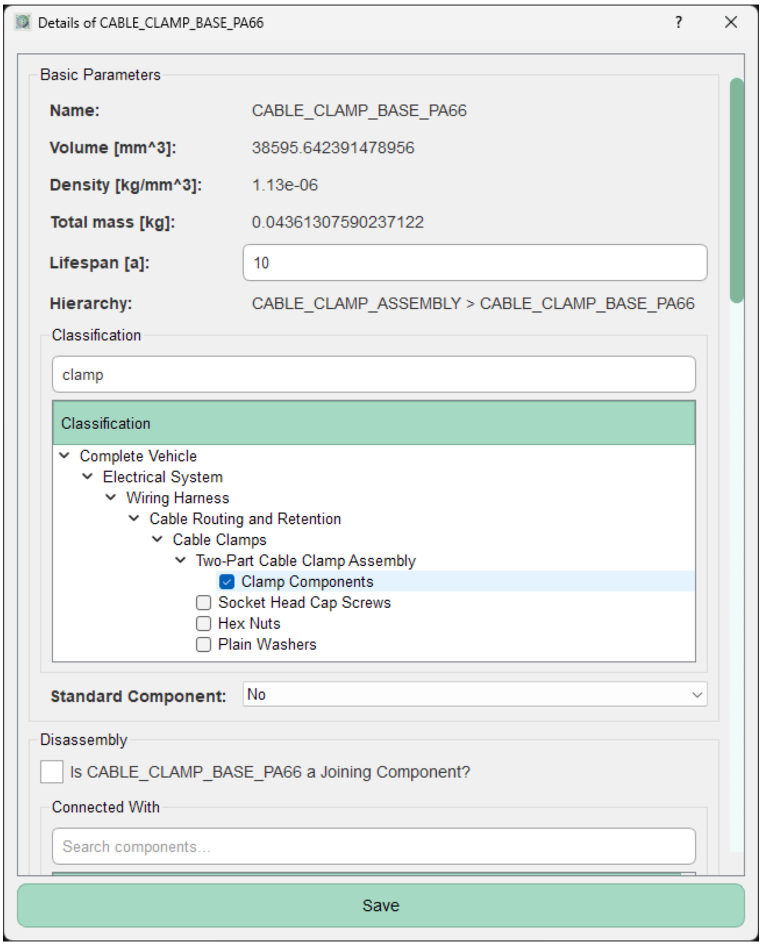


Figure 17: *Basic Parameters: input of life span and selection of classification*

Disassembly

First indicate whether the component is a joining component and under “Connected With” select the connected part(s). Under Connected By, add a connection by selecting the partner and the connection type, then choose the most fitting tool and enter the detachment time. The added connection appears in the list (see Figure 18 to Figure 21). Connections can be removed via “Delete Connection(s)” (with a success window).

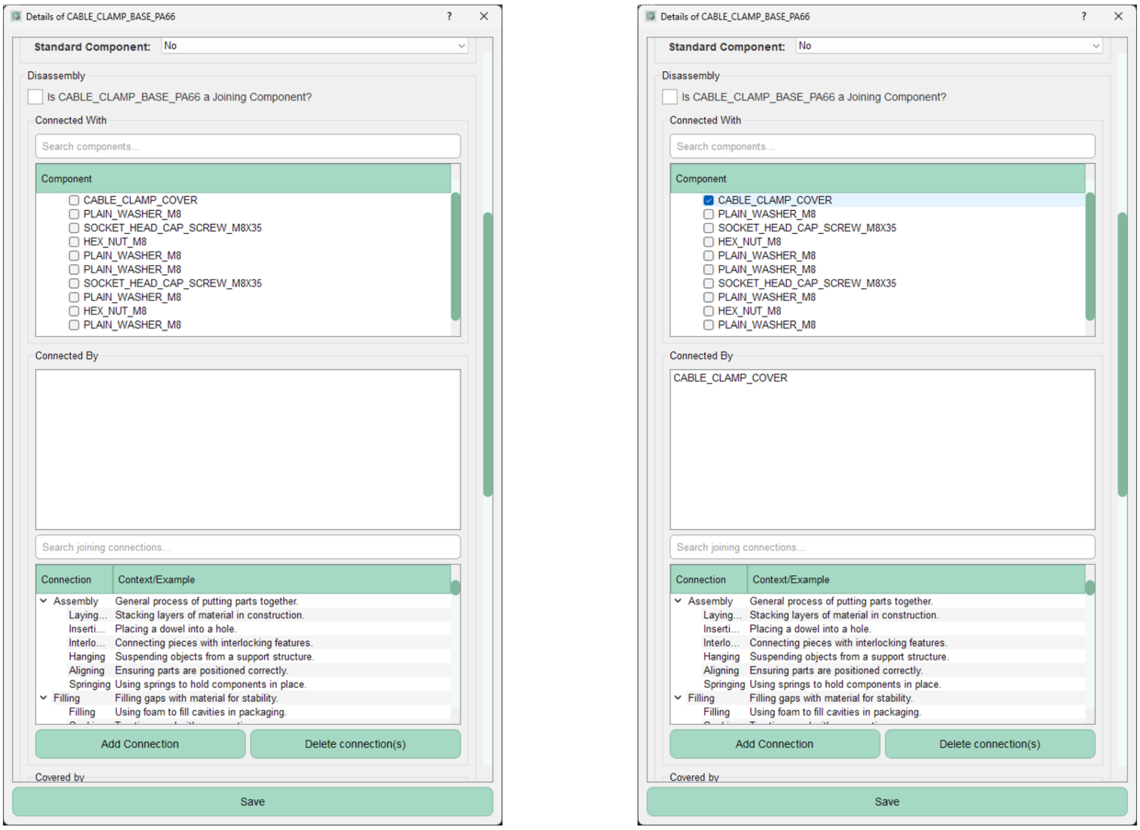


Figure 18: *Disassembly: selection of connected part(s)*

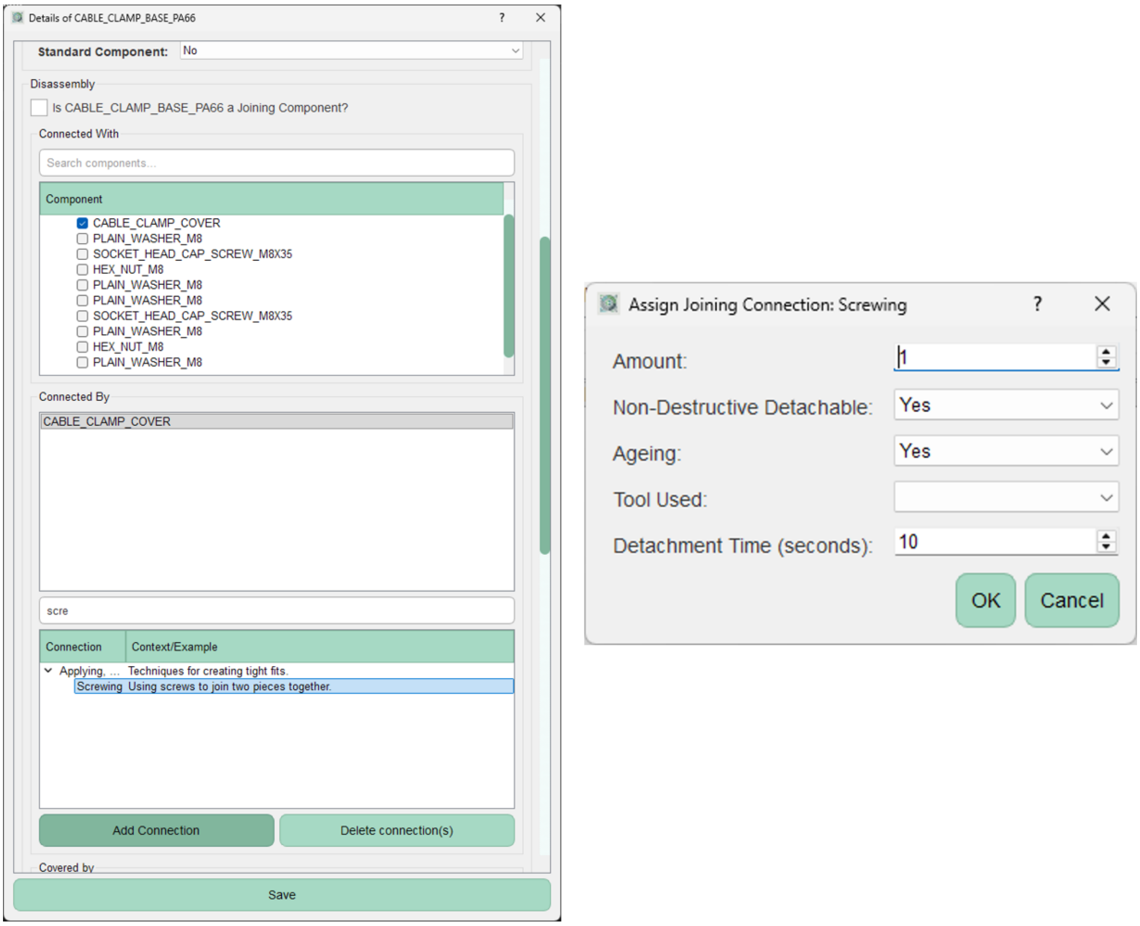


Figure 19: *Add connection: select the part and the connection type*

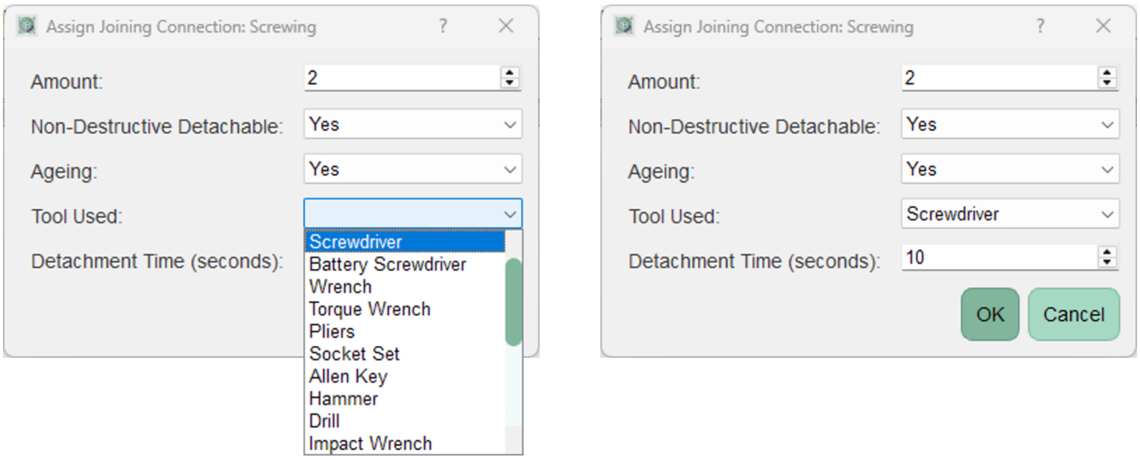


Figure 20: *Add connection: select the tool and enter the detachment time*

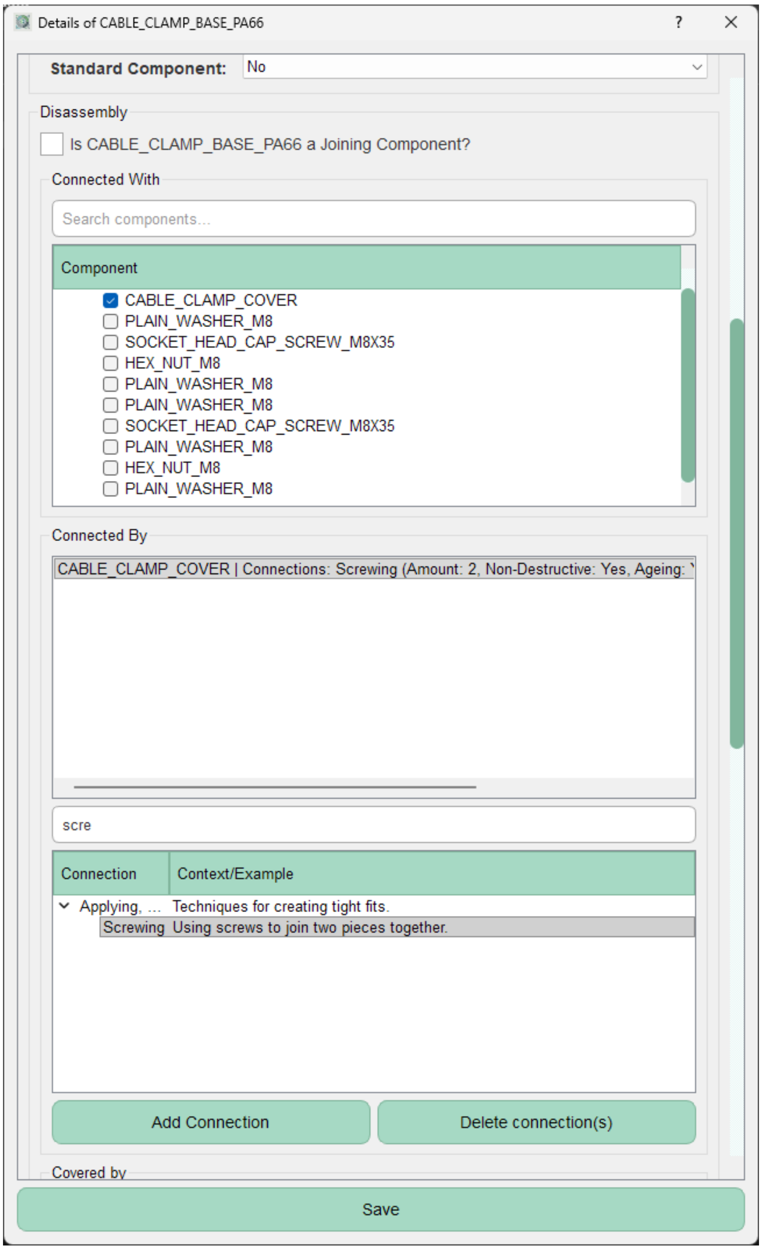


Figure 21: *Disassembly: result after adding a connection*

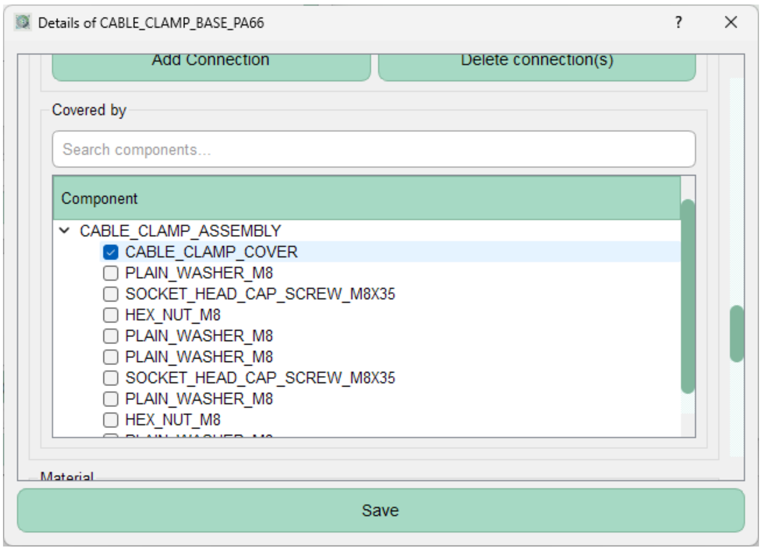


Figure 22: *Disassembly: select the parts that cover the analysed part (Covered by)*

Finally under "Covered by", select the parts that cover the part being analysed (see Figure 22)

Material

The Material section lists the materials in the materials database and shows "Number of Materials" (see Figure 23). Select the fitting material in the dropdown and click "Assess Material" to open its parameter dialog (see Figure 24). This step must be carried out for every material you wish to use, otherwise, its circular economy properties will not be assessed. In the material dialog, the material can be changed and its characteristics edited (density excepted, see Figure 25).

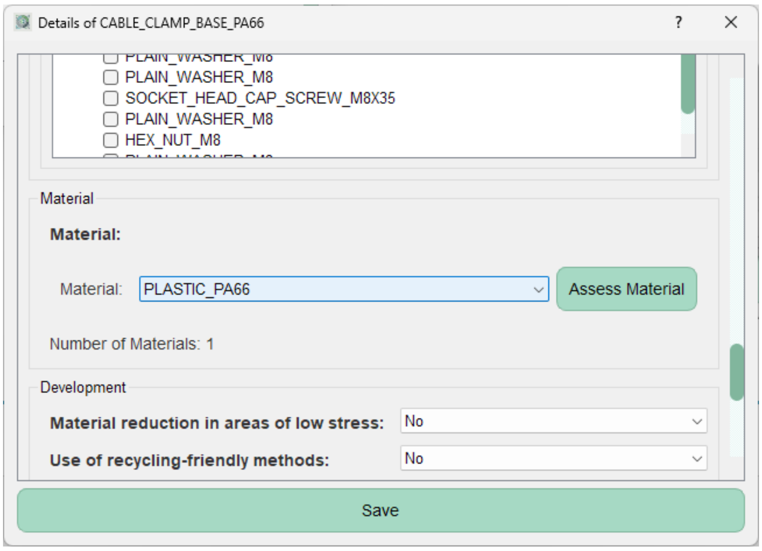


Figure 23: *Material section: select a material and click Assess Material ("Number of Materials" shows the count)*

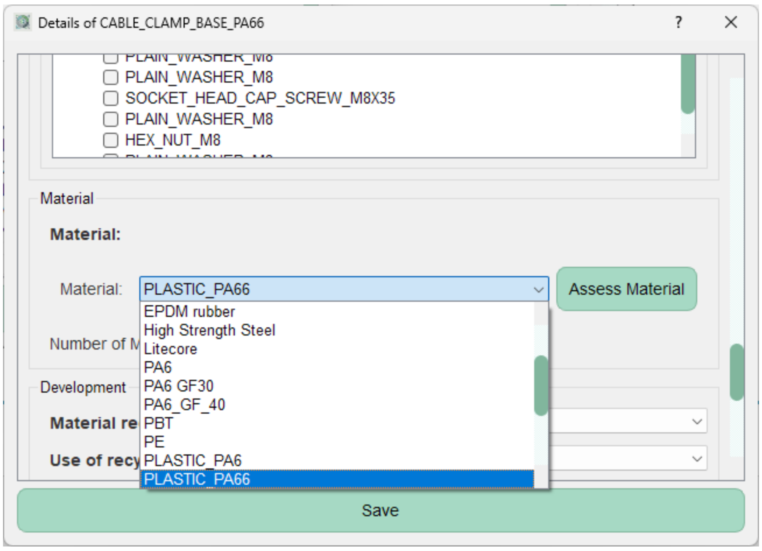


Figure 24: *Assess Material: change the material*

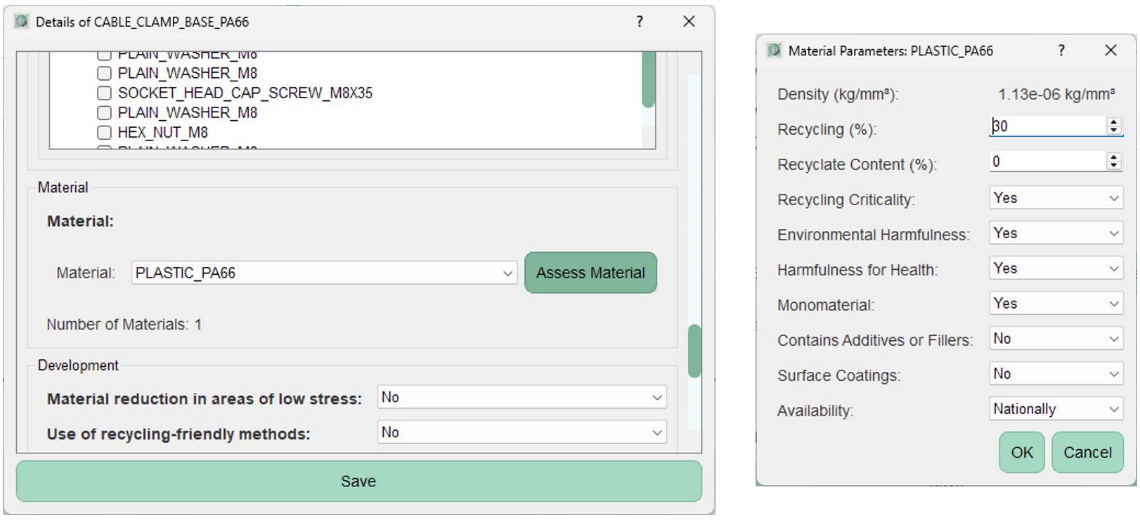


Figure 25: *Assess Material: change the material characteristics except density*

Development, and saving the component

In this category answer Yes/No for every development parameter via the combo boxes (see Figure 26), click Assessed and then Save (a success window confirms). Repeat this procedure for every component before calculation (see Figure 27).

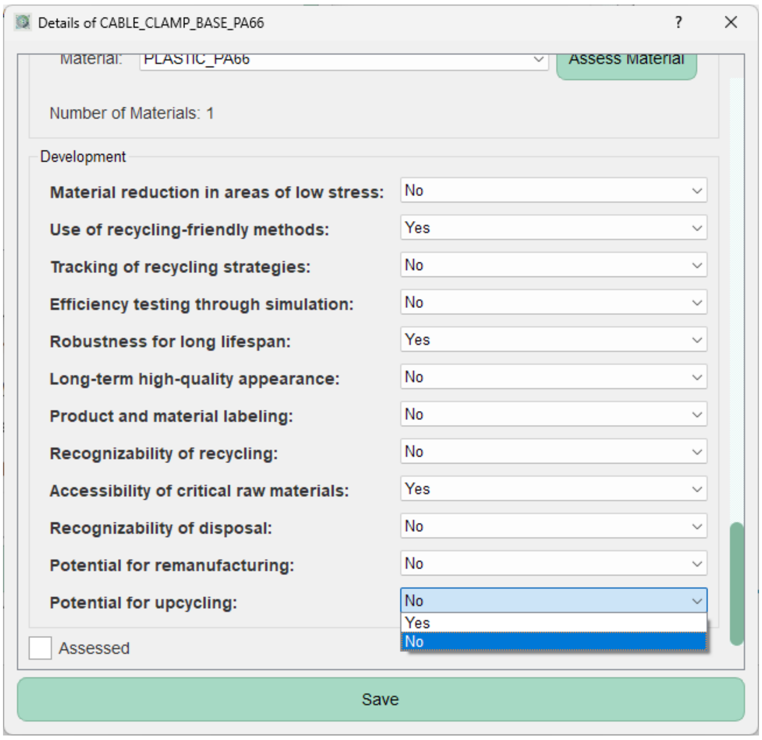


Figure 26: *Development: select Yes or No for every parameter*

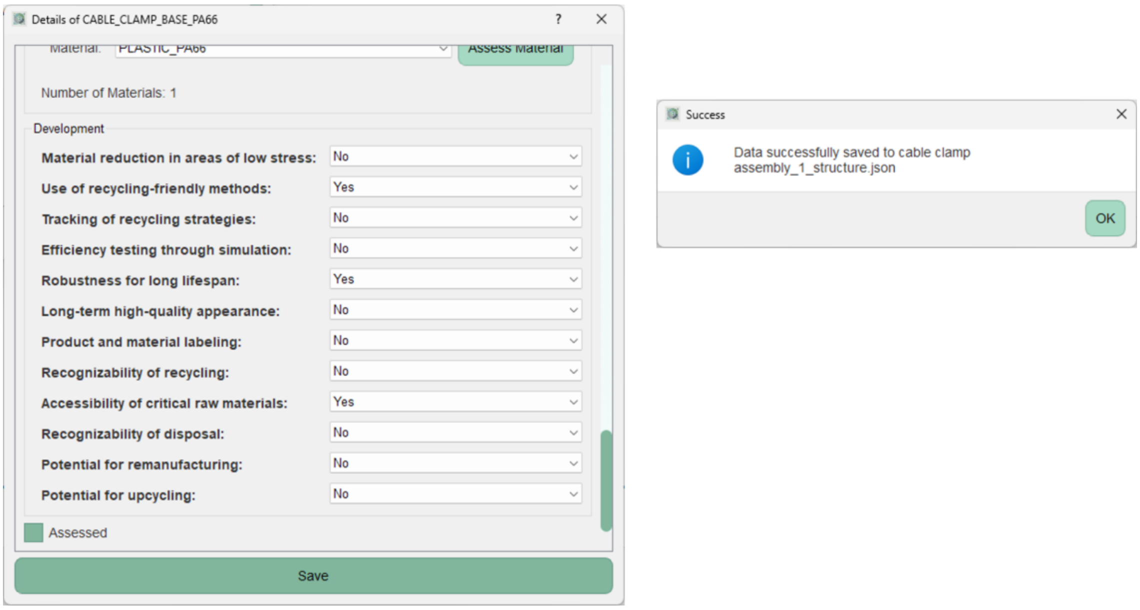


Figure 27: *Tick Assessed, save, and the success window*

Figure 28 shows the special case of a standard part that is also a connecting component.

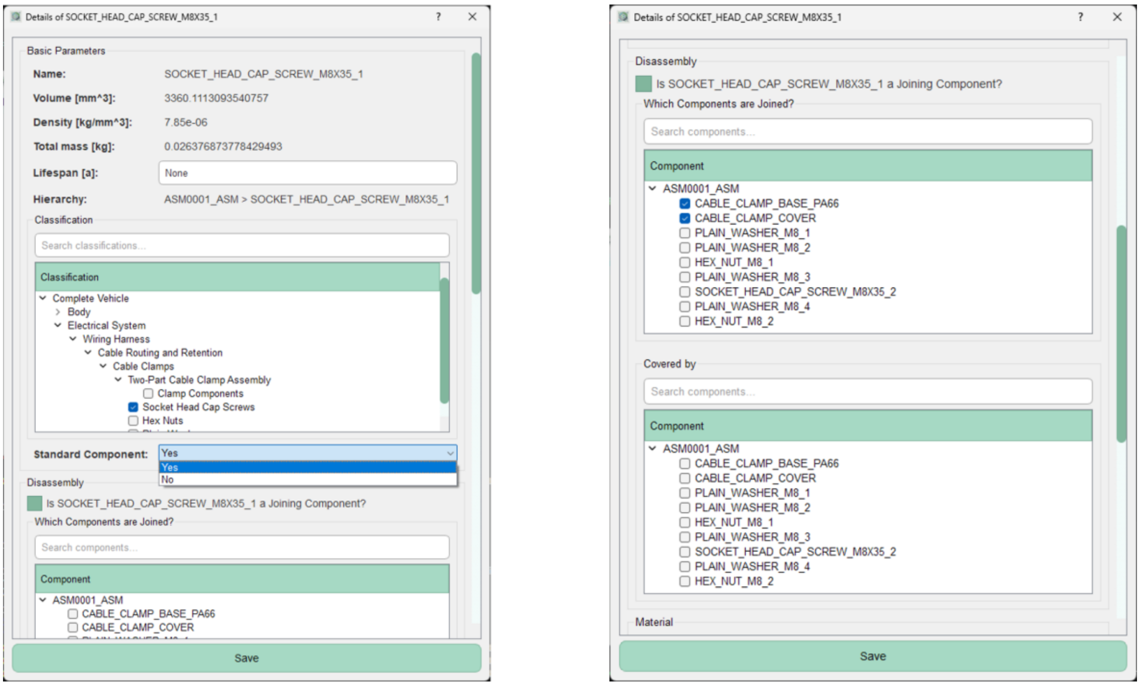


Figure 28: *Example of a standard and a joining component*

2.4.4 Step 4 – Run the calculation

After every component is assessed, confirm the selection with OK and a success window confirms that the analysis can proceed (see Figure 29). The "Start Calculation" dialog opens. Press "Start Calculation" to start the calculation. The status area reports the run and any input errors. On success ("All calculations completed successfully!"), press "Show Results". (see Figure 30).

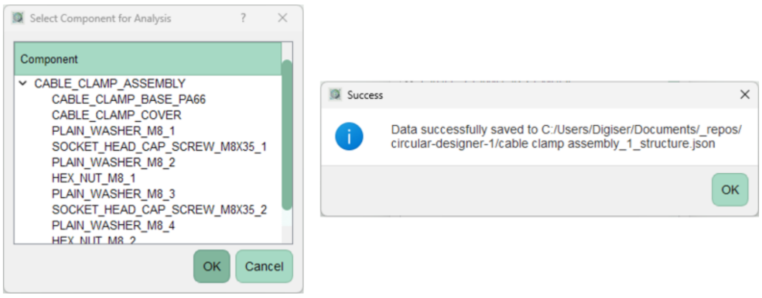


Figure 29: *Select Component for Analysis: OK and the success window confirming the analysis can proceed*

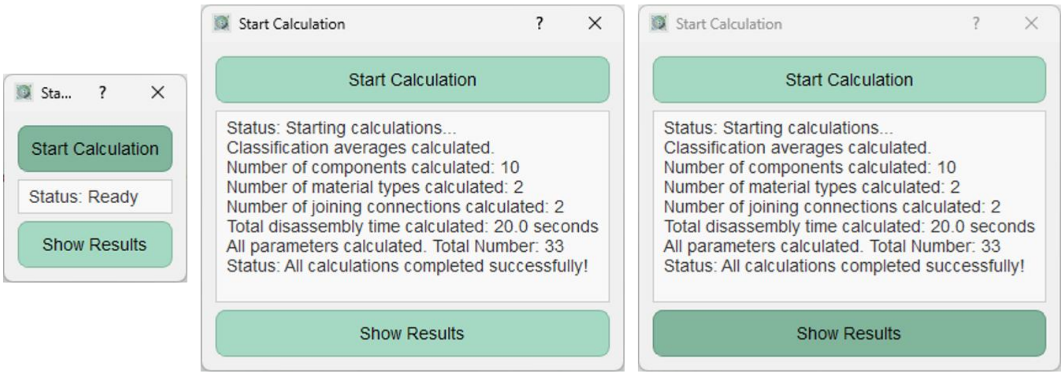


Figure 30: *Calculation dialog with status messages after a successful run*

2.5 Understanding the outputs and interpreting results

The following section explains how the tool's analysis is structured, and how it can be interpreted and used.

2.5.1 The result window

The result window ("R-Strategy Results") gathers all outputs on one screen. Scroll to reach every panel:

- Top area: summary KPIs (total mass, total volume, number of components, number of materials, number of joining connections, total disassembly time), a aterial Mass Distribution pie chart, and the Assembly Tree.
- Middle area: the bar chart "Suitability for R-Strategies" over R0–R9 (R0 Refuse … R9 Recover), with the value above each bar and the best/worst strategy highlighted in green/red.
- Lower area: the bar chart "Stage Averages" (average goal achievement per life-cycle stage) and, below it, the Logistics score (Section 2.5.3).

Figure 31: *Result window: KPIs and material chart (top), Assembly Tree (top-right) and Suitability for R-Strategies (middle)*

2.5.2 Assembly tree and component details

The Assembly Tree (top-right in Figure 32) lists the assessed product structure. When selecting a node, you open a "Details for Component" view with that component's data (see Figure 33)

Figure 32: *Result window: the Assembly Tree*

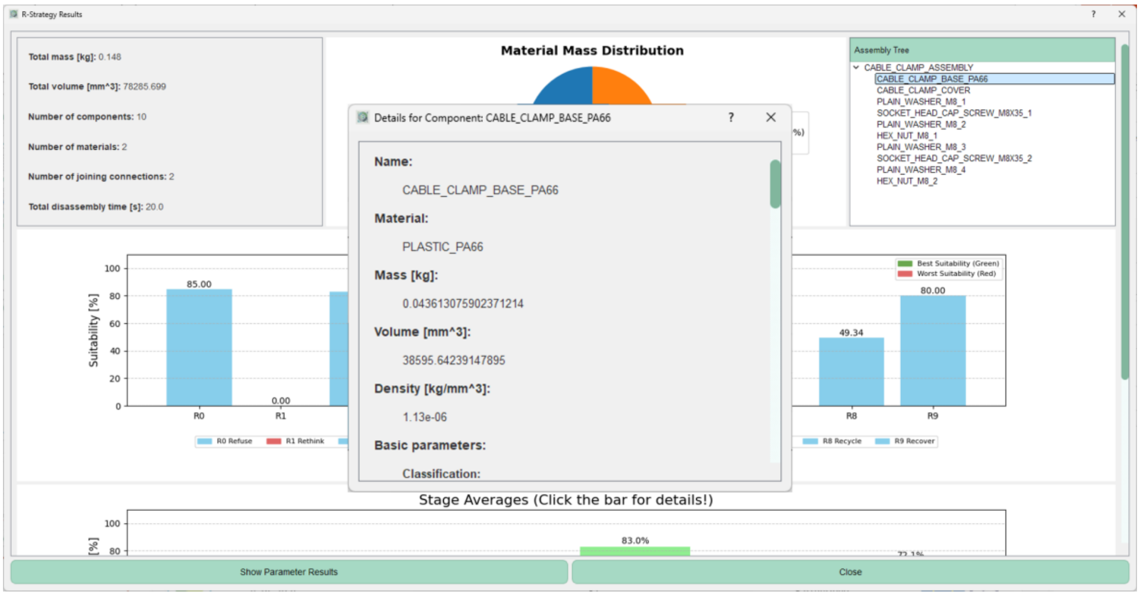


Figure 33: *Assembly Tree: details for a selected component*

2.5.3 Stage averages, category details and the logistics score

The "Stage Averages" chart (see Figure 34) shows the average goal achievement per life-cycle stage (1 Material Selection, 2 Development, 3 Production and Manufacturing, 4 Logistics, 5 Use, 6 End of Life). Clicking a stage bar opens a "Details for Category" view which lists the goals of that stage and their achievement (see Figure 35).

Below the chart, the Logistics score is shown as a single value on a 0–1 scale (in the example, 0.54) with a bar indicator. This additional indicator is based on a study analysing waste streams to and from the EU , which was carried out in Task 6.2.2 and will be published as part of the forthcoming Deliverable 6.10. A higher logistics value indicates more favourable logistical conditions for the component's future recovery within a circular economy ecosystem.

Figure 34: *Result window: Stage Averages chart and the Logistics score (value on a 0–1 scale)*

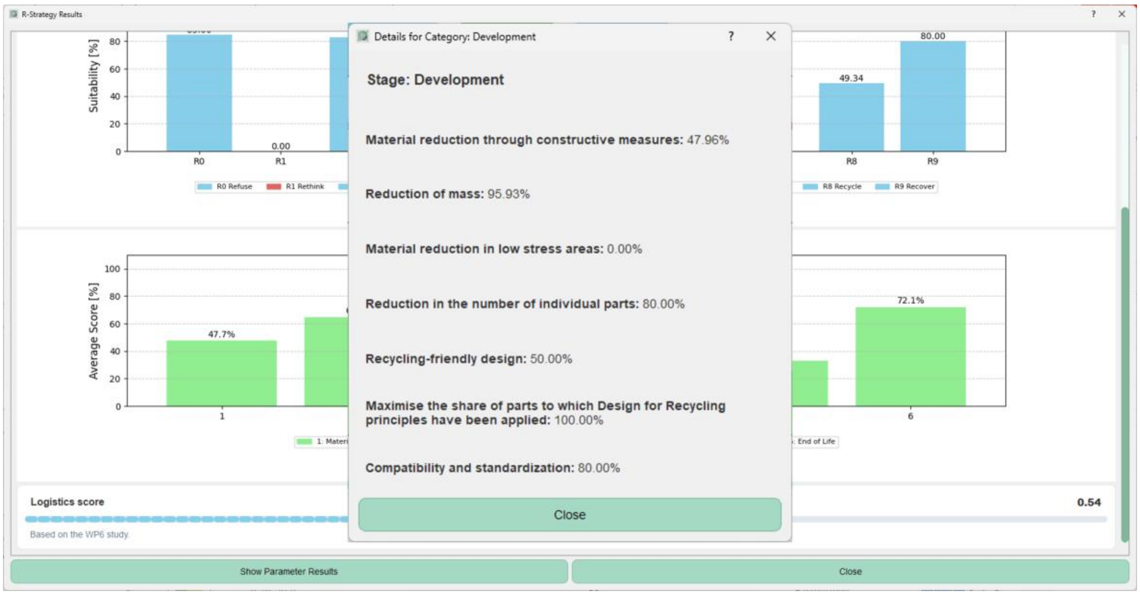


Figure 35: *Stage Averages: details for a selected category (life-cycle stage)*

2.5.4 Parameter results

The button "Show Parameter Results" opens a list with the computed value of every evaluation parameter (see Figure 36 and Figure 37).

Figure 36: *Result window: Show Parameter Results*

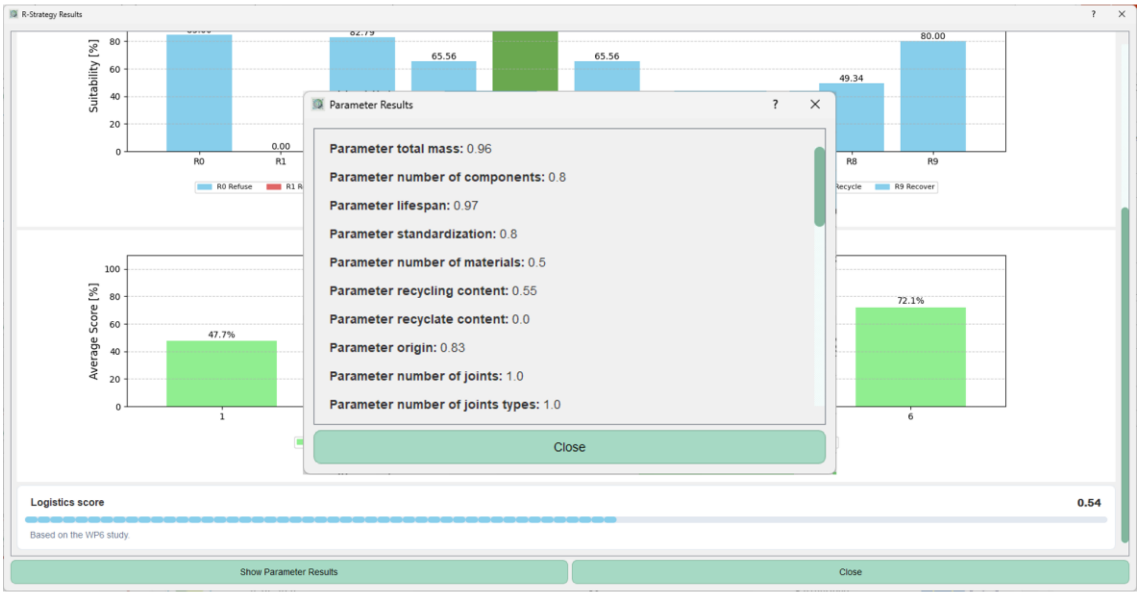


Figure 37: *Parameter Results: the computed value of every parameter*

2.5.5 Closing the analysis

"Close" ends the analysis and a final success window confirms completion (see Figure 38 and Figure 39)

Figure 38: *Result window: Close*

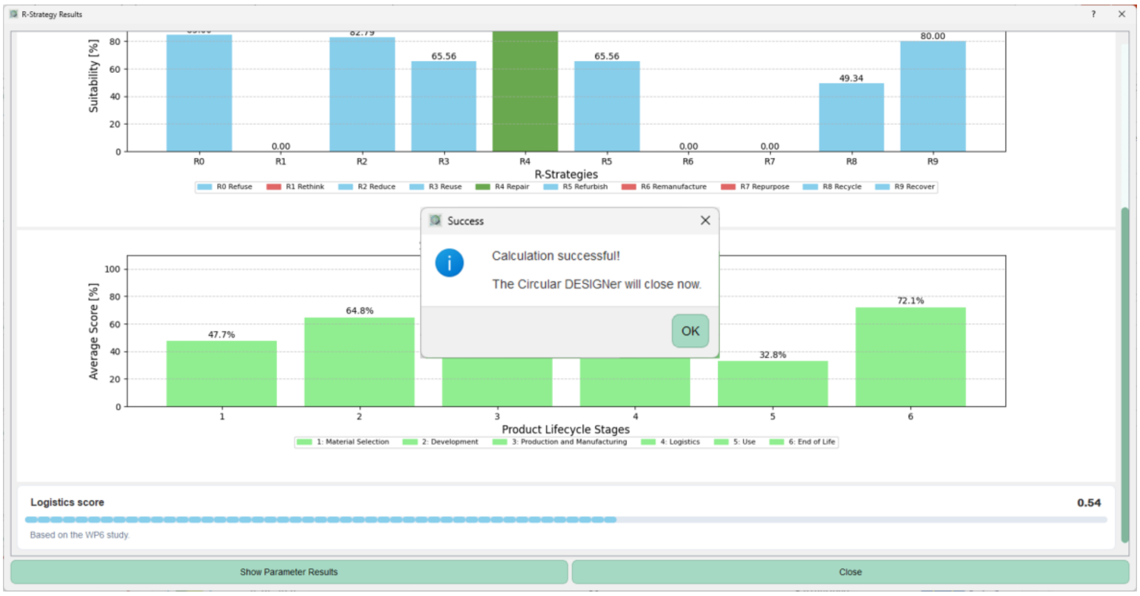


Figure 39: *Final success window after closing the analysis*

2.5.6 How to read the result

The R-strategy with the highest suitability is the one your current design supports best. Where scores and stage averages are low, there is the most room to improve. Results depend on the classification and its example data, and on the goal-to-strategy weighting (see Section 2.6.4).

2.5.7 Reference: computed parameters

The following parameters in Table 5 are computed from the inputs and reported via "Show Parameter Results".

Table 5: *List of computed parameters*

Parameter	What it expresses
Origin	Average distance of the material sources across all materials.
Recycling Content	Average recycling rate across all materials.
Recyclate Content	Average share of recyclate content across all materials.
Total Mass	Overall weight of the assembly.
Durability	Proportion of components designed with durability in mind.
Labeling	Proportion of components with complete, standard-compliant labeling.
Efficiency Simulation	Proportion of components for which an efficiency simulation is performed.
Recycling Strategies	Proportion of components with a clear predetermined recycling process.
Recognisability Disposal	Proportion of components for which the correct disposal route is clear.
Recognisability Recycling	Proportion of components for which the correct recycling route is clear.
Material Reduction	Proportion of components optimised by design for material reduction.
Aesthetics Longevity	Proportion of components aesthetically pleasing in the long term.
Upcycling Potential	Proportion of components that can be upcycled.
Remanufacturing Potential	Proportion of components that can be remanufactured.
Standardization	Proportion of components that do not follow common, standardised formats.
Recycling Methods	Proportion of components with recycling-oriented design methods applied.
Accessibility Critical	Proportion of components critical to recycle and easily accessible.
Joints Ageing	Proportion of joints sensitive to aging or wear.
Non-Destructive Joints	Proportion of joints dismantlable non-destructively.
Harmfulness Environment	Proportion of materials that are environmentally harmful.
Harmfulness Health	Proportion of materials harmful to health.
Monomaterial	Proportion of materials that are monomaterials.
Surface Coatings	Proportion of materials that are surface coated.
Additives & Fillers	Proportion of materials containing additives or fillers.
Recycling Criticality	Proportion of materials whose recycling is critical/difficult/impossible.
Lifespan	Ratio of average to maximum life span across components.
Disassembly Time (Disposal)	Time to disassemble for disposal (non-destructive and destructive).
Disassembly Time (Maintenance)	Time to disassemble for maintenance/repair (non-destructive).
Joints Number	Total number of connections/joints between parts.
Components Number	Total number of individual parts.
Joints Types	Total number of joint types.
Materials Types	Total number of material types.
Tools Types	Total number of tool types needed for dismantling.
Assembly Time	Roughly estimated time to assemble the assembly.

2.6 Populating the database with new strategies, materials, or component designs

This chapter guides the user in populating the database in Table 6 with other strategies, materials, or component designs. This is part of normal operation, because the assessment depends on these reference data.

Table 6: *List of databases*

Database	Content	How it is maintained
Classification	Benchmark catalogue of typical parts (with “Examples”)	Prepared manually before first use; grows as products are assessed
Material	Materials and their circularity attributes	Add Material; Add Material via Catena-X; Update Material; auto-updated during assessment
Parameter to Goal assignment	Which parameters contribute to which goal	Parameter Assignment menu; stored as JSON
Goal to R-strategy weighting	Weight (−4…+4) of each goal per R-strategy	Goals menu; stored as JSON

2.6.1 Adding component designs: the classification database

The file classification_validation.json defines a hierarchical product classification for vehicle components. It should be filled as a tree, starting with a broad top-level category and becoming more specific at each nested level.

General structure

Each classification level is represented as a JSON object key.

Use the following pattern:

```
{
	"Complete Vehicle": {
		"Main System": {
			"Subsystem": {
				"Component Group": {
					"Specific Component": {
						"Examples": []
					}
				}
			}
		}
	}
}
```

Each level may contain:

- further nested classification levels,
- an Examples array of one or more dictionaries or
- both nested levels and an Examples array of one or more dictionaries.

Use Examples for Usual Characteristics of Assemblies or Parts Being Evaluated

The Examples array should contain the usual characteristics of assemblies and parts at the classification level, to be evaluated later.

Example:

```
"Screws": {
      "Examples": [
            {
                  "name": "Steel-Screw",
                  "used_materials": ["S235JR"],
                  "number_of_components": 1,
                  "number_of_materials": 1,
                  "number_joining_connections": 1,
                  "number_of_different_joining_connections": 1,
                  "number_of_tools": 1,
                  "disassembly_time [s]": "22.5",
                  "assembly_time [s]": "26"
            }
      ]
}
```

The name should describe what differentiates this example from the other examples for the assembly or the part, if there is more than one example.

For used materials, a material from the materials database should be stated. If the material is not in the material database yet, it needs to be added for the evaluation to work later on. The parts should have a single material; the assemblies can have more than one, since all the materials used within the assembly are listed.

The number of components of parts is 1, and for assemblies, the corresponding number of parts.

The number of materials is 1, and for assemblies, the corresponding number of materials.

The number of joining connections corresponds to the number of connections the part has to other parts. Joining components, such as screws, washers, and nuts, are not included. For assemblies, the joining connections within the assembly are counted. This is not equal to the sum of the joining connections of the parts, because you would add the joining connection for each connection partner.

The number of different joining connections corresponds to the number of joining connections being of a different type after the standard family DIN 8593.

The number of tools corresponds to the number of different tools needed to disassemble or assemble the part. A list of tools considered can be found in the disassembly_tools.json file.

Add All Intermediate Levels

Do not place a specific part directly under a very broad category unless no meaningful intermediate category exists.

Prefer this:

```
"Complete Vehicle": {
	"Electrical System": {
		"Wiring Harness": {
			"Cable Routing and Retention": {
				"Cable Clamps": {
					"Two-Part Cable Clamp Assembly": {
						"Examples": []
					}
				}
			}
		}
	}
}
```

Avoid this:

```
"Complete Vehicle": {
	"Two-Part Cable Clamp Assembly": {
		"Examples": []
	}
}
```

Intermediate levels make the classification easier to search, extend, and reuse.

Recommended Naming Rules

Use clear English names for classification keys. Recommended:

- "Cable Routing and Retention"
- "Socket Head Cap Screws"
- "Plain Washers"
- "Hex Nuts"

Avoid unclear abbreviations:

- "Misc"
- "Parts"
- "Stuff"

- "Screws etc."

Use singular names for individual component types only when the category represents one specific part and use plural names for groups e.g.:

- "Cable Clamp Components"
- "Hex Nuts"
- "Plain Washers"

How to Classify Assemblies and Parts

Assemblies should be placed above their individual parts, e.g.:

```
"Two-Part Cable Clamp Assembly": {
      "Examples": […],
      "Clamp Components": {
            "Examples": […]
            },
      "Fasteners": {
            "Socket Head Cap Screws": {
                  "Examples": […]
            },
            "Hex Nuts": {
                  "Examples": […]
            },
            "Plain Washers": {
                  "Examples": […]
            }
      }
}
```

This structure makes it clear which parts belong to the assembly and which parts are functional subcomponents.

When to Create a New Branch

Create a new branch when a component belongs to a vehicle area that is not yet represented. For example, if the file currently only contains body-related categories and a new part belongs to the wiring harness, add a new branch such as:

```
"Electrical System": {
      "Wiring Harness": {
            "Cable Routing and Retention": {}
      }
}
```

Do not force unrelated components into an existing branch just because it already exists.

Where to Place Fasteners

Fasteners are classified according to the assembly in which they are used.

For small demonstration models, it is usually clearer to place fasteners directly under the related assembly:

```
"Two-Part Cable Clamp Assembly": {
	"Socket Head Cap Screws": {
		"Examples": []
	},
	"Hex Nuts": {
		"Examples": []
	},
	"Plain Washers": {
		"Examples": []
	}
}
```

Keep the JSON Valid

Before saving the file, check the following:

- Every opening { has a matching closing }.
- Every opening [has a matching closing].
- Every key is enclosed in double quotes.
- Commas are placed between entries, but not after the final entry in an object or array.
- Examples is always an array, even if it is empty.

Correct:

```
"Examples": [
	{
		"name": "Steel-Screw",
		…
	}
]
```

Incorrect:

```
"Examples":  "name": "Steel-Screw",
             …
```

Minimum Entry for a New Component

A minimum valid classification entry should include all relevant hierarchy levels and an Examples array at the final component level.

Example:

```
"Component Name": {
      "Examples": [
            "name": "Steel-Screw",
            "used_materials": ["S235JR"],
            "number_of_components": 1,
            "number_of_materials": 1,
            "number_joining_connections": 1,
            "number_of_different_joining_connections": 1,
            "number_of_tools": 1,
            "disassembly_time [s]": "22.5",
            "assembly_time [s]": "26"
      ]
}
```

Recommended Workflow

1. Identify the component or assembly.
2. Decide which vehicle system it belongs to.
3. Add missing intermediate levels.
4. Add the specific assembly or component category.
5. Add the usual characteristics of the parts to the Examples array.
6. Add the usual characteristics of the assemblies by creating usual combinations of their parts.
7. Validate the JSON syntax.
8. Review whether the component is placed in the most specific meaningful category.

2.6.2 Maintaining the material database

Adding materials manually

Materials can be added manually via the Materials section and the “Add Material” option. The dialog window shown in Figure 40 opens. Enter the material name and its characteristics: numerical inputs (e.g. density, recycling and recyclate share), Yes/No options, and the availability category (see Figure 41). Confirm to save the material and a success window confirms the entry (Figure 42).

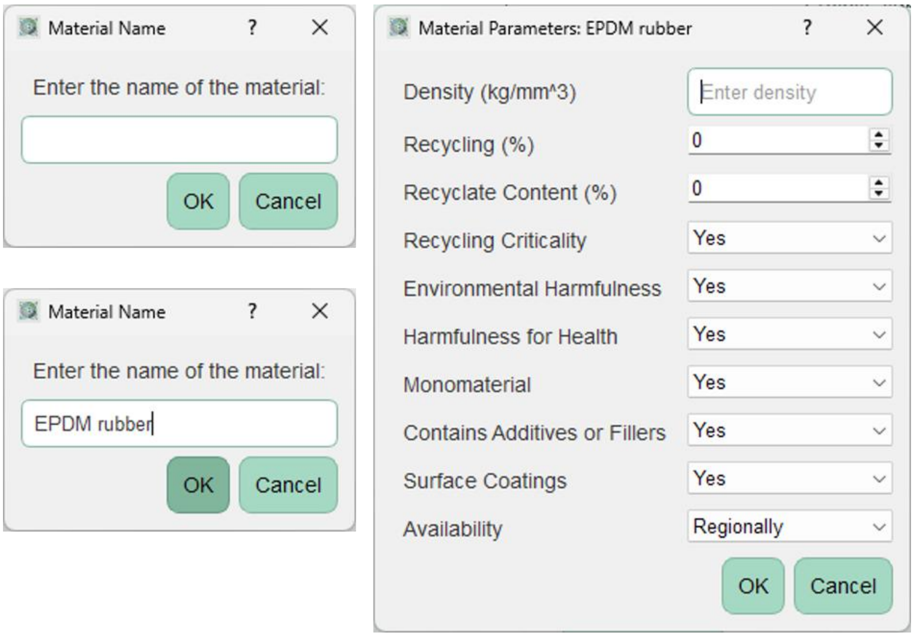


Figure 40: *Add Material: material name and other characteristics*

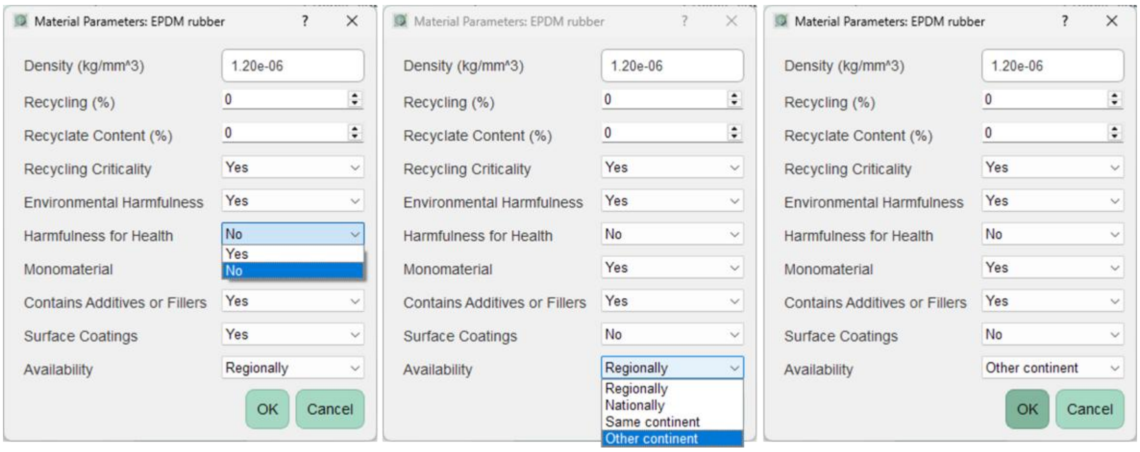


Figure 41: *Add Material: numerical inputs, Yes/No options and availability categories*

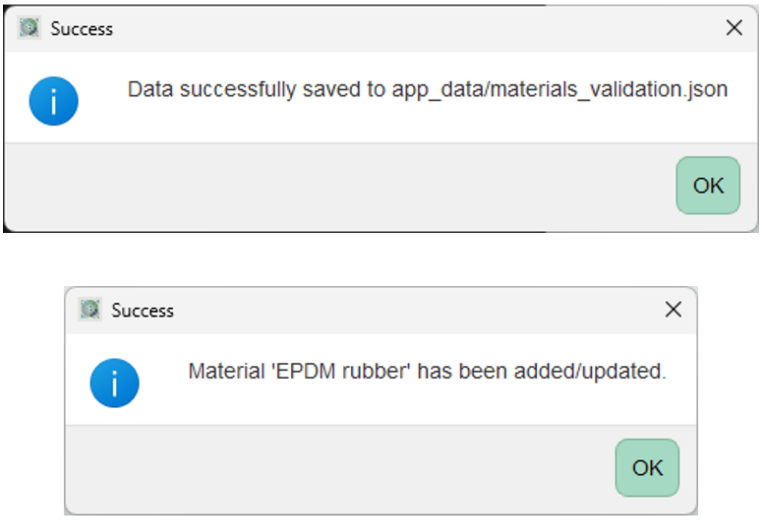


Figure 42: *Add Material: success windows*

Add materials via Catena-X

To add materials via Catena-X open Materials and click on “Add Material via Catena-X” (see Figure 43). The “Import Supplier Material” dialog opens where you can enter the mandatory Supplier material number (optionally Supplier BPNL and Site BPNS) and the materials DB path is shown (see Figure 44).

Press “Lookup” to retrieve the material (see Figure 45). Here two modes exist: in mock mode (the “Mock mode” box is ticked) the lookup returns example data without contacting any network. In real Catena-X mode it queries a live dataspace. Press “Add to materials DB” to transfer the looked-up material and then complete the missing values by updating the material (see Figure 46). Select the availability category (see Figure 47) based on the lookup country. After updating all information, a success window confirms the import (see Figure 48).

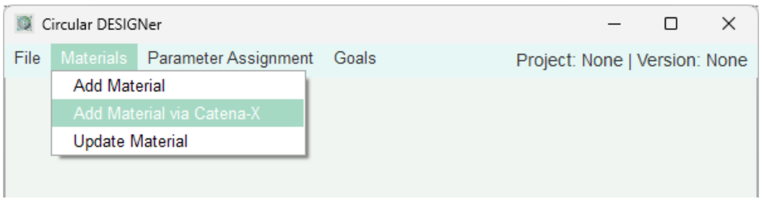


Figure 43: *Materials menu → Add Material via Catena-X*

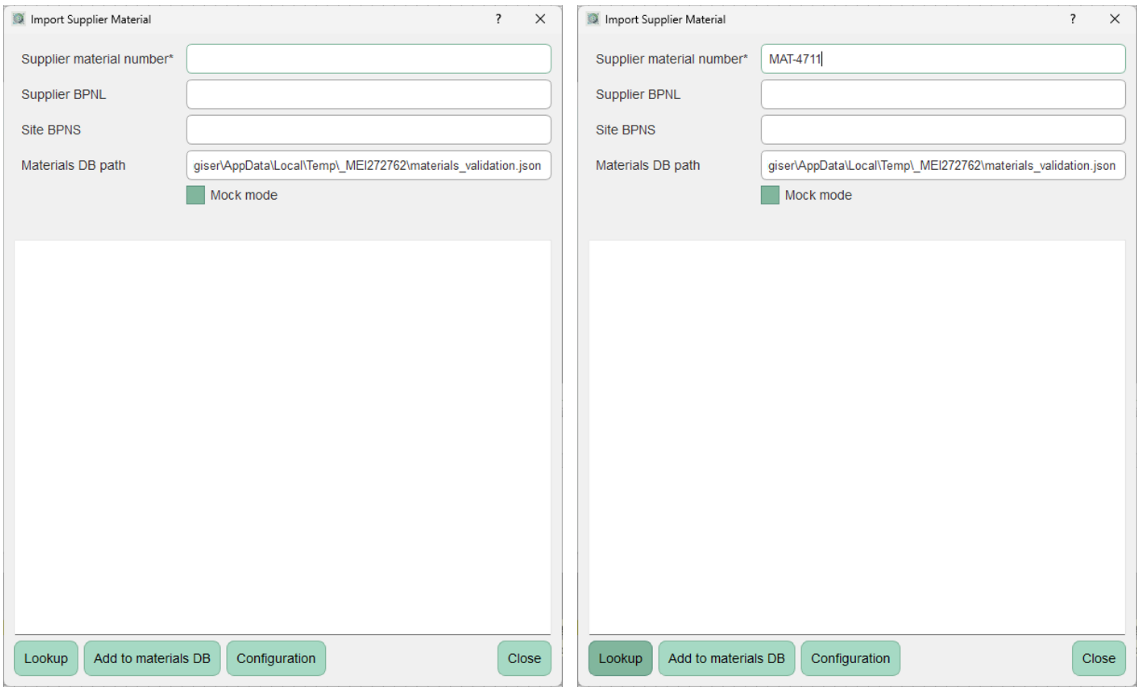


Figure 44: *Import Supplier Material: mandatory supplier material number and Lookup (mock mode)*

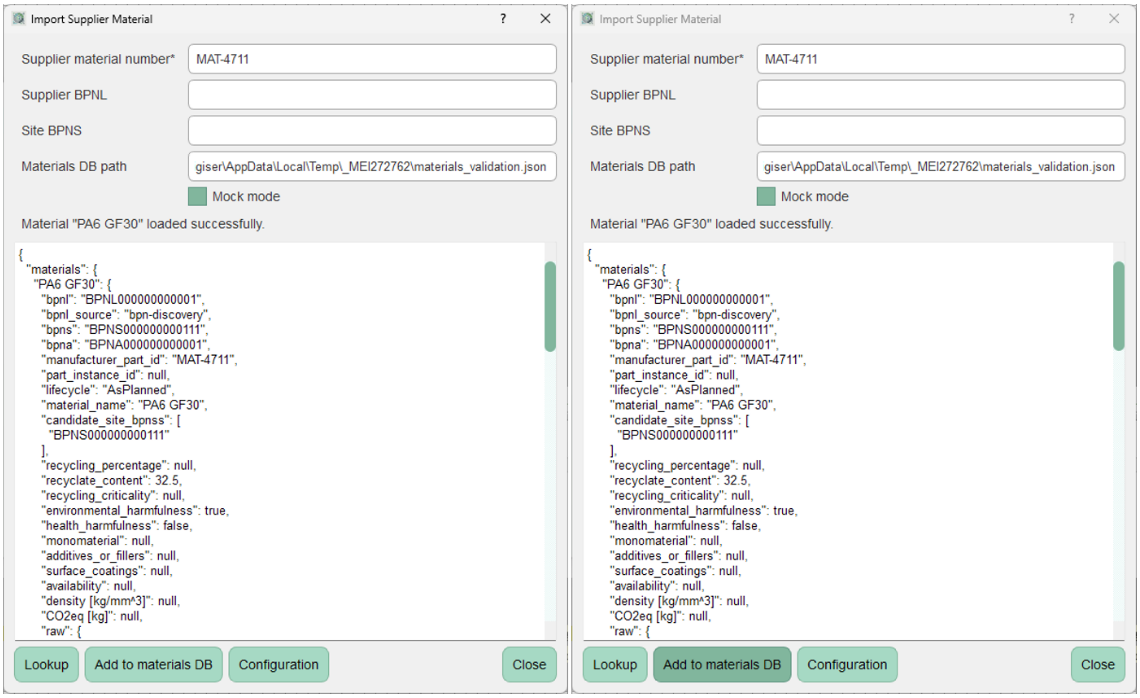


Figure 45: *Lookup in mock mode and Add to materials DB*

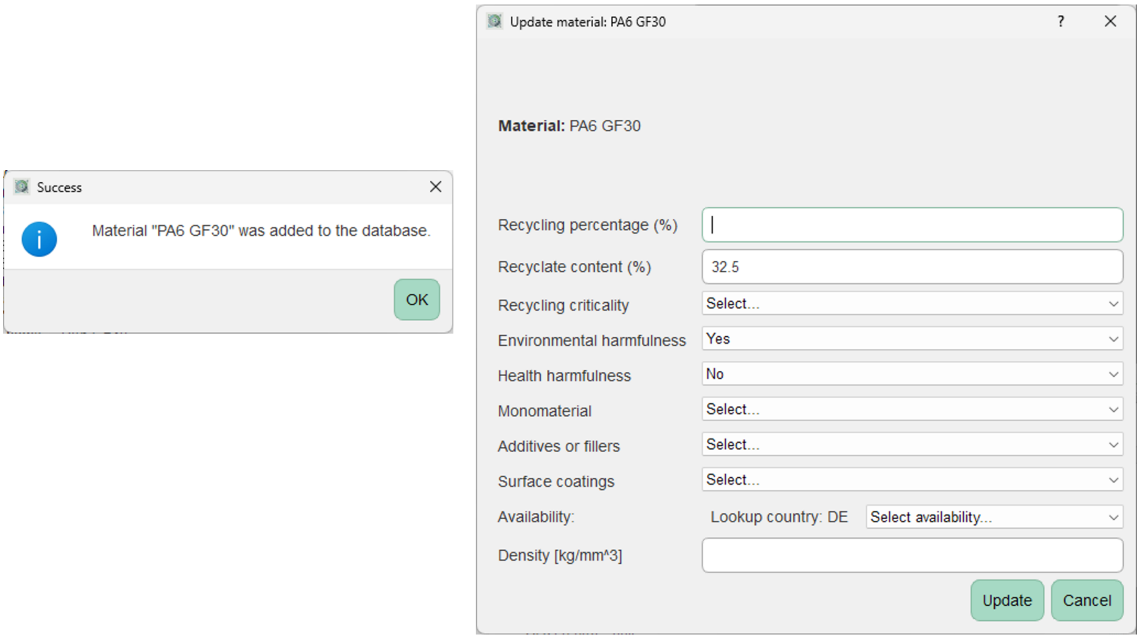


Figure 46: *Add to materials DB: adding the missing values*

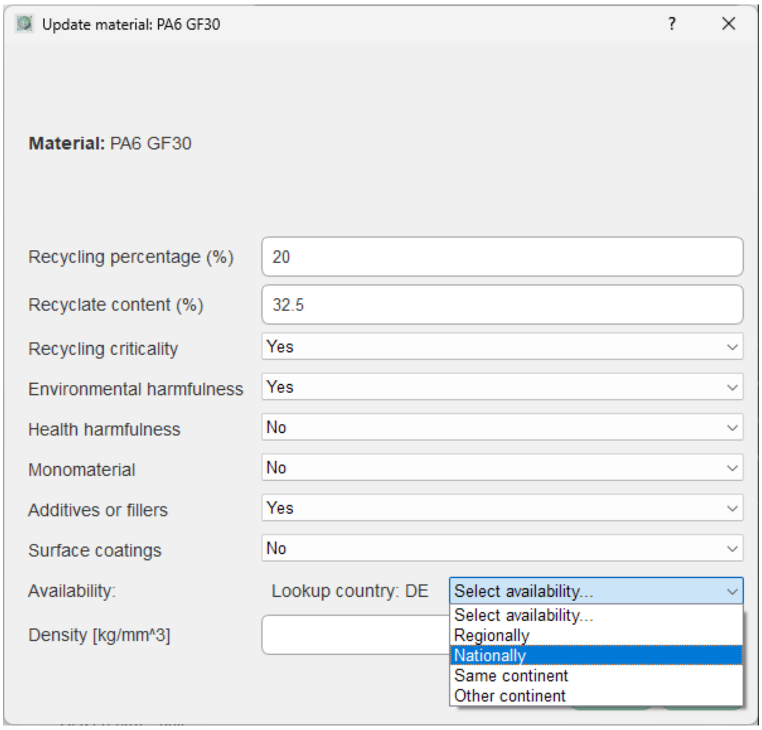


Figure 47: *Selecting the availability category based on the lookup country*

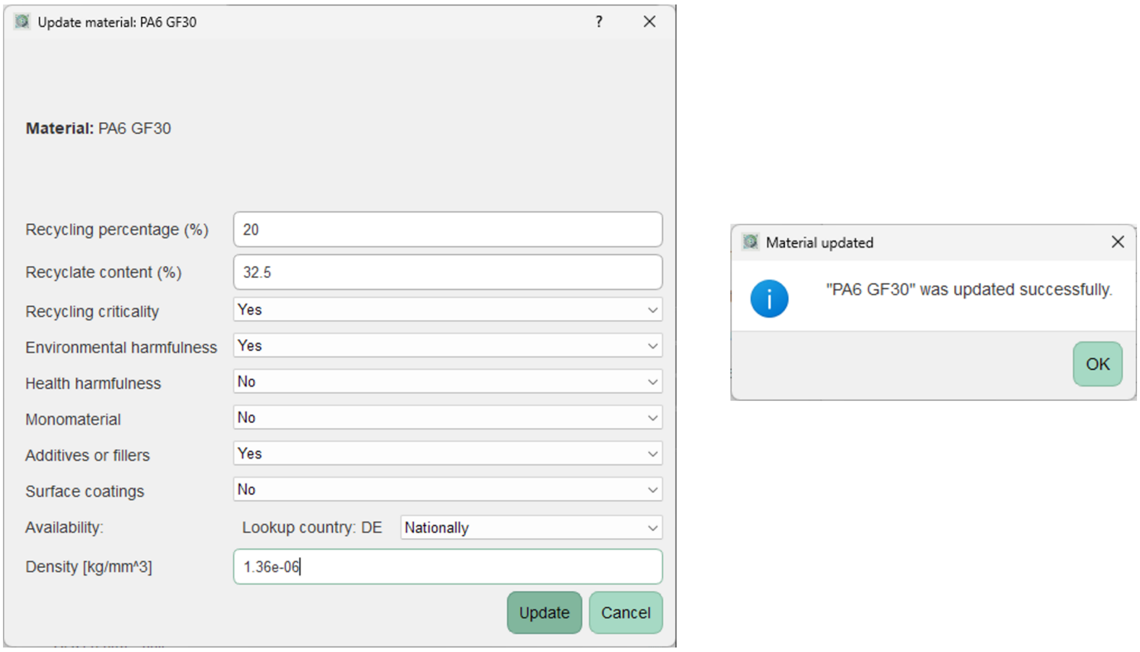


Figure 48: *Add to materials DB: success window*

“Configuration” (see Figure 49) opens a settings dialog for the real Catena-X connection: connector and discovery endpoints, credentials and the BPDM pool, plus optional/advanced parameters. The fields marked * are the minimum required for real mode. Once the configuration holds valid endpoints and credentials, the same Lookup performs a real material-data query against the Catena-X network and adds the returned material in the same way as in mock mode (see Figure 50).

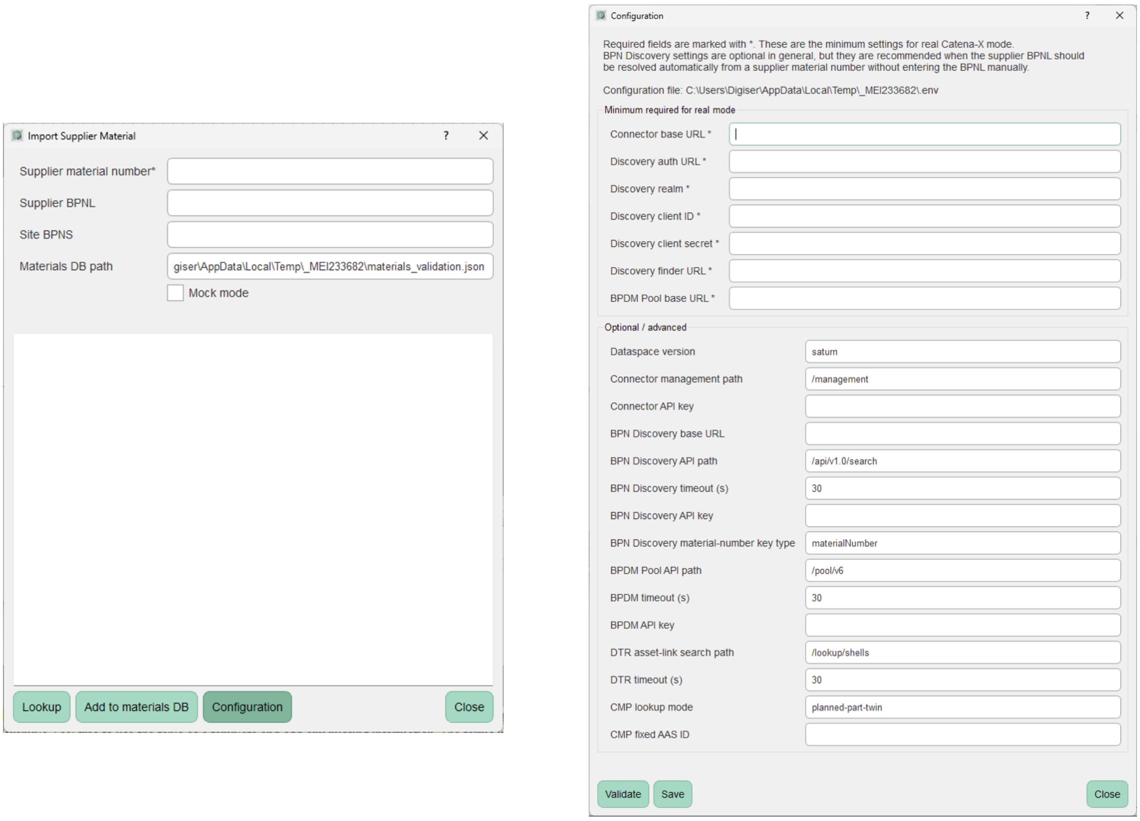


Figure 49: *Configuration of the real Catena-X connection*

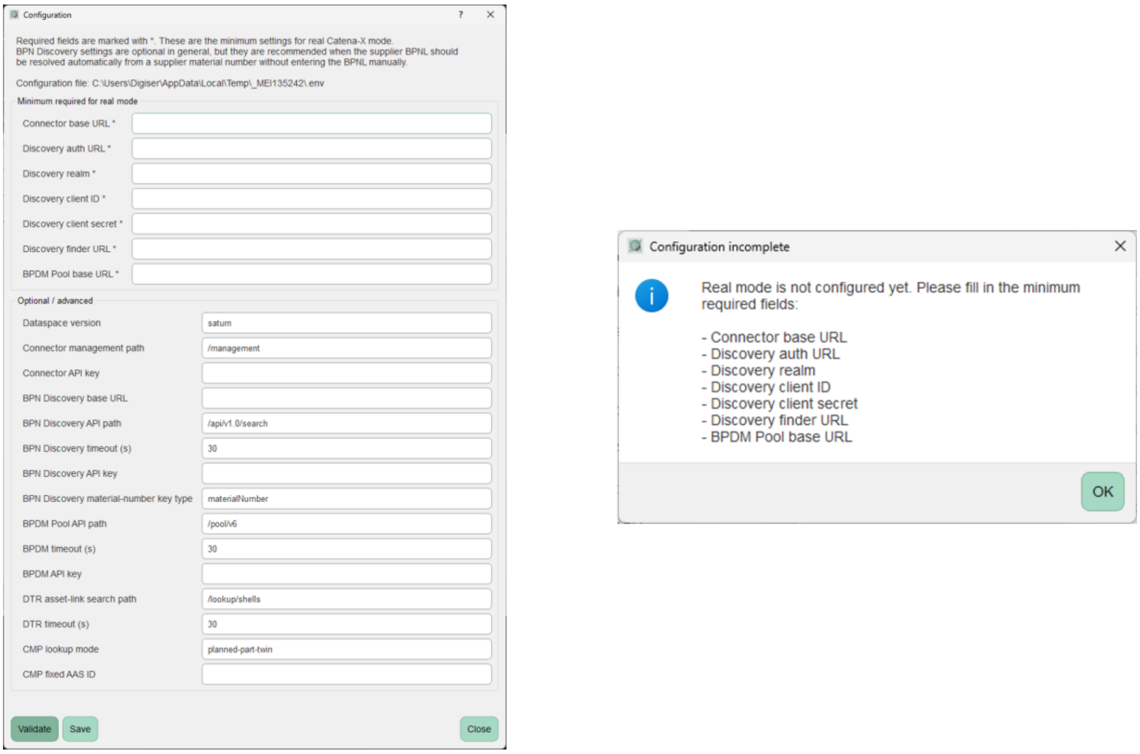


Figure 50: *Configuration warning message*

Update material

To update a material, in the main menu open „Materials“, click on „Update Material“ and select the material to be changed (see Figure 51).

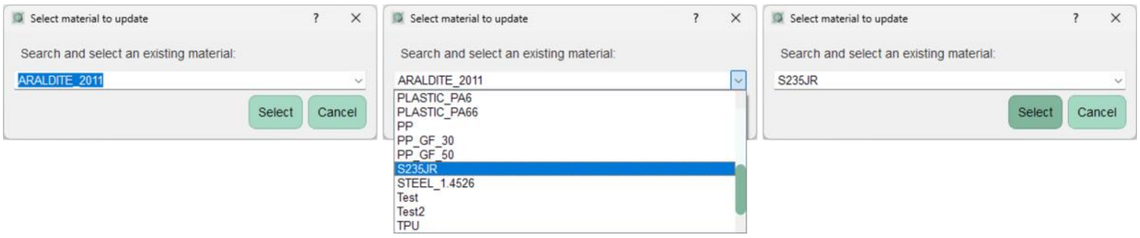


Figure 51: *Update Material: selecting the material to be changed*

Change the characteristics you want to change, then save the changes to the materials database which is confirmed with a success window (see Figure 52 and Figure 53).

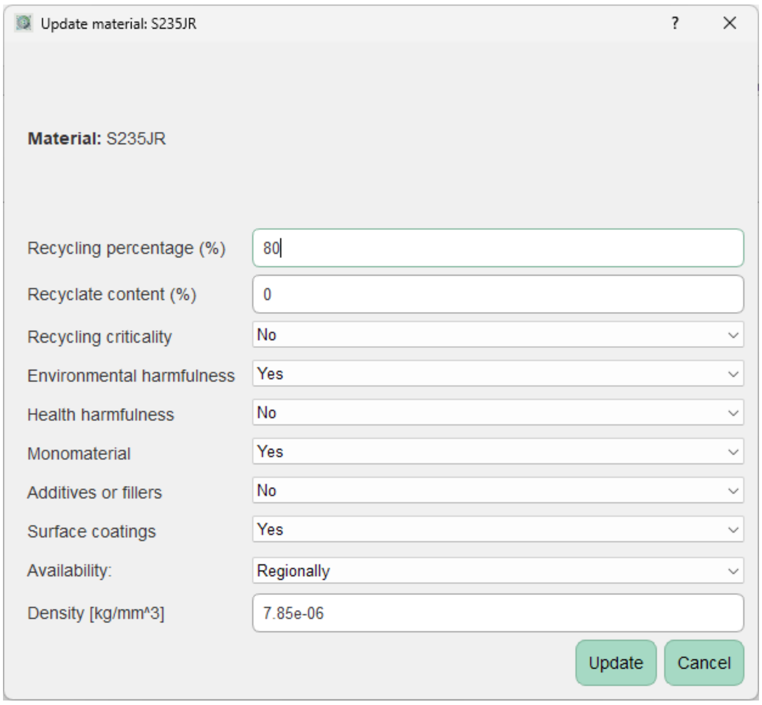


Figure 52: *Update Material: change the characteristics*

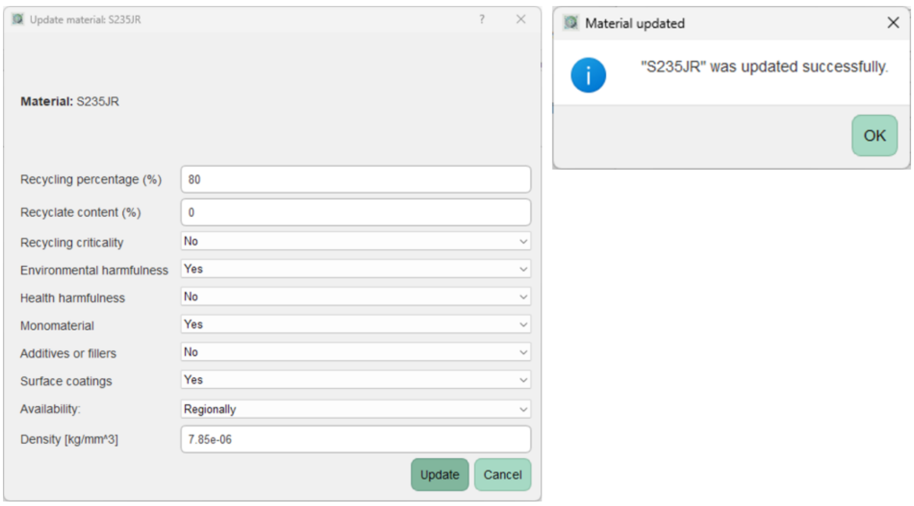


Figure 53: *Update Material: save the changes to the materials database*

2.6.3 Assigning parameters to goals

The tool is pre-configured to assign parameters to goals and goals to R-strategies, based on the project work and the definition provided. Nevertheless, to accommodate the dynamic nature of research as well as the individual needs of a user, these assignments and weightings can be adjusted and modified.

In the main menu, open "Parameter Assignment" and click on "Edit Parameter to Goal Assignments". The window that opens lists all goals grouped by their assigned life-cycle stage (see Figure 54). Select a goal to view the assigned and available parameters. Add or remove a parameter from a goal by selecting or deselecting the relevant parameter. Click "Save" to save the changes for them to take effect (see Figure 55 and Figure 56).

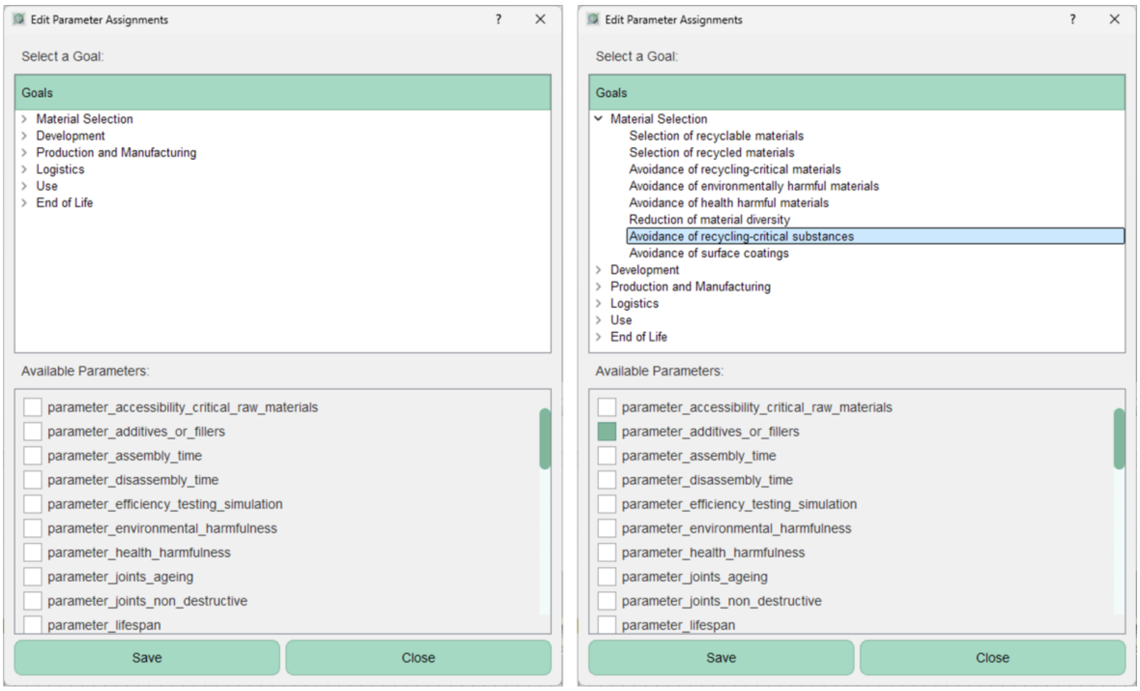


Figure 54: *Edit Parameter to Goal Assignments: start window and view when selecting a goal*

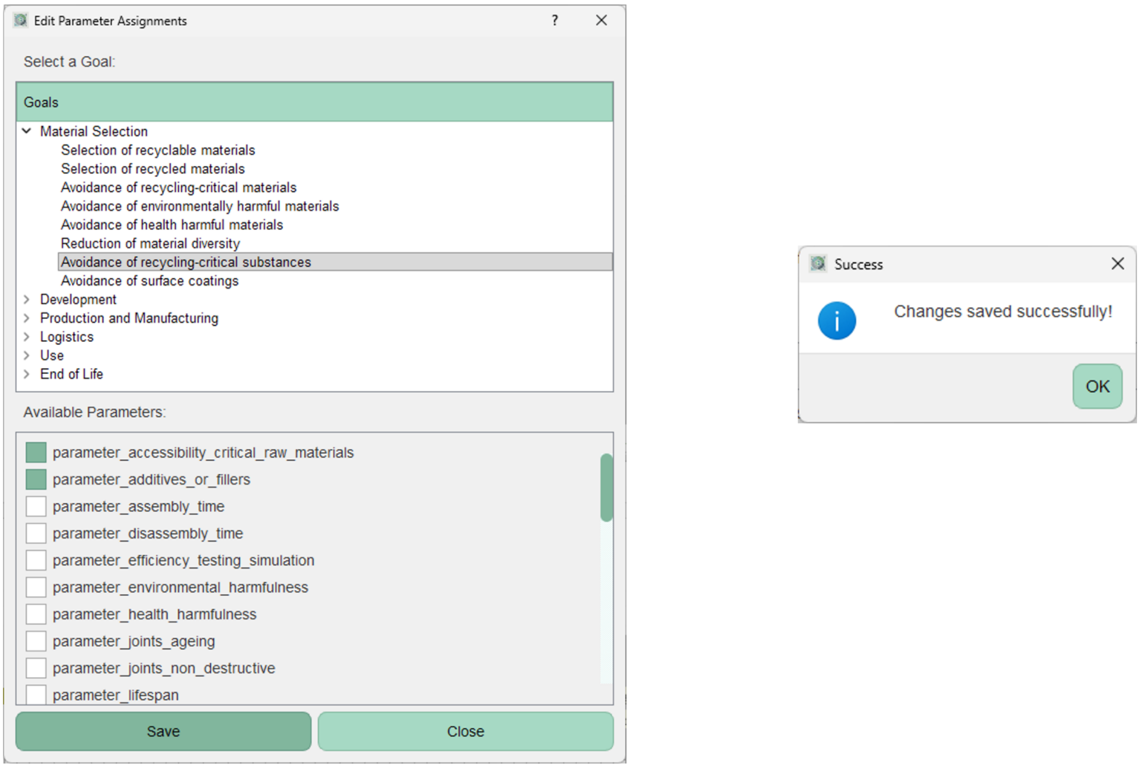


Figure 55: *Adding a parameter to the goal and saving*

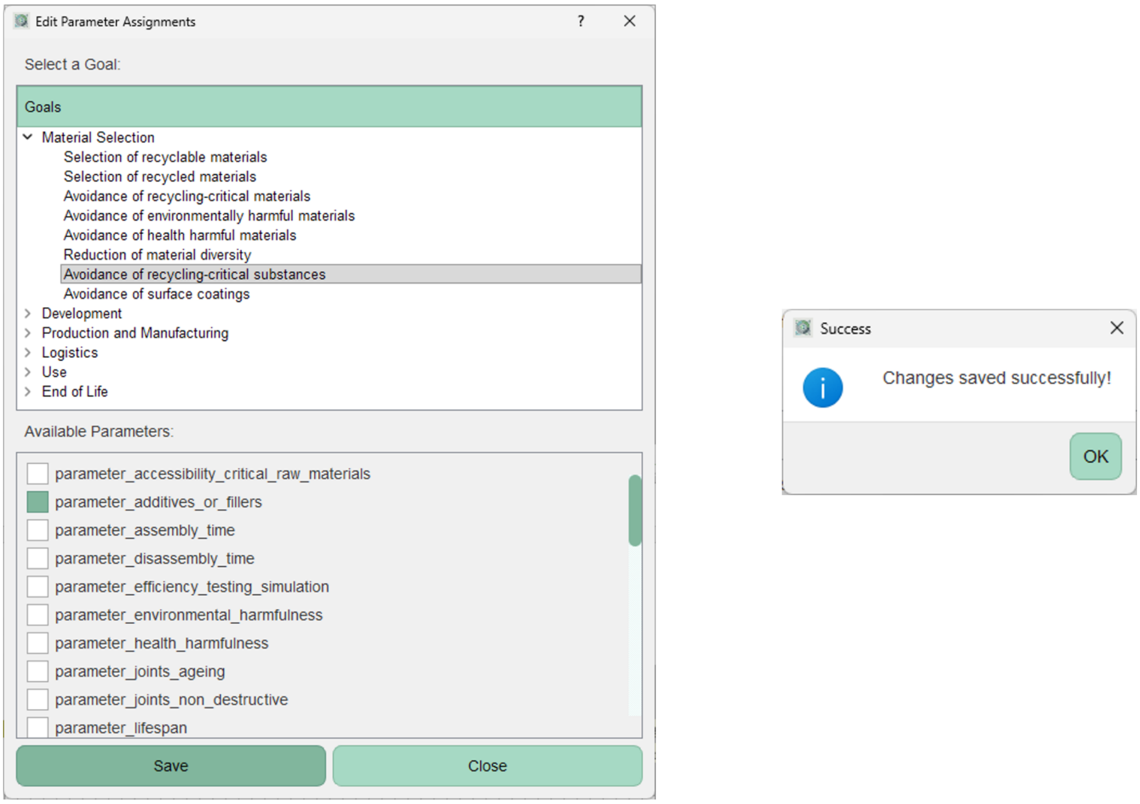


Figure 56: *Deleting a parameter from the goal and saving*

2.6.4 Adjusting strategy weightings (goal → R-strategy)

In the main menu, open “Goals” and click on “Edit Goal Weightings”. The window that opens lists the goals against the R-strategies R0–R9. (see Figure 57). Increase or decrease the weight of a goal for a strategy (e.g. increase Goal 1 for R0, decrease Goal 1 for R1) as it is shown in Figure 58 and Figure 59. Click “Save” to save the changes for them to take effect (see Figure 60).

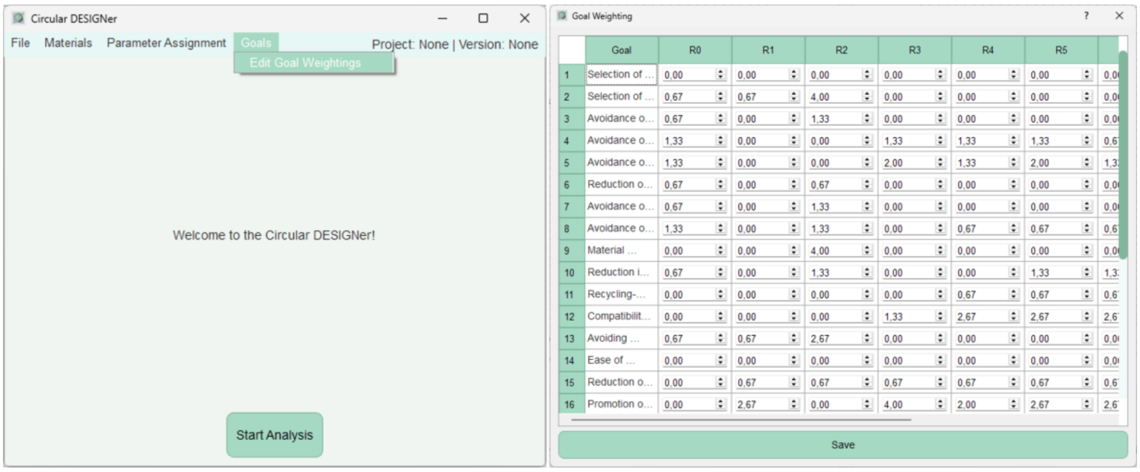


Figure 57: *Edit Goal Weightings: start view (goals vs R-strategies)*

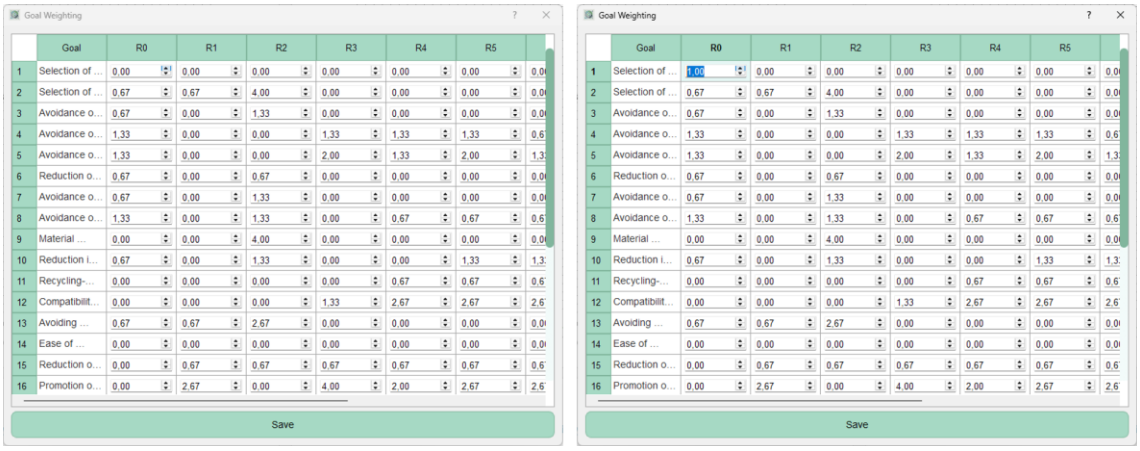


Figure 58: *Increasing the weight of Goal 1 for R0*

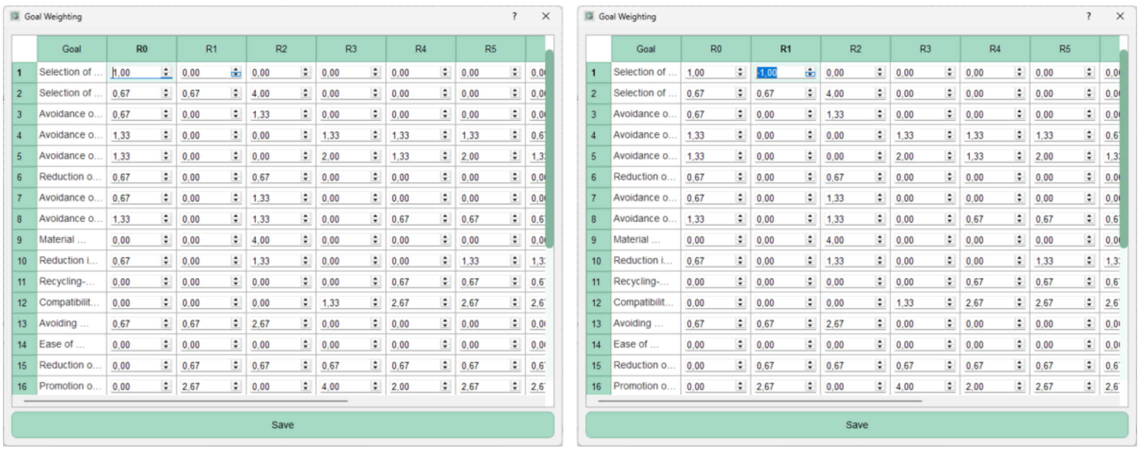
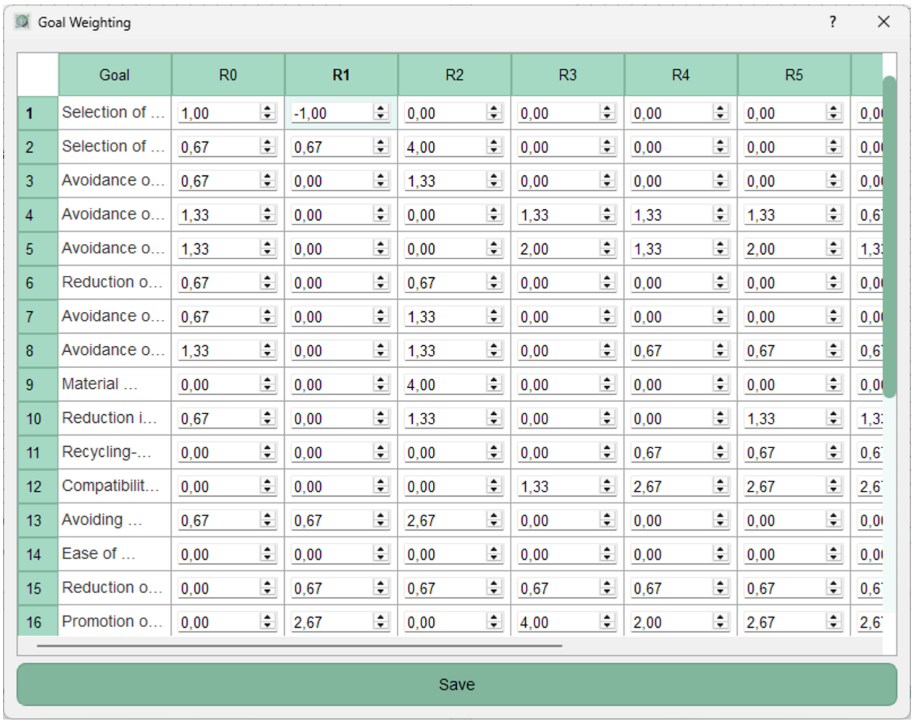


Figure 59: *Decreasing the weight of Goal 1 for R1*



	Goal	R0	R1	R2	R3	R4	R5	
1	Selection of ...	1,00	-1,00	0,00	0,00	0,00	0,00	0,0
2	Selection of ...	0,67	0,67	4,00	0,00	0,00	0,00	0,0
3	Avoidance o...	0,67	0,00	1,33	0,00	0,00	0,00	0,0
4	Avoidance o...	1,33	0,00	0,00	1,33	1,33	1,33	0,6
5	Avoidance o...	1,33	0,00	0,00	2,00	1,33	2,00	1,3
6	Reduction o...	0,67	0,00	0,67	0,00	0,00	0,00	0,0
7	Avoidance o...	0,67	0,00	1,33	0,00	0,00	0,00	0,0
8	Avoidance o...	1,33	0,00	1,33	0,00	0,67	0,67	0,6
9	Material ...	0,00	0,00	4,00	0,00	0,00	0,00	0,0
10	Reduction i...	0,67	0,00	1,33	0,00	0,00	1,33	1,3
11	Recycling-...	0,00	0,00	0,00	0,00	0,67	0,67	0,6
12	Compatibilit...	0,00	0,00	0,00	1,33	2,67	2,67	2,6
13	Avoiding ...	0,67	0,67	2,67	0,00	0,00	0,00	0,0
14	Ease of ...	0,00	0,00	0,00	0,00	0,00	0,00	0,0
15	Reduction o...	0,00	0,67	0,67	0,67	0,67	0,67	0,6
16	Promotion o...	0,00	2,67	0,00	4,00	2,00	2,67	2,6

Figure 60: *Edit Goal Weightings: Tick Save*

3 Summary

This report forms part of Deliverable D2.4 and refers to the repository for the tool itself, whilst also serving as a user manual for that tool. The tool, named Circular DESIGNer, assesses the circularity of components based on the ten R-strategies during the design phase, using CAD data, user-input data and a configurable classification scale. The definition of the R-strategies was adopted from the work carried out under WP1 in the ZEvRA project on harmonised circularity assessment. Their translation into objectives and parameters was carried out in close consultation between the partners. The aim of using the tool is to assess the suitability of the existing product design for the so-called R-strategies at an early stage of product development, thereby enabling the early optimisation of one's own products for a desired or planned strategy.

The operation follows a defined workflow: Create or open a project and import a STEP file, complete the profile for each component, perform the calculation and view the results in detail.

The evaluation process is based on the calculation of parameters, which are in turn assigned to life-cycle stage-specific goals. These goals, in turn, contribute on a weighted basis to the respective R-strategies. This pre-set, project-specific allocation is customisable and can be tailored by the user. The materials database can be updated by manually adding items, importing via Catena-X, and updating the materials. The required classification database must also be adapted before use by the specific user group.

The manual provides step-by-step instructions, an overview of the final assessment, the setup of the repository and the configuration of the databases. The document is based on the release version dated 30 June 2026. Future updates and enhancements are not covered in this document.

