Stepwise Approach for Using BesteEco-op Excel Tool

The excel is structured as follows:

- There are 6 sheets, namely, with a short description:
    - **Scenario Inputs** (the only sheet which you need to input data; starting sheet)
    - **Component Info** (a calculation sheet with formulas, no input required)
    - **CELD Results** (the top selected allocation method results per scenario)
    - Cut-off Results (a results sheet for the 'cut-off' allocation method)
    - N-Cycles Results (a results sheet for the '' allocation method)
    - Allocation Method Description (brief bullet point description of the method)

  ➔ The first three bullet points are the key sheets to use

Key information before using the workbook:

1. The BesteEcoOp Tool is intended to work with LCA results, as such an LCA must be conducted prior such that the results can be input into the BesteEcoOp tool. It is recommended to use the FootprintCalc tool developed by the Footprinters to do a 'quick' and rough LCA study as its user interface is intuitive and simple.
2. The BesteEcoOp tool is under development and is not free from mistakes, if you find errors we greatly appreciate if you send us feedback.
3. The CELD allocation approach **https://doi.org/10.3390/su12229579**
4. The Tool is best suited to 3 cycles or less, it is currently not possible to model more than 3 cycles in the current format.
5. Recycling credit distribution (consequential LCA) is not accounted for.
6. It is imperative that you model or can input data on one business as usual cycle for the comparison on the results sheets.

Stepwise Approach to Using the BesteEcoOp Tool:

The workbook functions such that you model 2-3 scenarios, one of which is the business-as-usual case. Each time you model a new scenario you fill in the data into the 'Scenario Inputs' sheet and then move to the 'CELD' results sheet (or another allocation approach results sheet) and then copy and paste the numerical values of calculated results (C20:C22) from the calculation table to the Scenario table of the scenario you have modelled. More information below.

1. Start on the first sheet "Scenario Inputs" (see image below)
    1.1. Fill in the columns of the pink table (right hand side of the page):
    > Total Number of Cycles (fill in the number of cycles)
    > Cycle 1 Length (the length in years of cycle 1)

> Cycle 2 Length (the length in years of cycle 2)
> Cycle 3 Length (the length in years of cycle 3), if no 3rd cycle fill in 0

1.2. Fill in the columns of the blue Table:
> Component (name/short description),
> Initial Life (component lifespan without refurbishing),
> Refurb Allowed (can it be refurbished TRUE/FALSE),
> Refurb Extension (how many service life years are added when refurbished),
> Manufacturing (kgCO2eq) – the LCA impact score for the manufacturing stage of the component
> EOL Disposal (kgCO2eq) – the LCA impact score for the End-of-life (EOL) stage of the component (excluding recycling credits)
> Refurbishment (kgCO2eq) – the LCA impact score for the remanufacturing stage of the component
> Do not fill in Number of Instances, Effective Life, or Instances Check these are calculation and error check columns.

Component	Initial Life	Refurb Allowed	Refurb Life Extension	Number of Instance	Effective Life	Instances Check	Manufacturing (kgCO2eq)	EOL Disposal (kgCO2eq)	Refurbishment (kgCO2eq)	Column1	Column2
		TRUE		#DIV/0!	0	#DIV/0!				Total Length of All Cycles	0
		TRUE		#DIV/0!	0	#DIV/0!				End of Cycle 1	0
		TRUE		#DIV/0!	0	#DIV/0!				End of Cycle 2	0
		TRUE		#DIV/0!	0	#DIV/0!				End of Cycle 3	0
		TRUE		#DIV/0!	0	#DIV/0!				CycleLength_1_years	0
		TRUE		#DIV/0!	0	#DIV/0!				CycleLength_2_years	0
		TRUE		#DIV/0!	0	#DIV/0!				CycleLength_3_years	0
		TRUE		#DIV/0!	0	#DIV/0!				Total Number of Cycles	0
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
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		TRUE		#DIV/0!	0	#DIV/0!					
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		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		TRUE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					

1.3. IMPORTANT STEP: the sheet requires some manual tidying up depending on your situation. Resize the table to fit your data and clear any remaining data outside the table. (see below picture examples)

Component	Initial Life	Refurb Allowed	Refurb Life Extension	Number of Instance	Effective Life	Instances Check	Manufacturing (kgCO2eq)	EOL Disposal (kgCO2eq)	Refurbishment (kgCO2eq)	Column1	Column2
Part A	10	TRUE	20	1	30	Mismatch	10	2	5	Total Length of All Cycles	30
Part B	10	TRUE	20	1	30	Mismatch	10	2	5	End of Cycle 1	10
Part C	10	TRUE	20	1	30	Mismatch	10	2	5	End of Cycle 2	20
Part D	10	TRUE	20	1	30	Mismatch	10	2	5	End of Cycle 3	30
Part E	10	TRUE	20	1	30	Mismatch	10	2	5	Cycle 1 Length	10
Part F	10	TRUE	20	1	30	Mismatch	10	2	5	Cycle 2 Length	10
Part G	10	TRUE	20	1	30	Mismatch	10	2	5	Cycle 3 Length	10
		FALSE		#DIV/0!	0	#DIV/0!				Total Number of Cycles	3
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
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		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					
		FALSE		#DIV/0!	0	#DIV/0!					

Component	Initial Life	Refurb Allowed	Refurb Life Extension	Number of Instance	Effective Life	Instances Check	Manufacturing (kgCO2eq)	EOL Disposal (kgCO2eq)	Refurbishment (kgCO2eq)	Column1	Column2
Part A	10	TRUE	20	1	30	1	10	2	5	Total Length of All Cycles	30
Part B	10	TRUE	20	1	30	1	10	2	5	End of Cycle 1	10
Part C	10	TRUE	20	1	30	1	10	2	5	End of Cycle 2	20
Part D	10	TRUE	20	1	30	1	10	2	5	End of Cycle 3	30
Part E	10	TRUE	20	1	30	1	10	2	5	Cycle 1 Length	10
Part F	10	TRUE	20	1	30	1	10	2	5	Cycle 2 Length	10
Part G	10	TRUE	20	1	30	1	10	2	5	Cycle 3 Length	10
		FALSE		#VALUE!	#VALUE!	#VALUE!				Total Number of Cycles	3

2. Move onto the second sheet ‘Component Information’
   2.1. If you had to extend the table size in the previous step 1 to fit more components then you may need to extend the formulas down to the final component row in the sheet ‘Component Info’.

> Select the whole row on the left-hand side and drag down till the last component in column A.

	A	B	C	D	E	F	G	H	I	J	K
1											
2	Component	InstanceID	Start	End	EndTrunc	ActiveYears (V)	Cycle 1	Cycle 2	Cycle 3	Manufacturing (kgCO2eq)	EOL Disposal (k
3	Part A	1	0	10	10	10	10	0	0	10	
4	Part A	2	10	20	20	10	0	10	0	10	
5	Part A	3	20	30	30	10	0	0	10	10	
6	Part B	1	0	10	10	10	10	0	0	10	
7	Part B	2	10	20	20	10	0	10	0	10	
8	Part B	3	20	30	30	10	0	0	10	10	
9	Part C	1	0	10	10	10	10	0	0	10	
10	Part C										
11	Part C										
12	Part D										
13	Part D										
14	Part D										
15	Part E										
16	Part E										
17	Part E										
18	Part F										
19	Part F										
20	Part F										
21	Part G										
22	Part G										
23	Part G										
24											

	A	B	C	D	E	F	G	H	I	J	K
1											
2	Component	InstanceID	Start	End	EndTrunc	ActiveYears (V)	Cycle 1	Cycle 2	Cycle 3	Manufacturing (kgCO2eq)	EOL Disposal (k
3	Part A	1	0	10	10	10	10	0	0	10	
4	Part A	2	10	20	20	10	0	10	0	10	
5	Part A	3	20	30	30	10	0	0	10	10	
6	Part B	1	0	10	10	10	10	0	0	10	
7	Part B	2	10	20	20	10	0	10	0	10	
8	Part B	3	20	30	30	10	0	0	10	10	
9	Part C	1	0	10	10	10	10	0	0	10	
10	Part C	2	10	20	20	10	0	10	0	10	
11	Part C	3	20	30	30	10	0	0	10	10	
12	Part D	1	0	10	10	10	10	0	0	10	
13	Part D	2	10	20	20	10	0	10	0	10	
14	Part D	3	20	30	30	10	0	0	10	10	
15	Part E	1	0	10	10	10	10	0	0	10	
16	Part E	2	10	20	20	10	0	10	0	10	
17	Part E	3	20	30	30	10	0	0	10	10	
18	Part F	1	0	10	10	10	10	0	0	10	
19	Part F	2	10	20	20	10	0	10	0	10	
20	Part F	3	20	30	30	10	0	0	10	10	
21	Part G	1	0	10	10	10	10	0	0	10	
22	Part G	2	10	20	20	10	0	10	0	10	
23	Part G	3	20	30	30	10	0	0	10	10	
24											

2.2. If you had to reduce the table size in the previous step 1 to fit the number of components then you need to clear all the rows where the formula spills over. (see image below for example)

> Select the whole row on the left-hand side and drag down till the last row of data (n/a) and press clear all.

	A	B	C	D	E	F	G	H	I	J
1										
2	**Component**	**InstanceID**	**Start**	**End**	**EndTrunc**	**ActiveYears (V)**	**Cycle 1**	**Cycle 2**	**Cycle 3**	**Manufacturing (kgCO2eq)**
3	Part A	1	0	30	30	30	10	10	10	10
4	Part B	1	0	30	30	30	10	10	10	10
5	Part C	1	0	30	30	30	10	10	10	10
6	Part D	1	0	30	30	30	10	10	10	10
7	Part E	1	0	30	30	30	10	10	10	10
8	Part F	1	0	30	30	30	10	10	10	10
9	Part G	1	0	30	30	30	10	10	10	10
10			30	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
11			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
12			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	A	B	C	D	E	F	G	H	I	J	K
1											
2	**Component**	**InstanceID**	**Start**	**End**	**EndTrunc**	**ActiveYears (V)**	**Cycle 1**	**Cycle 2**	**Cycle 3**	**Manufacturing (kgCO2eq)**	**EOL Disposal**
3	Part A	1	0	30	30	30	10	10	10	10	
4	Part B	1	0	30	30	30	10	10	10	10	
5	Part C	1	0	30	30	30	10	10	10	10	
6	Part D	1	0	30	30	30	10	10	10	10	
7	Part E	1	0	30	30	30	10	10	10	10	
8	Part F	1	0	30	30	30	10	10	10	10	
9	Part G	1	0	30	30	30	10	10	10	10	
10			30	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/
11			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/
12			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/
13			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/
14			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/
15			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/
16			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/
17			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/

	A	B	C	D	E	F	G	H	I	J	K
1											
2	**Component**	**InstanceID**	**Start**	**End**	**EndTrunc**	**ActiveYears (V)**	**Cycle 1**	**Cycle 2**	**Cycle 3**	**Manufacturing (kgCO2eq)**	**EOL Disposal**
3	Part A	1	0	30	30	30	10	10	10	10	
4	Part B	1	0	30	30	30	10	10	10	10	
5	Part C	1	0	30	30	30	10	10	10	10	
6	Part D	1	0	30	30	30	10	10	10	10	
7	Part E	1	0	30	30	30	10	10	10	10	
8	Part F	1	0	30	30	30	10	10	10	10	
9	Part G	1	0	30	30	30	10	10	10	10	
10											
11											
12											
13											
14											

> You do not need to fill in or input any data into this sheet (Component Info), it is a calculation sheet. The only actions should be to extend or remove formulas in the cells so that the calculations occur correctly.

3. Move onto the third sheet ‘CELD Results’

***** CELD standards for Circular Economy Linear Digression, more information about the allocation approach can be found in the PowerPoint presentation or upon request.

3.1. Fill in the goal, functional unit, and system boundary of the study

	B	C	D
2	**GOAL :**		
3			
4			
5	**Functional Unit (FU):**		
6			
7			
8	**System Bounadry:**		
9			

3.2. Give each scenario that you will model a short description, see example below. The first scenario should ideally represent three full replacements without reuse.

Scenario 1: Three Full Replacements (New) - No Remanufacturing

Scenario 2: Moderate Remanufacturing

Scenario 3: Maximum Remanufacturing

3.3. The first scenario you model should represent business as usual. Once you've done this and you're on the sheet 'CELD Results' or any other results sheet, you copy cell C20 and paste into cell C14 and copy cell C23 into cell C15. This sets up the baseline metrics.

11	**Baseline Metrics (Single Cycle + No Remanufacturing Case)**			
12	**Metric**	**Value**	**Notes**	
13	Product system life (years)	30	3 cycles × 10 years	
14	Baseline: Single-cycle impact (kg CO_2-eq)	Input Number	Manufacturing + EOL for 1 cycle	
15	**Scenario 1 Total Impact (kg CO_2-eq)**	Input Number	3 full replacements (no reuse)	
16	**Impact per year (kg CO_2-eq/year)**	#VALUE!	Annualized baseline	
17				
18	**Calculation Table**			
19	**Metric**	**Value**	**Notes**	The user copies (C20:22) the data from these cells and pastes them into the scenario table before adjusting the scenario input sheet for a different scenario NB: Paste option only numbers not formula
20	Cycle 1 Impact (kg CO_2-eq)	84,00	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 1.	
21	Cycle 2 Impact (kg CO_2-eq)	84,00	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 2.	
22	Cycle 3 Impact (kg CO_2-eq)	84,00	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 3.	
23	Total System Impact (kg CO2-eq)	252,00	Allocated using CELD triangular method to account for reused components.	
24				
25	**Scenario 1: Three Full Replacements (New) - No Remanufacturing**			
26	**Metric**	**Value**	**Notes**	
27	Scenario 1 Total Impact (kg CO_2-eq)	Input Number	3 full replacements (no reuse)	
28	Impact per year (kg CO_2-eq/year)	#VALUE!	Annualized baseline	

11	**Baseline Metrics (Single Cycle + No Remanufacturing Case)**			
12	**Metric**	**Value**	**Notes**	
13	Product system life (years)	30	3 cycles × 10 years	
14	Baseline: Single-cycle impact (kg CO_2-eq)	84	Manufacturing + EOL for 1 cycle	
15	**Scenario 1 Total Impact (kg CO_2-eq)**	252	3 full replacements (no reuse)	
16	**Impact per year (kg CO_2-eq/year)**	8,4	Annualized baseline	
17				
18	**Calculation Table**			
19	**Metric**	**Value**	**Notes**	The user copies (C20:22) the data from these cells and pastes them into the scenario table before adjusting the scenario input sheet for a different scenario NB: Paste option only numbers not formula
20	Cycle 1 Impact (kg CO_2-eq)	84,00	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 1.	
21	Cycle 2 Impact (kg CO_2-eq)	84,00	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 2.	
22	Cycle 3 Impact (kg CO_2-eq)	84,00	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 3.	
23	Total System Impact (kg CO2-eq)	252,00	Allocated using CELD triangular method to account for reused components.	
24				
25	**Scenario 1: Three Full Replacements (New) - No Remanufacturing**			
26	**Metric**	**Value**	**Notes**	
27	Scenario 1 Total Impact (kg CO_2-eq)	252	3 full replacements (no reuse)	
28	Impact per year (kg CO_2-eq/year)	8,4	Annualized baseline	

3.4. When modelling the second/third scenario the user copies the calculated results from the calculation table (C20:C22) and pastes them in the relevant scenario results table.

18	**Calculation Table**			
19	**Metric**	**Value**	**Notes**	The user copies (C20:22) the data from these cells and pastes them into the scenario table before adjusting the scenario input sheet for a different scenario NB: Paste option only numbers not formula
20	Cycle 1 Impact (kg CO_2-eq)	63,78	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 1.	
21	Cycle 2 Impact (kg CO_2-eq)	51,33	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 2.	
22	Cycle 3 Impact (kg CO_2-eq)	38,89	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 3.	
23	Total System Impact (kg CO2-eq)	154,00	Allocated using CELD triangular method to account for reused components.	

*Copy cells C20,C21,C23 and paste only the numerical values into the blank scenario value cells.

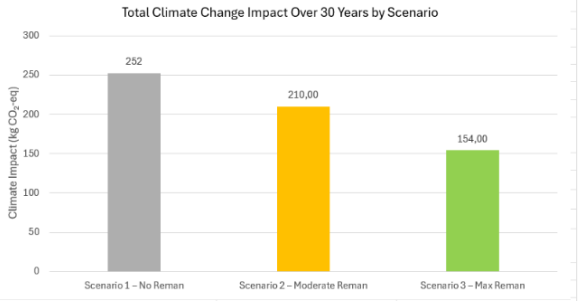
30	**Scenario 2: Moderate Remanufacturing**		
31	**Metric**	**Value**	**Notes**
32	Cycle 1 Impact (kg CO_2-eq)		Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 1.
33	Cycle 2 Impact (kg CO_2-eq)		Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 2.
34	Cycle 3 Impact (kg CO_2-eq)		Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 3.
35	**Total System Impact (kg CO_2-eq)**	0,00	Allocated using CELD triangular method to account for reused components.
36	**Impact per year (kg CO_2-eq/year)**	0,00	over the period of 30 years
37	**Reduction vs Baseline (%)**	#VALUE!	

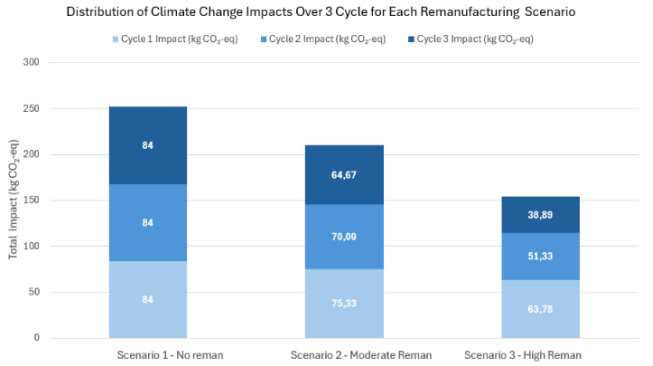
4. Once you have modelled the BAU (full replacements no reuse) scenario, save the document and return to the ‘Scenario Inputs’ sheet. Adjust the information to represent a different scenario and repeat steps 1-3. Do this for all three scenarios. (See below for example)

11	**Baseline Metrics (Single Cycle + No Remanufacturing Case)**		
12	**Metric**	**Value**	**Notes**
13	Product system life (years)	30	3 cycles × 10 years
14	Baseline: Single-cycle impact (kg CO_2-eq)	84	Manufacturing + EOL for 1 cycle
15	**Scenario 1 Total Impact (kg CO_2-eq)**	252	3 full replacements (no reuse)
16	**Impact per year (kg CO_2-eq/year)**	8,4	Annualized baseline
17			
18	**Calculation Table**		
19	**Metric**	**Value**	**Notes**
20	Cycle 1 Impact (kg CO_2-eq)	63,78	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 1.
21	Cycle 2 Impact (kg CO_2-eq)	51,33	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 2.
22	Cycle 3 Impact (kg CO_2-eq)	38,89	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 3.
23	Total System Impact (kg CO2-eq)	154,00	Allocated using CELD triangular method to account for reused components.
24			
25	**Scenario 1: Three Full Replacements (New) - No Remanufacturing**		
26	**Metric**	**Value**	**Notes**
27	Scenario 1 Total Impact (kg CO_2-eq)	252	3 full replacements (no reuse)
28	Impact per year (kg CO_2-eq/year)	8,4	Annualized baseline
29			
30	**Scenario 2: Moderate Remanufacturing**		
31	**Metric**	**Value**	**Notes**
32	Cycle 1 Impact (kg CO_2-eq)	75,33	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 1.
33	Cycle 2 Impact (kg CO_2-eq)	70,00	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 2.
34	Cycle 3 Impact (kg CO_2-eq)	64,67	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 3.
35	**Total System Impact (kg CO_2-eq)**	210,00	Allocated using CELD triangular method to account for reused components.
36	**Impact per year (kg CO_2-eq/year)**	7,00	over the period of 30 years
37	**Reduction vs Baseline (%)**	17%	
38			
39	**Scenario 3: Maximum Remanufacturing**		
40	**Metric**	**Value**	**Notes**
41	Cycle 1 Impact (kg CO_2-eq)	63,78	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 1.
42	Cycle 2 Impact (kg CO_2-eq)	51,33	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 2.
43	Cycle 3 Impact (kg CO_2-eq)	38,89	Includes allocated manufacturing, disposal, and refurb impacts for components active in Cycle 3.
44	**Total System Impact (kg CO2-eq)**	154,00	Allocated using CELD triangular method to account for reused components.
45	**Impact per year (kg CO_2-eq/year)**	5,13	over the period of 30 years
46	**Reduction vs Baseline (%)**	39%	

4.1. On the right-hand side of the results sheet the scenario comparison summary results should be visible.

Scenario Comparison Summary						
Scenario	Total Impact (kg CO_2-eq)	Annual Impact (kg CO_2-eq/year)	Reduction vs Baseline (%)	Cycle 1 Impact (kg CO_2-eq)	Cycle 2 Impact (kg CO_2-eq)	Cycle 3 Impact (kg CO_2-eq)
Scenario 1 – No Reman	252	8,4	0%	84	84	84
Scenario 2 – Moderate Reman	210,00	7	17%	75,33	70,00	64,67
Scenario 3 – Max Reman	154,00	5,133333333	39%	63,78	51,33	38,89





Scenario	Scenario 1 – Description	Scenario 2 – Description	Scenario 3 – Description
Cycle 1 Impact (kg CO_2-eq)	33%	36%	41%
Cycle 2 Impact (kg CO_2-eq)	33%	33%	33%
Cycle 3 Impact (kg CO_2-eq)	33%	31%	25%