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Abbreviations

Acronym	Description
CE	Circular economy
CO2e	CO2 equivalent
FU	Functional Unit
GHGs	Green House Gases
GWP	Global warming potential
LCA	Life cycle assessment
pc	piece
EF	Environmental Footprint

Executive Summary

This document updates the previous *D3.5 Sustainability and LCA Assessment Tools M12*, accompanying the tool developed for evaluating the sustainability and circularity performance of processes in Task 3.3. The sustainability and circularity assessment tool, named GRETA (GreenTargets), is part of the CIRCULOOS ecosystem, providing valuable insights for effective decision-making regarding sustainability. Furthermore, the document details the modelling process, including real data (LCI data) from three pilots in the leather, plastic, and wood sectors across different countries. In the context of developing new, more sustainable and circular practices, these models assess environmental impacts using EF3.1 methodology indicators to quantify the benefits of applying circular strategies within the project pilots. The results of the modelling process are presented. Finally, the integration of GRETA with the RAMP platform for data exchange is also outlined.

1 Introduction

As the global community confronts accelerating environmental challenges, the urgency for adopting sustainable industrial practices has reached a critical moment. The principles of the CE have emerged as a decisive solution to these pressing issues, offering a shift from traditional linear models of production and consumption. The CE emphasizes creating systems that minimize waste, optimize resource efficiency, and foster long-term ecological balance. By embracing circularity, industries can transition from a linear "take-make-dispose" approach to one that promotes continual reuse, recycling, and regeneration of materials. The need for integrating CE principles into business operations is driven by the growing recognition of resource scarcity, environmental degradation, and the adverse impacts of climate change. To effectively implement these principles, businesses must not only adopt new practices but also rigorously assess and evaluate their processes through sustainability and circularity indicators. This involves conducting detailed studies to measure how well current processes align with CE objectives and identifying opportunities for improvement.

Sustainability assessments are crucial in providing businesses with a comprehensive understanding of their environmental impact and the effectiveness of their circular practices. They encompass a range of evaluations, from lifecycle assessments and resource efficiency analyses to waste management and product design for reuse or recycling. By examining these aspects, companies can gain valuable insights into their operational performance, identify room for improvement, and develop strategies to better align with sustainability goals. Moreover, evaluating circularity within business processes is essential for driving continuous improvement and innovation. Such evaluations enable businesses to track progress, benchmark against industry standards, and implement targeted measures to enhance their circular practices. This not only supports environmental objectives but also offers competitive advantages, such as reduced operational costs, improved resource management and brand reputation.

Integrating comprehensive sustainability assessments and circularity evaluations into business operations is fundamental for advancing the CE. By adopting these practices, companies can contribute to a more sustainable future, support ecological balance, and play a significant role in addressing the environmental challenges of our time. Through dedicated efforts in evaluating potential circular practices that can be proposed to stakeholders, businesses can achieve significant progress toward a more resilient and sustainable industrial landscape.

1.1 Development of Circularity Enablers (WP3)

The Development of Circularity Enablers within WP3, led by SUPSI, was aimed at promoting circularity and sustainability in supply chains and manufacturing operations.

The main objective of WP3 is to develop a suite of tools that facilitate sustainable and circular practices. This includes creating pilot-ready versions while integrating feedback gathered during the development process. The focus has been on adapting these models to practical, real-world needs, ensuring their effective integration into operational environments. Moreover, WP3 provides essential support to stakeholders, enabling them to use the tools effectively and adapt them to their business requirements.

A key part of WP3 is the design and implementation of the LCA tool, that calculates relevant environmental indicators. The tool is designed to communicate with RAMP, allowing it to collect and provide various types of data and ensuring seamless integration with other platform components.

Through these multi-layered efforts, WP3 contributes substantially to the project's overall goals of promoting circularity and sustainability, leveraging advanced technologies and methodologies to optimize processes and support environmental objectives.

1.2 Relevance of Sustainability to the CIRCULOOS Project

In the context of the CIRCULOOS project, "sustainability and circularity" refer to the effort of transforming traditional linear business models into more sustainable and circular ones. A linear economy typically follows a "take, make, dispose" approach, where resources are used to create products and then discarded as waste. The goal of CIRCULOOS is to help, in the first phase, three pilot companies from the wood, leather, and plastic sectors transition to a circular economy, where resources are reused, waste is minimized, and sustainability is prioritized. Through different initiatives proposed by the partners taking part of the CIRCULOOS project, the three pilots are guided to enhance their circularity and sustainability of their operations by reducing waste, reusing materials, and improving resource efficiency. The sustainability and circularity of the different pilots are presented as follows:

- PILOT 1 - The wood sector pilot involves CIRCULEREN, Plennid and Herso. CIRCULEREN produces modular furniture designed for reuse, Plennid processes wood from damaged trees in the city of Rotterdam to produce reclaimed wood, and Herso supplies them with recycled materials. Although they have already implemented a circular approach, their focus in CIRCULOOS is demonstrating the origin of the recycled materials provided by Herso, ensuring that the circularity of their operations is fully traceable and verified.
- PILOT 2 - In the leather sector, the pilot involves Mototextile and B&A. Mototextile primarily uses large leather pieces, while B&A works with smaller fragments. The goal is to increase circularity by allowing Mototextile to pass on its leather leftovers to B&A, thus maximizing the use of the leather throughout the production chain. Additionally, both companies will sell any excess leather scraps on a marketplace, ensuring that as much material as possible is repurposed and nothing is wasted.
- PILOT 3 - The plastic sector pilot involves Thermolympics and Contenedores LOLO. Here, the goal is to close the loop by recycling Thermolympics' plastic waste at LOLO's recycling facility. By recirculating plastic waste within their own operations, these companies aim to reduce the amount of plastic waste that ends up in landfills, thereby improving the sustainability of their processes.

1.3 Deliverable Purpose

The purpose of this deliverable is to present GRETA, the LCA tool specifically developed to measure the environmental impacts of a product within a given scenario, serving as the environmental component in a comprehensive sustainability assessment. The LCA models developed within this task for the 3 pilots (wood, leather and plastic) are presented here, showcasing GRETA's functionalities and its potential to support data-driven sustainability decisions.

GRETA incorporates a range of critical inputs necessary for accurate emissions calculations, including detailed material and energy balances, which provide insights into the resources consumed and energy used at each stage of the process. The tool also integrates logistics information to evaluate emissions associated with transportation, considering factors such as distances travelled and fuel type used.

GRETA has been fully integrated with the CIRCULOOS data platform, enabling seamless data retrieval and ensuring applicability across multiple case studies.

2 Methodology

The methodology implemented in the tool presented in this deliverable relies heavily on the Life Cycle Assessment (LCA) approach to support end users in making informed decisions regarding sustainability and circularity benefits. In the following chapters, this methodology is explained in detail to help the reader understand the concepts calculated by the tool developed in WP3 and presented in this deliverable in the next section.

2.1 Life Cycle Assessment Approach

LCA is a standardized methodology used to evaluate the environmental impacts associated with all stages of a product's life cycle, from raw material extraction through manufacturing, distribution, use, and end-of-life management, including recycling or disposal. The system boundaries are established to determine which processes and life cycle stages are included in the study, defining the scope of the assessment and determining whether a cradle-to-gate or cradle-to-grave approach is applied. Cradle-to-gate assessments consider all processes from raw material extraction to the factory gate, excluding product use and end-of-life stages, whereas cradle-to-grave assessments include all life cycle stages, providing a holistic view of environmental impacts. Depending on the system boundary selected, LCA provides a comprehensive framework for assessing cumulative environmental effects of products and processes, enabling stakeholders to make informed decisions aimed at reducing ecological footprints and promoting sustainable development. The methodology is governed by international standards such as ISO 14040 and ISO 14044 (ISO 14040:2006; and ISO 14044:2006), which ensure consistency, transparency, and reproducibility of assessments.

The LCA process typically consists of four phases:

1. Goal and Scope Definition
2. Life Cycle Inventory (LCI) Analysis
3. Life Cycle Impact Assessment (LCIA)
4. Interpretation.

A key element of LCA is the definition of a **Functional Unit (FU)**, which represents a quantified description of the product system's function and serves as the reference to which all inputs, outputs, and impacts are normalized, ensuring meaningful comparisons across products, processes, or design alternatives.

During the **Life Cycle Inventory (LCI)** phase, all relevant mass and energy flows are collected and quantified, including material inputs, energy consumption, emissions to air, water, and soil, and waste generation, forming the basis for subsequent impact evaluation.

In systems where a single process produces multiple outputs or co-products, **allocation methods** are applied to distribute environmental burdens among the outputs in a scientifically justifiable manner (Gnansounou et al., 2015), often based on criteria such as mass, economic value, or energy content (Pachón et al, 2018; Pachón et al, 2020).

The inventory data are subsequently translated into environmental impacts during the Life Cycle Impact Assessment (LCIA) phase, encompassing multiple categories such as global warming potential, eutrophication, acidification, ozone depletion, photochemical smog formation, ecotoxicity, human toxicity, particulate matter formation, and resource depletion. The choice of **LCIA methodology** is crucial for accurately calculating these environmental indicators. Several methodologies exist, each differing in scope, selected impact categories, and level of detail. Midpoint methods focus on specific environmental mechanisms or processes before they result in final damage (for example, global warming potential, acidification, or eutrophication) and are generally closer to inventory data, thereby reducing uncertainty. In contrast, endpoint methods aggregate impacts into broader areas of protection (such as human health, ecosystem quality, or resource depletion) offering a more holistic but often less precise representation of environmental consequences. Widely used approaches include CML, TRACI, ReCiPe, Eco-indicator 99, and Environmental Footprint (EF), which differ primarily in whether they report results at the midpoint or endpoint level.

The final phase, interpretation, involves analyzing the results to identify environmental hotspots, evaluate alternative scenarios, and support data-driven decisions to improve sustainability.

LCA enables rigorous, transparent, and actionable assessments of environmental performance across diverse sectors, including manufacturing, energy, construction, healthcare, and agriculture, making it an indispensable tool for companies and policymakers aiming to optimize resource efficiency, minimize environmental impacts, and align production processes with global sustainability goals.

3 GRETA: Overview of the Lifecycle Assessment tool

This chapter describes the GRETA tool, its functionalities, integration with external platforms, and the selection of environmental indicators.

3.1 Functionalities

GRETA is a web, microservices-based, application designed to assess the sustainability performance of products and processes in manufacturing contexts. It offers diagnostic and advisory functionalities, enabling users to optimize their manufacturing practices and make data-driven decisions.

GRETA has been tailored to meet the demands of manufacturing companies focused on sustainable early-stage product design. It empowers users to generate and compare different production manufacturing and usage scenarios, leveraging the limited data typically available during the preliminary stages of product design. GRETA can be used to assess the sustainability performances of products and processes and see how the impacts are distributed across different life cycle phases.

GRETA allows the end-user to customize the production processes (previously modelled by the sustainability expert) to provide all the specific values needed to perform an LCA. Once the user has completed the customisation, the assessment can be executed, and useful insight can be obtained by the assessment charts (Figure 1).

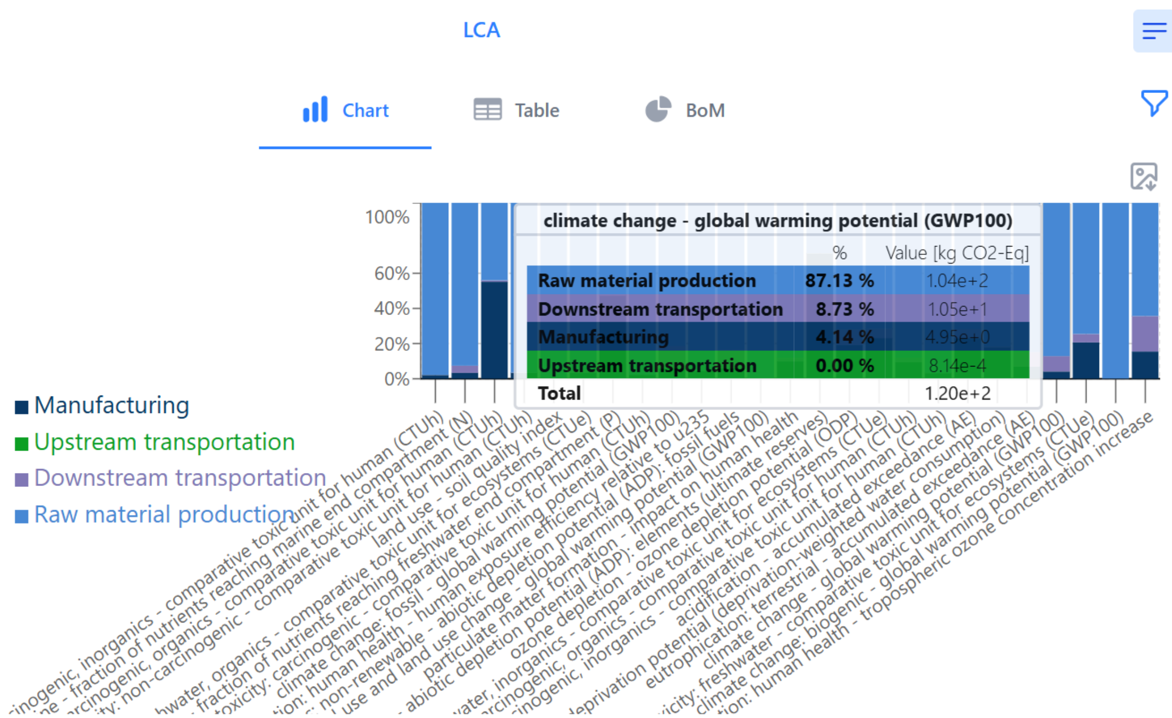

Figure 1 Example of Assessment Chart in GRETA – Leather Pilot, AS IS Scenario.

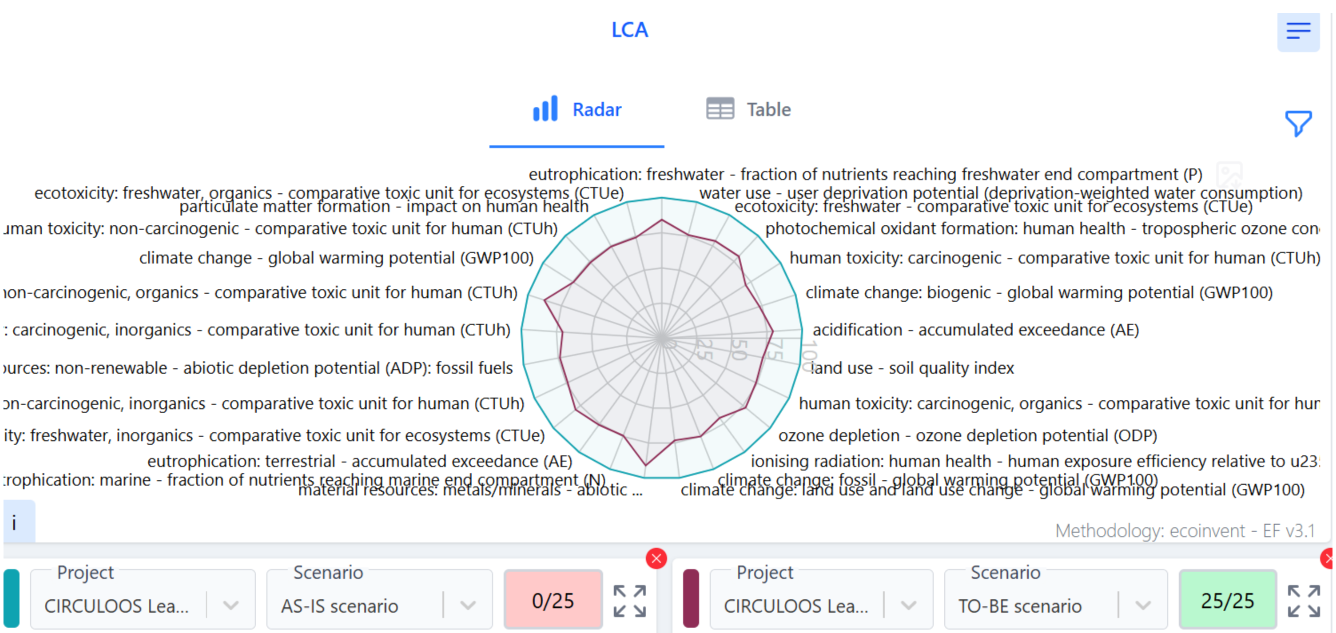

Figure 2 Radar Chart of the Leather Pilot AS IS Scenario (generated with GRETA)

GRETA not only allows the assessment of a single scenario but also supports comparative LCA among two or more scenarios. The comparative LCA is a method to evaluate and compare the environmental impacts of different scenarios, products, or design options. This comparison is visualised in GRETA through a radar chart, a graphical tool that displays multiple impact categories simultaneously, making it easier to see trade-offs and improvements across scenarios (Figure 2).

This functionality is supported by GRETA's real-time calculation engine, which allows manufacturers to dynamically adjust scenario parameters during the eco-design process. The platform calculates the resulting environmental impacts, enabling users to compare the outcomes with previous configurations or alternative scenarios directly through the radar chart figure. However, the calculated data can also be exported for further data analysis, supporting detailed investigations and data-driven decision-making. Additionally, the results of the assessment, including comparative analyses, can be automatically compiled into a PDF report. This report includes all alternatives considered, the corresponding sustainability parameters, and the full set of indicators generated by the assessment.

3.2 Integration with RAMP platform

The integration of GRETA with external digital platforms is a critical component for enabling real-time environmental assessment and decision support. GRETA is designed with a flexible integration layer that allows seamless communication with various data sources and external tools. This functionality ensures that environmental assessments can be dynamically updated and shared across different platforms, facilitating a data-driven approach to sustainability evaluation.

Key aspects of this integration include:

- **Data acquisition from external sources:** GRETA can automatically gather IIoT data to populate customization parameters and execute environmental assessments using near real-time information. Supported sources include IoT devices, MQTT brokers, REST APIs, databases, and other platforms. For example, data can be collected directly from the CIRCULOOS platform.
- **Data export to external platforms**: GRETA enables the export of assessment results to external data sources, such as databases, MQTT brokers, or other platforms. Environmental indicators produced by the assessment can be transmitted to the CIRCULOOS platform in JSON-LD format, leveraging the defined semantic context.
- **REST API for integration**: GRETA exposes its functionalities through a set of REST APIs, allowing other services to access these features for integration purposes. This capability positions GRETA as a sustainability service within broader digital ecosystems. The exposed APIs are presented in Annex 4.

This integration mechanism is particularly relevant within the context of the CIRCULOOS project, where GRETA can receive and provide data to tools such as RAMP, MPMS, SCOPT, and SCDT through the Orion LD. Such interoperability enables continuous monitoring, real-time assessment, and improved decision-making in sustainability management.

3.2.1 Architecture

Figure 3 below represents how GRETA interacts with the CIRCULOOS Data Platform: GRETA is a cloud application deployed in the SUPSI infrastructure, which interacts with the platform components through a set of REST APIs.

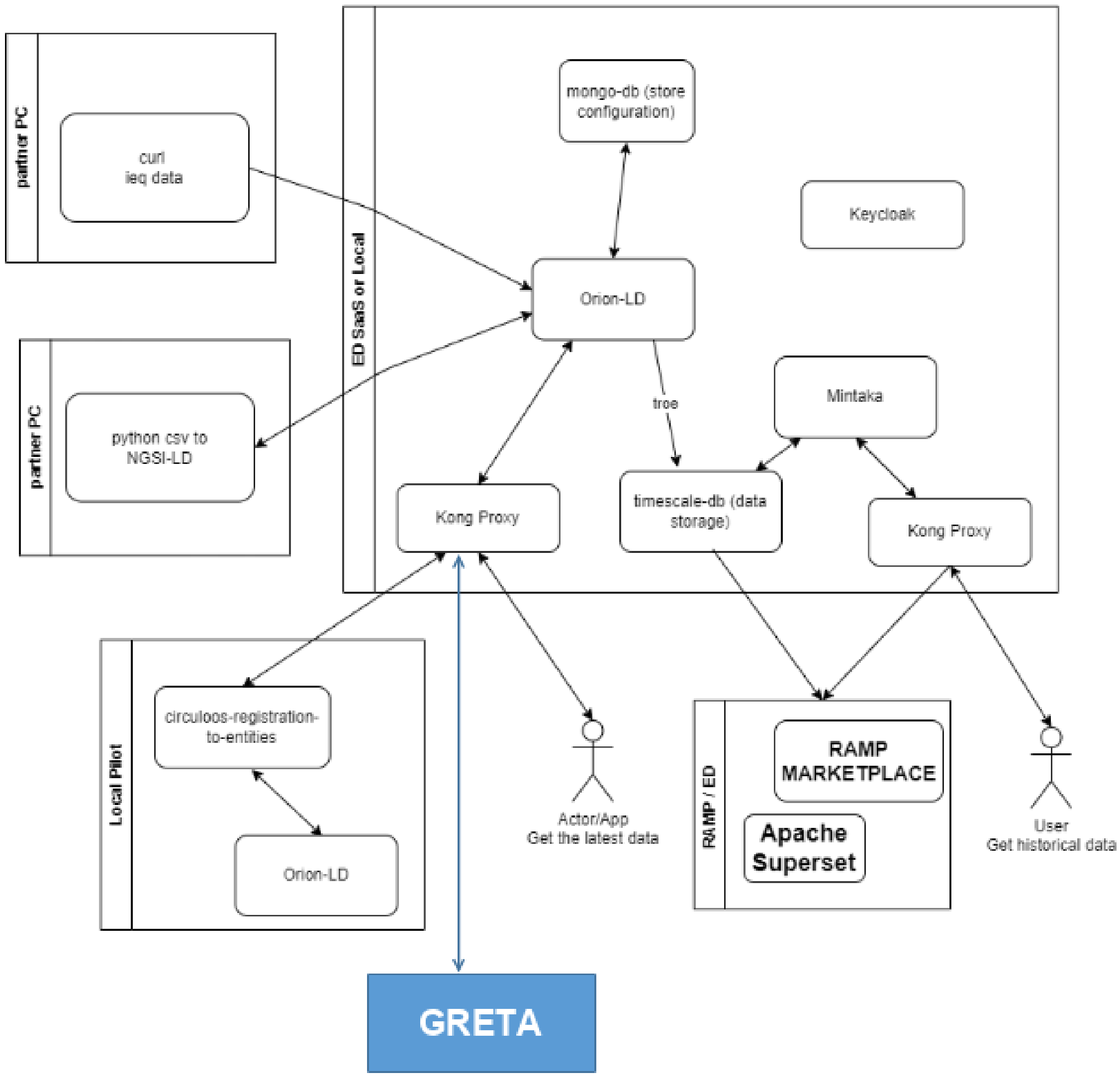

Figure 3: Integration of GRETA with the CIRCULOOS Data Platform

3.2.2 Interaction flow

Figure 4 depicts how GRETA, during the interaction with the user, exploits under the hood the integration with the CIRULOOS Data Platform.

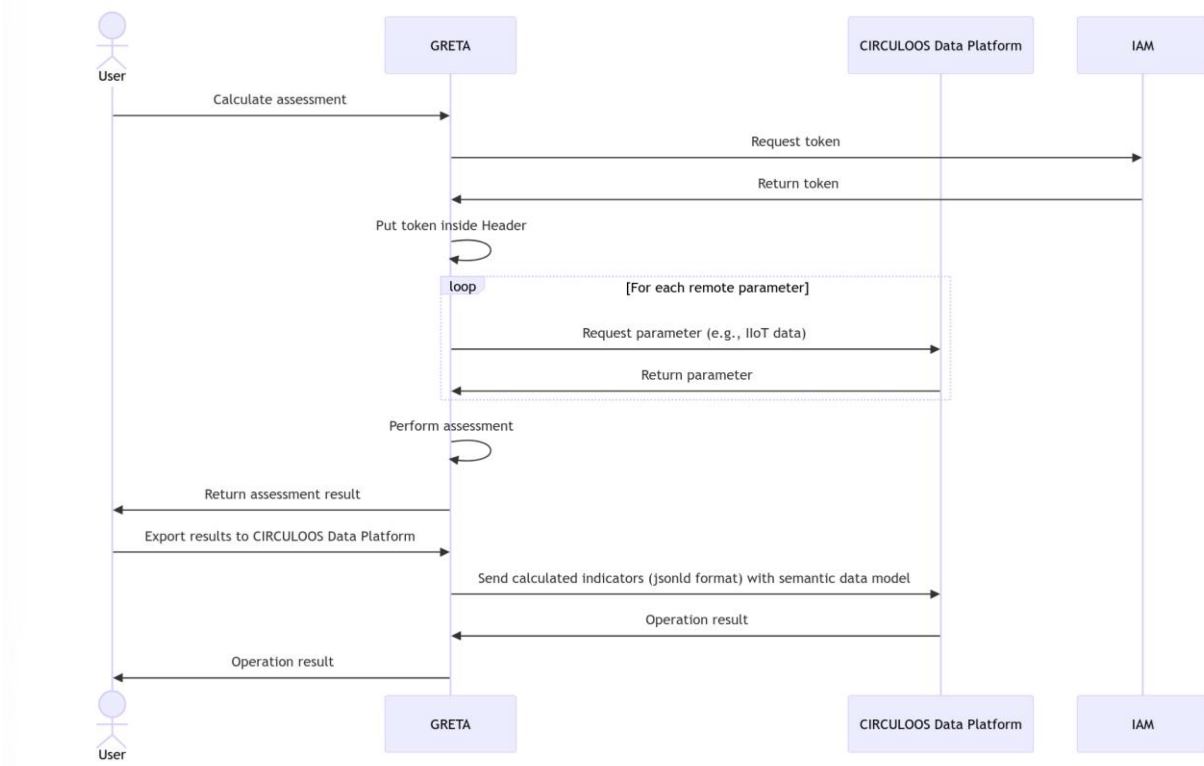

Figure 4: How GRETA reads data from the platform

GRETA communicates with the CIRCULOOS Data Platform in two different ways:

- **Input data**: GRETA gathers remote parameters needed for the calculation from a developed template for data collection. The format of the data can vary depending on the data and the data format defined in the Data model repository. In order to test this kind of operation, the *air quality* parameters have been taken from the platform (see

- Annex 1 for the format).
- **Output data**: The indicators generated by GRETA are saved into the platform to be available for other components, such as SCOPT. For that reason, a *new data model* was defined, following the guide presented
- Annex 2. An example of the data format used for the indicators can be found here[1].

For both these aspects, an ad-hoc integration pipeline has been developed and deployed in GRETA. These pipelines perform a machine-to-machine authentication and exploit the APIs both provided by Keycloak (as part of the platform) and then by the Orion Context Broker.

For what concern the definition of a new semantic data model for the sustainability indicators generated by GRETA, some technical aspects need to be taken into consideration:

- The Orion Context Broker has some problems dealing with small numbers, so they should be represented as strings. To address that problem, all indicator values are represented as strings.
- If there is no complete match between an indicator unit of measurement and a UNECE code, the user may assign their own code. However, a declaration must be added to a table in the CIRCULOOS Data Model GitHub repository[2]. The work done to define the EF3.1 LCA indicator is reported in

[1] https://github.com/isteps-sps-lab/CIRCULOOS_Data_model/blob/main/sustainabilityIndicators/examples/example-normalized.jsonld

[2] https://github.com/isteps-sps-lab/CIRCULOOS_Data_model/blob/main/sustainabilityIndicators/doc/uneceCodeDefinition/EF3.1-IC_CIRCULOOS_UNECE.xlsx

- Annex 3.

Once the integration flow, depicted in Figure 4, has been completed, all sustainability indicators calculated by GRETA have been sent to the data platform for collection by other tools via the REST APIs (see Postman collection[3]). An example of the indicators, taken from the platform and semantically enriched with the defined data model, is shown in Figure 5.


```
"@context": [
  "http://circuloos-ld-context/circuloos-context.jsonld",
  "https://uri.etsi.org/ngsi-ld/v1/ngsi-ld-core-context-v1.6.jsonld"
],
"id": "urn:ngsi-ld:efi:entity-002",
"type": "environmental_footprint_indicator",
"https://github.com/isteps-sps-lab/CIRCULOOS_Data_model/tree/main/sustainabilityIndicators/schema.json#acidificationAccumulatedExceedanceAE": {
  "type": "Property",
  "value": "345.67",
  "unitCode": "XMHQ",
  "observedAt": "2024-09-25T10:20:30.000Z"
},
"https://github.com/isteps-sps-lab/CIRCULOOS_Data_model/tree/main/sustainabilityIndicators/schema.json#climateChangeGlobalWarmingPotentialGWP":
{
  "type": "Property",
  "value": "1234.56",
  "unitCode": "XCO2",
  "observedAt": "2024-09-25T12:34:56.000Z"
```


Figure 5: Example of indicator structure

As demonstrated by the data example provided above, each JSON entity's key is not merely a simple string representing the name of the sustainability indicator; it also functions as a hyperlink intended to elucidate the meaning of the indicators and to illustrate how the associated value is constructed, including data types and explanations of nested fields.

3.3 Sustainability indicators in GRETA

GRETA computes 25 environmental indicators based on the inputs and outputs provided by the user, complemented by data from the Ecoinvent database or scientific literature whenever specific information is unavailable. All the environmental indicators are calculated relative to a selected FU for each scenario under study. The indicators calculated in GRETA are available in Table 1 and were derived following the LCA methodology (ISO 14040/14044). The environmental impact categories and indicators are defined according to the ILCD Handbook (European Commission, 2010).

[3] https://github.com/european-dynamics-rnd/circuloos-data-platform/blob/master/commands_URL/ED%20CIRCULOOS%20Platform.postman_collection.json

Table 1 Environmental impact indicators considered in the study

№	Category / Indicator	Unit
1	Eutrophication: freshwater – fraction of nutrients reaching freshwater end compartment (P)	kg P-Eq
2	Water use – user deprivation potential (deprivation-weighted water consumption)	m^3 world eq. deprived
3	Ecotoxicity: freshwater – comparative toxic unit for ecosystems (CTUe)	CTUe
4	Photochemical oxidant formation: human health – tropospheric ozone concentration increase	kg NMVOC-Eq
5	Human toxicity: carcinogenic – comparative toxic unit for humans (CTUh)	CTUh
6	Climate change: biogenic – global warming potential (GWP100)	kg CO_2e
7	Acidification – accumulated exceedance (AE)	mol H^+e
8	Land use – soil quality index	dimensionless
9	Human toxicity: carcinogenic, organics – CTUh	CTUh
10	Ozone depletion – ozone depletion potential (ODP)	kg CFC-11e
11	Ionising radiation: human health – relative to U-235	kBq U235e
12	Climate change: fossil – GWP100	kg CO_2e
13	Climate change: land use and land use change – GWP100	kg CO_2e
14	Material resources: metals/minerals – abiotic depletion potential (ADP, elements)	kg Sbe
15	Eutrophication: marine – fraction of nutrients reaching marine end compartment (N)	kg Ne
16	Eutrophication: terrestrial – accumulated exceedance (AE)	mol Ne
17	Ecotoxicity: freshwater, inorganics – CTUe	CTUe
18	Human toxicity: non-carcinogenic, inorganics – CTUh	CTUh
19	Energy resources: non-renewable – abiotic depletion potential (ADP, fossil fuels)	MJ
20	Human toxicity: carcinogenic, inorganics – CTUh	CTUh
21	Human toxicity: non-carcinogenic, organics – CTUh	CTUh
22	Climate change – global warming potential (GWP100, total)	kg CO_2e
23	Human toxicity: non-carcinogenic (total) – CTUh	CTUh
24	Particulate matter formation – impact on human health	disease incidence
25	Ecotoxicity: freshwater, organics – CTUe	CTUe

GRETA includes a comprehensive set of environmental indicators covering different impact categories. They are explained as follows: GWP100 measures the total greenhouse gas emissions, while GWP100 (biogenic, fossil, and land use change) further disaggregates emissions by source, distinguishing between biogenic carbon, fossil fuels, and land transformation. ODP quantifies the potential contribution to stratospheric ozone depletion, and POFP indicates the formation of ground-level ozone affecting human health. AE assesses acidifying emissions impacting soils and aquatic ecosystems.

Eutrophication indicators (freshwater, marine, and terrestrial) evaluate nutrient enrichment from phosphorus and nitrogen, which can cause algal overgrowth and ecosystem imbalance. Ecotoxicity indicators (CTUe) estimate toxic effects on freshwater ecosystems, separated into organics and inorganics.

Human Toxicity indicators (CTUh) measure potential impacts on human health, covering carcinogenic and non-carcinogenic effects, as well as organic and inorganic compounds.

PMF represents impacts of particulate emissions on human health, and Ionising Radiation quantifies potential human exposure. Land Use reflects the effects of land occupation and transformation on soil quality, while Water Use assesses consumption weighted by deprivation potential. Finally, ADP indicators estimate resource depletion, with ADP (fossil fuels) addressing non-renewable energy and ADP (metals/minerals) addressing abiotic minerals.

Together, these indicators provide a multidimensional perspective on the environmental performance of the Life Cyle of products and processes, enabling detailed analysis across ecosystems, human health, and resource depletion. The selection of which indicator to prioritize for process optimization in terms of environmental sustainability depends on the objectives of the project.

The GRETA tool, developed by SUPSI, can calculate not only environmental indicators but also economic, social, and circularity indicators. All those indicators, after the assessment, can be sent to RAMP. The results can serve as a guide for end users in choosing alternative solutions that yield more sustainable outcomes than the current process.

4 Results – GRETA for CIRCULOOS

In this section, all scenarios implemented in GRETA are defined here for further assessment. The system boundaries, functional units, main products and their counterparts, allocation methods where applicable, and all variables necessary to complete the LCI for each pilot are described.

These elements form the results of WP3, together with the development of the GRETA tool described above. The environmental indicators calculated for each pilot scenario presented here are reported in Deliverable D5.2. All the details required to complete the implementation of the models in GRETA are provided in the following sections.

4.1 LCA in the CIRCULOOS pilots

In the CIRCULOOS project, the **system boundaries** for all pilots were defined as cradle-to-gate, since the primary goal of the stakeholders is to enhance the sustainability of their own products. In most cases, information on the fate of the products beyond the factory gate is unavailable (Pachón et al., 2024), making cradle-to-gate the most practical and relevant scope for the assessments.

In all cases, the **FU** was defined based on a selected product that the stakeholders aim to improve in terms of environmental sustainability, while simultaneously enhancing the circularity of the company's operations (Fontana et al., 2024). For the wood pilot, the FU is a wood-based panel; for the leather pilot, it is a leather bag and a leather keyholder; and for the plastic pilot, it is a plastic-based washing machine detergent dispenser. They will be further explained in the Results section. In every case, the alternative product produced through a more sustainable process provides exactly the same functionality and service to the final customer. This ensures that a meaningful comparison can be made between the current scenario (AS IS) and the proposed scenario (TO BE), allowing the assessment of environmental improvements associated with the new process.

If allocation is required in the LCA of a pilot scenario, economic allocation is applied, based on the minimum selling price established by the company for the product under study.

The LCI in the CIRCULOOS project was developed using data collected through direct interactions with stakeholders. For processes or flows where primary data were unavailable, information was supplemented with values from scientific literature or the widely recognized commercial Ecoinvent database (Moreno-Ruis et al, 2023). The source of each individual data point used in the LCI for each pilot will be described in detail in the following chapter.

For the CIRCULOOS project, the LCIA framework selected to develop the GRETA tool is the standardized European Environmental Footprint (EF) v3.1 methodology, developed by the Joint Research Centre. EF v3.1 provides a harmonized set of impact categories and updated characterization factors aligned with the latest scientific data, ensuring consistency and comparability across product systems (De Rosa-Giglio, 2018). This methodology was selected because it aligns with EU guidelines for Product Environmental Footprint assessments and supports reliable decision-making for improving the environmental performance of pilot products within the project.

4.2 Pilot Scenarios

4.2.1 Leather Pilot

Two independent companies in the leather goods industry, based in Hungary, have joined the CIRCULOOS project to establish the Leather Pilot. The companies, Mototextil Kft. (which replaces the previous partner KHOANI with the same role in the pilot) and B&A Kft., each specialised in different aspects of leather goods production and has operated independently up to this point.

AS-IS Scenario

The current situation (AS-IS) reflects the individual operations of the three companies, as described below:

- **Mototextil** specialises in manufacturing leather and textile products. The company uses a wide range of fabrics, including automotive upholstery, artificial leather, and genuine leather. They also use various upholstery accessories and materials in their production processes, emphasising high-quality raw materials and customer service. At the beginning of the project, they only relied on virgin raw material and landfilled leftovers.
- **B&A** focuses on producing small leather goods and generates waste during its manufacturing processes. The company, like the previous one, relies exclusively on virgin raw materials and wastes leftovers, leading to significant environmental impact.

TO-BE Scenario

This pilot aims to integrate their operations, fostering a CE approach that minimizes waste, and enhances overall competitiveness in the leather goods industry.

Through this collaboration, Mototextil will supply its leather leftovers to B&A for repurposing into new products, effectively reducing waste and minimizing the need for virgin materials. Any materials (leftovers) not utilized by B&A will be listed on a shared marketplace, allowing other interested parties to repurpose them, further promoting sustainability within the industry.

This partnership exemplifies a CE model within the leather goods industry, demonstrating how small enterprises can collectively achieve significant sustainability objectives, enhance profitability, and strengthen market positions. If successful, this approach could be expanded to include additional companies and other reusers (schools, kindergartens, etc.), further promoting CE principles in the leather goods sector and among consumers and broader society

To model the AS-IS and TO-BE scenarios for the LCA, a **cradle-to-gate** approach was selected as the system boundary, as previously mentioned. The stages included in both AS-IS and TO-BE scenarios are shown in Figure 6.

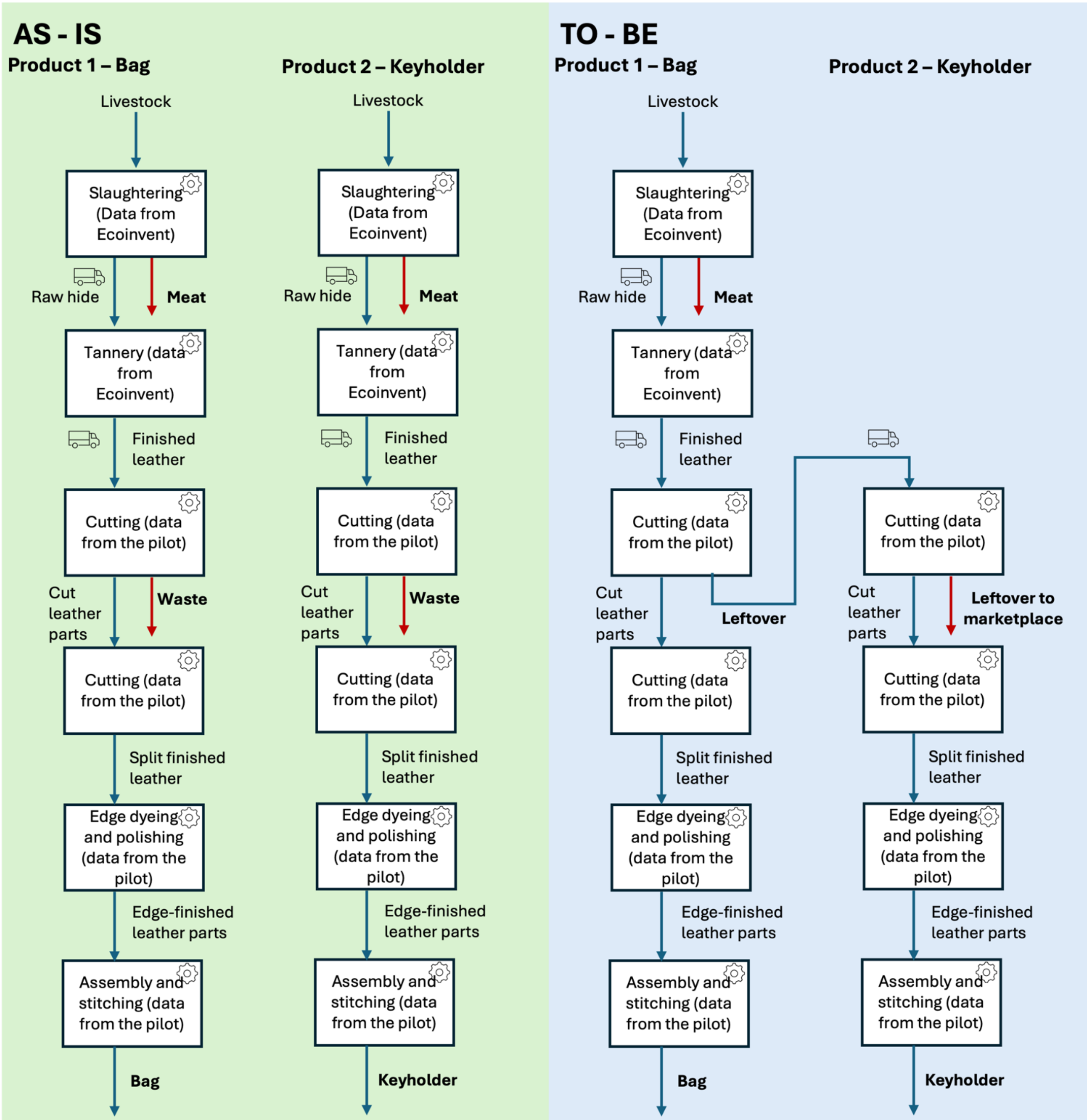

Figure 6 Leather Pilot LCA Model AS IS — TO BE Flow Diagrams

In this pilot, the FU is defined as one leather bag. However, both the AS-IS and TO-BE scenarios represent multi-product systems, as two products are obtained in each case: a bag and a keyholder. The two products in both scenarios are the same, they only differ in the keyholder production.

In both AS-IS and To-BE scenarios, allocation is required to distribute the environmental impacts associated with leather production from the animal among its different co-products (meat and raw hide in this scenario). As described in the Methodology chapter, allocation in LCA is used when a process yields multiple outputs, allowing environmental impacts to be fairly assigned to each product. The allocation factor for rawhide, obtained from the literature (De Rosa-Giglio et al., 2018), is 0,035. This means that 3.5% of the total impacts from livestock to slaughtering are allocated to leather, with the remaining impacts assigned to meat.

In the AS-IS scenario, the reference products are:

- **bag**, of a weight of 2 kg, produced from virgin finished leather (after the tanning process)
- **keyholder** of a weight of 0,6 kg, produced from virgin finished leather (after the tanning process)

In the TO-BE scenario, the products are:

- **bag**, of a weight of 2 kg, produced from virgin finished leather (after the tanning process)
- **keyholder** of a weight of 0,6 kg, produced from the leftovers coming from the production of the leather bag

In the TO-BE scenario, an additional allocation factor is required to account for the impact of producing the finished leather for the keyholder (leftover). Here, the allocation method applied is economic allocation, which distributes the environmental impacts of a process based on the relative market value of each co-product. The allocation factor is therefore calculated from the market selling price of each item produced (bag: 200€, keyholder: 20€). This approach reflects the principle that products with higher economic value should bear a proportionally larger share of the environmental burdens, making it a widely used method in LCA when dealing with multi-product systems (Pachón et al. 2018).

The variables employed to build the **LCI** are summarized in the following tables (Table 2, Table 3).

Table 2 Leather LCI1 List of variables, assumptions and real data

Scenario	Product	Process	Location of the Process	Company	Variable	Unit	Value	Data Source Type
AS IS	Bag	Livestock and Slaughtering	Unknown	Unknown	Red meat production	kg	1	Secondary[1]
			Unknown	Unknown	Live weight of cattle	kg	71.7	Secondary[2]
			Unknown	Unknown	Allocation	%	3.5	Secondary[2]
		Tannery	Unknown	Unknown	Chromium for tanning	kg	1.763	Calculated
					Sludge	kg	2.132	Secondary[3]
					Waste water	l	0.084	Secondary[3]
					Water requirements	kg	99.22	Secondary[3]
					Energy consumption	kWh	60.418	Secondary[3]
					Finished leather	m2	0.82	Secondary[3]
		Cutting	Hungary	Mototextile	Energy consumption	kWh	1.25	Primary
					Leftovers	kg	0.492	Primary

					Oil used	kg	0.02	Primary
		Splitting and skiving	Hungary	Mototextile	Energy consumption	kWh	0.193	Primary
					Waste	kg	0.001148	Primary
		Edge dyeing and polishing	Hungary	Mototextile	Chemicals	l	0.005	Primary
					Dyes	l	0.005	Primary
					Energy consumption	kWh	0.41	Primary
		Assembly and stitching	Hungary	Mototextile	Energy consumption	kWh	0.49	Primary
		Livestock and Slaughtering	Unknown	Unknown	Red meat production	kg	1	Secondary[1]
			Unknown	Unknown	Live weight of cattle	kg	20	Secondary[2]
			Unknown	Unknown	Allocation	%	3.5	Secondary[2]
		Tannery	Unknown	Unknown	Chromium for tanning	kg	0.645	Calculated
					Sludge	kg	0.78	Secondary[3]
					Waste water	l	0.031	Secondary[3]
					Water requirements	kg	36.3	Secondary[3]
					Energy consumption	kWh	22.104	Secondary[3]
					Finished leather	m2	0.3	Secondary[3]
	Keyholder	Cutting	Hungary	B&A	Energy consumption	kWh	0.4	Primary
					Leftovers	kg	0.0018	Primary
					Oil used	kg	0	Primary
		Splitting and skiving	Hungary	B&A	Energy consumption	kWh	0.2	Primary
					Waste	kg	0.000042	Primary
		Edge dyeing and polishing	Hungary	B&A	Chemicals	l	0.005	Primary
					Dyes	l	0.005	Primary
					Energy consumption	kWh	0.03	Primary
		Assembly and stitching	Hungary	B&A	Energy consumption	kWh	0.02	Primary
		Livestock and Slaughtering	Unknown	Unknown	Red meat production	kg	1	Secondary[1]
			Unknown	Unknown	Live weight of cattle	kg	71.7	Secondary[2]
			Unknown	Unknown	Allocation	%	3.5	Secondary[2]
		Tannery	Unknown	Unknown	Chromium for tanning	kg	1.763	Calculated
					Sludge	kg	2.132	Secondary[3]
					Waste water	l	0.084	Secondary[3]
TO BE	**Bag**				Water requirements	kg	99.22	Secondary[3]
					Energy consumption	kWh	60.418	Secondary[3]
					Finished leather	m2	0.82	Secondary[3]
		Cutting	Hungary	Mototextile	Energy consumption	kWh	1.25	Primary
					Leftovers for keyholder	kg	0.492	Primary
					Oil used	kg	0.02	Primary
		Splitting and skiving	Hungary	Mototextile	Energy consumption	kWh	0.193	Primary
					Waste	kg	0.001148	Primary

	Edge dyeing and polishing	Hungary	Mototextile	Chemicals	l	0.005	Primary
				Dyes	l	0.005	Primary
				Energy consumption	kWh	0.41	Primary
	Assembly and stitching	Hungary	Mototextile	Energy consumption	kWh	0.49	Primary
	Selling	Hungary	Mototextile	Selling price of the bag	Eur	200	Primary
	Livestock and Slaughtering	Unknown	Unknown	Red meat production	kg	1	Secondary[1]
		Unknown	Unknown	Live weight of cattle	kg	20	Secondary[2]
		Unknown	Unknown	Allocation	%	3.5	Secondary[2]
	Tannery	Unknown	Unknown	Chromium for tanning	kg	0.645	Calculated
				Sludge	kg	0.78	Secondary[3]
				Waste water	l	0.031	Secondary[3]
				Water requirements	kg	36.3	Secondary[3]
				Energy consumption	kWh	22.104	Secondary[3]
				Finished leather	m2	0.3	Secondary[3]
Keyholder	Cutting	Hungary	B&A	Energy consumption	kWh	0.4	Primary
				Leftovers	kg	0.0018	Primary
				Oil used	kg	0	Primary
	Splitting and skiving	Hungary	B&A	Energy consumption	kWh	0.2	Primary
				Waste	kg	0.000042	Primary
	Edge dyeing and polishing	Hungary	B&A	Chemicals	l	0.005	Primary
				Dyes	l	0.005	Primary
				Energy consumption	kWh	0.03	Primary
	Assembly and stitching	Hungary	B&A	Energy consumption	kWh	0.02	Primary
	Selling	Hungary	B&A	Selling price of the bag	Eur	20	Primary

Note:

[1] Secondary data retrieved from Ecoinvent database vs.3.9.1

[2] Secondary data retrieved from literature (De Rosa-Giglio, et al., 2018)

[3] Secondary data from literature (COTANCE & industriAll-Europe., 2020)

Table 3 LeatherLCI2 Transport logistics for AS-IS and TO-BE scenarios

Scenario	Flow	Route (From → To)	Distance (km)	Material / Product	Transport mode	Source
AS-IS	Raw hide transportation	Slaughtering → Tannery (Pakistan)	1	Raw hide	Lorry	Assumption
	Finished leather transportation	Pakistan → Budapest	4800	Finished leather	Plane	Pilot
		Budapest → Mototextile	200	Finished leather	Lorry	Pilot

	Bag or keyholder production	Unknown location for supplier → Mototextile or B&A	200	Accessories	Lorry	Pilot
TO-BE	Leftovers transportation	Mototextile → B&A	0	Leftovers		Pilot

In summary, using the bag's leftovers in the TO BE scenario as feedstock for keyholder production will provide both environmental and economic benefits by avoiding the incineration of leftovers and reducing the need to purchase virgin materials.

4.2.2 Plastic Pilot

Two independent companies specializing in plastics and one company focused on robotics for component identification in materials have joined forces within the CIRCULOOS framework to participate in the **Plastic Pilot**. Although each operates independently in Spain and specializes in different activities, their collaboration aims to foster greater circularity and sustainability.

AS-IS Scenario

The current situation (AS-IS) reflects the individual operations of the three companies, as described below:

- **Thermolympic**, based in Zaragoza, specializes in manufacturing plastic parts using various molding technologies. They rely on virgin raw materials for their products. In an effort to improve the sustainability of their business, they evaluated the possibility of incorporating recycled plastic into their feedstock. However, the company faced challenges in integrating recycled materials due to customer requirements for high-quality, functional, and aesthetically precise parts. So far, they have not been able to implement recycled materials in their supply chain. Nevertheless, they are aware that some other clients, such as those in the home appliance industry, might be willing to accept recycled plastic if it meets specific characteristics. Currently, Thermolympic incinerates plastic waste. This approach makes their processes less efficient, releases pollutants, and contributes to environmental impact.
- **Contenedores Lolo**, located in Ávila, focuses on collecting and processing waste plastics. They collect plastics from wholesalers and retailers, aiming to provide high-quality recycled materials for various applications.
- **Canonical Robots** acts as a third-party contributor to this pilot. While their involvement in the initial phase of the project is not planned, they play a significant role in the upcoming phases through open calls. They offer technological solutions to improve recycling processes. Specializing in robotics and automation, they focus on the identification and classification of recycled plastics. Currently, they collaborate closely with Contenedores Lolo to assist in qualifying the recycled and processed plastics.

TO-BE Scenario

To develop a more sustainable, efficient, and resilient business model, the three companies have united under a consortium as part of the TO-BE scenario proposed for the Plastic Pilot. This pilot aims to integrate the operations of Thermolympic and Contenedores Lolo, fostering a CE approach that maximizes resource utilization, minimizes waste, and enhances overall sustainability in the industry.

Thermolympic plans to utilize recycled plastics processed by Contenedores Lolo, incorporating them into their manufacturing processes to produce a specific component that meets both recycled content and quality requirements. This component is a white plastic container used in the home appliance industry, specifically designed to hold detergent inside washing machines.

In this TO-BE scenario, scrap generated during the injection molding of the three plastics (across the five components) is sent to the LOLO recycling centre. However, since the amount of scrap produced is insufficient to meet demand, additional recycled material from external sources is needed. The external sources may consist of companies that deposit their production scraps free of charge at Contenedores Lolo. In LCA terms, these scraps can be classified as waste, since the supplying companies receive no economic or material benefit from providing them. As such, the environmental impacts of these scraps are generally allocated as zero to the recipient process, in line with standard waste allocation principles.

In both scenarios:

- lid and distributor are made from ISOFIL H50 C2V NATURALSIRMAX
- fixed and sliding tubs are made from Hostacom HKC 182 L W92607 WHITE
- siphon is made from ISOFIL HK 30 TFH2 BL2092 (blue)

The siphon is blue while the other parts are white plastic. The siphon is the only part that does not produce scrap in Thermolympic, so its recycled material must come from external sources. The other parts (the white components) do generate scrap during production.

To model the AS-IS and TO-BE scenarios for the LCA, a **cradle-to-gate** approach was selected as the system boundary, as previously mentioned. The stages included in both AS-IS and TO-BE scenarios are shown in

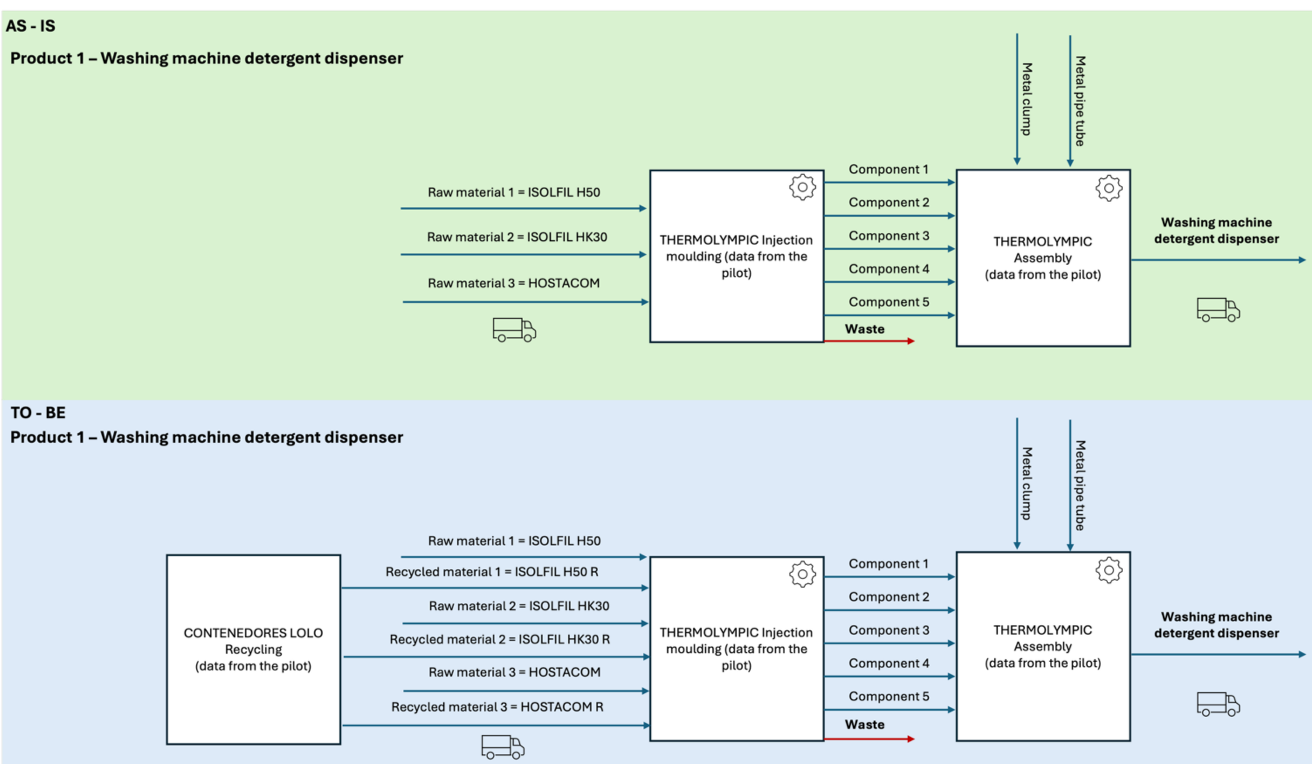

Figure 7.

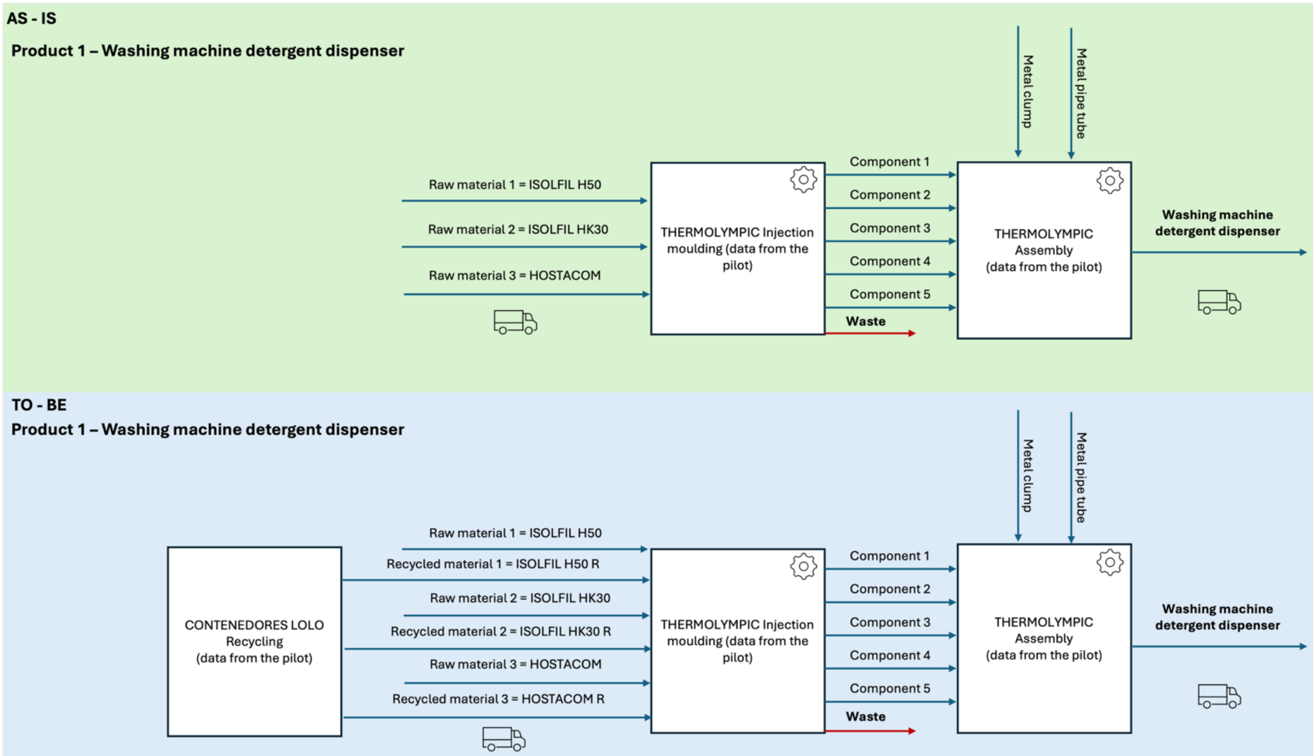

Figure 7 Plastic Pilot LCA Model AS IS — TO BE Flow Diagrams

In this pilot, the FU is defined as one washing machine detergent dispenser. However, both the AS-IS and TO-BE scenarios involve generating the final item from different raw materials (virgin and recycled feedstock). The two products in both scenarios provide the same functional service to the community, ensuring a fair and consistent basis for comparison.

In the AS-IS scenario the reference product is:

- **Washing machine detergent dispenser** made from virgin plastic, weighing 0.81 kg, produced by assembling five distinct plastic components—a lid, a distributor, a fixed tub, a sliding tub, and a siphon—manufactured from three different plastics (ISOFIL H50 C2V NATURALSIRMAX, Hostacom HKC 182 L W92607 WHITE, and ISOFIL HK 30 TFH2 BL2092) along with additional materials (clamp and pipes) for the assembly.

In the TO-BE scenario the product is:

- **Washing machine detergent dispenser** made from a blend of virgin and recycled plastics, weighing 0.81 kg, produced by assembling five distinct plastic components—a lid, a distributor, a fixed tub, a sliding tub, and a siphon—manufactured from three different plastics, each using a specific mix of virgin and recycled granulates, along with additional metal parts (clamp and pipes). After several tests conducted at Thermolympic for the TO-BE scenario using scrap in the feedstock, it was concluded that a 50:50 ratio of recycled to virgin material can produce plastics with the same characteristics as the virgin-based ones, without significant changes to the production line or energy requirements. This ratio could be further optimized in the future. In this deliverable, the TO-BE scenario refers to the use of 50% recycled ISOFIL H50 C2V NATURALSIRMAX, 50% recycled

Hostacom HKC 182 L W92607 WHITE, and 0% recycled ISOFIL HK 30 TFH2 BL2092 (since external suppliers for this plastic are not yet available) in the production process.

The variables employed to build the **LCI** are summarized in the following tables (Table 4 and Table 5).

Table 4 PlasticLCI1 List of variables, assumptions and real data

Scenario	Product	Process	Location of the Process	Company	Variable	Unit	Value	Data Source Type
AS IS	Washing machine detergent dispenser	Raw material production			Hostacom HKC 182 L	kg	0.425	Primary
					ISOFIL H50 C2V	kg	0.347	Primary
					ISOFIL HK 30 TFH2	kg	0.02761	Primary
					Clamp	kg	0.00187	Primary
					Pipes	kg	0.00976	Primary
		Injection Moulding	Zaragoza (Spain)	Thermolympic	Electricity consumption	kWh	0.7265	Primary
					Injection moulding process per kg plastic produced (electricity modified with primary data)	kg	1	Secondary[1]
		Assembly	Zaragoza (Spain)	Thermolympic	Electricity consumption	kWh	0.01	Primary
		Incineration	Zaragoza (Spain)	Unknown	waste from ISOFIL H50 C2V	%	0.7	Primary
					waste from ISOFIL HK 30 TFH2	%	0	Primary
					waste from Hostacom HKC 182 L	%	0.68	Primary
TO BE	Washing machine detergent dispenser	Raw material production			Hostacom HKC 182 L	kg	0.2125	Primary
					Recycled Hostacom HKC 182 L		0.2125	Calculated
					ISOFIL H50 C2V	kg	0.1735	Primary
					Recycled ISOFIL H50 C2V		0.1735	Calculated
					ISOFIL HK 30 TFH2	kg	0.013805	Primary
					Recycled ISOFIL HK 30 TFH2		0.013805	Calculated
					Clamp	kg	0.00187	Primary
					Pipes	kg	0.00976	Primary
		Injection Moulding	Zaragoza (Spain)	Thermolympic	Electricity consumption	kWh	0.7265	Primary
					Injection moulding process per kg plastic produced (electricity modified with primary data)	kg	1	Secondary1
		Assembly	Zaragoza (Spain)	Thermolympic	Electricity consumption	kWh	0.01	Primary
		Incineration	Zaragoza (Spain)	Unknown	waste from ISOFIL H50 C2V	%	0	Primary
					waste from ISOFIL HK 30 TFH2	%	0	Primary
					waste from Hostacom HKC 182 L	%	0	Primary

	Recycling	Avila (Spain)	Contenedores Lolo	Electricity consumption	kWh	0.3	Primary

Table 5 PlasticLCI2 Transport logistics for AS-IS and TO-BE scenarios

Scenario	Flow	Route (From → To)	Distance (km)	Material / Product	Transport mode	Source
AS-IS	Hostacom HKC 182 L	Supplier → Thermolympic	300	Raw material	Lorry	Pilot
	ISOFIL H50 C2V and ISOFIL HK 30 TFH2	Supplier → Thermolympic	1200	Raw material	Lorry	Pilot
	Pipes	Supplier → Thermolympic	4000	Accessories	Lorry	Pilot
	Clamp	Supplier → Thermolympic	1200	Accessories	Lorry	Pilot
TO-BE	Recyled plastic	Contenedores Lolo → Thermolympic	420	Recycling material	Lorry	Pilot

In summary, using the detergent dispenser residues in the TO BE scenario as feedstock, mixed with virgin plastic in the Thermolympic supply chain, will provide both environmental and economic benefits by avoiding the incineration of residues and reducing the need to purchase virgin materials.

4.2.3 Wood Pilot

Three independent wood-related companies have joined forces within the CIRCULOOS framework to participate in the **Wood Pilot**. Although each operates independently within the Netherlands and specializes in different stages of the wood supply chain, their collaboration aims to foster greater circularity and sustainability.

AS-IS Scenario

The current situation (AS-IS) reflects the individual operations of the three companies, as described below:

- **Circu-Leren** specializes in modular wood construction projects, such as wooden houses, using primarily virgin wood and occasionally recycled materials. The company uses modular building components to coordinate and design easy assembly and disassembly building projects, extending the lifecycle of its products. This modular approach allows furniture and housing units to be dismantled and repurposed when no longer needed, promoting material reuse and minimizing waste.
  Despite its strong commitment to sustainability and circularity, Circu-Leren continues to rely heavily on virgin wood. This dependence arises mainly from challenges in sourcing and processing recycled wood—such as limited supplier availability, longer lead times, and complex order logistics. In particular, the company depends on virgin wood based **cross-laminated timber (CLT)**, a key material in modular housing. Circu-Leren's main goal is to enhance the circularity of its supply chain by collaborating with partners who use reclaimed wood to manufacture comparable CLT materials. Through this approach, the company aims to offer products with equivalent structural performance while integrating more sustainable and circular sourcing practices.

- **HERSO** specializes in collecting and processing waste wood, transforming it into new, high-quality materials for furniture and other applications. The company's production process is highly artisanal, relying on the owner's expertise to optimize each project. Every piece of furniture is custom-designed based on the characteristics of the reclaimed wood available. HERSO operates with a zero-waste philosophy—any leftover materials from fabrication are stored for use in future designs, ensuring full material utilization.
- **Plennid** focuses on repurposing wood from urban trees in Rotterdam that have been removed due to disease, storm damage, or routine city maintenance. Rather than allowing this wood to be incinerated in low-efficiency energy plants, Plennid processes and supplies it to third parties seeking high-quality reclaimed urban timber. This approach promotes the reuse of valuable natural resources and contributes to more sustainable raw material sourcing practices.

TO-BE Scenario

To develop a more sustainable, efficient, and resilient business model, the three companies have united under a consortium as part of the TO-BE scenario proposed for the Wood Pilot. Through collaboration, they aim to streamline production processes and generate higher-value products from reclaimed materials.

In the envisioned model, Circu-Leren will use building components manufactured by HERSO from damaged urban trees (urban timber) sourced by Plennid. This closed-loop system will provide a sustainable alternative to conventional CLT panels used in interior construction. The integration between Plennid, HERSO, and Circu-Leren is designed to establish a seamless, circular supply chain that maximizes the value and reuse of reclaimed wood:

- Plennid sources and collects urban timber.
- HERSO processes and refines the urban timber into building panels.
- Circu-Leren purchases and integrates these panels into modular housing systems.

This collaborative framework enhances resource efficiency, reduces dependency on virgin materials, and strengthens circular economy practices across the wood sector.

To model the AS-IS and TO-BE scenarios for the LCA, a **cradle-to-gate** approach was selected as the system boundary, as previously mentioned. The stages included in both AS-IS and TO-BE scenarios are shown in Figure 8.

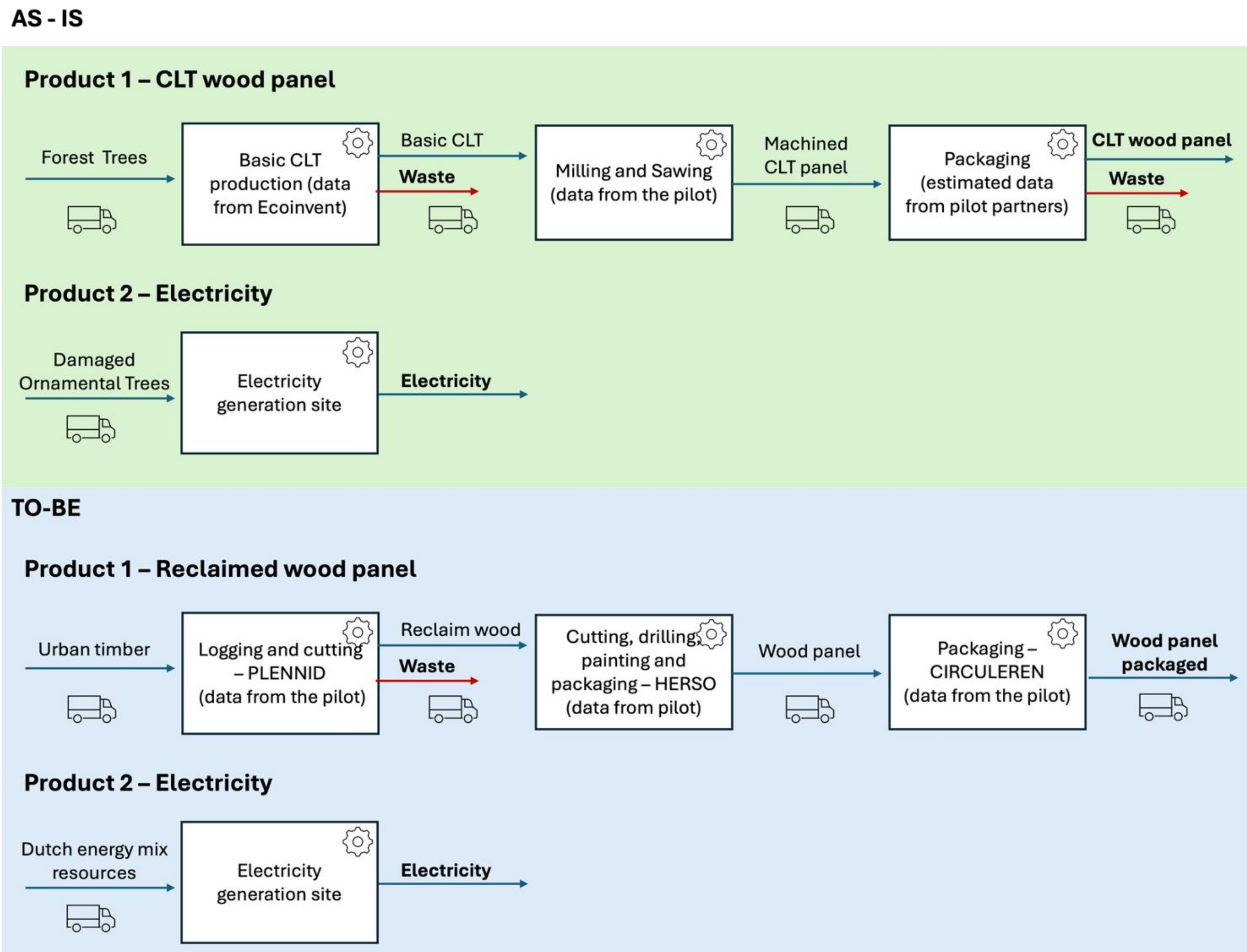

Figure 8 Wood Pilot LCA Model AS IS — TO BE Flow Diagrams

In this pilot, the FU is defined as one interior CLT panel. However, both the AS-IS and TO-BE scenarios represent multi-product systems, as two products derived from different raw materials are obtained in each case: a CLT panel and electricity. The two products in both scenarios provide the same functional service to the community, ensuring a fair and consistent basis for comparison.

In the AS-IS scenario the reference products are:

- **CLT panel** — produced from virgin wood harvested from forests. The panel dimensions are 3.00 m × 1.25 m × 0.021 m, with a density of 460 kg/m^3, resulting in a total weight of 38.5 kg. The panel undergoes several processing steps before being packaged.
- **Electricity** — generated from damaged ornamental trees collected within the City of Rotterdam. In this case, 43.84 kWh of electricity is produced by burning 54.8 kg of wood (corresponding to the amount required to manufacture one CLT panel from virgin wood). The cogeneration process operates at 20% efficiency, assuming a calorific value of 4 kWh per kilogram of wood. Electricity generation is included in the assessment to ensure a consistent and equitable comparison with the TO-BE scenario, in which reclaimed urban wood is instead used to produce CLT panels rather than for energy recovery.

In the TO-BE scenario, the products are:

- **Reclaiming wood panel**, starting from ornamental trees collected in the City of Rotterdam. The dimensions of that panel are 3.00 m × 1.25 m × 0.021 m, with a density of 700 kg/m^3, resulting in a weight of 54.8 kg. This panel is processed by different operations and then packaged.
- **Electricity**, generated from the mix of resources used for making the Dutch energy mix. The electricity produced is 43.84 kWh, as is the case in the AS-IS scenario.

In the TO-BE scenario, the effects of cutting trees for CLT panels are considered avoided impacts. The key benefit is that the forest remains undisturbed, preventing impacts related to harvesting new wood.

The variables employed to build the **LCI** are summarized in the following tables (Table 6 and Table 7).

Table 6 List of variables, assumptions and real data

Scenario	Product	Process	Location of the Process	Company	Variable	Unit	Value	Data Source Type
AS IS	CLT panel (packaged) from harvested wood	Basic CLT production	Berlin (Germany)	Unknown	CLT panel	pc	1	Secondary[1]
		Milling and Sawing	Beverwijk (Netherlands)	BLOK	CLT panel weight	kg	38.5	Primary
					Density of CLT panel	kg/m^3	460	Secondary[2]
					Energy required for milling process	kWh	3.5	Primary
		Packaging Material Production	Amsterdam (Netherlands)	UNILIN Evola	Bottom and top protection (melamine and particleboard)	pc	1	Secondary[1]
			Gorinchem (Netherlands)	Kortpack B.V.	Seal plastic (polyethylene)	pc	1	Secondary[1]
		Packaging	Amsterdam (Netherlands)	CIRCULEREN	Melamine weight (bottom/top protection component)	kg	3.15	Primary
					Particleboard volume (bottom/top protection component)	m^3	0.285	Primary
					Seal plastic weight	kg	0.27	Primary
					Number of CLT panels transported on a pallet	pc	1	Primary
					Bottom and top protection waste	%	30	Primary
	Electricity from Damaged Ornamental Trees	Raw material production	Rotterdam (Netherlands)	Unknown	Weight of damaged ornamental trees wood	kg	54.8	Primary
		Electricity generation site	Assumed Location	Unknown	Efficiency of co-generation site	%	20	Assumption
					LHV wood	kWh/kg	4	Secondary[3]
					kWh generated by wood combustion	kWh	43.84	Calculated

TO BE	**Wood panel (packaged) from Reclaimed Wood**	Raw material production	Rotterdam (Netherlands)	PLENNID	Weight of damaged ornamental trees wood	kg	54.8	Primary
					Seal plastic weight	kg	0.057	Primary
					Diesel used for cutting process	L	2.108	Primary
		Packaging Material Production	Amsterdam (Netherlands)	UNILIN Evola	Bottom and top protection (melamine and particleboard)	pc	1	Secondary[1]
			Gorinchem (Netherlands)	Kortpack B.V.	Seal plastic (polyethylene)	pc	1	Secondary[1]
			Molenstede (Netherlands)	Ermapack	Cardboard	pc	1	Secondary[1]
			Den Bosch (Netherlands)	Unknown	Tape (polypropylene)	pc	1	Secondary[1]
		Ancillary Material Production	Waalwijk (Netherlands)	Maiburg	Formaldehyde-free glue (ethylene)	pc	1	Primary
			Den Bosch (Netherlands)	Pehavo	Lubricant (oil)	pc	1	Primary
		Wood panel production	Loosbroek (Netherlands)	HERSO	Formaldehyde-free glue (ethylene) weight	kg	0.75	Primary
					Lubricant required by CNC machine	kg	0.02	Primary
					Cardboard weight (packaging)	kg	3	Primary
					Tape weight (packaging)	kg	0.075	Primary
					Energy required by CNC machine	kWh	135	Primary
		Packaging	Amsterdam (Netherlands)	CIRCULEREN	Seal plastic weight	kg	0.27	Primary
	Electricity from Grid	Electricity mix	Netherlands	Unknown	Electricity generated	kWh	43.84	Secondary[1]

Note:

[1] Secondary data retrieved from Ecoinvent database vs.3.9.1

[2]Density retrieved from literature (Moser & Spearpoint, 2016)

[3]LHV wood retrieved from literature (Krajnc, 2015)

Table 7 Transport logistics for AS-IS and TO-BE scenarios

Scenario	Flow	Route (From → To)	Distance (km)	Material /Product	Transport mode	Source
AS-IS	CLT wood panel logistic	Berlin → Beverwijk	690	CLT material	Lorry	Ecoinvent, Pilot

	CLT wood panel logistic	Beverwijk → Amsterdam	25	CLT panel (processed)	Lorry	Ecoinvent, Pilot
	CLT wood panel logistic	Gorinchem → Amsterdam	95	Packaging material	Lorry	Ecoinvent, Pilot
	CLT wood panel logistic	Amsterdam → BLOK company	25	Packaged panel	Lorry	Ecoinvent, Pilot
	Electricity logistic	Forestry → Co-generation site	120	Damaged ornamental wood	Lorry	Ecoinvent, Pilot
TO-BE	CLT wood panel logistic	Rotterdam → PLENNID site	20	CLT material	Lorry	Ecoinvent, Pilot
	CLT wood panel logistic	PLENNID site → HERSO site	95	CLT panel (processed)	Lorry	Ecoinvent, Pilot
	CLT wood panel logistic	HERSO site → CIRCULEREN site	90	Packaging material	Lorry	Ecoinvent, Pilot

In summary, using urban timber in the TO BE scenario as feedstock for the production of building materials will provide environmental benefits by avoiding the use of virgin wood and preserving the remaining trees in the forest.

4.3 Sustainability indicators in the CIRCULOOS project

In this project, environmental impacts are calculated in GRETA using the LCA EF3.1 methodology[4]. Since a FU is defined for each pilot, all environmental indicators can be expressed relative to the selected FU.

The choice of which indicator to prioritize for process optimization in terms of environmental sustainability depends on the project objectives. In the CIRCULOOS case, GWP - Climate Change (kg CO_2e) was selected as the key indicator. This selection is motivated by the current global focus on mitigating climate change and reducing GHG emissions, which are major priorities for industry and policymakers seeking to align production processes with international climate targets and sustainability goals.

The environmental indicator related to total GWP, once assessed, is sent to RAMP. Since the goal of other tools in the project is to identify alternative solutions that offer more sustainable outcomes compared to existing processes, this metric can be used as a "cost function". CO_2e is the key metric targeted for reduction in this project; therefore, the objective function in the optimization will focus solely on minimizing CO_2 emissions.

As indicated at the outset of this section, the environmental indicators calculated for the three pilots defined herein are presented in D5.2.

[4] https://eplca.jrc.ec.europa.eu/LCDN/developerEF.html

5 Conclusions

The activities carried out under **Task 3.3 – Sustainability and LCA Assessment Tools** have resulted in a fully operational version of GRETA (GreenTargets), now capable of seamless communication with the CIRCULOOS Data Platform. The integration framework is complete and functional, enabling bidirectional data exchange: GRETA can retrieve input parameters from the platform, perform the assessment, and send back the calculated environmental indicators in JSON-LD format through secure REST APIs. This ensures full interoperability within the CIRCULOOS ecosystem, allowing other tools such as RAMP, SCOPT, SCDT, and MPMS to access GRETA outputs and use them for further analysis and optimisation.

Within this deliverable, the complete Life Cycle Assessment (LCA) models for the three project pilots (leather, plastic, and wood) have been developed, implemented, and validated. Each model includes all relevant assumptions, system boundaries, allocation procedures, functional units, and Life Cycle Inventory (LCI) data, ensuring full transparency and reproducibility. The assessments are based on the Environmental Footprint 3.1 (EF3.1) methodology, following a cradle-to-gate approach and integrating primary industrial data collected from the pilot companies with secondary datasets from the Ecoinvent database and scientific literature.

- The **leather pilot** models the creation of a circular production loop where leftovers from one SME are reused by another to produce new leather goods, applying economic allocation to distribute impacts.
- The **plastic pilot** evaluates the environmental improvements obtained by replacing virgin feedstock with recycled plastics, supported by industrial validation of a 50:50 material mix that maintains quality and performance.
- The **wood pilot** compares conventional CLT panels with alternatives made from urban timber, capturing the avoided environmental impacts associated with forest harvesting.

Through these implementations, GRETA now enables comparative scenario assessments (AS-IS vs TO-BE) and provides real-time sustainability results for all pilots, aligned with the broader project objective of supporting SMEs in their transition towards circular business models.

In summary, this deliverable consolidates all outcomes of Task 3.3, documenting the methodological framework, the data modelling process, and the integration architecture that together make GRETA a fully functional and interoperable LCA tool within the CIRCULOOS ecosystem. The tool is now ready to be adopted in the upcoming Open Calls, where external users will be able to perform sustainability assessments and share results through the CIRCULOOS Data Platform.

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Annex 1


```
[
  {
    "id": "urn:ngsi-ld:circuloos:demo_1:ieq-001",
    "@context": "http://circuloos-ld-context/circuloos-context.jsonld",
    "type": "ieq_sensor",
    "pm25": {
      "type": "Property",
      "value": 31.1,
      "unitCode": "GQ",
      "observedAt": "2024-01-11T10:00:07.446Z"
    },
    "temperature": {
      "type": "Property",
      "value": 39,
      "unitCode": "CEL",
      "observedAt": "2024-01-11T10:00:07.446Z"
    },
    "relativeHumidity": {
      "type": "Property",
      "value": 16,
      "unitCode": "P1",
      "observedAt": "2024-01-11T10:00:07.446Z"
    },
    "hashValue": {
      "type": "Property",
      "value": "empty",
      "observedAt": "2024-01-11T10:00:07.446Z"
    }
  }
]
```

Annex 2

CIRCULOOS Data model

For CIRCULOOS data model we will utilize components of the Smart Data Models

How to combine existing data models into one, @context file

@context file is needed from Orion-LD to correctly link the data

1. Go to Smart Data models and find select the data models that you need
2. From each model, copy the RAW URL of the context.jsonld ie for https://github.com/smart-data-models/dataModel.Device/tree/master https://raw.githubusercontent.com/smart-data-models/dataModel.Device/master/context.jsonld
3. Create a new json file with one line per data model ie for device: "dataModel.Device": "https://raw.githubusercontent.com/smart-data-models/dataModel.Device/master/context.jsonld",
4. Upload it on-line (github or webserver)
5. Go to Generate a local @context
6. Save the json file and check for conflicts

Create a new Data model

See files under folder custom_data_model.

1. Edit schema.json and all files in /examples to represent the new schema
2. Upload it to Git or webserver
3. For generating the model.yaml Edit and run utils/10_model.yaml_v10.py, Line 129: schemaUrl="" to point to the repository or webserver of the custom_data_model folder
4. Move generated yaml to custom_data_model and sync with Git or webserver
5. For generating the spec.md Edit and run utils/20_create_spec_v11.0.py L230: customRepository="" to point to the repository or webserver of the custom_data_model folder
6. Copy generated file to custom_data_model/doc
7. For generating the context.jsonld Edit and run 25_create_subject_context_V7.py, L323: customRepository="" to point to the repository or webserver of the custom_data_model folder

8. For updating the url for each properties with the SmartDataModel webpage. Run update_urls_to_show_smart_data_model.py.

You can use the docker-compose.yml file located on the utils folder for a local webserver based on NGINX

unit code aka 3 alphanumeric code to represent a physical quantity

unitCode : https://docs.peppol.eu/poacc/billing/3.0/codelist/UNECERec20/

Fiware dictionary/terms with for data models: https://github.com/smart-data-models/data-models/blob/master/terms.jsonld

Annex 3

Name of the indicator	CamelCase name	Reference unit	UNECE CODE	Description of the indicator
acidification_accumulated_exceedance_AE	acidificationAccumulatedExceedanceAE	mol H+-Eq	XMHQ	Acidification refers to the process where emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and ammonia (NH_3) lead to the formation of acidic compounds in the atmosphere, which then deposit in soils and water bodies, reducing pH levels. This indicator measures the potential impact of these emissions on ecosystems, using an accumulated exceedance approach to assess how much ecosystems can tolerate before damage occurs.
climate_change_global_warming_potential_GWP100	climateChangeGlobalWarmingPotentialGWP	kg CO2-Eq	XCO2	This indicator measures the contribution of greenhouse gas emissions to global warming over a 100-year timeframe, expressed in kilograms of CO_2-equivalent. It accounts for all major greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), each normalized to its global warming potential.
climate_change_biogenic_GWP100	climateChangeBiogenicGWP100	kg CO2-Eq	XCO2	This measures the global warming potential of biogenic (plant-derived) carbon emissions over a 100-year period, which includes CO_2 released from the combustion or decomposition of biomass. Biogenic emissions are distinguished from fossil emissions, with a focus on the carbon cycle of living organisms.
climate_change_fossil_GWP100	climateChangeFossilGWP100	kg CO2-Eq	XCO2	This indicator measures the global warming potential from fossil fuel-derived emissions, such as CO_2 from coal, oil, and natural gas combustion. It captures the long-term impact of these emissions on climate change, expressed in kilograms of CO_2-equivalents over a 100-year period.
climate_change_land_use_and_LULUC_GWP100	climateChangeLandUseAndLULUCGWP	kg CO2-Eq	XCO2	Land use and land use change (LULUC) impacts on climate change refer to greenhouse gas emissions caused by deforestation, land conversion for agriculture, and other changes in land use. This indicator measures the potential warming effect of land use-related CO_2 emissions over 100 years.

ecotoxicity_freshwater_comparative_toxic_unit_CTUe	ecotoxicityFreshwaterComparativeToxicCTU	CTUe	XCTE	This indicator measures the potential harm of chemical substances released into freshwater ecosystems. It quantifies the toxicity of substances (e.g., heavy metals, pesticides) to aquatic organisms, expressed in Comparative Toxic Units for ecosystems (CTUe). It evaluates the impact on biodiversity and ecosystem health.
ecotoxicity_freshwater_inorganics_CTUe	ecotoxicityFreshwaterInorganicsCTUe	CTUe	XCTE	This indicator focuses on the toxicity of inorganic chemical pollutants, such as heavy metals and minerals, in freshwater ecosystems. It assesses the potential for harm to aquatic life due to exposure to these inorganic substances, expressed in CTUe.
ecotoxicity_freshwater_organics_CTUe	ecotoxicityFreshwaterOrganicsCTUe	CTUe	XCTE	This measures the toxicity of organic pollutants, including pesticides, herbicides, and other organic chemicals, in freshwater environments. These pollutants may disrupt aquatic ecosystems and harm species, with impacts measured in Comparative Toxic Units for ecosystems (CTUe).
energy_resources_abiotic_depletion_potential_fossils	energyResourcesAbioticDepletionFossils	MJ, net calorific value	XMJN	This indicator measures the depletion of non-renewable energy resources, primarily fossil fuels (oil, coal, natural gas). It reflects the consumption of these resources and the impact on their long-term availability, expressed in megajoules (MJ), focusing on energy content and environmental sustainability.
eutrophication_freshwater_nutrients_reaching_P	eutrophicationFreshwaterNutrientsP	kg P-Eq	XPEQ	Freshwater eutrophication occurs when excessive nutrients, especially phosphorus (P), enter water bodies, leading to algal blooms and oxygen depletion. This indicator measures the potential for nutrient pollution to cause eutrophication, expressed in kilograms of phosphorus equivalents (kg P-Eq).
eutrophication_marine_nutrients_reaching_N	eutrophicationMarineNutrientsN	kg N-Eq	XNEQ	Marine eutrophication is caused by nitrogen (N) pollution, which can lead to harmful algal blooms in oceans and coastal waters. This indicator measures the impact of nitrogen runoff on marine ecosystems, expressed in kilograms of nitrogen equivalents (kg N-Eq).
eutrophication_terrestrial_accumulated_exceedance	eutrophicationTerrestrialAccumExceedance	mol N-Eq	XMNE	This measures the impact of nutrient pollution, particularly nitrogen, on terrestrial ecosystems. It assesses the potential for

				nutrient accumulation to exceed the natural capacity of the land, leading to changes in vegetation and soil degradation, expressed in mol N-Eq.
human_toxicity_carcinogenic_CTUh	humanToxicityCarcinogenicCTUh	CTUh	XCTH	This indicator assesses the potential impact of exposure to carcinogenic substances on human health. It is expressed in Comparative Toxic Units for humans (CTUh) and measures the risk of developing cancer from exposure to various chemicals, such as heavy metals, industrial solvents, and certain organic compounds.
human_toxicity_carcinogenic_inorganics_CTUh	humanToxicityCarcinogenicInorganicsCTU	CTUh	XCTH	This focuses on the carcinogenic risks to humans from exposure to inorganic substances, such as arsenic, lead, and other heavy metals. It evaluates the potential harm in terms of cancer development, expressed in CTUh.
human_toxicity_carcinogenic_organics_CTUh	humanToxicityCarcinogenicOrganicsCTU	CTUh	XCTH	This indicator assesses the carcinogenic potential of organic chemical substances, such as formaldehyde, benzene, and pesticides, on human health. It evaluates the risk of cancer associated with exposure to these compounds, expressed in CTUh.
human_toxicity_non_carcinogenic_CTUh	humanToxicityNonCarcinogenicCTUh	CTUh	XCTH	This indicator measures the potential risk to human health from non-carcinogenic substances. It assesses the likelihood of harm such as organ damage or neurological effects from exposure to chemicals, expressed in CTUh.
human_toxicity_non_carcinogenic_inorganics_CTUh	humanToxicityNonCarcinogenicInorganicsCTU	CTUh	XCTH	This focuses on non-carcinogenic health risks from inorganic substances, including heavy metals like cadmium and lead. It evaluates the impact of these chemicals on human health, expressed in CTUh.
human_toxicity_non_carcinogenic_organics_CTUh	humanToxicityNonCarcinogenicOrganicsCTU	CTUh	XCTH	This indicator assesses the non-carcinogenic health risks posed by organic substances, including solvents, pesticides, and other chemicals. It measures the potential for organ damage or other chronic effects, expressed in CTUh.
ionising_radiation_human_health_U235	ionisingRadiationHumanHealthU235	kBq U235-Eq	XKBQ	This measures the potential health impact of ionizing radiation exposure on humans. It is based on the efficiency of radiation exposure relative to uranium-235 (U235), expressed in kilobecquerels (kBq). This indicator focuses

				on risks such as radiation sickness or long-term health effects like cancer.
land_use_soil_quality_index	landUseSoilQualityIndex	dimensionless	XDIM	This indicator evaluates the impact of land use on soil quality, taking into account factors such as organic carbon content, nutrient availability, and erosion potential. It provides a measure of how land use practices affect soil health and sustainability.
material_resources_abiotic_depletion_potential_elements	materialResourcesAbioticDepletionElements	kg Sb-Eq	XSBQ	This indicator measures the depletion of non-renewable material resources, particularly metals and minerals (e.g., copper, zinc, antimony). It reflects the long-term availability of these elements and the environmental impact of their extraction, expressed in kilograms of antimony equivalents (kg Sb-Eq).
ozone_depletion_potential_ODP	ozoneDepletionPotentialODP	kg CFC-11-Eq	ODE	This indicator measures the potential for chemical substances to deplete the stratospheric ozone layer. It is expressed in kilograms of CFC-11 equivalents (kg CFC-11-Eq), focusing on substances like chlorofluorocarbons (CFCs) that contribute to ozone layer depletion.
particulate_matter_formation_health	particulateMatterFormationHealth	disease incidence	XDIS	This indicator assesses the impact of particulate matter (PM) emissions on human health. Particulates such as PM10 and PM2.5 can penetrate the respiratory system, causing conditions like asthma, bronchitis, and cardiovascular diseases. This is expressed in disease incidence cases.
photochemical_oxidant_formation_human_health	photochemicalOxidantFormationHealth	kg NMVOC-Eq	XNMV	This measures the impact of emissions of volatile organic compounds (VOCs) and nitrogen oxides (NOx) that lead to the formation of ground-level ozone (smog), which affects human respiratory health. It is expressed in kilograms of NMVOC equivalents (kg NMVOC-Eq).
water_use_user_deprivation_potential	waterUseUserDeprivationPotential	m3 world eq. deprived	XMWD	This indicator evaluates the potential for water consumption to lead to human water deprivation, considering local water scarcity and water use efficiency. It is expressed in cubic meters of world equivalents deprived (m^3 world Eq. deprived).

Annex 4

GRETA provides an integration layer through which a set of services has been made available through a suite of REST APIs, safeguarded by a security layer controlling access. Such layer of web services allows third-party applications to exploit the GRETA functionalities, from the creation of a new scenario (product alternative) till to the execution of all types of sustainability assessment.

The following tables are meant to describe the list of APIs exposed by GRETA where each API will be presented with a short description, the URL, the HTTP call method, any parameters, a list of any errors, an example of a CURL request and any payload.

<table>
<tr><th colspan="2">PROJECT CREATION</th></tr>
<tr><td colspan="2">Description: this API allows the creation of a new project given a name and a description. The project is like a folder that contains multiple scenarios.</td></tr>
<tr><td>URL: /api/v1/project</td><td>http://<GRETA>/api/v1/project</td></tr>
<tr><td colspan="2">Method: POST</td></tr>
<tr><td colspan="2">URL Params: none</td></tr>
<tr><td colspan="2">Success response: 200</td></tr>
<tr><td>200
Response content:

{
"created":"2024-0222T13:38:32.862665476Z",
"createdBy": "6336334b-c90d-4d5a-989b-5854277fe05d",
"description": "Project Description",
"id": "41ba5aa3-be08-4cb6-bc6c-bfdc5359e9bf",
"lastUpdated": "2024-02-22T13:38:32.862685927Z",
"name": "project Name",
"scenarioCount": null
}</td><td>Request was successful</td></tr>
<tr><td colspan="2">Error response: 500, 401</td></tr>
<tr><td>500</td><td>Internal Server Error</td></tr>
<tr><td>401</td><td>Unauthorized</td></tr>
<tr><td colspan="2">Example of CURL request:

curl --location 'http://<GRETA>/api/v1/project' \
--header 'Content-Type: application/json' \
--header 'Authorization: Bearer ...' \
--data '{
"id": "",
"name": "Test",
"description": "test description"
}'</td></tr>
<tr><td colspan="2">Payload for POST request body:

{
"id":"",
"name":"Test",
"description":"test description"
}</td></tr>
</table>

Notes: this endpoint is **authenticated**. It requires an authentication **token** in the HTTP header.

<table>
<tr><th colspan="2">SCENARIO CREATION</th></tr>
<tr><td colspan="2">Description: this API allows the creation of a new scenario based on a specified scenario Template, a name, a description and the projectId related to a project which must already exist.</td></tr>
<tr><td>URL: /api/v1/scenario</td><td>http://<GRETA>/api/v1/scenario</td></tr>
<tr><td colspan="2">Method: POST</td></tr>
<tr><td colspan="2">URL Params: none</td></tr>
<tr><td colspan="2">Success response: 200</td></tr>
<tr><td>200
Response content:

{
"created": "2024-02-22T13:39:04.227735697Z",
"createdBy": "408cf4e7-8b33-4a2e-9ae9-9b7b75b79ade",
"description": "Scenario description",
"id": "b850976d-cf5d-4996-b76c-de41a76fc55c",
"lastUpdated": "2024-02-22T13:39:04.227772578Z",
"name": "Scenario name",
"projectId": "2d2b17df-5370-4a12-a6f7-c1ce2281972d",
"scenarioTemplateId": "65d61e369135ba79b7544814",
"tags": []
}</td><td>Request was successful</td></tr>
<tr><td colspan="2">Error response: 500, 401</td></tr>
<tr><td>500</td><td>Internal Server Error</td></tr>
<tr><td>401</td><td>Unauthorized</td></tr>
<tr><td colspan="2">Example of CURL request:

curl --location 'http://<GRETA>/api/v1/scenario' \
--header 'Content-Type: application/json' \
--header 'Authorization: Bearer ...' \
--data '{
"name": "Demo",
"id": "",
"projectId": "a133c678-db9f-406d-8f2b-f33b579d9954",
"scenarioTemplateId": "65cf1f55edd4034cfcd4628a",
"tags": [],
"description": "Demo desc"
}'</td></tr>
<tr><td colspan="2">Payload for POST request body:

{
"name": "Test",
"id":"",
"projectId":"a133c678-db9f-406d-8f2b-f33b579d9953",
"scenarioTemplateId":"65cf1f55edd4034cfcd46282",
"tags": [
{id: "be431452-de80-4ad6-819f-284ecbaa49f8"}</td></tr>
</table>

],
"description": "Test description"
}

Notes: this endpoint is **authenticated**. It requires an authentication **token** in the HTTP header.

GET PHASES	
Description: This API will respond with all the defined phases.	
URL: /api/v1/phase	*http://<GRETA>/api/v1/phase*
Method: GET	
URL Params: none	
Success response: 200	
200 **Response content:** [{ "id": "d8fd6490-b982-4157-98ba-cbb1e75cd070", "name": "Manufacturing", "description": "Manufacturing", "color": "#f6d183", "created": "2023-10-20T15:02:08.570168Z", "lastUpdated": "2024-07-10T07:45:50.054837Z", "createdBy": "7944fb06-7256-45a7-b0a2-62b8a8b7ce57", "displayOrder": 0 }, ...]	*Request was successful*
Error response: 500, 401	
500	*Internal Server Error*
401	*Unauthorized*
Example of CURL request: curl --location 'http://<GRETA>/api/v1/phase' \\ --header 'Authorization: Bearer ...'	
Notes: this endpoint is **authenticated**. It requires an authentication **token** in the HTTP header.	

GET SCENARIO CUSTOMIZATION	
Description: given a scenarioId, this API aims to gather the parameters customization (list of parameters and their values) of the related scenario.	
URL: /api/v1/customized-process/	*http://<GRETA>/api/v1/customized-process/*
Method: GET	
URL Params: scenarioId	

scenarioId	*The ID of the scenario for which the customization is required*
Success response: 200	

200

Response content (truncated for example purpose):


```
{
  "created": "2024-02-16T08:43:36.510000+0000",
  "lastUpdated": "2024-02-22T10:03:31.917000+0000",
  "createdBy": "83457779-ab97-4e56-b0fb-71801f56a1d7",
  "realm": "test",
  "id": {
    "timestamp": 1708073016,
    "date": "2024-02-16T08:43:36.000+00:00"
  },
  "refId": "21fad086-514b-443e-9954-933c89958661",
  "customization": {
    "parameters": [
      {
        "parameterName": "electricity_mix_assembly",
        "parameterType": "OPTION",
        "unitOfMeasure": null,
        "value": "05aa5-f931-489c-beee-325f3808b686",
      },
            ...
    ]
  }
}
```


Request was successful

Error response: 500, 401	
500	*Internal Server Error*
401	*Unauthorized*

Example of CURL request:

```
curl --location 'http://<GRETA>/api/v1/customized-process/e7621be0-8725-4065-a198-03b241966e87' \
--header 'Authorization: Bearer ...'
```

Notes: this endpoint is **authenticated**. It requires an authentication **token** in the HTTP header.

SUSTAINABILITY ASSESSMENT CALCULATION (without payload, with scenario ID)	
Description: given a scenarioId, this API calculates the *sustainability impacts* of the specified scenario. The assessment result is organized by *assessment type* (LCA, LCC, SLCA and CE) and it follows the *sustainability methodology* specified in the related scenario template(s).	
URL: /api/v1/[bom/basic]/calculate-scenario	*http://<GRETA>/api/v1/bom/calculate-scenario*
Method: POST	
URL Params: scenarioId	
scenarioId	*The ID of the scenario that wants to be calculated*
componentsOnly	*Boolean flag: set it to true to get impacts only for the components in the Bill of Materials (BoM). Impacts from subprocesses will be excluded.*

Success response: 200	

200
Response content (truncated for example purpose):
 	
[
{
"assessmentType": "LCA",
"phaseResults": [
{
"nodeImpactResult": {
"children": [
...
],
"impactList": [
{
"percentage": 100.00,
"selfImpact": -1.2619045E-6,
"unit": "kg P-Eq",
"value": 0.0020714450245917426
},
...
],
"item": false,
"name": "Manufacturing",
},
"phaseId":"df6490-b982-4157-98ba-cbcd170"
}
],
...
}
]
	Request was successful

Error response: 500, 401	
500	*Internal Server Error*
401	*Unauthorized*
Example of CURL request: curl --location --request POST 'http://<GRETA>/api/v1/basic/calculate-scenario?scenarioId=e7621be0-8725-4065-a178-03b241966e84&componentsOnly=true' \\ --header 'Authorization: Bearer ...'	
Notes: this endpoint is **authenticated.** It requires an authentication **token** in the HTTP header.	

SUSTAINABILITY ASSESSMENT CALCULATION (with payload)	
Description: given an object which represents a *customized scenario*, this API calculates its *sustainability impacts*. The assessment result is organized by *assessment type* (LCA, LCC, SLCA and CE) and it follows the *sustainability methodology* specified in the related scenario template(s). This API calculates impacts starting from a customization and not from a scenarioId.	
URL: /api/v1/[bom/basic]/calculate-scenario-with-payload	*http://<GRETA>/api/v1/[bom/basic]/calculate-scenario-with payload*
Method: POST	
URL Params: none	

Success response: 200	
200 **Response content (truncated for example purpose):**	*Request was successful*


```
[
  {
    "assessmentType": "LCC",
    "phaseResults": [
      {
        "nodeImpactResult": {
          "children": [
            ...
          ],
          "impactList": [
            {
              "percentage": 100.00,
              "selfImpact": 0.0,
              "unit": "EUR",
              "value": 17.5
            },
            ...
          ],
          "item": false,
          "name": "Manufacturing",
          "refId": "4027653"
        },
        "phaseId": "6490-b982-4157-98ba-cbb1e75cd070"
      }
    ]
  }
]
```


Error response: 500, 401	
500	*Internal Server Error*
401	*Unauthorized*

Example of CURL request (partially truncated for example purpose):

```
curl --location 'http://<GRETA>/api/v1/basic/calculate-scenario-with-payload' \
--header 'Content-Type: application/json' \
--header 'Authorization: Bearer ...' \
--data '{
  "parameters": [
    {
      "alias": "Material",
      "description": null,
      "options": [
          ...
      ],
      "parameterName": "material_production",
      "parameterType": "OPTION",
      "unitOfMeasure": null,
      "validations": null,
      "value": "2c9cfce1-da81-4c4a-8657-0f79e1069e81"
    },
    ...
  ]
...
```

}'

Payload for POST request body (truncated for example purpose):
 	
{
"parameters": [
"parameterName": "electricity_mix_assembly",
"parameterType": "OPTION",
"unitOfMeasure": null,
"validations": null,
"value":"05aa578b-f931-489c-beee-325f3806b686",
"index":0
},
...
]
}

Notes: this endpoint is **authenticated**. It requires an authentication **token** in the HTTP header.

CIRCULOOS

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