A circular economy approach for lifecycles of products and services

System specification and requirements for the traceability solutions, including access model

Deliverable 5.1

PROJECT INFORMATION	
Type of Project	European Commission Horizon 2020
Topic	CIRC-01-2016-2017 Systemic, eco-innovative approaches for the circular economy: large-scale demonstration projects
Grant Agreement No.	776503
Project Duration	01/05/2018 – 30/04/2021 (36 months)
Project Coordinator	Nottingham Trent University (NTU)
Project Partners	Enviro Data (ENV), Jonathan Michael Smith (JS), Kosnic Lighting Limited (KOS), Centre of Research for Energy Resources and Consumption (CIR), European EPC Competence Center GmbH (EECC), The Institute for Ecology of Industrial Areas (IETU), SWEREA IVF AB (SWE), Make Mothers Matter (MMM), ONA PRODUCT (ONA), INDUMETAL Recycling (IND), GS1 Germany GMBH (GS1G), Laurea University of Applied Science (LAU), Center for European Policy Studies (CEPS), Institute of Communication and Computer Systems (ICCS), Recyclia (REC), S.A.T. Alia (ALIA)

DOCUMENT INFORMATION	
Title	D 5.1: System specification and requirements for the traceability solutions, including access model
Version	1.0
Release Date (dd/mm/yy)	25/01/2019
Work Package	WP5
Dissemination Level	PU

DOCUMENT AUTHORS AND AUTHORISATION	
Document Responsible	EECC
Contributors	Nicolas Becker, EECC; Dr. Sebastian Schmittner, EECC;Falk Nieder, EECC; Dr, Georg Schwering, EECC; Conrad von Bonin, EECC; Bongartz, Nicole, GS1G; Bartram, Tim, GS1G
Reviewed by	GS1 Germany, Kosnic Lighting
Approved by	Daizhong Su, NTU

DOCUMENT HISTORY			
Version	Date (dd/mm/yy)	Description	Implemented by
0.1	12/12/18	First draft	EECC
0.2	17/12/18	Second draft, added chapter 4	GS1G, N. Bongartz
0.3	11/01/19	Third draft, To be reviewed in QA process	EECC
0.4	18/01/19	Fourth draft after Partner Reviews	EECC, NTU, GS1G, KOS
1.0	25/01/19	Optimized formatting and fixed typos Final Document D5.1	EECC

Summary

The goal of Task 5.1 “System Specification and Requirement for the Traceability Solutions, including Access model” is to find standardized descriptions for a solution that is able to track of product and service lifecycles for the circular economy business models.

The depiction of product lifecycles consists of static properties, such as product master data, and dynamic properties which occur in processes that handle the products and services. The dynamic processes produce data with timestamps and location data that can differ even for similar articles, e.g., feed intake for animals, production, manufacturing, repair, recycling or distance of transport.

In the first step, relevant business processes in general and for the four CIRC4Life demo scenarios are identified. Investigations show, that the exact identification of each product and service is essential for lifecycle depiction. Usage of worldwide established standards such as EPCIS (Electronic Product Code Information Services) to describe processes, and standardized identifiers for FMCG (Fast moving consumer goods) such as GS1 serialized article identifiers are indispensable for cross company data exchange.

The main advancement compared to former consideration on sustainable processes is that this project intends to describe the processes individually for each product and service based on primary data. Even individual users shall be able to receive this sustainable information aggregated to eco-points. This enables consumers to make a sustainable buying decision at the point of sale (online and offline).

This individualization demands serialisation, which has an enormous impact on the technical specification of the traceability module. According to this consideration, the EPCIS framework, including necessary capturing and accessing applications, is developed. This framework is able to handle all business events for the products in focus on the basis of worldwide standardised data interfaces.

In this work package we focus on the eco impact of processes such as waste, transport, recycling, etc. events and the EPCIS event flows are described in detail for the CIRC4life business models and demo cases.

On basis of these descriptions of real-life processes, we developed the business event model, system specification and requirement for the traceability module and the access model. All necessary components such as the EPCIS core system, capturing & accessing components and connectors are defined.

These specifications describe how to access the traceability module and exchange these data between the partners. The traceability module is able to collect all relevant dynamic, primary data to track lifecycles of products and services for circular economy business models.

Table of Content

List of Tables

List of Figures:

Acronyms and abbreviations

Abbreviation	Description
ASN	Advanced Shipping Notice
CBV	Core Business Vocabulary for EPCIS
CEBM	Circular Economy Business Model
EPC	Electronic Product Code
EPCAT	Product Name of EPCIS Implementation by EECC
EPCIS	Electronic Product Code Information System
FMCG	Fast Moving Consumer Goods
GCP	GS1 Global Company Prefix
GEPIR	GS1 Global Electronic Party Information Registry
GIAI	GS1 Global Individual Asset Identifier
(S)GLN	GS1 Global Location Number (with Extension)
GRAI	GS1 Global Returnable Asset Identifier
GTIN	GS1 Global Trade Item Number
IoT	Internet of Things
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
POS	Point of Sale
PU	Public, fully open, e.g. web
RFID	Radio-Frequency Identification
RTI	Returnable Transport Items
SSCC	GS1 Serial Shipping Container Code
SGTIN	GS1 Serialised GTIN
WP	Work Package

1 Introduction

The four demonstration cases and three CEBMs in CIRC4Life need to be supported by a traceability solution that makes the individual impact on the life cycle of a product transparent.

The task 5.1 aims to set up the specification of this EPCIS-based traceability solution. EPCIS is a traceability standard of GS1 for consumer goods and also for industrial supply chains an ISO standard to capture and share supply chain activities across multiple stages across the stakeholders. It enables to track processes at the individual item level as well as on batch/lot level.

An item in CIRC4Life can for example be everything physical e.g. a pig, a piece of meat, feed for the pig, a lamp, a LED light component, a tablet, resources, etc. With the described traceability solution, the dynamic ecological footprint of each individual product or item shall become transparent and enable an LCA calculation based on dynamic data.

The demonstration cases reflect all three CEBMs developed in the project and will include the consumer's perspective for both sectors: the electrical and electronic products and farming/agri-foods. The four demonstration cases will also involve different type of consumers, private persons, industry partners and governmental organizations.

The activities conducted in this task include:

- Identification of relevant business processes to capture in EPCIS events in order to provide adequate and sufficient information for the circular economy business models.
- Identification of relevant identifiers for items, shipping units, locations, resources etc.
- Development of a business event model for the circular supply chains, defining the depiction of specific process steps (e.g. production, shipping, recycling) in standardized EPCIS events.
- Investigation into need for tracing and recording the product information, including the information related to the product development processes, product sustainability data, and geographical information of different collection/recycling points, etc.
- Investigation to the regulations and standards required for developing the traceability solutions which are used in three circular economy business models.
- Specification of the major components and services within the EPCIS-based traceability solutions and the interoperability between the components.
- Identification of the functions of each component and service.
- Identification of requirements for an EPCIS data access model to allow and prevent data access on individual event or item level, respectively.
- The means to access the data resource, including the eco-point/information inventory developed in WP1.

In the following chapters we present the results of these activities.

2 Identification of Relevant Business Processes

The specific new feature of the CIRC4Life project is the goal to establish a life cycle assessment (LCA) approach incorporating the ECO impact of an individual product instance. Today, most of the known LCA approaches focus on product categories using generic data from databases.

In the three supply chains that will be demonstrated in this project (micro farming, meat, and electronics), the relevant business processes need to be identified in order to define the necessary business events.

The technical representation of these events including the data format specifications for storing and querying of the information are described in chapter 7.

The following 3 sections describe these supply chains in general in order to provide a basis to also develop the models beyond the specific demonstration cases within CIRC4Life. Chapter 7 will focus the scope to CIRC4Life only and introduce the features needed to trace individual item ECO impact.

2.1 Food Supply Chain

2.1.1 Generic Approach

A generic food supply chain covering meat as well as fruit and vegetables is shown in the picture below.

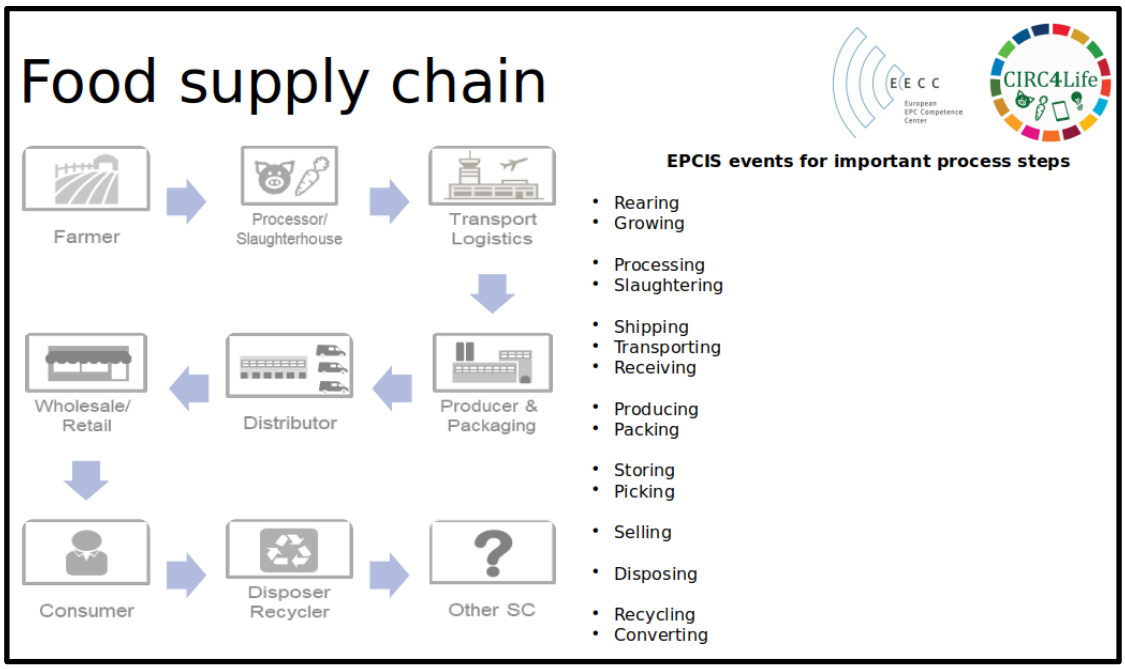


Figure 1: Food Supply Chain as presented in Cracow Innovation Camp

To provide the goal of tracking

- ✓ all processes
- ✓ of all partners
- ✓ for all products
- ✓ and their handling (events)

All supply chain partners must define their process steps in such detail, that LCA calculation can be supported. That for EECC documented in a first step the processes with the partners as good as describable. When not possible EECC tried to find a mostly generic description.

In a second step EECC elaborated a scheme to depict these results in a comprehensive table.

Table 1: Description of food supply chain processes and actors

Supply Chain Partner	Process Steps	Description
 Farmer	Rearing	An animal is reared at a farm. Might include more fine-grained information about the type and amount of food and other resources used.
	Growing	A batch of vegetables is grown at a farm.
 Processor/ Slaughterhouse	Slaughtering	An animal is slaughtered at a slaughterhouse.
	Processing	For the meat supply chain processing means, e.g. cutting an animal into quarters, enriching meat with herbs, producing sausage, etc. Vegetables can for example be processed into ready meals. Freezing the food is a possible process in both supply chains.
 Transport Logistics	Shipping	The food product is shipped from one supply chain partner to the next (might occur several times in the supply chain). This process depicts the “leaving” procedure e.g. at a goods exit.
	Transporting	The products are transported. This process depicts the “moving” procedure, e.g. while the products are on a truck.
	Receiving	The products are received. This process depicts the “arriving” procedure, e.g. at a receiving dock door.
 Producer & Packaging	Producing	Raw or intermediate meat products or vegetables are produced further, e.g. as ingredients for a soup.
	Packaging	After producing, the products are packed into cases / packages / pallets
 Distributor	Storing	At a central distributor, the cases / packages / pallets are stored in a warehouse
	Picking	Cases / packages / pallets are picked from the warehouse according to an order by a retailer.
 Wholesale/ Retail	Selling	The retailer / wholesaler sells the meat products to a customer.
 Consumer	Disposing	Unsold food products are disposed by the retailer. Also, the customer / consumer might dispose unused food.
 Disposer Recycler	Recycling	Products are recycled, e.g. composting vegetables produces natural fertilizer.
	Converting	For example, extracting fat from disposed meat to be used in cosmetics.

Within the Project time frame not all of this information can be gathered from all actors, processes and products. That for we had to focus on available information to be referred as CIRC4Life focus in the following. The specification we designed will be valid for all actors, processes and products.

2.1.2 CIRC4Life Focus

In this project with the partners, only a subset of business events can be considered as these partners do only cover these steps. The following picture shows the relevant steps where information is available (described with "EPCIS"). For the remaining steps data is available with big efforts, only. Those will not be necessarily covered by the demo cases.

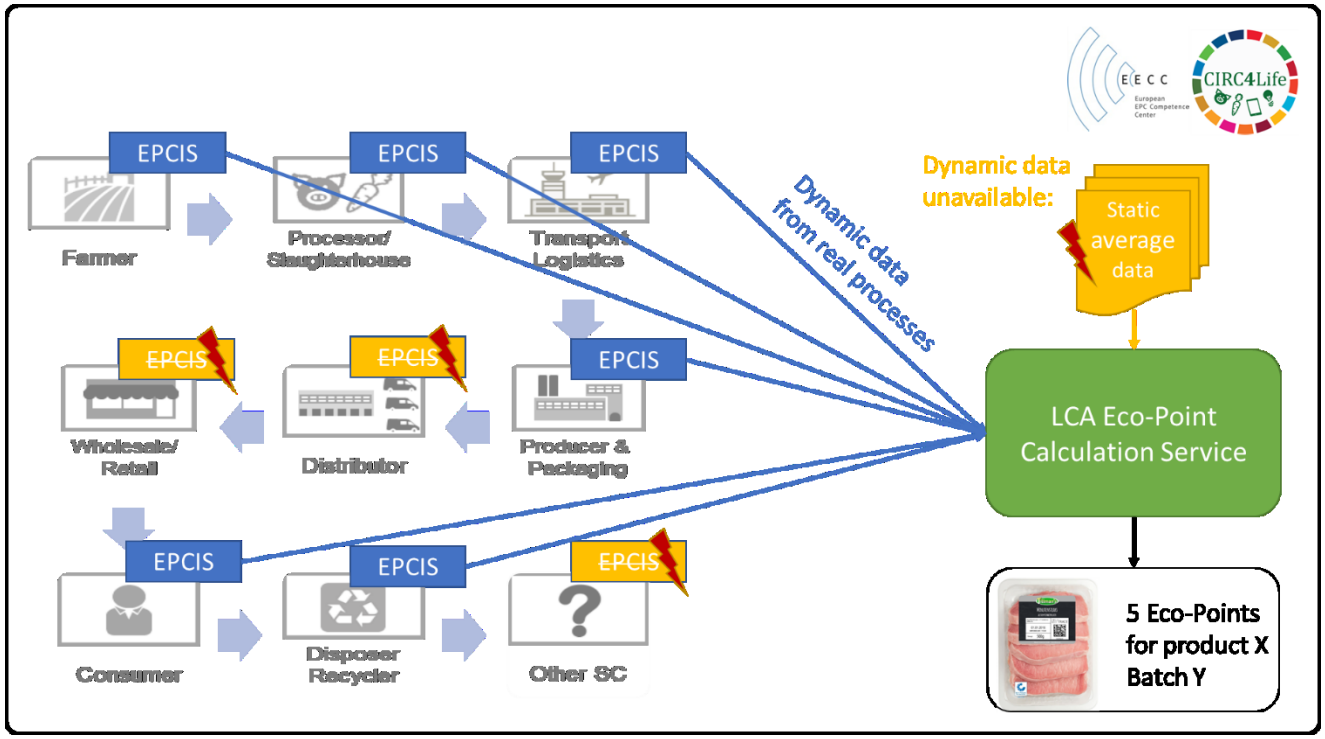


Figure 2: CIRC4Life identified relevant food supply chain process steps

In detail:

The Farmer, Processor/Slaughterhouse and Disposal/Recycler as partners (represented by ALIA for the meat supply chain and Jonathan Smith for the micro farming demo) provide dynamic data from real processes at the mentioned locations and process steps. The information generated there deliver the input for the LCA tool. The chapter "7 Development of a Business Event Model" describes the identified processes in terms of EPCIS events.

2.2 Electronics Supply Chain

A simplified but generic electronics supply chain can be described like shown in the following picture. Raw materials are mined or recycled from e.g. electronic waste and are transported to production plants. Producers are producing parts and others combine them to electronic devices. This may involve many producing parties. This can reach very high complexity which shall not be reflected in the simplified picture. The manufactured devices are distributed and sold by a retailer to a customer who uses the device. When the device's lifetime has ended, it will be disposed and the materials are recycled.

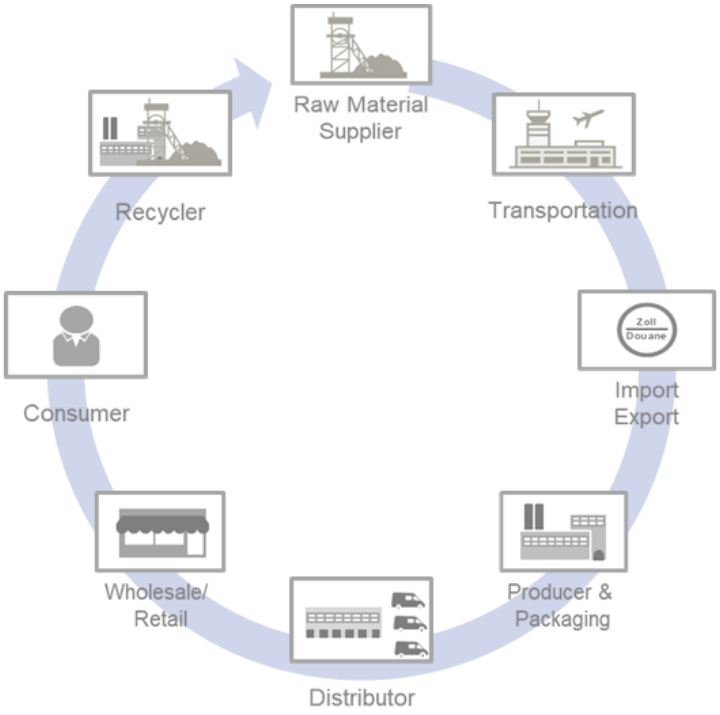


Figure 3: Generic simplified Electronics lifecycle.

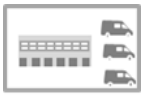
The general partners and the process steps occurring are described in Table 2.

In detail:

Following detailed processes have been elaborated and described with the partners.

For CEBM 2 (Collaborative Recycling and Reuse) the electronics repair and recycling process steps have been identified to be very relevant for the LCA calculation.

Table 2: Comprehensive description of electronics supply chain processes and actors:

Supply Chain Partner	Process Steps	Description
 Raw Material Supplier	Raw material extraction	Primary raw material production, e.g. mining.
	Recycling	Secondary raw material production, i.e. recycling
 Transportation	Shipping	Raw materials, electronic parts or products are shipped from one supply chain partner to the next (might occur several times in the supply chain). This process reflects the “leaving” procedure e.g. at a goods exit.
	Transporting	Raw materials or electronic parts or products are transported. This process depicts the “moving” procedure, e.g. while the products are on a truck.
	Receiving	Raw materials or electronic parts or products are received. This process depicts the “arriving” procedure, e.g. at a receiving dock door.
 Import Export	Inspecting	Raw materials or electronic parts or products are crossing a border. This step represents the control by the customs at the border.
 Producer & Packaging	Producing	Electronic products are produced by assembling parts or electronic components, e.g. assembling a tablet.
	Packing	After producing, the products are packed into cases / packages / pallets.
 Distributor	Storing	At a central distributor, the cases / packages / pallets are stored in warehouse.
	Picking	Cases / packages / pallets are picked from the warehouse according to an order by a retailer.
 Wholesale/ Retail	Selling	The retailer / wholesaler sells the electronic products to a customer.
 Consumer	Disposing	The consumer is disposing the used electronic device to a recycling bin.
 Recycler	Reuse	Products can be reused, possibly after repairing/refurbishing.
	Recycling & Converting	Products are disassembled and/or decomposed in order to reuse parts of it or extract raw materials.

2.2.1 Repair Center

After a device has been disposed by a customer, the following steps might be carried out at a repair center to determine the status of the device:

- Testing of the tablet for assessing if it could be reused or must be recycled
- In case of reuse:
  - refurbishment/remanufacturing/repairing
  - Marketing the reused/remanufactured tablets
- Otherwise:
  - WEEE treatment (disassembling)
  - Raw material extraction (shredding, fractioning,...)
  - See below for details.

The exact processes for repairing/remarketing are still quite unclear at the present project stage. Developing them in detail will be a major outcome of development of Task 6.3,. The business model developed here will be flexible enough to incorporate various possible processes here.

2.2.2 Recycling Process

In case of recycling, the tablets follow this process:

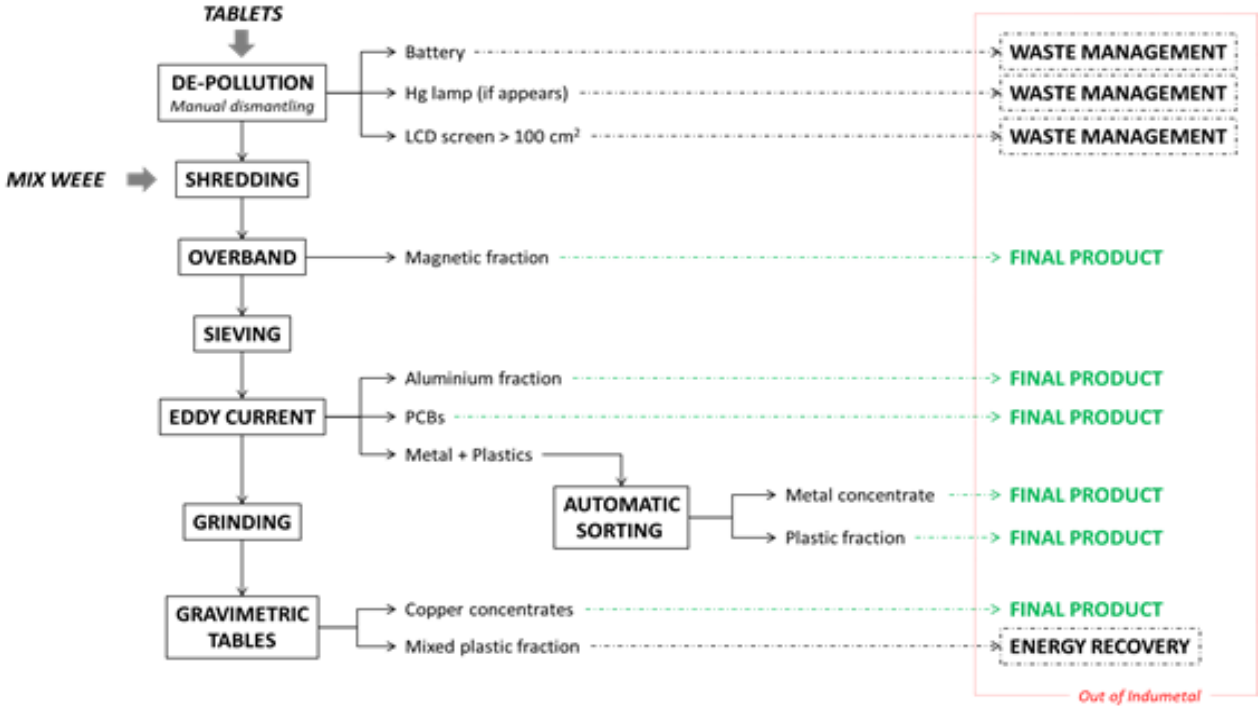


Figure 4: Generic Recycling process for tablets at INDUMETAL's facilities

2.2.3 Recycling Bins and Reuse/Recycling

According to the foreseen execution of CEBM 3 (Sustainable Consumption) and taking into account that for tablets won't exist a sustainable purchase, the relevant information to be considered is related to the estimation of eco-debits/eco-credits obtained by the end user caused by the tablet disposal.

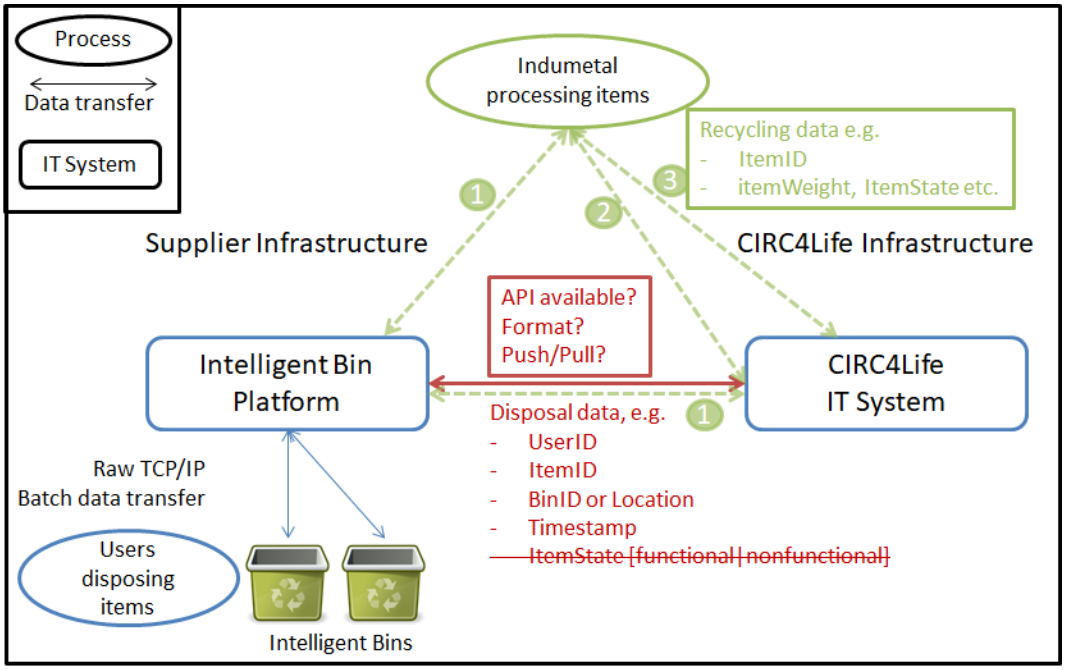


Figure 5: Information available and to be exchanged at the recycle bin

A proposal of Indumetal as recycler for the Information exchanged after a consumer disposes a device into a recycle bin and when processing the devices is shown in the Figure 5. The information available have been identified to be the following:

- Data supplied by the intelligent bin
  - Date and place of the tablet collection. The place where the bin is placed is important to determine distances from the collection point to recycling facilities
  - Weight of the tablet
  - Conditions of the tablet provided by the end user
  - Identification of the end user
  - Number of devices placed by the end user

- Data supplied by the repair centre
  - Weight of the tablets
  - Model and specifications of the tablets
  - Verification of the conditions of the tablet
  - Operations required for a tablet reuse/remanufacturing (substitution of battery, cleaning steps, updating software, change of the screen, etc.)
  - Final use of the tablet (second hand shops, schools, etc.)

- Data supplied by the recycling centre
  - Weight of the tablets
  - Weight of components removed from the tablets during the depollution step
  - Weight of the depolluted tablet sent to the recycling process
  - Recycling ratios and recovered fractions from the treatment of tablets and mix WEEE

This description of the processes is the basis for all following activities, especially the definition of the Identifiers to be used, transformation into business events and the integration into the CIRC4Life ICT Platform.

3 Relevant Standards and Regulations

The analysis of which standards and the (EU) regulations apply and must be applied for the traceability of the previously mapped supply chains has led to the following results, all of which relate to the food supply chain. For the electronic supply chain, no legal regulations for traceability could be identified.

The standards identified to be applicable on traceability in general are

- GS1 Global. (2016) _EPC Information Services (EPCIS) Specification - Release 1.2 _ Brussels: Global Standards One
- GS1 Global. (2017) _Core Business Vocabulary (CBV)Specification – Release 1.2.2_ Brussels: Global Standards One
- International Organization for Standardization. (2017) _ISO/IEC 19987:2017: Information technology -- EPC Information Services (EPCIS) Standard_ Geneva: ISO.
- GS1 Global. (2017) _ EPC Tag Data Standard defines the Electronic Product Code and specifies the memory contents of Gen 2 RFID Tags_ Brussels: Global Standards One
- GS1 Global. (2018) _ GS1 General Specifications - Release 18_ Brussels: Global Standards One

On the regulatory requirements we could identify the following applicable regulations:

- European Parliament and the Council for food of animal origin (2011). _COMMISSION IMPLEMENTING REGULATION (EU) No 931/2011 of 19 September 2011 on the traceability requirements set by Regulation (EC) No 178/2002_ Brussels: European Commission
- European Commission. (2013) _ COMMISSION IMPLEMENTING REGULATION (EU) No 208/2013 of 11 March 2013 on traceability requirements for sprouts and seeds intended for the production of sprouts. _ Brussels: European Commission
- European Parliament and the European Council. (2013) _: REGULATION (EU) No 1169/2011 of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004_ Brussels: European Commission
- European Commission. (2013) _ COMMISSION IMPLEMENTING REGULATION (EU) No 1337/2013 of 13 December 2013 laying down rules for the application of Regulation (EU) No 1169/2011 of the European Parliament and of the Council as regards the indication of the country of origin or place of provenance for fresh, chilled and frozen meat of swine, sheep, goats and poultry

At this point we decided not to detail all included regulation information as they are available on the pertinent portals of the European Commission (European Union, 2018). For the electronics supply chains no regulations or standards could be identified.

Besides the regulation, it is very important to follow the standards and use their dedicated standard identifiers in order to be able to define worldwide applicable interfaces. In the following chapter we collected those on the appropriate GS1 standards.

4 Identification of Relevant Identifiers

4.1 Introduction to GS1 Standards

The international GS1 community is the neutral competence and service centre for cross-company business processes along the value chain in a global economy. It is regarded as mover for the development and implementation of automatic identification, communication and process standards that can be used in all industries and in addition offers platforms for cooperation, networks and know-how sharing for companies across industries – from POS (Point of Sale) upstream to the agricultural domain.

Figure 6: The global GS1 Community

GS1 standards represent the “global language of business” with 111 Member Organisations comprising 1.300.000 member-companies and 150 countries served. Briefly, GS1 is

- neutral and not-profit oriented,
- user-driven and governed,
- global and local,
- inclusive and collaborative.

GS1 standards help to make business processes efficient by ensuring important information is accessible, accurate and easy to understand. They are classified in four categories:

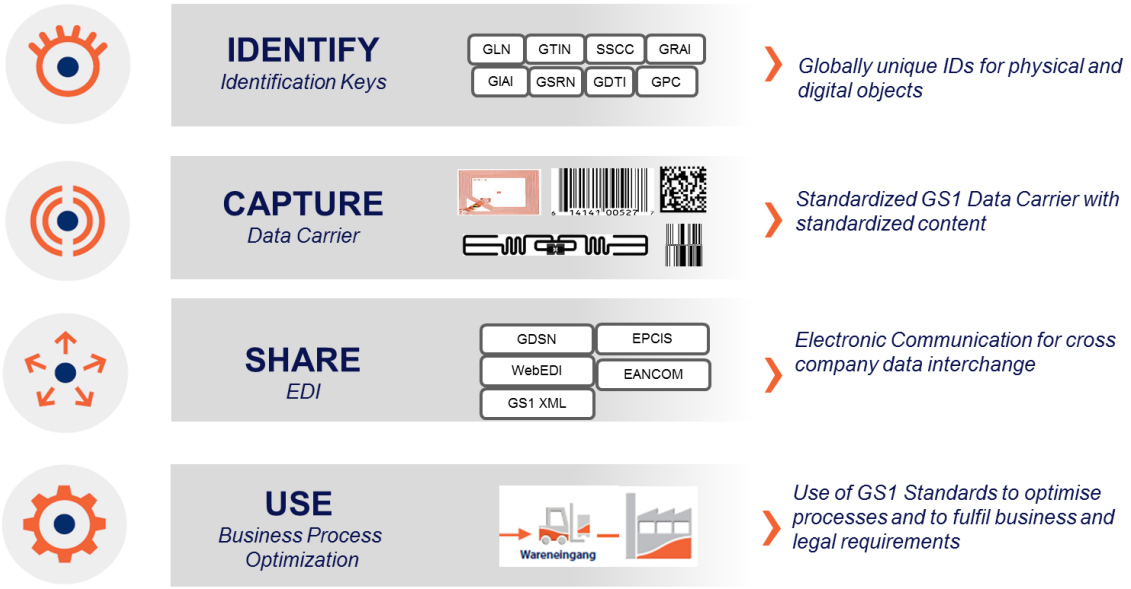


Figure 7: Illustration: The four pillars of GS1 Standards

Identify – GS1 identification standards include standards that define unique identification codes (called GS1 identification keys) which may be used to refer unambiguously to physical or digital entities such as a trade items, logistics unit, physical location or documents.

Capture – GS1 data capture standards currently include definitions of barcode and radio-frequency identification (EPC/RFID) data carriers which allow GS1 identification keys and supplementary data to be affixed directly to a physical object. The most famous GS1 Code is the EAN/UPC Code with the GTIN encoded and used on nearly every consumer package.

Share – GS1 standards for information sharing include data standards for master data, business transaction data, and physical event data (EPCIS).

Use – Businesses can also combine various GS1 standards to streamline business processes such as traceability.

In this context the **GS1 Global Company Prefix** is a unique string of four to twelve digits used to issue GS1 identification keys. It guarantees uniqueness and associability. It is indicated in **GEPIR** (Global Electronic Party Information Registry) that gives access to basic contact information for companies that use GS1's globally unique identification system. By simply typing a GS1 key or a company name you can find relevant contact details respectively the GCP. As an example (see Figure 8) GEPIR contains the following information about GS1 Germany:

Figure 8: The GCP Concept within the GLN Identification Number

4.2 Item Identifiers

The **Global Trade Item Number (GTIN)** can be used by a company to uniquely identify all of its trade items. GS1 defines trade items as products or services that are priced, ordered or invoiced at any point in the supply chain.

Figure 9: Illustration: GS1 Standards along the Supply Chain

The GTIN can be used to identify types of products at any packaging level (e.g. consumer unit, inner pack, case, pallet). Groups of trade items with similar production and usage characteristics such as production batches can be further identified with the help of the batch/lot number, expiry date, and similar data elements. Individual trade items can be uniquely identified using a GTIN plus serial number.

Once a company has assigned a GTIN to a trade item, it provides a common language for all of its entities and trading partners worldwide to uniquely identify the item and easily communicate information about the item.

The GTIN can be encoded in a barcode or an EPC/RFID tag. By scanning the barcode or EPC/RFID tag, companies can efficiently and accurately process products and related information; for example, at check out in a store, when receiving goods in a warehouse, and when administering medication in a hospital.

GTINs can be used to unambiguously identify trade items online, for example in catalogues, in electronic messages such as purchase orders and invoices, and embedded in web pages to optimise use by search engines and other information consumers.

THE GTIN IS FULLY COMPATIBLE WITH ISO/IEC 15459 – PART 4: INDIVIDUAL PRODUCTS AND PRODUCT PACKAGES

The **Electronic Product Code (EPC)** permits the automatic and unambiguous identification of objects. The EPC can be encoded in GS1 data carrier (barcodes) or in EPC/RFID technology. With the EPC, the flow of goods and information can be managed efficiently across sectors and globally. A **SGTIN** (Serialized GTIN, kind of EPC) is the combination of a GTIN and a unique serial number of up to 20 alphanumeric characters. Each instance of a given trade item receives a different serial number. For example, a particular GTIN might be assigned to identify the trade item "30-tablet bottle of drug XYZ". All 30-tablet bottles of drug XYZ will have the same GTIN, but each individual 30-tablet bottle of drug XYZ will have a different serial number, and therefore a different SGTIN. In this way, the SGTIN can be used to track and trace that one individual bottle through the supply chain.

4.3 Location Identifiers

The **Global Location Number (GLN)** can be used by companies to identify their locations, giving them complete flexibility to identify any type or level of locations required.

- The GLN can identify a company's physical locations, for example a store, a warehouse, or a berth in a port.
- The GLN can be used to identify an organisation as a corporate entity.
- The GLN can also identify a company's legal and functional entities engaging as parties in a particular business transaction, for example as buyer, seller, or carrier.
- The GLN is encoded in either a barcode or EPC/RFID tag to automatically identify locations like storage places in a warehouse, the destination of a pallet, or the origin of a product.
- The GLN can be used in electronic messages and registries to inform trading partners about companies and their corresponding GLNs and associated GLN information.
- The GLN extension component can be added to a GLN to provide more precise recording and sharing of supply chain events. For example, an extension component may identify sub-locations such as storage bins, dock doors, scan and read points.
- The GLN is also used by organisations in the public sector. In fact, various applications exist where governments use GLNs, either to identify their own agencies or to identify companies using central government databases.

GLN IS FULLY COMPATIBLE WITH ISO STANDARD 6523. THE INTERNATIONAL CODE DESIGNATOR (ICD) FOR THE GLN IS '0088'.

4.4 Identifiers for Shipping Units, Resources, Services and others Assets – in extracts

The **Serial Shipping Container Code (SSCC)** can be used by companies to identify a logistic unit, which can be any combination of trade items packaged together for storage and/or transport purposes; for example, a case, pallet or parcel.

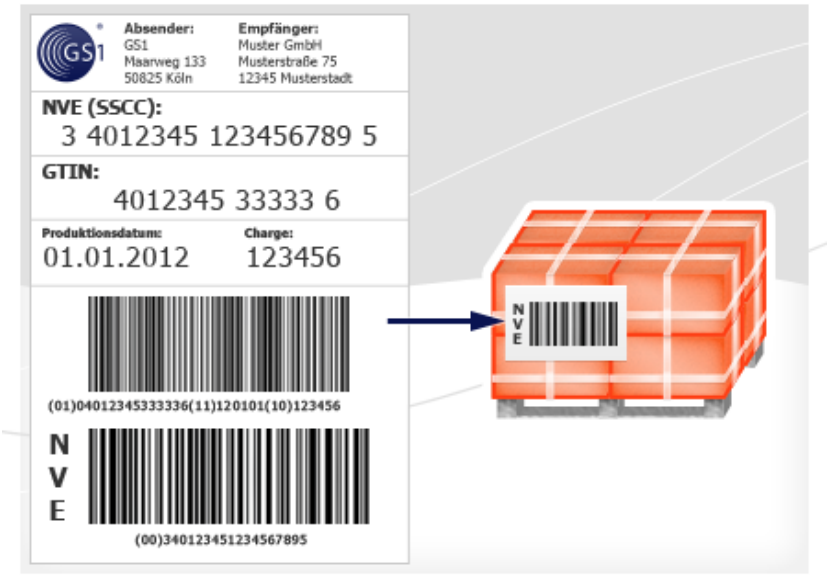


Figure 10: Example NVE (SSCC) label

- The SSCC is a crucial key for traceability, since it uniquely identifies each distributed logistic unit and its content.
- The SSCC enables companies to track each logistic unit for efficient order and transport management.
- The SSCC can be encoded in a barcode or EPC/RFID tag, ensuring the logistic unit can be accurately and easily identified as it travels between trading partners, anywhere in the world.
- When SSCC data is shared electronically via EDI or EPCIS, this enables companies to share information about the status of logistic units in transit, and reliably link it to related transport information such as shipment details.
- The SSCC enables companies to link to additional information about the logistic unit. This information can be communicated via a Despatch Advice or Advanced Shipping Notice (ASN) prior to the logistic unit's arrival. Upon receipt the SSCC will be scanned, providing the required information to speed up the receipt of goods as well as the subsequent invoicing process.

THE SSCC IS FULLY COMPATIBLE WITH ISO/ IEC 15459 – PART 1: UNIQUE IDENTIFIERS FOR TRANSPORT UNITS. THIS IS OFTEN REFERRED TO AS THE ISO LICENCE PLATE AND IS A PREREQUISITE FOR TRACKING AND TRACING LOGISTIC UNITS IN MANY INTERNATIONAL SUPPLY CHAINS.

The **GRAI (Global Returnable Asset Identifier)** identifies every returnable container or packaging Returnable transport items (RTI) are reused for multiple deliveries, e.g. crates, trays and pallets. A GRAI is encoded in a barcode or EPC/RFID tag. Thereby the GRAI helps companies to more easily track and manage their valuable returnable assets. In an EPCIS aggregation event a product (GTIN) can be associated to a GRAI.

Figure 11: Example of Unique Identification of Assets along Supply Chains with GS1 Standards

GIAI (Global Individual Asset Identifier) identifies any asset throughout its lifetime. This can be a vehicle, machine, computer or spare part. Also a sensor may be identified with GIAI in an IoT (Internet of Things) scenario. A typical EPCIS event depicts the movement of a tractor within a determined location.

5 Investigation into Need for Tracing and Recording the Product Information to Collect Dynamic Data on Individual Item Level

Within the CIRC4Life project three new circular economy business models are developed and demonstrated: Co-creation of Products/Services model, Sustainable Consumption model, and Collaborative Recycling/Reuse model. Although these models follow different approaches, they all aim for improved sustainability of products and services throughout their lifecycle. Therefore, it is essential to provide sustainability related KPIs (Key Performance Indicators) to the business models in order to enable for informed decisions during the process.

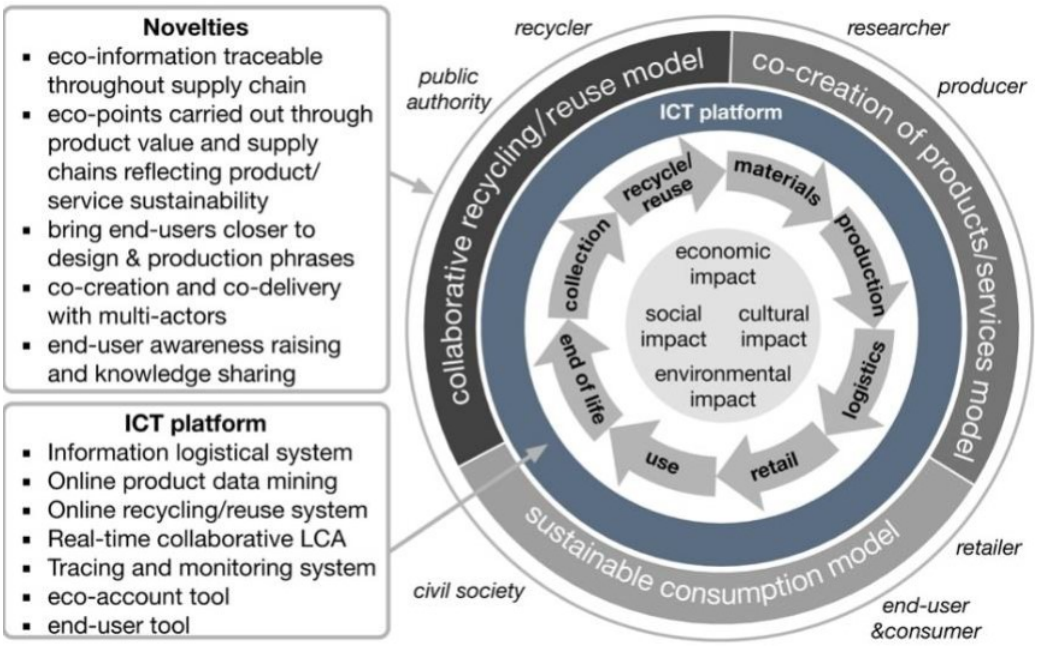


Figure 12: Illustration of CIRC4Life Project scope.

5.1 Relevance for the Circular Economy Business Models

The following sections outline the main reasons why product and service sustainability information are important to the CIRC4Life business models.

5.1.1 Co-creation of Products/ Services Model

Within the co-creation of products by end-users, different - sometimes competing - KPIs must be evaluated and weighted. These product KPIs refer to price, functionality, quality, retail options and environmental impact. The latter is not easily accessible and understandable for end-users. Thus, within CIRC4Life, the environmental impact of different design choices must be made measurable. The choice between e.g. different kinds of materials, production technologies and services (e.g. lease vs. buy) can then be rated and evaluated at all KPI dimensions.

5.1.2 Sustainable Consumption Model

The sustainable consumption model enables end-users to know and evaluate the sustainability of a product or service at the time of purchase. The Eco-point methodology (CIRC4Life, 2018) (Huijbregts, et al., 2017) - a one-dimensional value reflecting the overall environmental impact - will be applied to each product. When the end-users purchase a product, the eco-points are added to her account as eco-debits. In order to calculate the eco-point value, it is necessary to capture and provide the multi-dimensional environmental impact data of the product, such as used resources and produced waste at production and distribution.

5.1.3 Collaborative Recycling/Reuse Model

Within this business model, end-users will be credited with eco-credits for products disposed to a recycle bin. Eco-credits are similar to eco-debits, but reflect the overall *positive* environmental impact of the recycling of a product. In order to calculate the eco-credit, it is necessary to capture and provide data on the recycled components of the product, the disposed components or whether the product is refurbished and reused.

5.2 Granularity of Product Sustainability Data

Eco-points are calculated by utilising a life-cycle assessment tool (CIRC4Life, 2018). This requires multidimensional environmental impact data (such as used resources and produced waste) as input parameters. This data has to be collected provided for every product throughout the value chain, as every process step may have an impact on the overall impact of a product. Three different levels of granularity are possible: class, batch and item level.

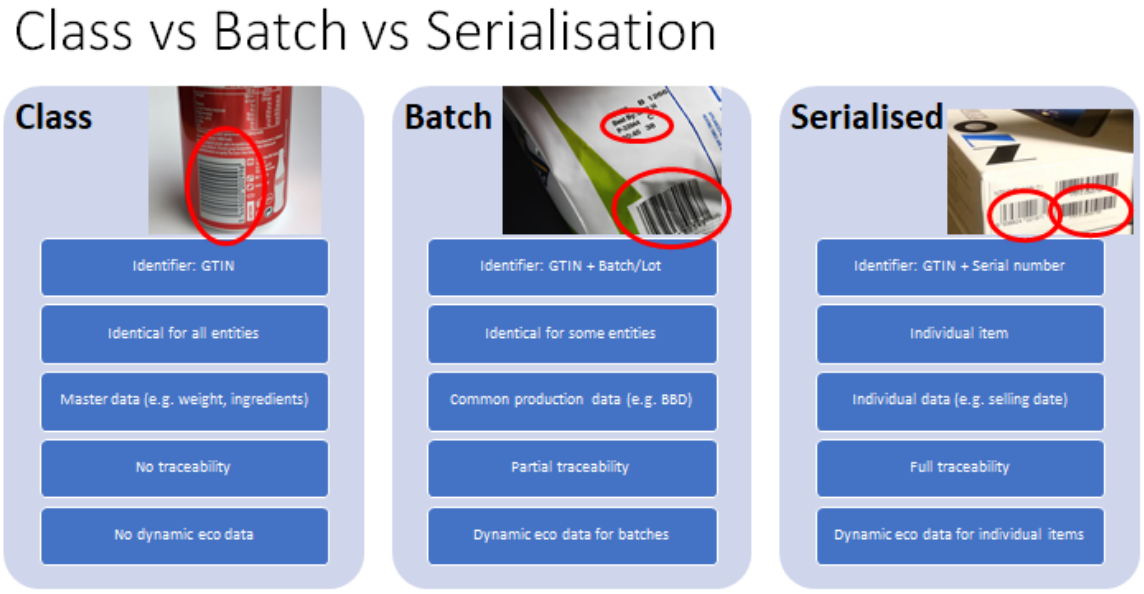


Figure 13: Illustration of product granularity levels

5.2.1 Class Level

Class level, in other words a product category's, sustainability data refers to all entities of a specific product. A product is e.g. a tablet of a specific manufacturer or a specific meat product. Product sustainability data is calculated by measuring or estimating the average resource consumption and waste production for this product class. As a result, all products of one product class have the same eco-point, regardless of differences between specific production batches or distribution channels. Sustainability information based on static class level data is already established and supported by common LCA tools.

5.2.2 Batch Level

Batch level sustainability data refers to all entities of a specific production batch of products. These products all share the same environmental data during production. Tracing and using environmental data on batch level is a novelty in this project which enables dynamic eco-point calculation for different product batches. For example, batches of vegetable in the off-season may have a higher eco-point than batches in the main season. Supply chain impact may still be based on a mixture of tracked and average data.

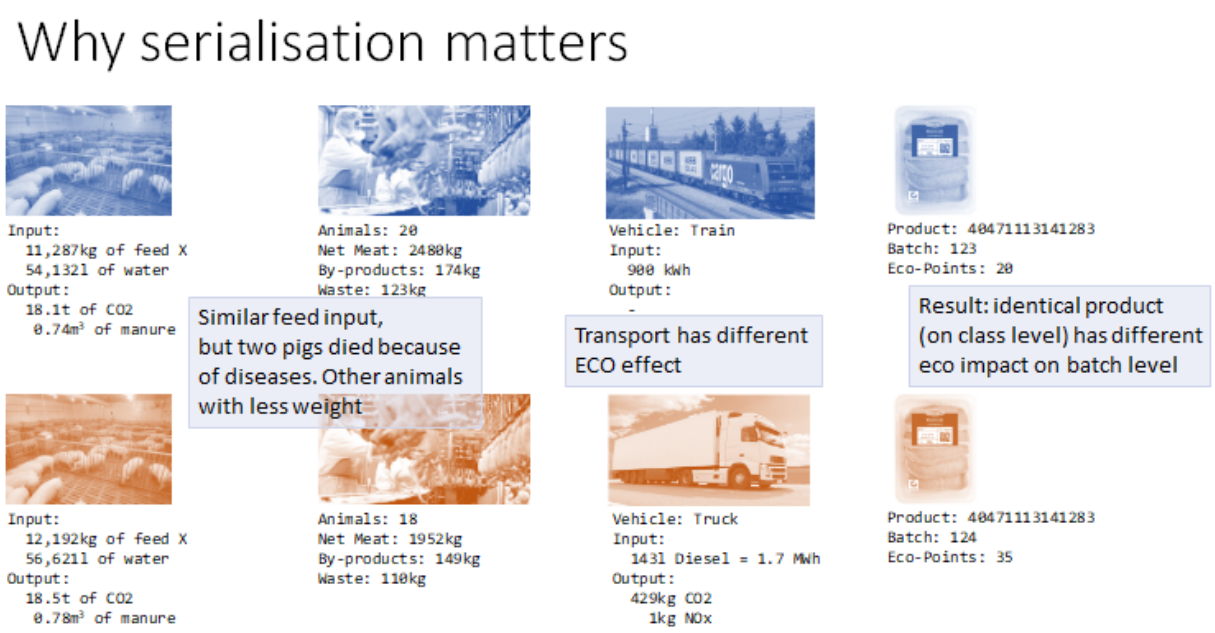


Figure 14: Illustration of ECO impact differences in item or batch product level.

5.2.3 Item Level

Serialised item level sustainability data refers to an individual entity of a specific product. This allows to trace individual environmental data for every item at every process step throughout the whole supply chain. Tracing and using environmental data on item level is a novelty in this project which enables dynamic eco-points for every individual product entity.

Moving from static (class level) to dynamic (batch and item level) environmental impact data is a key requirement in order to provide accurate eco-point values and give end-customers, designers and producers a real choice between different products, resources and services (see section 2.1.2).

6 Solution Design: Specification of the Major Components and Services

Electronic Product Code Information Services (EPCIS) is a global GS1 Standard for creating and sharing visibility event data, both within and across enterprises, to enable users to gain a shared view of physical or digital objects within a relevant business context. "Objects" in the context of EPCIS typically refers to real things that are handled in physical steps of an overall business process involving one or more organizations. Examples of such physical objects include trade items (products), logistic units, returnable assets, fixed assets, physical documents, etc. “Objects” may also refer to digital goods which participate in comparable business process steps. Examples of such digital goods include digital trade items (music downloads, electronic books, etc.), digital documents (electronic coupons, etc.), and so forth.

The EPCIS standard was originally conceived as part of a broader effort to enhance collaboration between trading partners by sharing of detailed information about physical or digital objects. The name EPCIS reflects the origins of this effort in the development of the **Electronic Product Code** (EPC). However, EPCIS does not require the use of Electronic Product Codes, nor of **Radio-Frequency Identification** (RFID) data carriers, and as of EPCIS 1.1 does not even require instance-level identification (for which the Electronic Product Code was originally designed). The EPCIS standard applies to all situations in which visibility event data is to be captured and shared, and the presence of “EPC” within the name is of historical significance only. The following sub-chapters describe the relevant EPCIS components. The next main chapter describes the CIRC4Life specific EPCIS components to be developed following the EPCIS Release 1.2 standard (GS1 Global, 2016).

6.1 EPCIS Framework

The interoperability between the components should be compliant to EPCIS where applicable, and developed capture and accessing applications should access the developed EPCIS repository via its standardized interfaces (capture and query interface). The following picture shows the EPCIS framework and (boxed) the covered components in the CIRC4Life project.

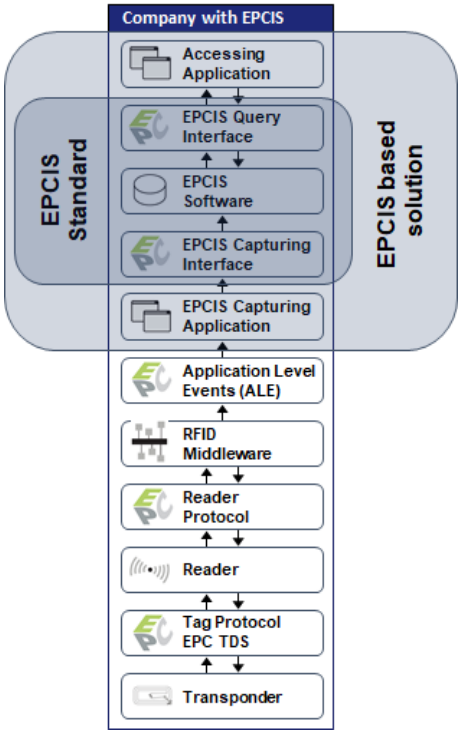


Figure 15: EPCIS Architecture Framework, Source (GS1 Global, 2016)

An EPCIS based solution consists of the EPCIS repository (standardised), one or more capture applications and one or more accessing applications. Capture and accessing applications are customized according to specific requirements. All components together implement the functionality that is needed for a specific application or use case.

6.2 EPCIS Events

EPCIS provides traceability information for all kinds of products. The key component, the EPCIS repository, stores and provides business event data along the product life cycle. The data is collected as information about relevant business events occurring in the life cycle of a product and is stored as an EPCIS event depicting this physical business step as a digital twin.

Business event data occurs every time products are handled, processed, transformed, transported, sold, repaired, disposed, recycled and so on. The information is represented in standardized EPCIS events, which consist of four dimensions (Figure 16): What (animals, product), Where (locations), When (time of business event) and why (information on the business process). All items and locations are represented by standardized GS1 identifiers as described in chapter 3.

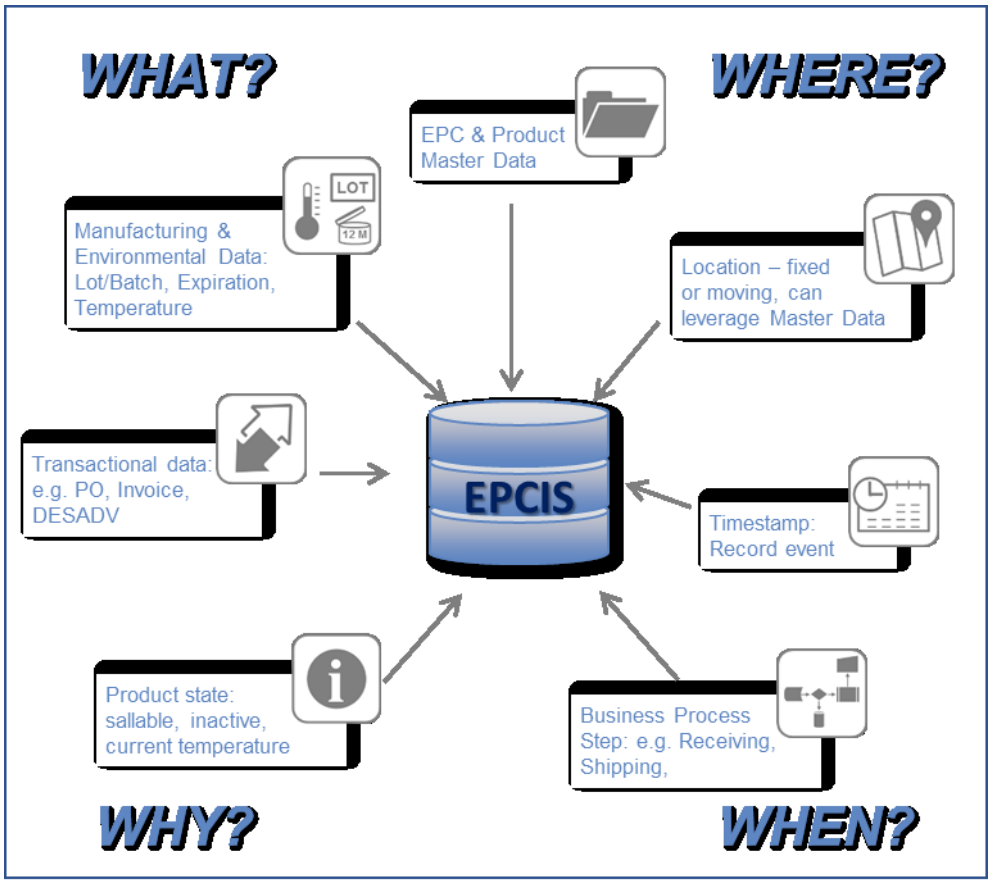


Figure 16: Dimensions of Information in EPCIS Events.

Within the EPCIS solution, it is possible to track data for individual item instances as well as lot/batch or even class information. The interfaces for data input (capture) and data output (query) are standardized, too. Thus, the EPCIS event data can be used by many services without the need of bilateral agreements on data interpretation. Standardized identifiers and interfaces guarantee that each item can be identified throughout the whole supply chain without the need for mapping of proprietary data structures.

6.3 EPCIS Capture Application

An EPCIS capture application retrieves (business relevant) data from a source system. It validates and verifies the data with regard to the business context, enriches data with additional information, creates EPCIS events and sends them to a capture interface as shown in Figure 17.

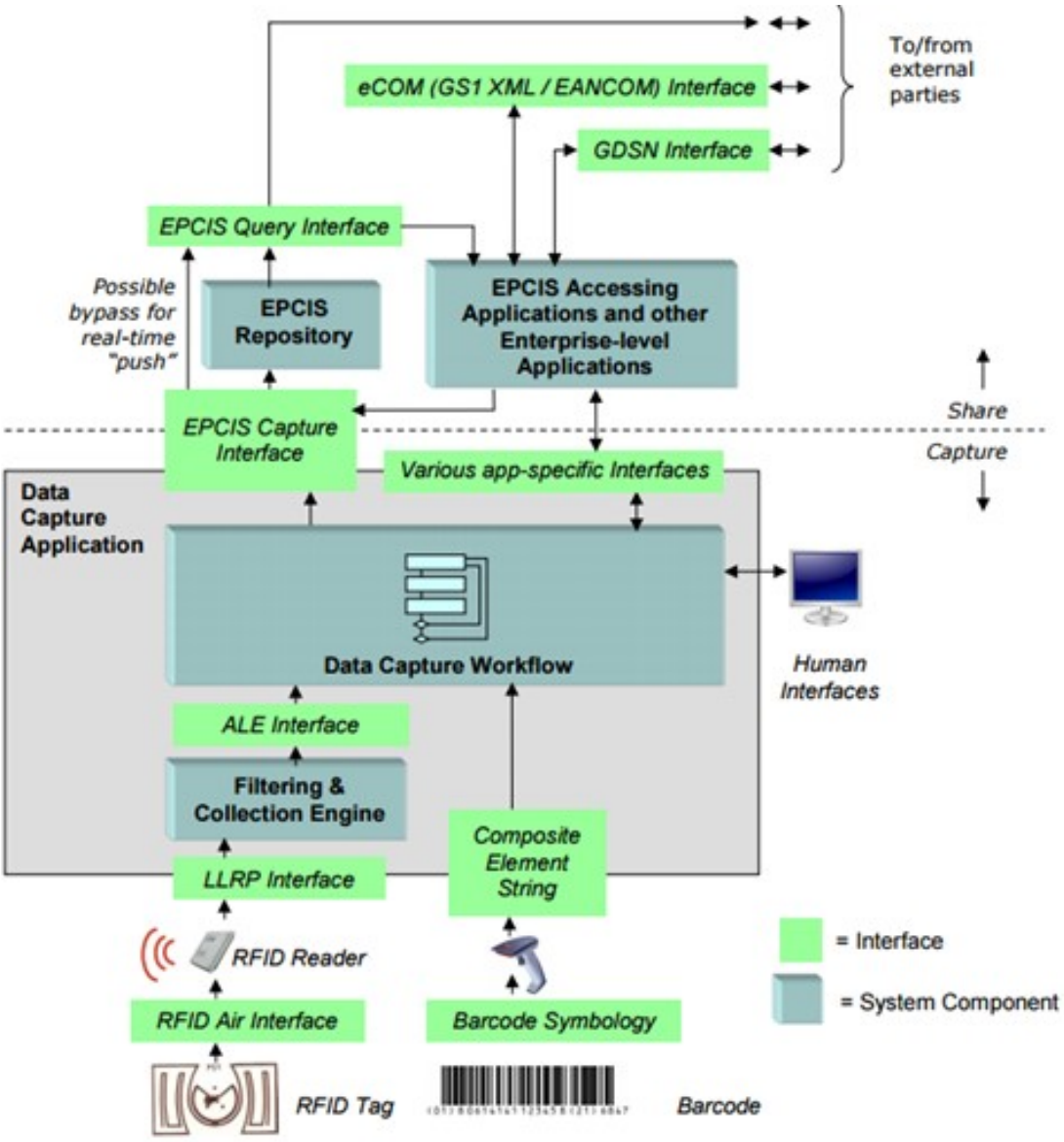


Figure 17: Capture and Accessing Applications in the EPCIS framework, Source (GS1 Global, 2016)

6.4 EPCIS Accessing Application

An EPCIS accessing application, as shown in Figure 17, retrieves events from an EPCIS repository from the standardized query interface, enriches this information with additional data, implements business logic to transform from event data to status data. It might provide a service for a user or a target system, e.g. a dashboard with process KPIs, stock information, control process and much more.

7 Development of a Business Event Model

This chapter gives insight to the identified business process steps in the demo cases after the innovation camp in Nov. 2018. These business steps have to be depicted by business (EPCIS) events to translate the real process chain into the corresponding digital event chain. For this a proper EPCIS event model has to be created describing the matching events for a business step and defining the data to be collected in this event and the allowed event flow.

The new and innovative component invented in this project is the individual item information that can be transported by EPCIS along the supply chain to contain ECO relevant information like particular resources consumed, particular waste created after disposing/recycling and the recycling rate that could be achieved for a specific individual instance of a product.

To achieve this, this ECO information needs to be integrated into an EPCIS event. For the different demo cases in the project the specific implementation has to be adapted individually what will be described in this chapter. At this stage of the project, it is not possible to precisely define the information sources at a final detail level. Since EPCIS is an open standard with a standardized terminology (GS1 Global, 2017) for describing business processes, it does not hinder the progress of the project. For the upcoming development, the new component, the ECO information, has to be specified. All other information dimensions "what", "when", "where" and "why" are defined within the EPCIS standard (GS1 Global, 2017), (GS1 Global, 2016)

Although this project focuses on the environmental factors of sustainability, we would like to mention at this point that social factors can also be recorded in a similar way with EPCIS events. However, a respective model will not be developed in this document.

7.1 ECO Extension

Within CIRC4Life we develop means to include dynamic (primary) ECO information into EPCIS event structure. To this end we define EPCIS Event User Extensions with the prefix “eco:” – called ECO extension. These extensions shall contain lists with the relevant energy and resource in flows and out flows as well as other information needed for the LCA computation and may be added to any EPCIS event type.

Figure 18 gives an overview as a simplified class diagram for EPCIS events extended by the ECO extension.

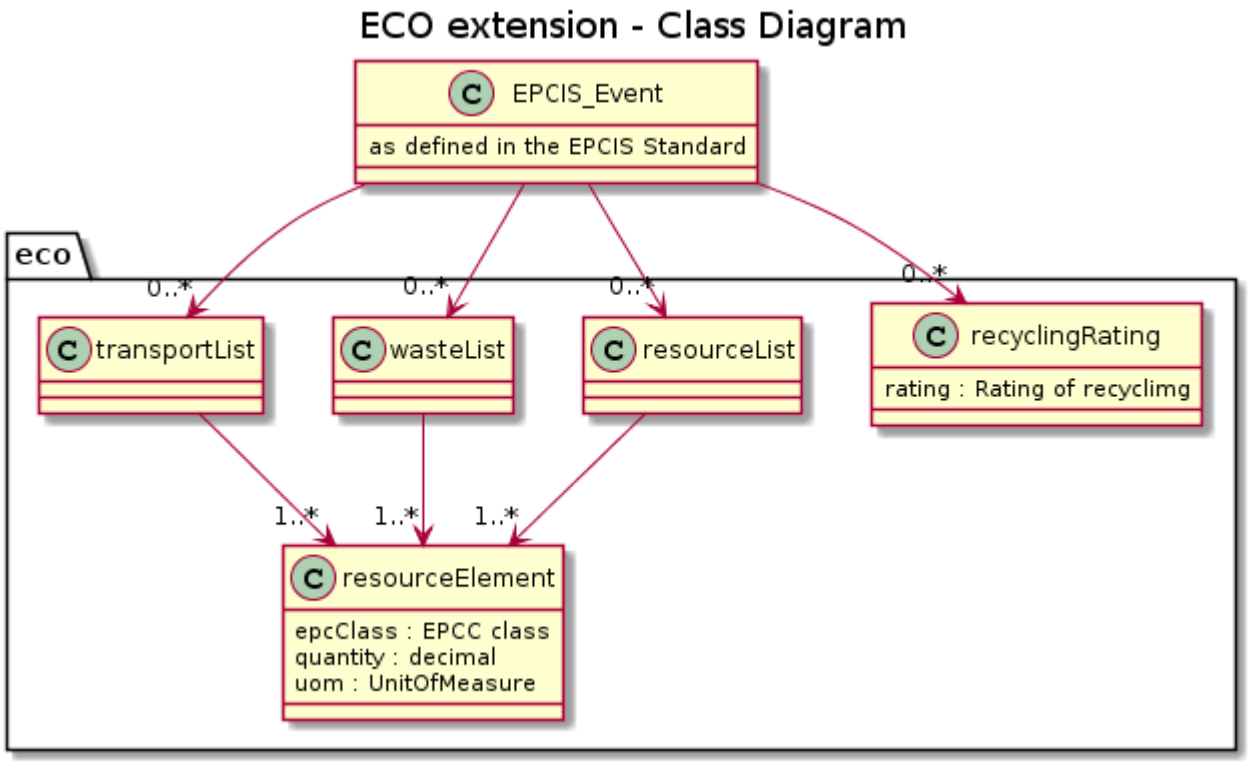


Figure 18: Class Diagram of EPCIS Event extended by ECO information.

More specifically, we define the following ECO extensions elements:

7.1.1 eco: resourceElement

In the following, a resourceElement shall be described by an EPC or a Quantity Element. An EPC describes for example parts or countable resources which are serialised and are used to build or grow the product. The Quantity Element describes unsterilized or uncountable resources, reflecting the quantity of the resource used for the product.

Examples for such resources are:

- Gas
- Water
- Nutrition
- Fertilizer
- (Electric) Energy
- Fuel
- Raw Materials (Metals, Glass, Plastics: PET, ...)
- Consumables (Solder, …)
- Tools (write-off)
- etc.

7.1.2 eco: resourceList

This element contains a list of these resourceElements. The semantic meaning is that all resources in this list are used to build or grow the product in the business step described by the EPCIS event containing the list.

7.1.3 eco: wasteList

The WasteList element contains resource elements which describe be waste the production, growth or disposal of the product creates in the process step described by the EPCIS event containing the list.

Waste described by this list may be:

- manure
- CO_2
- NH_4
- polluted water
- ...

7.1.4 eco:transportList

This is an important indicator for the eco impact, as a same kind of a product with the same eco impact in production or growth can have big differences in the transport to the customer. The transportList contains resource elements describing the transport of the product. e.g. distance the product was transported with a specific transport method.

- distance: The total distance travelled (number and unit of measure)
- vehicle: lorry, train, airplane, ship, etc.

7.1.5 eco:recyclingRating

This data should be attached to recycling assessment events (inspection) to include the information needed for the LCA/eco credit calculations. The information to be recorded (e.g. sellable/repairable/broken) depends on the product category and shall be defined by the LCA calculation procedures in the demo cases. EPCIS will be capable to store any information e.g. in a string variable to transport this information.

7.2 Example Definition of Specific Events with ECO Impact

This chapter describes individual product item's ECO information carried along a supply chain in EPCIS events. Any business event depicted in the system shall be extendable with the ECO extensions in general. Here we describe specific events which commonly occur in a product's lifecycle. This is done without claiming completeness, but gives good examples for the implementation of future requirements as well.

7.2.1 Production

The first step in a product's lifecycle is the manufacturing of goods. This has an enormous implication on the ECO impact as it consumes resources. The Figure 19 is showing the class diagram for the events collected in production and assembly processes.

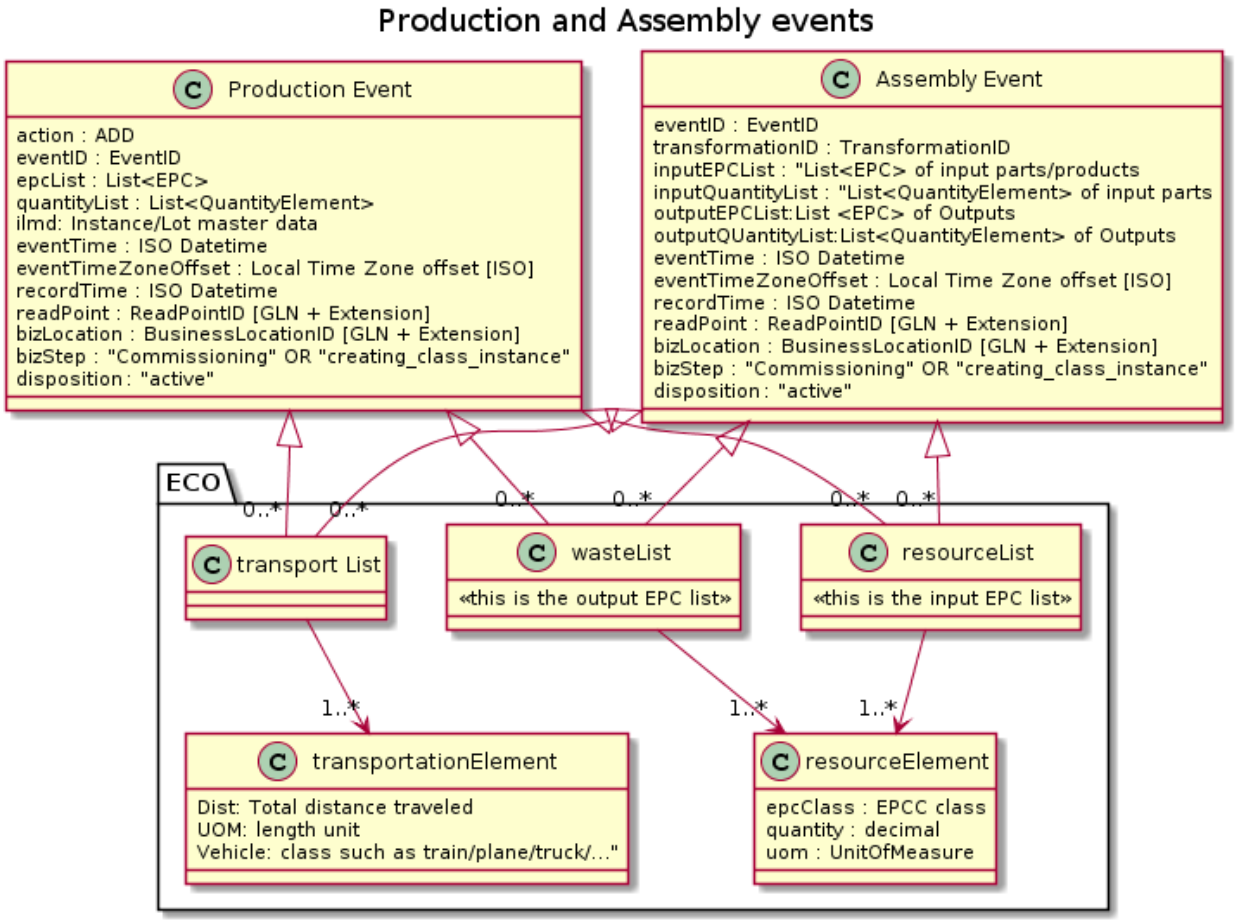


Figure 19: Class diagram of Inspection and Recycling events.

7.2.2 Transport: Shipping, Transportation and Receiving

Transport is one of the most common business processes and affects almost any product several times in its lifecycle. The standard EPCIS depiction of this process is a shipping event followed by a receiving event. The ECO information shall be stored in an additional transportation event as shown in Figure 20.

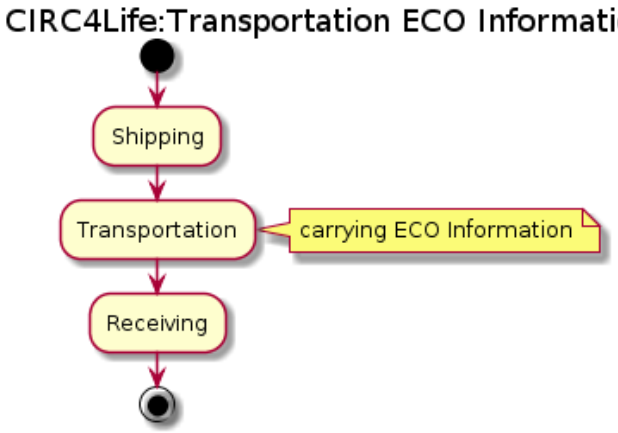


Figure 20: Transportation event in the transportation flow.

This additional transportation event shall store the information given by Figure 21.

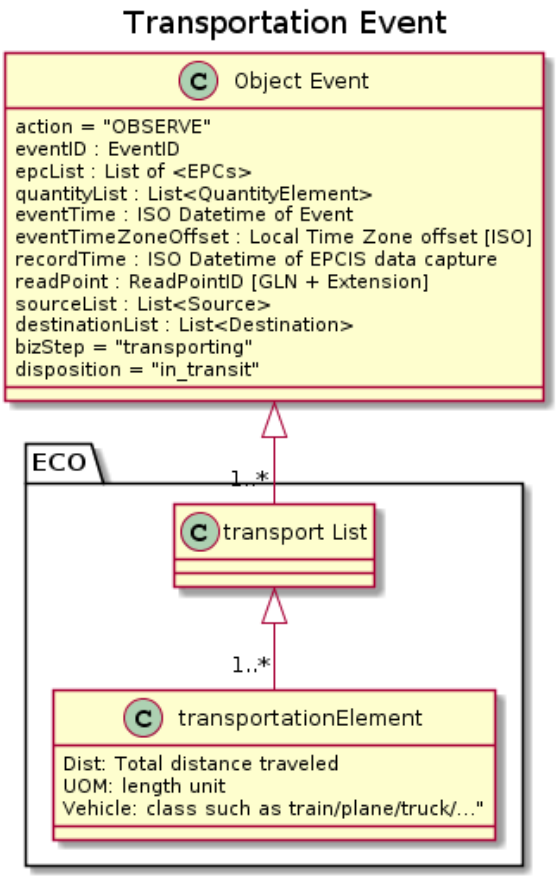


Figure 21: Class diagram of Transportation event.

7.2.3 Selling and Disposing

The standard retail selling EPCIS event and the disposal event need to be extended by a consumer or ECO account identification to enable the assignment of the credits and debits to the correct account. This results in the event classes in Figure 22. The ECO impact of the sold or disposed product is to be calculated from the events of production and recycling of the affected item.

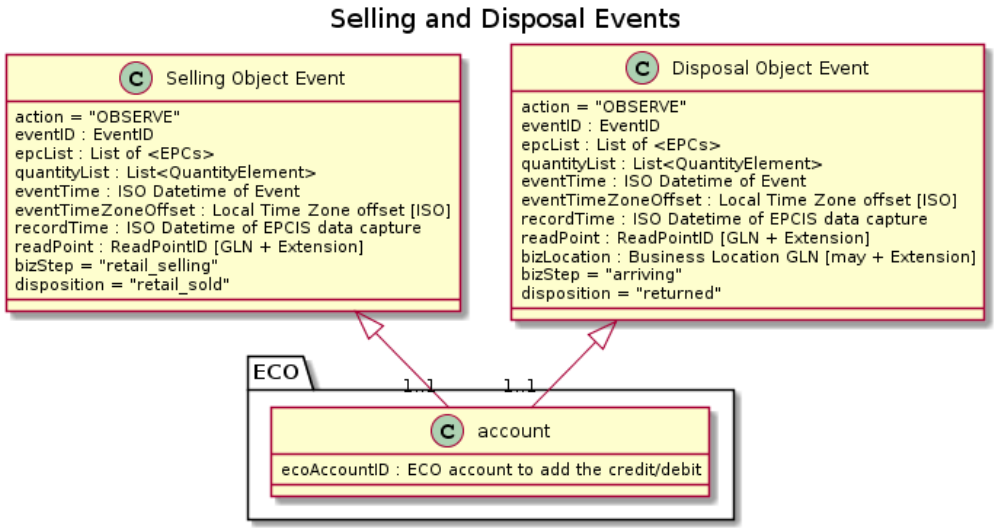


Figure 22: Class diagrams of Selling and Disposal Events.

7.2.4 Recycling

The recycling of materials has a tremendous impact on the ECO footprint of a product. In the recycling process the events shall record the further use of the product, if it can be subjected to a new use, or in case the product is disassembled the resulting recycled resources.

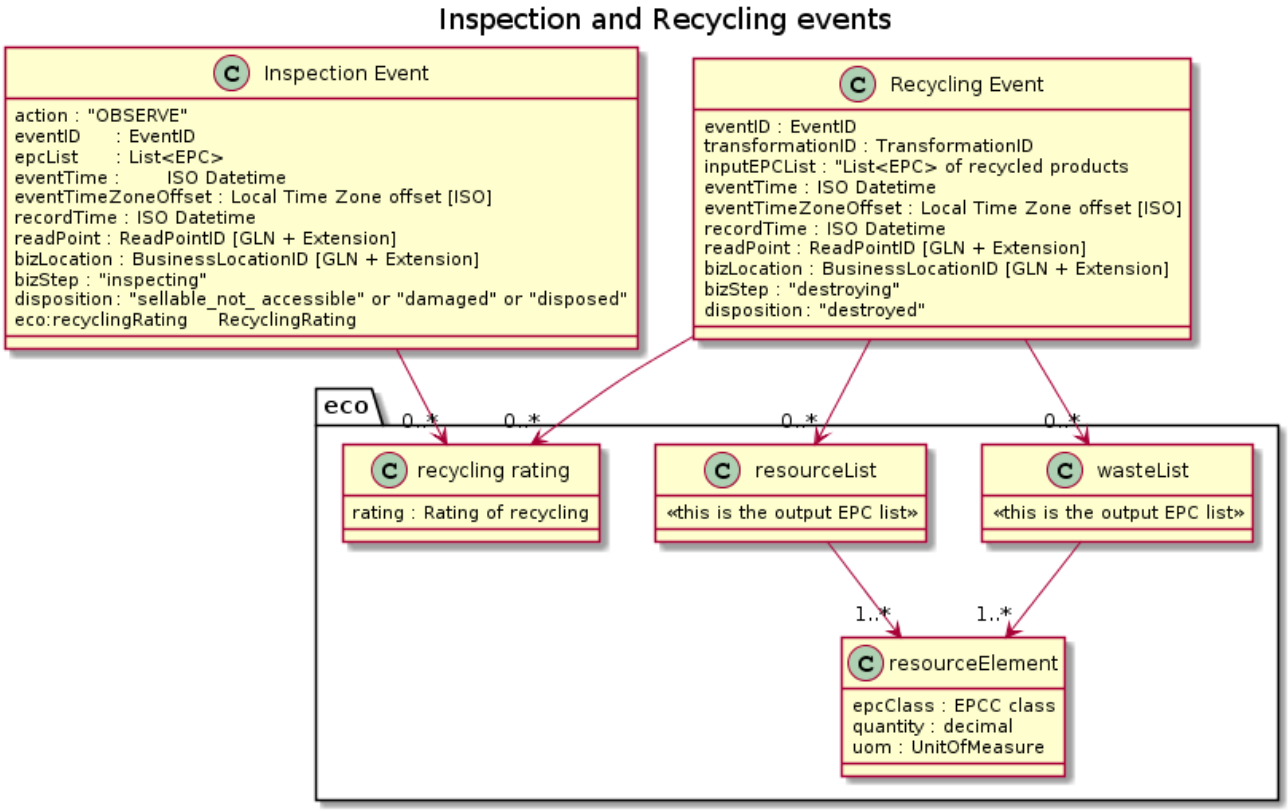


Figure 23: Class diagrams of Inspection and Recycling Events.

7.3 EPCIS Event Flows

Generally, besides of the specific content of the EPCIS events depicting the business processes, the flow of the process shall become clear with the Business Event Model. To achieve this, we collected information from the different demo cases and built up activity diagrams to describe probable process flows to be described by the EPCIS events. Also, this happens without claiming completeness, but aims to give a good starting point to understand what happens in the lifecycles of products in the different demo cases. As the four demo cases in CIRC4Life are not completely defined yet, we expect modifications to the preliminary Business Event Model to arise. The solution will be open to support changes in the described flows if needed.

For the demo cases different flows have been drafted with the input form the Innovation Camp in Cracow in Nov. 2018. The models (see Figure 24 to Figure 27 below) are showing the events, the flow and the information which might be available in the steps as described in the following.

7.3.1 DEMO 1: LED lighting

In the LED lighting demo case, the following lifecycle processes have been identified. Kosnic Lighting as a provider for B2B solution focuses not only on the ECO impact of the production of the lighting solutions, but aims at tracing the servicing of the sold or leased solutions as well as the recycle and remanufacture process at the lifecycle end of the solutions at a customer. An appropriate event flow is given in Figure 24.

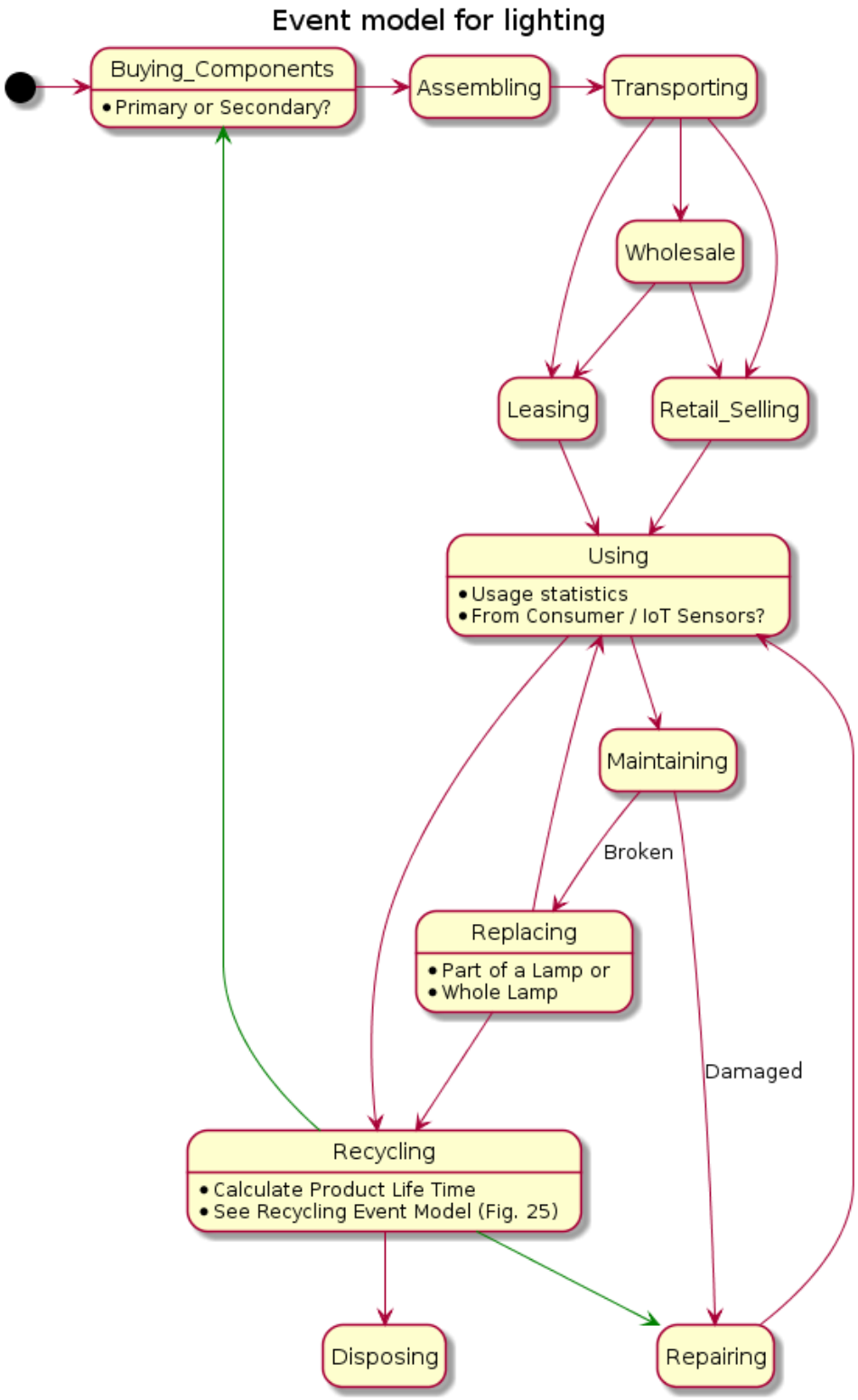


Figure 24: Event flow model for the lighting supply chain.

7.3.2 DEMO 2: Recycling of Tablets

The recycling of tablets demo case is focusing on the processes after a product is disposed by a user/consumer. Mainly the inspection of the disposed devices and the assessment and classification of the returned tablets need to become transparent. An appropriate event flow model is given in Figure 25.

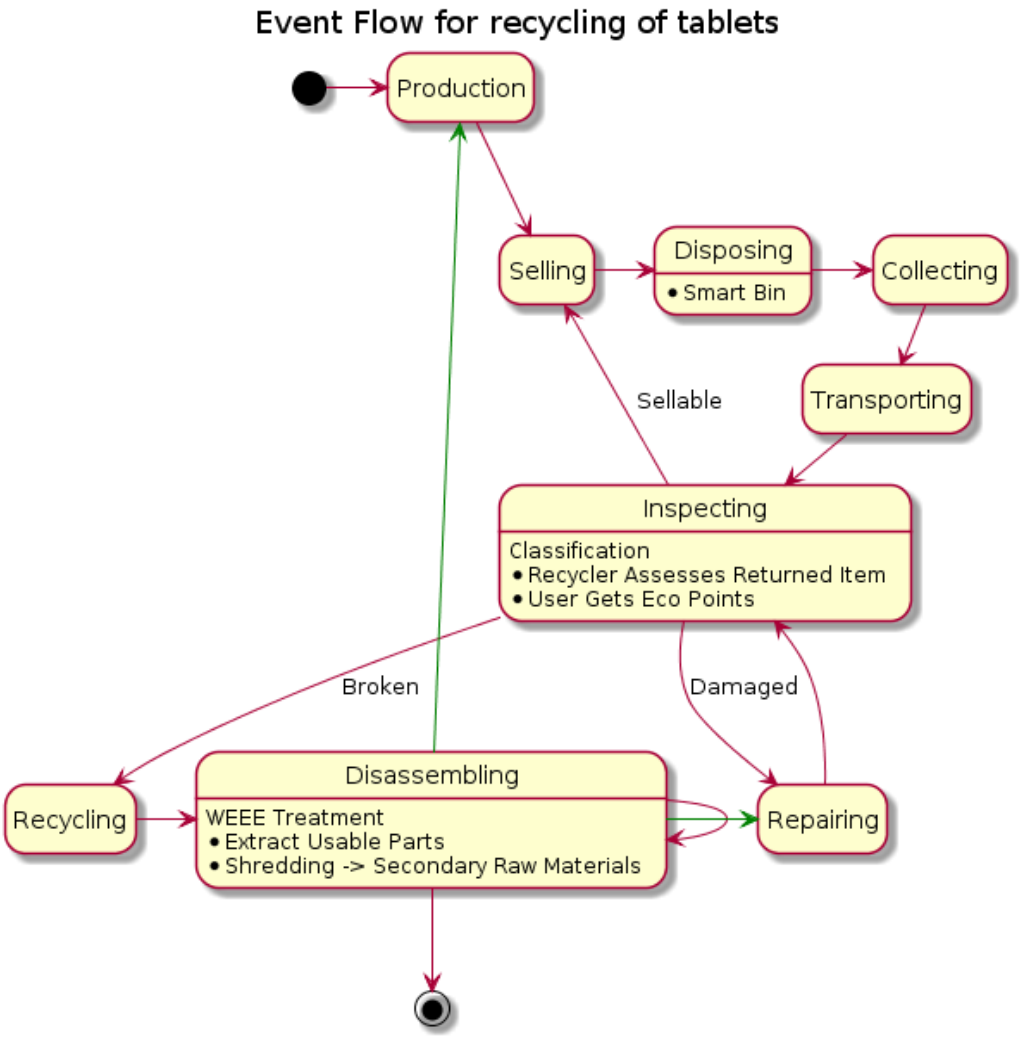


Figure 25: Event flow model for the tablet supply chain.

7.3.3 DEMO 3: Micro Farming

The micro farming case is covering a bundle of processes. The particular challenge in this area is the availability of data. The use of fertilisers and modern methods to accelerate growth, such as the use in greenhouses, are difficult to detect and assign to the correct batch of grown vegetables. Also the availability of data beyond the sale has to be evaluated in the demo case. An event flow model is given in Figure 26.

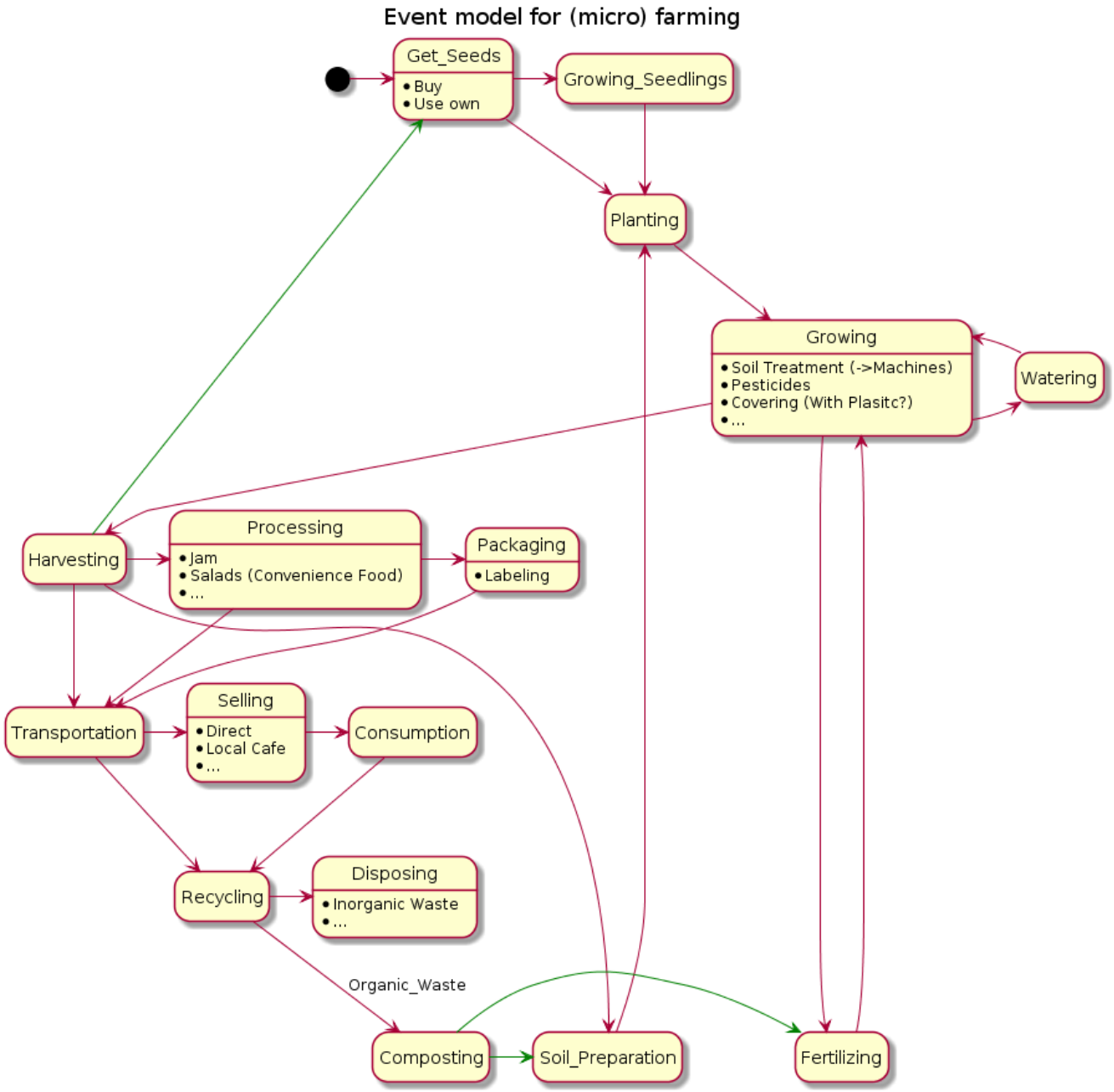


Figure 26: Event flow model for micro farming.

7.3.4 DEMO 4: Meat Supply Chain

Information on use of resources in the breeding and fattening phase of animals is available from precision livestock farming solutions. Information on slaughtering and meat processing is well established in traceability solutions already today (fTRACE GmbH, 2018).Information on the use of by-products and waste is rarely available and shall be investigated in this demo case with the event flow model in Figure 27.

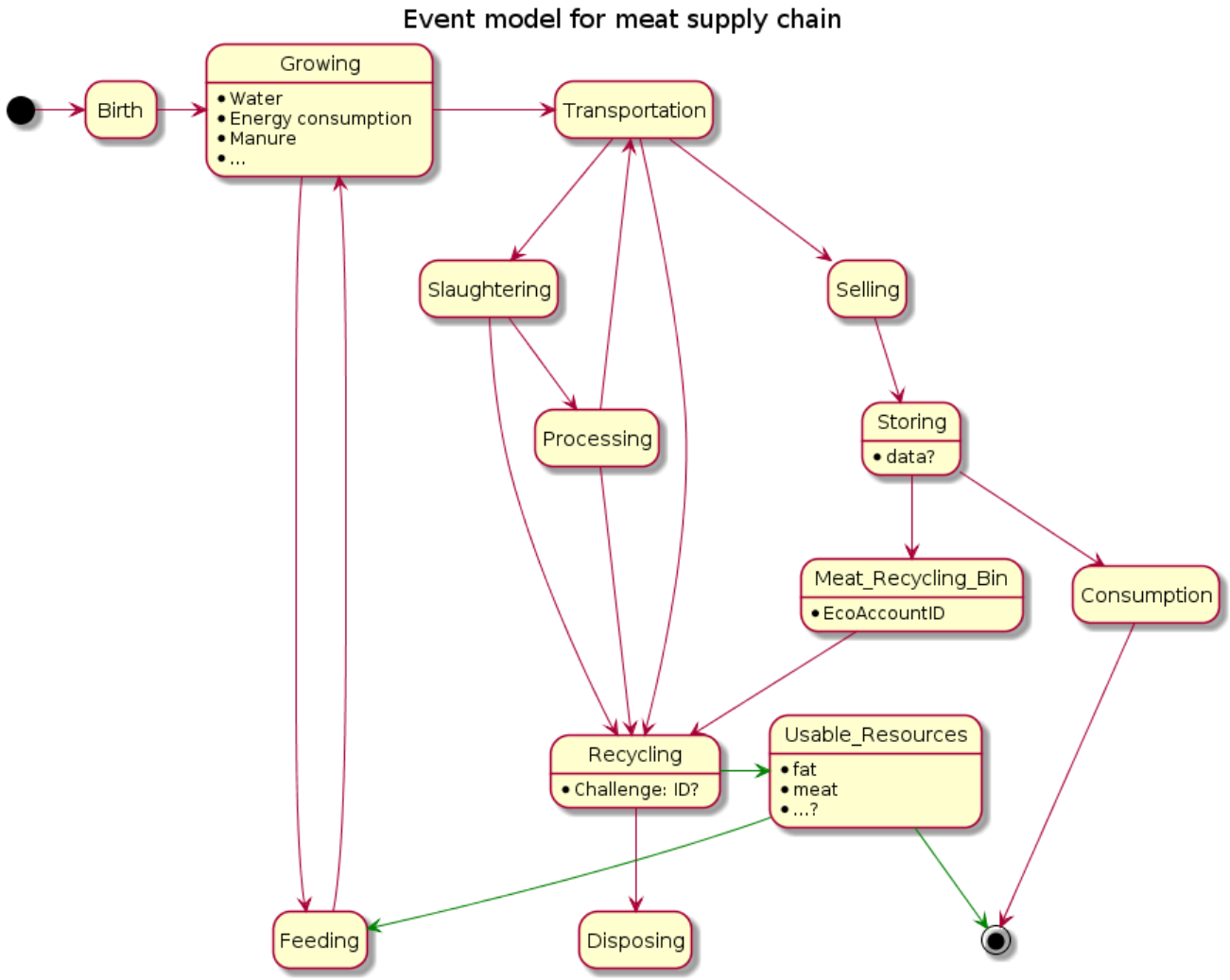


Figure 27: Event flow model for a meat supply chain.

8 Functions of each Component and Service

This chapter introduces the requirements to the applications in the traceability module in CIRC4Life. EPCIS standard interfaces are specified in chapter 1 of this document. The data format and enrichment of EPCIS event with eco-information is also described in chapter 0 and in the standard documents (GS1 Global, 2017) and (GS1 Global, 2016). This section now describes in detail the customised modules which are needed to collect and process data as well as transform, analyse and provide information to the ICT platform and subsequent tools.

8.1 Approach

The modules of the ICT platform which require traceability information need to be identified. Each of these modules requests formalized specific requirements which contain the data to be provided, the technical way of data provisioning, e.g. push or pull transfer, and (in case of push) the schedule of data submissions.

Additional accessing applications might be needed to ensure proper capture processing because some of the capture applications require additional information before capturing new events, i.e. querying the EPCIS repository for a specific state of an item.

8.2 EPCIS Core System

An EPCIS core system is able to provide the capture and query functionalities which are specified in the EPCIS Standard (GS1 Global, 2016). It has to support all standard EPCIS Event elements and in addition the ECO extensions defined for CIRC4Life in section 7.1. The EPCIS core system has to store all events in a persistent way and to accept requests to the query interface and provide a response containing all matching events within near-real-time.

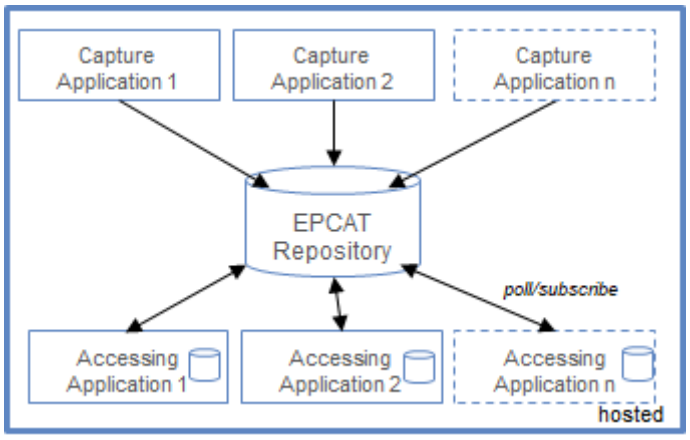


Figure 28: Schematic view on EPCIS repository with accessing and capture apps.

The EPCIS core system in CIRC4Life will be provided by EPCAT, a fully compliant EPCIS repository implementation of EECC. EPCAT will be provided by EECC as software as a service.

8.3 Capture Components

EPCAT provides a standardised interface to retrieve and store EPCIS events. However, usually many companies along the supply chain (producers, logistics, retail, recycling) do not have extensive knowledge on EPCIS and very few source systems are able to generate EPCIS events directly. Thus, the traceability module will contain components which ease the integration of EPCIS in the existing IT landscape of the relevant supply chains.

Requirements on these capture components were identified during group discussions in CIRC4Life. In addition, questionnaires were handed out to the industrial partners of the project in order to identify existing IT systems and potential integration tools.

Depending on the IT capabilities of the data providing partners (Company), customized capture applications might apply. These differ from M2M interface with EPCIS In- and Output, M2M with custom In- and EPCIS-Output and data entry websites with web-based forms and EPCIS-Output – see Figure 29.

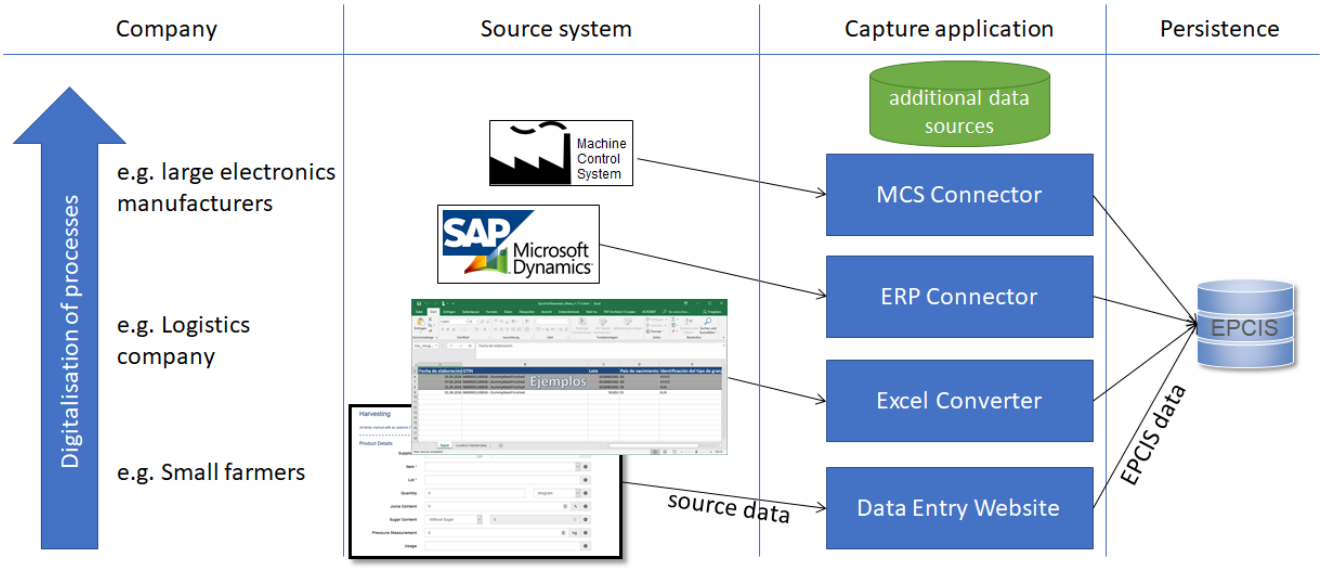


Figure 29: Potential Capture Applications

For CIRC4Life, a homogenized capture adaptor supporting a wide range of partners without providing too many customised applications is planned to be implemented. Partners may need to adjust their data format output to the capture adaptors provided. A data entry website will be made available additionally for very small industries without relevant IT support for their processes.

The capture components enable partners to provide relevant process and ECO information. In addition, they must provide the following functionalities

- enrich the provided data with additional information (e.g. master data)
- translate between human readable object descriptions and GS1 identifier (e.g. company name → GLN)
- validate the provided data and detect invalid or erroneous data
- create one or more EPCIS events per process step and forward these to the EPCIS core system

8.4 Accessing Components

In CIRC4Life, the accessing applications are intended to be provided within the traceability module and via custom adaptors to the ICT platform. The accessing components offer interfaces for the specific requirements of the CIRC4Life business models and the corresponding tools. Every data exchange will be encapsulated by the ICT platform (Figure 30) i.e. any end user tool will request data from the ICT platform. The ICT platform will request traceability and dynamic ECO information from the traceability module, if required in order to fulfil the client's request. Thus, end user tools have to communicate exclusively with one system. In addition, the traceability module can utilise the access control module of the ICT platform for authentication and authorisation.

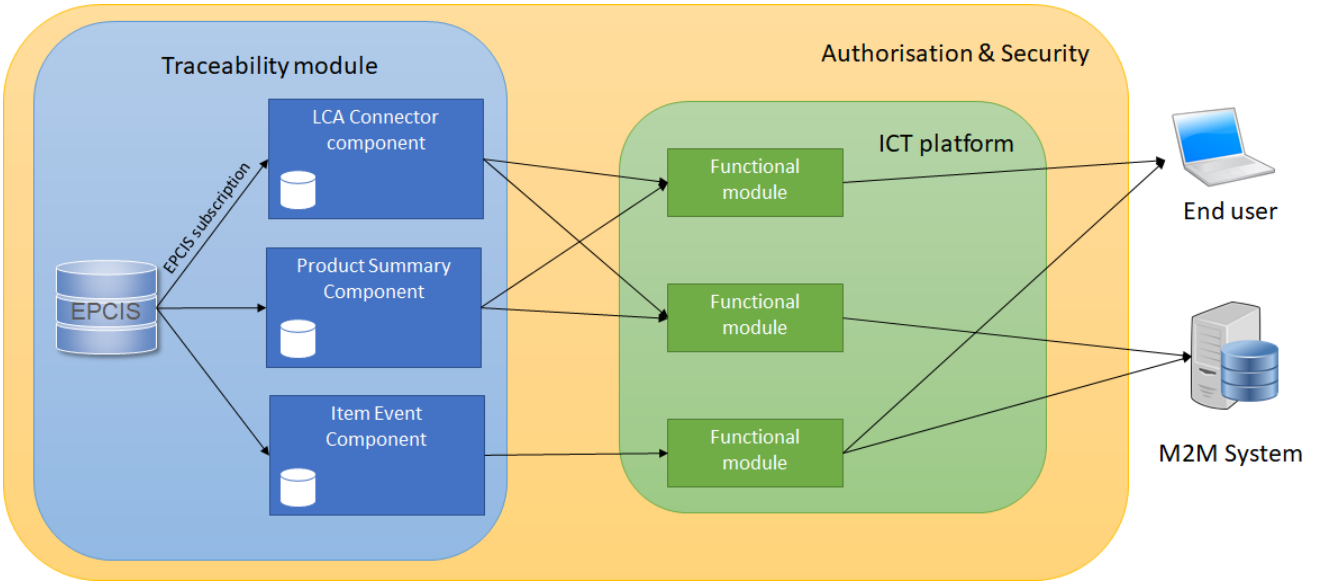


Figure 30: Schematic view of traceability module and platform.

8.4.1 LCA Connector

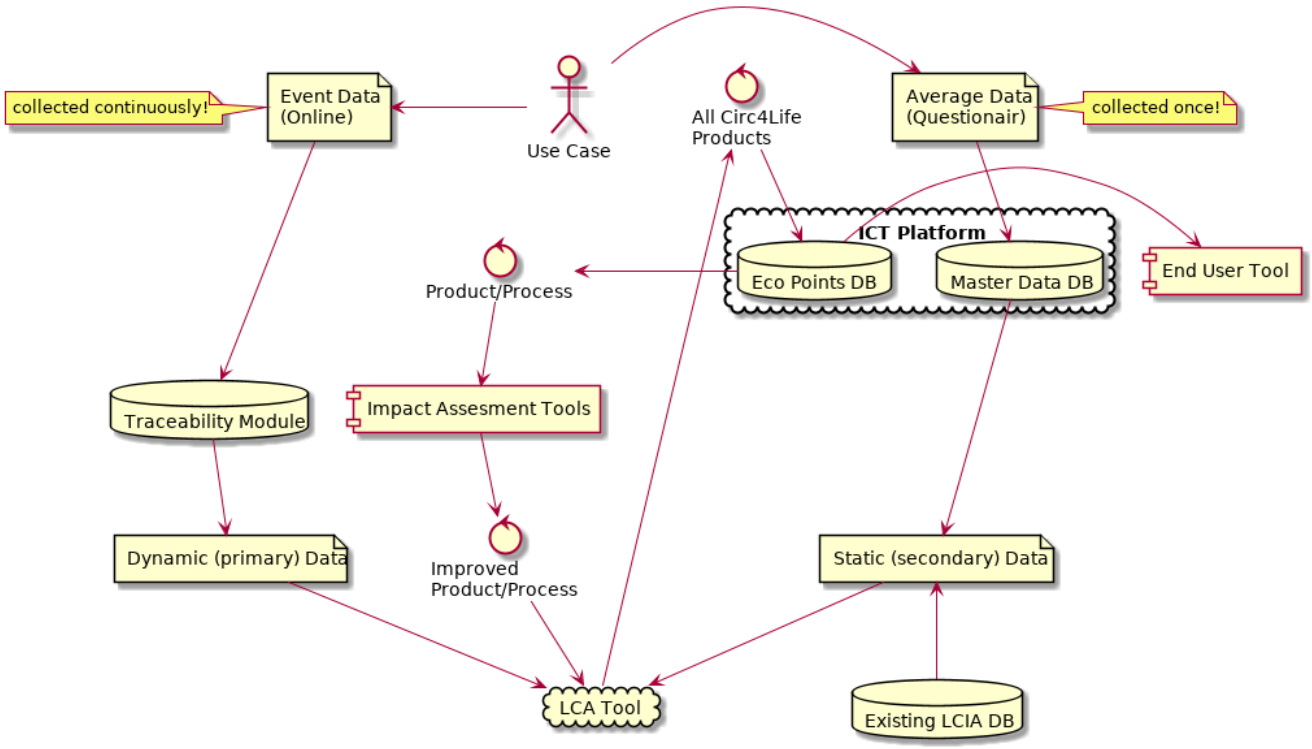


Figure 31: Schematic view of traceability module integration to LCA tool.

An LCA connector provides information on the ECO impact of a product during its lifecycle. This includes all resources used during production, logistics etc. as well as produced waste (e.g. manure, emissions to air (e.g. CO_2)). Data is collected from all EPCIS events tracked for this product or product batch, transformed in a suitable format for the LCA tool and returned in a single response (Figure 31). The response also may contain an estimated data completeness level, which reflects how much dynamic eco data is present in comparison to all ecologically relevant process steps. The LCA tool could use this information to add static data for the missing process steps (data gaps) to its calculation procedure.

8.4.2 Product Summary Component

This component works on class level and provides aggregated values over all entities for a given product. It can be used to compare different products/ resources in their overall ecological impact. The data is derived from the real process depiction of the EPCIS events (provicing high quality primary data). Thus, it may be more accurate than (estimated) static data (using secondary data of unknown quality and sources). Such information may be relevant to improve data quality and for the impact assessment tool, which by this could provide better ecological impact estimation for specific design decisions.

8.4.3 Item Event Component

This component can be used internally by the ICT platform. It retrieves a serialised or batch identifier (SGTIN or LGTIN) as parameter. It will return all EPCIS events which reflect process steps where this item or batch of product was involved. This generic interface can be used by other ICT components to do their own raw data processing, showing the supply chain flow of a product etc.

8.4.4 Partner Exchange Component

This component can be used by supply chain partners to exchange EPCIS events directly. It is useful to share relevant information (e.g. product delivery, availability, production) between partners directly. The availability of near-real-time information could be used to optimise the supply chain processes, resulting in more efficiency and thereby a smaller ecological footprint per item. The partner exchange component uses, in addition to the access control module of the ICT platform, a data exchange model to enable partners to decide which partner is able to see what kind of information has to be implemented as described in the following chapter.

9 Identification of Requirements for an EPCIS Data Access Model

In order to allow and prevent data access on different levels, a model is required. It's necessary to distinguish between data access needed from external applications like the tools connected to the ICT platform and data access for data exchange of partners in the chain.

9.1 Access to EPCIS Data From Platform Tools

The user and role model must be handled by the ICT platform in order to have a central point of truth and administration of the users. Roles and their user must be created and maintained in the ICT platform. 3 roles are necessary at least:

- Admin role (also applicable e.g. for governmental access) with all access rights
  - Gets access to all data without restrictions
- Standard user role (limited access)
  - E.g. gets access to only some of the supply chain partner's data
- Consumer role (very limited access)
  - E.g. for a given GTIN and Lot, only the Eco points are returned

If applicable, in the ICT platform users can also explicitly allow other users access to their data, independent from their role.

9.2 Data Exchange Between Partners

Until now, there is no demand for direct exchange of traceability information between partners identified in the demo cases. In order to allow generic access and exchange of EPCIS event data, the following standard functions should be implemented. The data providing party decides the level of external access to their provided data:

- **Public**: The providing party decides their event is "public". The event information will be shown to everybody.
- **Restricted**: The providing party decides their traceability event is "restricted". The event information will be shown to selected users, only. This user selection must be made specifically for each party.
- **Governance**: This is a role enabling governance institutions to query all EPCIS's involved for a specific ID in case of public needs / scandals etc.
- **Private**: The traceability will never be returned, only to the supplying party itself.

9.3 Means to Access the Data Resource Developed in WP1

In WP1, Task 1.3, the eco-accounting architecture is defined like shown in Figure 32.

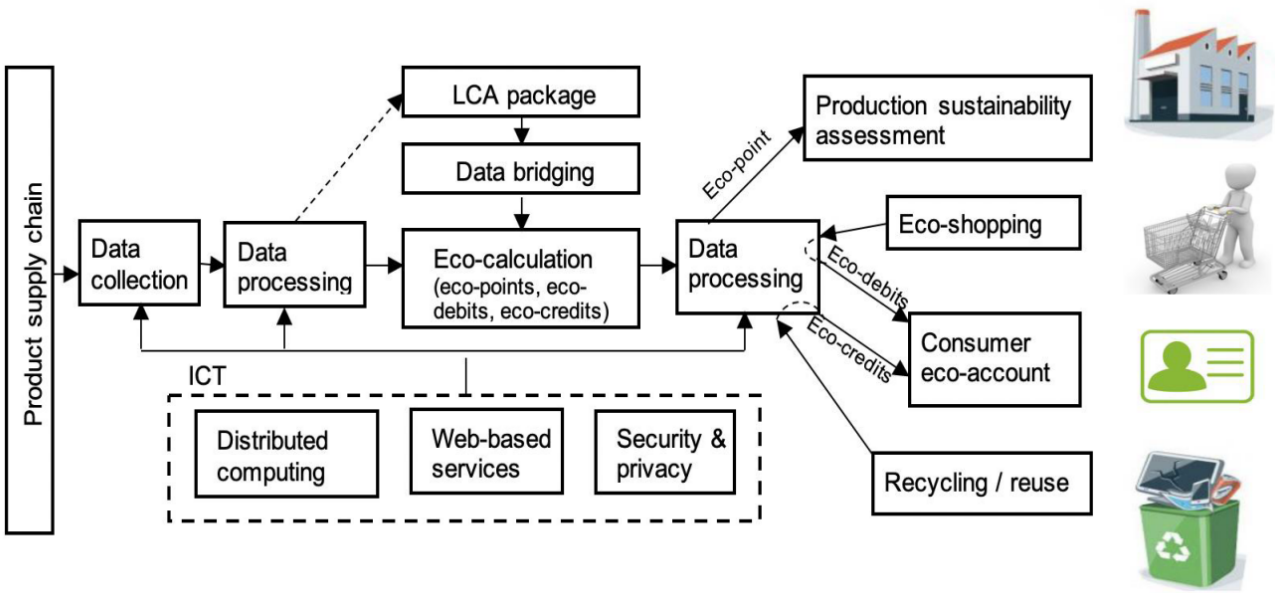


Figure 32: Eco accounting platform of CIRC4Life

Source: (CIRC4Life, 2018)

The traceability tools developed within WP5 get and provide trace data form the product supply chain on individual item level to support eco-calculation. Trace data might include used or consumed resources in the specific supply chain steps as described in chapter 0. Based on these “raw” data, the calculation can be performed and eco-points ca be credited or debited to consumer eco-accounts.

10 Conclusion

For the preparation of this document, the most important business processes in the four planned demonstration scenarios were examined with regard to the necessary information for the three CEBMs and those processes were identified that could contribute meaningful data to the LCA calculation.

On the basis of this knowledge, appropriate standards and regulations were identified that can or must be applied for tracking the objects in the process chains.

The traceability module is based on the standards developed by GS1 for the consumer goods industry, in particular the EPCIS standard (GS1 Global, 2016) and the associated core business vocabulary (GS1 Global, 2017). The new development with regard to these standards is the introduction of a new terminology for the description of eco information, which is not yet explicitly described in the already standardized CBV.

An essential part of this work was therefore to investigate at which product levels the information may have to be collected and to develop the corresponding vocabulary and to design it generically so that processes beyond the demonstration scenarios dealt with in CIRC4Life can also be described and captured. The corresponding results can be found in chapters 5 and 6. The further chapters describe the requirements for integration into the CIRC4Life system landscape and thus enable the fulfilment of the project mission in the overall context.

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Appendices

Appendix 1: Further Information on GS1 Standards

- System of GS1 Standards:
  http://www.gs1.org/standards
- GS1 Traceability Standard:
  https://www.gs1.org/traceability/traceability/2-0
- GS1 Identification Keys:
  http://www.gs1.org/id-keys
- GS1/EPCIS and CBV Standard:
  http://www.gs1.org/epcis
- Fruit & Vegetable Master Data Attribute Implementation Guide.
  https://www.gs1.org/docs/freshfood/Fruit_Vegetable__Master_Data_Attribute-ImpGuide.pdf
- Case study : Traceability in Fresh Foods:
  https://www.gs1.org/sites/default/files/docs/casestudies/traceability_case_study_egypt.pdf
- GS1 and Internet of Things:
  http://www.gs1.org/standards/internet-of-things
- A Global Farm Registry for the United Nations
  https://www.gs1.org/sites/default/files/docs/retail/gln-for-farms.pdf