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Final report

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Extension of legal information requirements for products and digital implementation by the example of energy-related products and textiles

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Abstract: Product Information 4.0

The project aims to establish the foundations for a European digital product passport by expanding the legal information requirements. These requirements will be determined together with the stakeholders using the example of energy-related products and textiles. The main question is how relevant product information can be digitally tracked along the product life cycle, brought together and made available to various target groups. The large number of already existing tracking concepts and product information are identified and evaluated within a front-end demonstrator similar to a digital product passport.

In conclusion towards the first part of the study (part A and B on information requirements and gaps): for all legal acts it is recommended to clearly specify the required information and in particular its meta data (granularity, format, accessibility) and the necessary infrastructure. Thus, the main reason for gaps or barriers is the lack of clear and specific descriptions of the information requirements as well as exemptions. If legislation needs to provide room for discretion or exceptions for companies who can't provide all information due to their capabilities such as SMEs, these companies should be granted (financial) support. Exemptions for SMEs to provide information would lead again to information gaps, which are in particular challenging for recycling.
Looking into detail, the textiles sector would benefit from a comprehensive material declaration for fabrics, with a push to eliminate exceptions in current legislation. This could extend to dyes and chemicals, and the implementation of standard sizing systems could reduce online returns. For the electronics sector, the analysis focused on improving accessibility to material information for sorters and recyclers under the Ecodesign and WEEE Directives, and addressing consumer confusion caused by marking (e.g. CE mark or crossed-out wheeled bin). The ESPR's upcoming requirements for a digital product passport could also encompass the current product group specific Ecodesign Regulations, mandating easily accessible and machine-readable data carriers. Cross-Sector: The need for enhanced material information e.g. through Safety Data Sheets under REACH, improved CLP labelling, and digitalization of packaging information was identified. Proposals include stricter enforcement of REACH, digitised labels for substances and mixtures, and QR codes for packaging reuse systems.

The second part (C) analyses aspects of the technical infrastructure required for a product information system and proposes a concept based on this: Vocabulary, ontology and taxonomies; Data storage; Data exchange; Ownership and data verification; Access management and identifiers and data carriers. Data storage considerations suggest a decentralised system that can be supplemented with a central registry for stakeholders with legitimate interests, while data exchange calls for EU Commission-mandated standards to ensure interoperability. Access management should be realised through user profiles based on the need-to-know principle, which was tested by implementing a front-end demonstrator in this project. Requirements for identifiers and data carriers should be defined in regulations. Trade secrets and IP rights, and the use of data carriers like RFID in textiles should adhere to WEEE Directive exemptions and be in compliance with the GDPR.

Kurzbeschreibung: Produktinformation 4.0

Das Projekt dient der Etablierung von Grundlagen zur Entwicklung eines europäischen digitalen Produktpass und Weiterentwicklung der gesetzlichen Informationsanforderungen am Beispiel energieverbrauchsrelevanter Produkte und Textilien. Untersucht wird, wie relevante Produktinformationen entlang des Produktlebenszyklus digital erfasst und für verschiedene Zielgruppen bereitgestellt werden können, um zur Kreislaufwirtschaft beizutragen. Die Vielzahl bereits vorhandener Nachverfolgungskonzepte und Informationsanforderungen wird innerhalb eines Front-End-Demonstrators dargestellt und bewertet.

Schlussfolgerung zum ersten Teil der Studie hinsichtlich Informationsanforderungen und -lücken (Teil A und B): Informationslücken treten vor allem durch Ausnahmen in der Gesetzgebung auf, sodass diese minimiert werden sollten. Unternehmen mit begrenzten Ressourcen, sollten bei der Informationserbringung unterstützt werden. Eine flächendeckende Verfügbarkeit von Informationen ist wichtig, um z.B. eine Vergleichbarkeit für Verbraucher oder eine Sortierung von Altgeräten und Textilien zu ermöglichen. Sofern Informationen verfügbar sind, gibt es Nutzungsbarrieren aufgrund unpassender Granularität, Format oder Zugänglichkeit. Grund dafür ist die fehlende Beschreibung dieser drei Merkmale, auch Metadaten genannt, in den Gesetzestexten. Daher wird für alle Rechtsakte empfohlen, die erforderlichen Informationen und insbesondere deren Metadaten klarer zu spezifizieren.
Der Textilsektor würde von einer umfassenden Materialdeklaration für Stoffe, einschließlich Prozessmittel wie Farbstoffe und Chemikalien, profitieren, erwirkt durch Abschaffung von Ausnahmen in der aktuellen Gesetzgebung. Die Einführung von standardisierten Größensystemen könnte Online-Rücksendungen reduzieren. Im Elektroniksektor können Nutzungsbarrieren durch eine Verbesserung der Zugänglichkeit von Materialinformationen für Sortierer und Recycler reduziert werden. Für den Verbraucher unverständliche Kennzeichnungen (z. B. CE-Kennzeichnung oder durchgestrichene Abfalltonne) könnten durch zusätzliche, digitale Informationen ergänzt werden. Die Anforderungen der ESPR für einen digitalen Produktpass könnten hierbei die bestehenden Informationsanforderungen (der Ökodesign-Gesetzgebung) aufgreifen, um diese leichter zugänglich und maschinenlesbar zu machen. Sektorübergreifend wurde ein Bedarf an verbesserten Materialinformationen festgestellt. Vorschläge zur Weiterentwicklung umfassen eine strengere Durchsetzung von REACH, die potentielle Nutzung von digitalisierten Sicherheitsdatenblättern, digitale Label für Substanzen und Gemische sowie QR-Codes für Verpackungswiederverwendungssysteme.

Schlussfolgerungen zum zweiten Teil hinsichtlich der Analyse der technischen Infrastruktur, die für ein Produktinformationssystem erforderlich ist (Teil C): Dazu wurden sechs Aspekte der technischen Infrastruktur untersucht, die für ein Produktinformationssystem benötigt werden: Vokabular, Ontologie und Taxonomien; Datenspeicherung; Datenaustausch; Eigentümerschaft und Datenverifizierung; Zugriffsmanagement; Identifikatoren und Datenträger. Hinsichtlich der Datenspeicherung wird ein dezentrales System vorgeschlagen, das durch ein zentrales Register für Stakeholder mit berechtigten Interessen ergänzt werden kann. Für den Datenaustausch sind EU-Standards zur Gewährleistung der Interoperabilität nötig. Das Zugriffsmanagement sollte durch Benutzerprofile auf Basis des Need-to-Know-Prinzips realisiert werden, was durch einen Front-End-Demonstrator in diesem Projekt getestet wurde. Anforderungen an Identifikatoren und Datenträger sollten reguliert werden. Betriebsgeheimnisse und IP-Rechte sowie der Einsatz von Datenträgern wie RFID in Textilien sollten die Ausnahmeregelungen der WEEE-Richtlinie und die Bestimmungen der DSGVO einhalten.

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List of abbreviations

2FA	Two-Factor Authentication
3TG	Tin, tantalum, tungsten, gold (conflict minerals)
AAS	Asset Administration Shell
ACID	Atomicity, Consistency, Isolation and Durability concept
AI	Artificial Intelligence
API	Application Programming Interface
Battery Directive	Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators
Battery Regulation	Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC
BMUV	Federal Ministry for Environment and Consumer Protection
BMWSB	Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen (Federal Ministry for Housing, Urban Development and Building)
BOM	Bill of material
CAHRA	Conflict Affected and High-Risk Areas
CAS	Chemical Abstracts Service (number)
CE	Circular Economy
CEAP	Circular Economy Action Plan
CEN	European Committee for Standardisation
CEWI	Circular Economy Wirtschaft Innovationsmotor
Circular Textiles Strategy	EU Strategy for Sustainable and Circular Textiles (COM(2022) 141 final)
Circularity.ID	The circularity.ID® Open Data Standard is provided by circular fashion GmbH, intended to store, label and identify digital product data for circular practices in the textile sector.
CLP Regulation	Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures
COM	EU Commission
Conflict Mineral Regulation, CMR	Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas
CSDD Directive Proposal	Proposal for a Directive on Corporate Sustainability Due Diligence, COM(2022) 71 final, 2022/0051(COD)
CSR	Corporate Social Responsibility
CSV	Comma Separated Values
DFKI	Deutsches Forschungszentrum für Künstliche Intelligenz (German Research Centre for Artificial Intelligence)
DID	Digital Identifier
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DiTEX	Digitales Tracking-ID für die Kreislaufführung von B2B Textilien
DL	GS1 Digital Link
DLT	Digital Ledger Technology
DMA	Digital Markets Act
DoS	Denial-of-service-attack
DPP	Digital Product Passport

DTD	Document Type Definition
EAN	European Article Number
EASD	Concept of Enhancing Access to and Sharing of data
EC	European Commission
Ecodesign Directive	Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products
Ecodesign Regulation Computer	Commission Regulation (EU) No 617/2013 with regard to ecodesign requirements for computers and computer servers
Ecodesign Regulation Displays	Commission Regulation (EU) 2019/2021 of 1 October 2019 laying down ecodesign requirements for electronic displays
Ecodesign Regulation Washing Machine (WM)	Commission Regulation (EU) 2019/2023 of 1 October 2019 laying down ecodesign requirements for household washing machines and household washer-dryers
EDI	Electronic Data Interchange
eIDAS	Short form: Electronic Identification, Authentication and Trust Services Long form: REGULATION (EU) No 910/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 July 2014 - on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC
ELV Directive	Directive 2000/53/EC on end-of life vehicles
EMAS	Eco-Management and Audit Scheme
Energy Labelling Regulation	Regulation (EU) 2017/1369 setting a framework for energy labelling
EoL	End-of-Life
EPC	Electronic Product Code
EPD	Environmental Product Declaration
EPLCA	European Platform on Life Cycle Assessment
EPR	Extended producer responsibility
EPREL	European Product Registry for Energy Labelling
ERP	Enterprise Resource Planning
ESPR	Proposal 2022/0095 (COD) on a Regulation for setting ecodesign requirements for sustainable products
ESPR Regulation Proposal	Proposal establishing a framework for setting ecodesign requirements for sustainable products, COM(2022) 142 final, 2022/0095(COD)
ETSI	European Telecommunications Standards Institute
EU	European Union
FMD	Full Material Declaration
GDPR	General Data Protection Regulation
Gen2v2	(GS1 Air Interface Standard) Generation 2, Version 2
GIZ	Gesellschaft für Internationale Zusammenarbeit
GLN	Global Location Numbers
GOTS	Global Organic Textile Standard
GPSD	General Product Safety Directive
GS1	Global Standards Organisation
GTIN	Global Trade Item Number
GTL	Global Textile Language
GTS	Global Textile Scheme
GUID	Globally Unique Identifier
HF	High Frequency

HTML	Hypertext markup language
IAM	Identity and Access Management
ICT	Information and Communication Technology
ID	Identification
IEC	International Electrotechnical Commission
IL	Identification Link
IMDS	International Material Data System
IMDS	International Material Data System
IP	Intellectual Property
IPC	International Trade Association for the Printed-Board and Electronics Assembly Industries
IS	Information Systems
ISO	International Organization for Standardization
IT	Information Technology
ITC	International Trade Center
ITU	International Telecommunication Union
IVN	Internationaler Verband der Naturtextilwirtschaft
JSON	JavaScript Object Notation
LCA	Life Cycle Assessment
LKSG	Lieferkettensorgfaltspflichtengesetz
MFA	Multi-Factor Authentication
MHz	Megahertz
NFC	Near Field Communication
NGO	Non-governmental organization
NIST	National Institute of Standards and Technology (U.S. Department of Commerce)
OAR	Open Apparel Registry, now called Open Supply Hub, see Os Hub
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
OEM	Original Equipment Manufacturer
OS Hub	Open Supply Hub / formerly Open Apparel Registry (OAR)
Packaging Directive, PPWD	Directive 94/62/EC on packaging and packaging waste
PAiCE	Platforms/Additive Manufacturing/Imaging/Communication/Engineering
PCB	Printed Circuit Board
PCB/PCT	Polychlorinated Biphenyls and Polychlorinated Terphenyls
PCSD	Product Circularity Data Sheet
PEF	Product Environmental Footprint
PIM	Product Information Management
PIS	Product Information System
PKI	Public Key Infrastructure
PLM	Product Lifecycle Management
PPWD	Directive 94/62/EC on packaging and packaging waste
PtL	Power-to-Liquid
QR code	Quick Response code
RAMI 4.0	Reference Architectural Model Industry 4.0
RDM	Reference Data Models

REACH Regulation	Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals
REST	Representational State Transfer
RFID	Radio-frequency identification
RMIS	Raw Material Information System
RoHS Directive	Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment
RSC	Reverse Supply Chain
SaaS	Software as a Service
SCIP	Substances of Concern In articles as such or in complex objects (Products)
SCIP	Database for information on Substances of Concern in articles as such or complex objects (Products)
SDK	Software Development Kit
SDS	Safety Data Sheet
SME	Small and Medium-sized Enterprises
SPI	Sustainable Product Initiative
SRL	Substances Reporting List
SSO	Single-Sign-On
SVHC	Substance of Very High Concern
TEU	Treaty on European Union
Textile Regulation	Regulation (EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products
TFEU	Treaty on the Functioning of the European Union
TID	Serialised Transponder ID
TLS	Transport Layer Security
TWh	Terawatt hours (measuring units for energy)
Type I Ecolabel "Label declaration"	ISO 14024 - Environmental labels and declarations — Type I environmental labelling — Principles and procedures
Type II Ecolabel "Self-Declaration"	ISO 14021:2016 Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling)
Type III Ecolabel "Product declaration"	ISO 14025:2006 Environmental labels and declarations — Type III environmental declarations — Principles and procedures
UBA	German Environment Agency (Umweltbundesamt)
UHF	Ultra-High Frequency
UI	User Interface
UID	Unique identifier
UMP	Urban Mining Platform
UN	United Nations
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
UNECE	United Nations Economic Commission for Europe
UNGP	United Nations Guiding Principles
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	Universal Serial Bus
UUID	Universally Unique Identifier
VC	Verifiable Credential
W3C	World Wide Web Consortium

WBCSD	World Business Council for Sustainable Development
WEEE	Waste of Electrical and Electronic Equipment Directive
WEEE Directive	Directive 2012/19/EU on waste electrical and electronic equipment
WFD	Waste Framework Directive
WLTP	Worldwide Harmonized Light-Duty Vehicles Test Procedure
WP	Work package
XML	Extensible Markup Language

Summary

Background and goal

Over the past few decades the range and variety of products has proliferated, reflecting advancements e.g. in manufacturing and technology. This proliferation has brought a multitude of challenges, particularly concerning the realisation of a Circular Economy. The rising product variety, new trends and individual product life cycles in the market result in a shortened life of products through premature obsolescence. Next, the increasing variety of products and their individual product properties (design, functionality, repairability) are resulting in more difficult repair [Makov 2021, Prose 2016]. It makes waste management more burdensome, as the different material compositions and designs of devices make it more difficult to separate and obtain secondary materials [Bryan 2021, Auma 2022].

To tackle the increasing complexity of the physical and digital product world, the European Union (EU) and the German BMUV[1] intend to standardize and culminate all product-related information with the help of a Digital Product Passport (DPP). Against this background, the German Federal Environment Agency launched the project “Extension of legal information requirements for products and digital implementation by the example of energy-related products and textiles" (in short: "Product Information 4.0"; funding code: REFOPLAN 372 0363 010) at the beginning of 2021. The project aims to evaluate current legal information requirements towards their suitability to address Circular Economy goals. Part A and B focus on the evaluation of information requirements, Part C evaluates the technical infrastructure and proposes a concept for a product information system, Part D provides legal recommendations on the previous parts (information requirements and product information system concept):

- Part A: screening and evaluation of the existing mandatory information requirements and whether voluntary approaches (labels, indicators) or current activities close the gaps in the legal framework;
- Part B: stakeholder’s perspective on information requirements needs and demands across the product lifecycle;
- Part C: recommendations and proposal for a product information system 4.0;
- Part D: analysis of legal gaps and future potentials for closing information gaps.

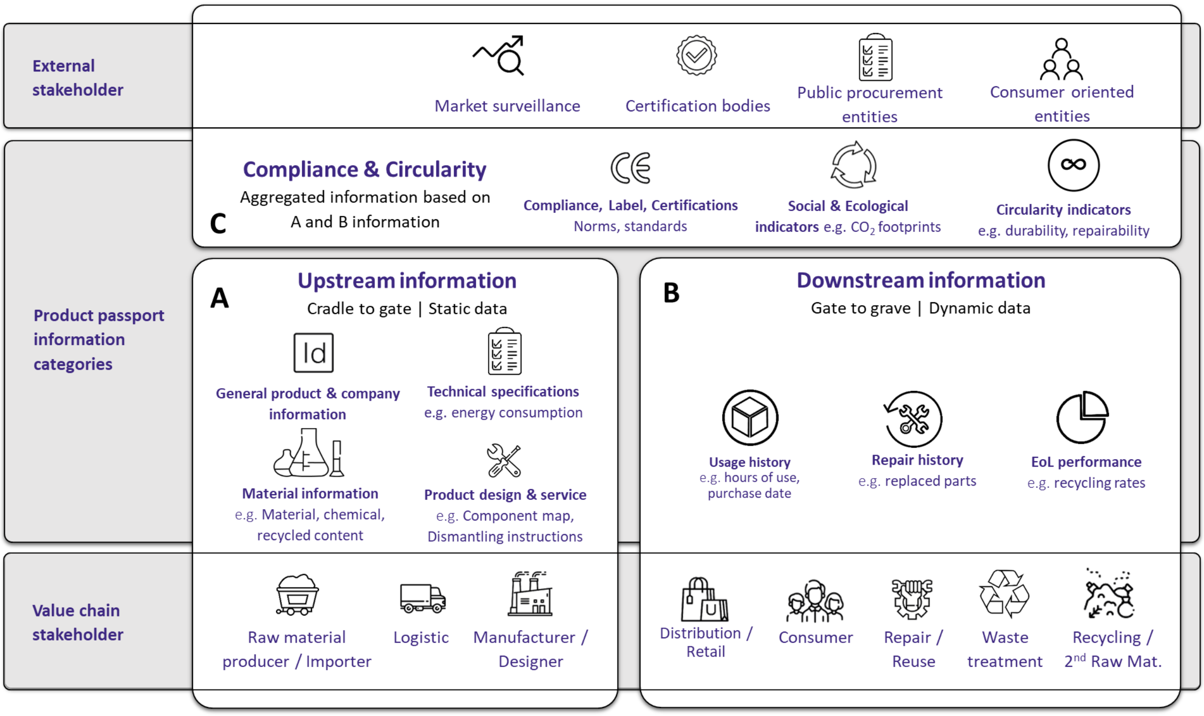
The following summarizes the research approach, key findings, and conclusions.

Research approach: categorisation of DPP relevant stakeholder and information

While undertaking the study a major challenge arose from the understanding of heterogenic terminology and information requirements in legislation, voluntary approaches and stakeholder information profiles. Therefore, a categorisation scheme was derived that reflects chemical, product, waste, corporate legislation as well as circularity indicators, certifications and information that are generated by all stakeholders in the product life cycle.

[1] Federal ministry for the environment, nature conservation, nuclear safety and consumer protection

Figure 1: Proposal for a categorisation framework of product information



(source: TU Berlin 2022)

The categorisation system is split up into two stakeholder cluster and three information groups (A-C):

(1) Upstream: Stakeholders in the upstream value chain and product lifecycle (cradle-to-gate) are in general responsible for the product design and production phase. They usually have access to and provide primary product data, such as general information, technical specifications, material composition and product design. For durable and non-perishable physical goods, this product information is often static and does not change after the product is placed on the market. As a simple analogy, one can also speak of product "birth data".

(2) Downstream: Stakeholders in the downstream value chain and product lifecycle (gate-to-grave) include retailers, consumers, repairers and further parties involved in the end-of-life (EoL) phase of the product. Product-related data generated in this lifecycle stage often depends on the individual usage pattern of the product (e.g., usage intensity, usage hours, repair history). The products constantly alter their physical state and characteristics, e.g., due to wear and tear or repair during usage. Therefore, the data generated in the downstream value chain is often dynamic and part of the individual product life. As a simple analogy, one can also speak of a product's individual biography, after it was put into first use (c.f., Barata et al. 2020).

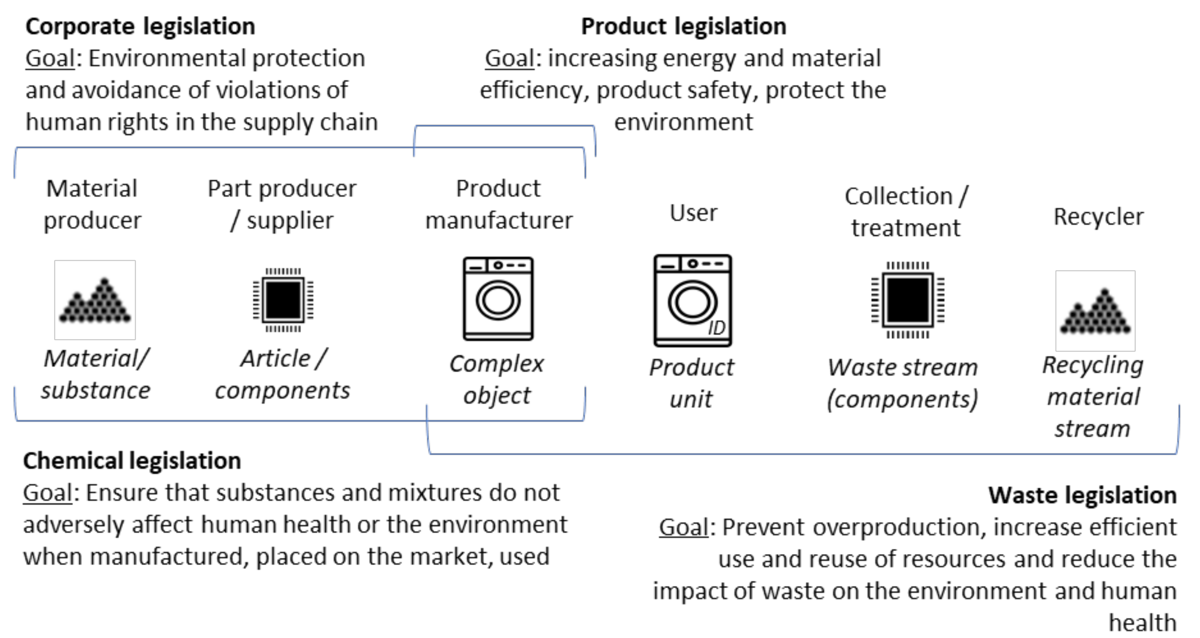
(3) External stakeholders and third parties that are not a direct part of the production and consumption process of a product (product lifecycle) but make use of product data generated from information categories A and B to generate commensurable product data. For example, this could include scoring systems, environmental label, certification schemes or product life cycle assessments. Typical stakeholders are market authorities and surveillance, certification bodies or environmental and consumer-oriented entities.

The scheme is used as the analysis framework for this study. It allows to structure legal acts by information categories, underlying barriers and potentially supporting approaches. Part A of this study focuses on legal requirements which are mainly upstream and circularity information, necessary for product compliance, to be provided by manufacturers or EU importers. Part B evaluates from a stakeholder's perspective legal information requirements and any other important information. Therefore, also downstream information coming from users, repairers, etc. are considered where no legal obligations for the provision of data exist.

Research scope: legal areas, goals and subject matter

Figure 2 shows the scope and selection approach of legal acts. Based on the subject matter and Circular Economy related goals four legal areas are identified within the scope: corporate, chemical, product and waste legislation.

Figure 2: Goal and scope of legal areas along the value chain (abstracted overview)



(source: TU Berlin 2022)

The legislative landscape already set information obligations which set a foundation for relevant data for the DPP. The following criteria was used to identify relevant legislation:

- Subject matter: the information needs to relate to a material (chemicals, substances, mixtures), product (objects, articles), waste or company.
- Product group: in addition to textiles and energy-related products, the screening includes batteries, automotive, packaging, plastics, and software. This allows the inclusion of learnings from sectors with well-established information requirements, which might face similar challenges.
- Stakeholder relation: a direct relation between a stakeholder (data provider) and the information requirement.
- Operation domain: an information requirement is at least part of one of the following domains of EU legislation and voluntary standards or conventions: Energy; Industrial policy and internal market; Environment, Consumers and Health protection.

The relevant legislation is structured towards chemical, product, waste and corporate legislation (Table 1).

Table 1 List of relevant legislation selected with relation to predefined criteria (subject matter, product group, stakeholder relation, operation domain)

Legal area	Legal act (short)	Legal act
Chemicals legislation	"REACH Regulation"	Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals
	"CLP Regulation"	Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures
Product legislation	"Textile Regulation"	Regulation (EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products
	"Ecodesign Directive"	Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products
	"Ecodesign Regulation PC"	Example: Commission Regulation (EU) No 617/2013 with regard to ecodesign requirements for computers and computer servers
	"Ecodesign Regulation WM"	Example: Commission Regulation (EU) 2019/2023 laying down ecodesign requirements for household washing machines and household washer-dryers
	"Ecodesign Regulation Displays"	Example: Commission Regulation (EU) 2019/2021 laying down ecodesign requirements for electronic displays
	"Energy Labelling Regulation"	Regulation (EU) 2017/1369 setting a framework for energy labelling
	"ESPR Regulation Proposal"	Proposal establishing a framework for setting ecodesign requirements for sustainable products, COM(2022) 142 final, 2022/0095(COD)
	"Circular Textiles Strategy"	EU Strategy for Sustainable and Circular Textiles (COM(2022) 141 final)
	"Type Approval Regulation"	Regulation (EU) 2018/858 on the approval and market surveillance of motor vehicles and their trailers …
Waste legislation	"Battery Directive"	Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators
	"Battery Regulation"	Regulation (EU) 2023/1542 concerning batteries and waste batteries
	"ELV Directive"	Directive 2000/53/EC on end-of life vehicles
	"Packaging Directive"	Directive 94/62/EC on packaging and packaging waste
	"RoHS Directive"	Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment

Legal area	Legal act (short)	Legal act
	"WEEE Directive"	Directive 2012/19/EU on waste electrical and electronic equipment
	"WFD"	Directive 2008/98/EC on waste (Waste Framework Directive)
Corporate legislation	"CSDD Directive Proposal"	Proposal for a Directive on Corporate Sustainability Due Diligence, COM(2022) 71 final, 2022/0051(COD)
	"Conflict Minerals Regulation", "CMR"	Regulation (EU) 2017/821 laying down supply chain due diligence obligations for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas

Heterogenic terminology and requirements result in a variety of over 122 product information requirements along all value chain stakeholders extracted from existing legislation. To make the diversity of information tangible, the following overview shows the most common information requirements categorised by the four information categories (see

Figure 1):

Material related information:

- **Hazardous substances**: REACH Regulation, RoHS Directive, CLP Regulation, Ecodesign Directive, WEEE Directive, ELV Directive Art. 8(3), Battery Directive Art. 21
- **Material composition**: Textile Regulation, WEEE Directive, ELV Directive
- **Minerals from conflict and high-risk areas**: Conflict Mineral Regulation
- **Material origin**: Conflict Mineral Regulation, CSDD Directive Proposal

Product design related information:

- **Use, maintenance and update information**: Ecodesign Directive, Type Approval Regulation
- **Repair information** (for professional repair): Ecodesign Directive, Type Approval Regulation
- **Dismantling information**: Ecodesign Directive, WEEE Directive, ELV Directive Art. 8(3) and 8(4)
- **Disposal information**: Ecodesign Directive, WEEE Directive, Battery Directive, Packaging Directive, ELV Directive Art. 9(2)

Functional and technical specifications

- **Energy consumption related information**: Energy Labelling Regulation

Circularity information:

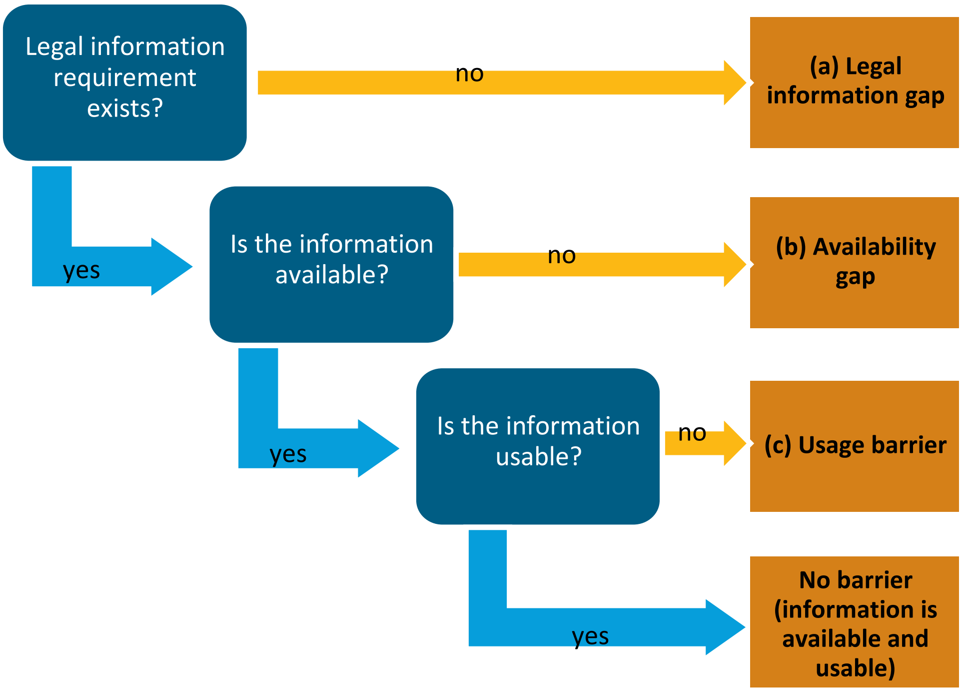
- **Environmental impact information**: Ecodesign Directive
- **Social impact information**: CSDD Directive Proposal

In addition, voluntary information obligations and legal developments were also considered and evaluated in the analysis.

Information requirements, gaps and legal recommendations

The analysis comprises the identification which information requirements exist in legislation, which information requirements exist but with exemptions, which do not exist but are required by stakeholders and which exist but can't be used by the target stakeholder.

Figure 3: Successive identification of gaps and barriers in legislation. Information requirements need to be existing, information needs to be available and usable.



(source: TU Berlin 2022)

Legal information gaps (a) were mainly found due to exemptions in legislation. Availability gaps (b) are subject to enforcement deficits or structural reasons. Usage barriers (c) occurred due to missing or improper definition of the accessibility, format or granularity of the information requirement.

Gaps and barriers were mainly found in three categories, summarised in three tables below:

- Material related information requirements
- Product design and service related information requirements
- Circularity related information requirements

No barriers were found for the information category "functional and technical specifications" which comprise energy consumption related legal information requirements.

The following tables provides a holistic overview of the information requirements present in the legal acts applicable for electronic and textile products. They contain context information (metadata) on information granularity, target information user, access and format. The rows in the tables are grouped by sector and target information user. The identified gap or barrier was initially identified in Part A of this study and validated qualitatively by the target information user in Part B, which is elaborated in the second right column ("evaluation by the target information user"). The right column derives recommendations to extend or adapt legislation, based on the found gap or barrier. A qualitative description of the gaps and barriers as well as further information requirements beyond legislation are elaborated beneath the tables.

Material related information requirements

Table 2: Material related information requirements, sorted by sector and information user. Identified gap and evaluation of information requirements shown in right column. Context information (meta data) for evaluation includes access/format and granularity.

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Cross-sector	REACH Regulation (Art. 31)	Identification of hazardous substances and mixtures	**Recipient of the substance/ mixture**	Safety data sheet (SDS)	Availability gap	Information gap between **producer/supplier** of substance/mixture and assembled article **manufacturer**, SDS is not handed over. Validation of material information is seen beneficial. The SDS is only provided to the professional user, not to consumers or the general public. *Voluntary approach: information system like the circularity.ID supports to gather and distribute extended information i.e. on material content.* *Voluntary approach: The International Material Data Space (IMDS) in the automotive sector provides a modular system to gather material information with a focus on component and material suppliers.*	• Amend the REACH Regulation so that (1) suppliers (both in the European Union and in Third Countries) **must provide any further suppliers** along the supply chain with information about chemicals used in the substance or mixture using the SDS, **without exceptions**, (2) **including**, whether a **cumulation** of chemicals reaches a (do be determined) threshold which is considered to be “risky” (e.g., hazardous). This information should additionally be included in a digital data carrier. In the beginning, correctly filling-in the digital data carrier information requirements could lead to being able to print a correct SDS. Over time, using the SDS could be phased out until only a digital data carrier is used. • Evaluate whether it is feasible to require suppliers to provide information, certificates or audit reports that help **validate** whether a substance or mixture contains hazardous substances or even to prove that no such chemicals are included;

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Cross-sector	REACH Regulation (Art. 33)	Identification of articles containing an SVHC above 0.1% to all actors	**Recipient of the article (manufacturer, importer, downstream user and distributor)**	SCIP database (requirement of the WFD Directive)	Legal information gap, availability gap	**Consumer:** information available only on request and with a delay up to 45 days, which is not sufficient for the consumers purchase decision. Information on substances too complex. Many article suppliers do not respond to SVHC information requests sent by consumers. *Voluntary approach: Smartphone apps like Scan4Chem and ToxFox improve the usage barrier by providing or help consumers to request material information such as SVHCs, but the availability gap (delay) can't be overcome as it results from the article producer.* **Repair and reuse** might be affected when reselling parts or products. **Waste treatment**: Accessing information only possible via SCIP website and only to single articles, which is not effective in sorting processes. In practice, articles in SCIP are not linked to the finished product.	• Shorten the current legal timeline of 45 days to provide consumers with information to "without undue delay, but at least within 72 hours". Evaluate whether alternatively, the relevant information must be made **publicly available** in the SCIP database for a consumer to **easily find** (e.g., by GTIN or another identifier readily available to the end-user and/or consumer) and access **at any given time**; • Additionally, the SCIP database should be **extended to finished products** (with serial number, e.g., GTIN or another number known to the end-user and/or consumer) and entries in the database should be **machine-readable** in a way that the necessary provision of information is given to all relevant stakeholders in a timely manner, e.g., via an **Application Programming Interface (API)**;
Cross-sector	CLP Regulation	Hazard pictograms, signal words, hazard statements, precautionary statements	**Recipient of the substance, mixture (incl. consumer)**	Labels	Usage barrier (format)	**Consumer:** Markings can be misinterpreted by some consumers. For both product groups (textile and electronics) consumers state, that enough information is available and the effort to find all necessary information for the purchase is very low. *Current legal activity: a legal initiative aims to simplify and digitalise labelling requirements.*	• Add **digital labels** with additional information on physical products; • Add information for consumers on how to **sort, recycle or dispose of** the mixtures and substances; • Include information for sorters, recyclers and waste treatment.

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Cross-sector	Packaging Directive	Information on return, collection and recovery systems	**Consumer**	Labels	Usage barrier (format)	The format (labelling) does not specify how or where the information should be made available to **consumers**, leading to a heterogeneous transposition of the Directive into national legislation. Art. 11 (2) of the current draft proposal of the Packaging and Packaging Waste Regulation considers data carriers to provide such information digitally.	• Switch from a European directive to a **regulation** (as proposed by the EU Commission); • Follow the **proposal of the EU Commission** as set out in Art. 11 (2) and (4) of the Proposal for a Regulation on packaging and packaging waste (COM(2022) 677 final).
Textile	Textile Regulation	Textile fibre name and composition of each component (above 5-15%)	**Consumer**	Labels	Legal information gap	**Waste treatment**: Important material information is not available, as they do not need to be disclosed if their proportion in the product is below a specific percentage threshold. **For consumers** information on materials included in textiles are amongst the most important aspects. However, most consumers stated to have enough information and the effort to find all information that are needed for the purchase is low.	Amend the wording of Art. 9(2) and (4) of the Textile Regulation, delete Art. 9(5), as proposed in Part D. Main recommendations include: • Declare all fibres (100%), but also chemicals and dyes used on fabrics; consider derogations only for small manufacturers with, e.g., fewer than 250 employees and under additional strict conditions; • Information must be included in a digital data carrier, such as a digital product passport. • e.g., allow
Electronics	Ecodesign Regulation Computer/ Displays	Identification of mercury (computer); marking of cadmium and plastic components (displays)	**Waste treatment**	Marking	Usage barrier (accessibility)	**Waste treatment:** Identification of markings not effective, as dismantling might be required to be able to identify the markings optically; markings not always readable and additional time does not justify slightly higher purity.	• Introduce (as a minimum) an obligation to provide for the information and/or marking not only to be “clearly visible” (anywhere, e.g., even after dismantling some parts); but for example, “clearly visible without the product having to be dismantled”;

Sector	**Legal act**	**Information requirement and granularity**	**Target information user**	**Access/ format**	**Identified gap or barrier**	**Evaluation by the target information user**	**Recommendation for extension of legal information requirements**
Electronics	WEEE Directive	Information on different materials and location of dangerous substances and mixtures in EEE	**Waste treatment**	Manuals, electronic media	Usage barrier (accessibility, granularity)	**Waste treatment**: No public platform with centralised information on dismantling available. Collection distributed information from each manufacturer individually entails high effort. *Voluntary approach: Information is provided through industry driven platforms:* *The platform "Information for recyclers" (I4R) provides dismantling and material information on product group level* *Though it was mentioned that such platform is useful for training purposes but the contained information is not complete (only product group level) and not intended for automated sorting, thus not machine readable.*	• Introduce an obligation to provide the necessary information on a **digital** data carrier that is **easily accessible**, **machine-readable** and can provide the relevant information digitally to all relevant stakeholders, especially to sorters and recyclers. • Switch from a European directive to a regulation; • Introduce an obligation for manufacturers to provide information about specific materials contained in parts of EEE and information on how to disassemble EEE on a **product model level**; • Amend the wording of Art. 15(1) WEEE Directive as proposed in Part D. Main recommendations include: • Removal of phrases that are not clear or ease the obligation for producers to provide information, for example “as far as it is needed by centers”; • Information must be available in digital, machine-readable form, in a digital data carrier, such as a digital product passport. • Consider phasing out physical manuals or electronic media such as CD-ROMs.

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Electronics	RoHS Directive	Confirmation of absence of certain hazardous substances by CE marking	**Market surveillance**	Datasheet CE-Label	Usage barrier (granularity)	**Consumer**: Although the CE marking is not addressing consumers, it is visible to the public on products. The marking is mostly known, however with the assumption that it indicates product safety, because of the misinterpretation as the GS marking ("Geprüfte Sicherheit"). Therefore, the CE-label might be removed or supported with additional information, if consumers shall be addressed.	• CE markings should be removed from parts of the product that are visible to consumers and other end-customers of products; • CE markings should be made a mandatory part of the digital product passport and as such made easily and readily available to relevant stakeholders, such as Market Surveillance Authorities.
Automotive	ELV Directive	Plastic type of component etc.	**Waste Management**	Coding, label	**Usage barrier (accessibility)**	- see evaluation "Ecodesign Regulation Computer/ Displays"	see recommendations "Ecodesign Regulation Computer/ Displays"

Product design and service related information requirements

Table 3: Product design and service related information requirements, sorted by sector and information user. Identified gap and evaluation of information requirements shown in right column. Context information (meta data) for evaluation includes access/format and granularity.

Sector	Legal act	Information requirement	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Electronics	Ecodesign Regulation Washing Machines	Information on use, maintenance, access to professional repair, spare part availability	**Consumer**	Manual	-	**Consumers** state a high importance to maintenance information, user manual and repair services.	
Electronics	Ecodesign Regulation Displays	Information about spare parts and repair instructions	**Consumer**	Datasheet Websites	-	Spare part availability and repair instructions which would support self-repair is seen of relevance by some **consumers**.	

Sector	Legal act	Information requirement	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Electronics	Ecodesign Regulation Displays	Availability of software and firmware updates, availability of spare parts and product support	**Consumer**	Product information sheet	-	**Consumers** state a high relevance of information on product use and repair, followed by information on software updates.	
Electronics	WEEE Directive, Battery Directive	Information on disposal, return and collection schemes	**Consumer**	Crossed-out wheeled bin marking	**Usage barrier (accessibility, format)**	The crossed-out wheeled bin logo does indicate not to dispose waste in the regular bin, but does not provide further information about the correct disposal, collection and return schemes.	• Add **digital labels** with additional information on physical products; • Add information for consumers on how to **sort, recycle or dispose products**; • Include information for sorters, recyclers and waste treatment.
Electronics	Ecodesign Regulation Washing Machines/ Displays	Repair and maintenance instructions (Component maps diagrams, disassembly map, etc.)	**Repair**	Manual	**Usage barrier (accessibility)**	Exclusively for professional repairer; competence of repairer has to be proven and accepted by manufacturer.	• Independent repairers deprecate the prioritisation of professional repairers, as this prevents access to important information, spare parts and finally cheaper repairs.

Sector	Legal act	Information requirement	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Electronics	Ecodesign Regulation Displays	Information about dismantling of the product components according to ANNEX VII WEEE Directive	**Waste treatment**	Datasheet Websites	**Usage barrier (accessibility)**	**Waste treatment**: No public platform with centralised information on dismantling available. Collection of distributed information from each manufacturer individually entails high effort. *Voluntary approach: Information is provided through industry driven platforms such as: The platform "Information for recyclers" (I4R) provides dismantling and material information on product group level. The International Dismantling Information System (IDIS) provides dismantling and other information for cars. Though it was mentioned that such platforms are useful for training purposes, the contained information is not complete (only product group level) and not intended for automated sorting, thus not machine readable.*	• Introduce an obligation to provide the necessary information on a **digital** data carrier that is **easily accessible**, **machine-readable** and can provide the relevant information digitally to all relevant stakeholders, especially to sorters and recyclers.
Electronics	WEEE Directive	Information on dismantling and recycling, different EEE components (and materials, as well as the location of dangerous substances and mixtures in EEE)	**Waste treatment**	Manuals or electronic media	**Usage barrier (accessibility)**	See evaluation for WEEE Directive in table 1	See recommendations for WEEE Directive in table 1

Circularity related information requirements

Table 4: Circularity related information requirements with context information: sector, information user. Identified gap and evaluation of information requirements shown in right column. Meta data for evaluation includes access/format and granularity.

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Evaluation by the target information user	Recommendation for extension of legal information requirements
Cross-sector	Corporate Sustainability Due Diligence Directive (proposal)	Information on social issues	**Consumer**	Report	**Usage barrier (granularity)**	Information in the corporate social responsibility reports are too complex for consumers and are self-declared by the manufacturer. *Voluntary approaches: Type I labels validate and aggregate information on due diligence, such as TCO, Blue Angel, EU Ecolabel, TÜV Rheinland Green Product Mark or Nordic Ecolabel. However, type I labels are trusted, but only used by 34% of consumers when purchasing a product. Manufacturer information is even more trusted.*	Corporate social responsibility (CSR) reports require a comprehensive assessment of various aspects on corporate level. A clear product relation and less complexity might not be possible. The consumer may not be explicitly defined as a target group, but rather the general public. However, trust in the CSR reports may be increased by third party verification. These could also provide for more consumer friendly information.

Stakeholder information requirements - data gaps and remedies

Identified information requirements as well as gaps and barriers (part A) were evaluated within interviews, workshops and surveys towards their suitability to support Circular Economy goals (part B). Each actor faces different challenges for upstream, downstream and circularity information:

Material related information is mainly required in chemical and waste legislation. Both aim to exclude hazardous substances, either from the beginning or the end of the product / material cycle. Product legislation aims to restrict or disclose the occurrence of certain distinctive substances and materials. **Product design and service related information** requirements coming from Commission / Delegated Ecodesign Regulations are majorly important for use, maintenance, repair, disposal and sorting of products. **Downstream information** is currently not legally required to be collected. Downstream information means information, e.g., on the usage or repair history which would be provided by users or repairers. An exception are treatment facilities who have to report information on collection rates to the European Commission. Only little mandatory **circularity related information** is available in particular to consumers, mainly required in due diligence legislation.

Requirements of manufacturers (for product compliance)

Liability and pressure are on the stakeholder who places the products on the EU market, usually manufacturers, to gather upstream material information from their material producer or supplier. Such top-down obligations can be challenging, even for companies who are intrinsically motivated and actively pursue transparency in their supply chain. Solutions like the IMDS demonstrate a well-established data collection and reporting tool for the automotive industry: Top-down data request from manufacturer as well as bottom-up data provision by supplier are possible. Suppliers benefit from a free of charge system and a given set of automotive specific material information requirements, coming from the manufacturer respectively the legislation they need to comply with. Suppliers can submit the data about their parts to their direct customer. A Chinese version of the IMDS, called CAMDS[2], addresses Chinese suppliers to provide material information to meet Chinese compliance. The system is interoperable to the IMDS for data exchange. For this best-case example, the convincing power of the few car manufacturers have to be taken into account, generating supply chain control and pressure to provide material data.

Requirements of consumers

In the context of the potentially increasing information availability (not least due to the product passport), the format of information has to be carefully adapted to consumer needs. Highly aggregated information in form of pictograms and logos such as the crossed-out wheeled (WEEE Directive) bin or hazard pictograms are helpful to raise consumer awareness about recycling practices or the presence of hazardous substances. However, logos do not fully provide the necessary information to be understood. Thus, additional information might be made available digitally and on demand if necessary (in a product information system) to obtain further details online and in a convenient way. Such ambitions are already pushed forward in the EU initiative "Chemicals – simplification and digitalisation of labelling requirements." Complex circularity information (e.g., CSR reporting) on the other hand are partially aggregated by voluntary labels

[2] China Automotive Material Data System, interoperable to the IMDS

such as TCO certified, Blue Angel, EU Ecolabel, TÜV Rheinland Green Product Mark or Nordic Ecolabel, although not all consumers have trust in them. Yet, each label is based on individual criteria, thus resulting on limited comparability between the labels. For electronic products, consumers stated a high relevance of information on durability, repairability and whether the device requires internet. For textile products most consumers demand information on durability and longevity. Legislation is in duty to provide standards from which standardised information can arise, e.g., according to the EN4555X standards which can be used to develop circularity indicators.

Information on use, maintenance, repair and disposal as required by Ecodesign legislation is seen important amongst consumers.

Requirements of professional repairers

Professional repairers benefit from repair information (Ecodesign Commission Regulations) while they have to provide a proof of competence, which is not clearly defined and can impose a burden. Repairers of electronic products state a gap on downstream information including the purchase date to check if the product is still under warranty, usage history to estimate the condition and repair history (e.g., exchanged parts). Within the textile sector, laundry, repair and rental service require information on the history of garments care and repair as well as material composition to give a more accurate service and cost of service.

Requirements of reuse and refurbishment operators

Reuse, refurbishment and preparation for reuse operators require information to estimate the residual value of the product, based on costs for repair or refurbishment and/or the resell price of the individual product. For electronics, necessary information comprises the energy efficiency class, original sales price, technical and functional specifications, which are mostly available. Relevant downstream information includes the usage history (usage time, cycles, age) as well as the repair history on component level, which is usually not available or only stored locally (e.g., at the repair shop). Textile specific important information comprises the purchase date or season, material composition, size and colour specifications, usage (washing) cycles and the condition (potential damages, state of product prior to refurbishment). Such information is sometimes already collected in professional rental services.

Requirements of waste treatment operators

One of the biggest challenges is seen in the communication of material information from suppliers at the beginning of the value chain to treatment facilities at the end. Today, waste treatment processes are tailored to the current materials profile in the waste stream. Therefore, it was stated that additional information on the material content of products is not particularly useful today. First, the additional time to scan and identify each device individually to eventually sort towards specific substances does not justify the slightly higher purity. Second, a data carrier (e.g., RFID chip) and material information for products in the market which eventually become waste is seen essential, which will require a specific amount of time to be established. However, higher material complexity in future waste streams and rising restrictions will increase the viability to implement a product identification system. The SCIP database started to gather structured material information (since January 2021) and makes it publicly available i.e. to waste treatment operators. However, it is seen to be yet incomplete, not readily accessible or if articles are registered, they miss a harmonic identification and allocation to the product.

Requirements from electronic waste treatment operators

Similar challenges arise for information for disassembly as well as hazardous materials and their location in EEE products (WEEE Directive). There is no public website which provides such information centrally to waste treatment operators. Industrial initiatives like the I4R platform aim to fill these gaps by providing a central platform for information on dismantling and hazardous materials per product group. In general, product and waste legislation have a stronger focus on electronics rather than textiles.

Requirements from textile waste treatment operators

Specifically, for textiles, sorter suffer from exemptions in the Textile Regulation (EU) No 1007/2011. Important material information does not need to be disclosed if their proportion in the product is below a specific percentage threshold.

The staple fibre length is in particular relevant for mechanical recycling and yarn spinning as it determines the potential recycling cycles and quality (lower fibre length means lower quality). To decide on a distinctive recycling process the fibre composition and non-textile materials present (i.e. buttons, membranes) as well as information on dyes, applications as well as polluting material are seen necessary.

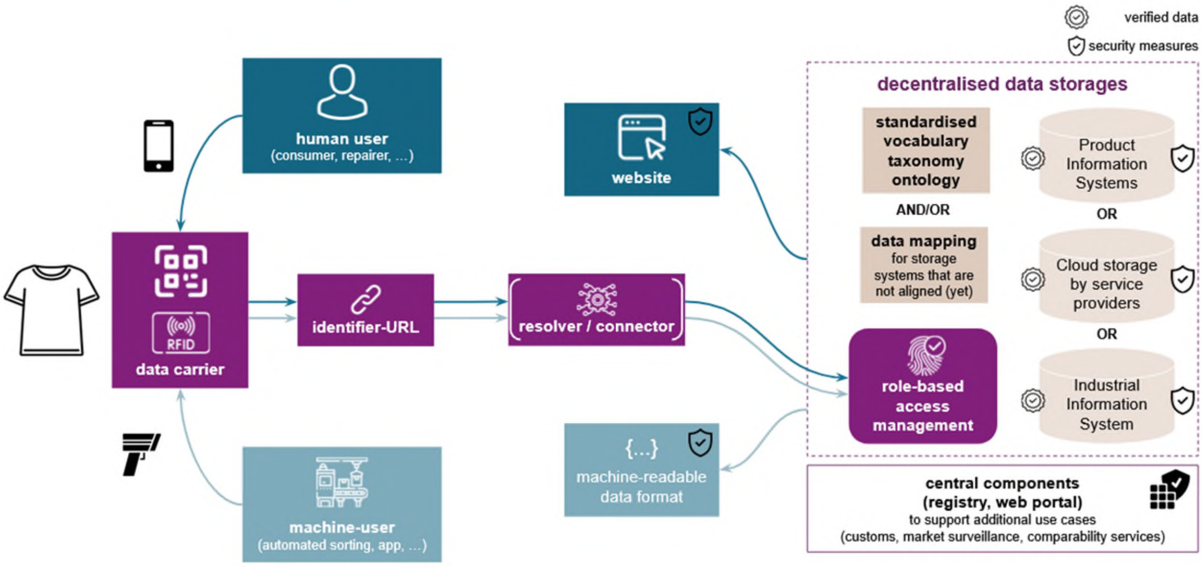
The thresholds for declaring material content present in the Textile legislation are not considered appropriate. Low metal content in textiles is usually not declared but even small amounts are degrading the quality of recycled textiles. The recycling technology has to cope with such uncertainties. Mechanical recycling needs information on dangerous substances as they stay in the new material after shredding and recycling. Chemical recycling on the other hand can remove hazardous chemicals but the subsequent handling and disposal of hazardous chemicals is effortful.

Product information 4.0 concept (technical infrastructure) and legal recommendations

Part C analyses aspects of the technical infrastructure required for making product data available to stakeholders along the circular value chain in a product information system: Vocabulary, ontology and taxonomies; data storage; data exchange; ownership and data verification; access management, identifiers and data carriers. It discusses existing approaches and technologies as well as the question of the extent to which the different aspects need to be standardised to enable seamless interoperability.

Figure 4 shows an overview over a concept for the technical infrastructure for a product information system.

Figure 4: Overview and interrelation of the technical aspects of a product information system



(source: Circular Fashion 2022)

Standardization of **vocabularies, ontologies, and taxonomies** aims to achieve technical interoperability and enhance user understanding, particularly benefiting consumers in making informed purchasing decisions. Ideally, standardized vocabularies should be built on existing standards for ease of interoperability. They should also be extendable, flexible, scalable, consistent, and machine-readable. However, the variety of existing standards poses challenges, as transitioning to a single new standard can be costly. Cross-sectoral interoperability, especially for low-tier suppliers serving multiple industries, is another challenge. Each sector must define its information requirements, followed by collaborative efforts to develop standardized datasets meeting these needs across industries. While a fully standardized vocabulary is desirable, practical constraints necessitate starting with a minimal standardized dataset per product group, supplemented by modular datasets to meet sector-specific needs. This study suggests a compromise by allowing non-standardized data, alongside data mapping tools, ensures effective technical interoperability while balancing standardization and flexibility.

Regarding the legal challenges around vocabulary, ontology and taxonomy,

- Definitions used in Directives and Regulations in the context of the Circular Economy Action Plan (CEAP) should be reviewed and aligned to improve coherence and lessen legal uncertainty.
- Essential requirements for the product information system should be regulated coherently in each relevant legislative act and aligned with harmonised standards (to be developed).
- For any product that must have a data carrier for a product information system. Relevant information regarding circularity / environmental / sustainability claims should be included in the product information system.

In terms of **data storage**, a decentralized system is recommended, offering stakeholders the choice to store information on-premise or with a third-party provider. Decentralized storage involves storing data in different physical locations, accommodating various company needs and technical capacities without requiring the exchange of currently used systems - instead, they can be adapted to become interoperable. This could help to avoid copying of data and the resulting redundancy. To ensure interoperability in this decentralized system, standardization is crucial for data, interfaces, and access management. While adapting existing systems to these standards requires effort, enforcing centralized storage comes with other disadvantages. A centralized system could also lead to industry reluctance, slower development, and a higher risk of a single point of failure. This study finds a hybrid solution with central components like registries to be a good compromise to complement the system, providing a single access point for specific information such as product identifiers, aiding in additional features like customs checks, comparison of products with industry ranges and long-term archiving.

Regarding the legal challenges around data storage,

- Stakeholders should be able to choose between storing information on their own premises or with a third-party platform provider.
- In addition to the decentralised data storage, a central registry should be set up with access by persons with "legitimate interest", e.g., market surveillance authorities or customs authorities. Information accessible to such stakeholders could entail details protected from public access in order to protect trade secrets or other similar interests of the provider of the information.
- The legal framework of a product information system should refer to the applicability of the GDPR whenever personal data is stored or otherwise processed.

For effective **data exchange**, standardization is crucial for both human-machine and machine-machine interfaces, improving accessibility and comprehension for consumers while ensuring technical interoperability among stakeholders and existing systems. Amongst the most critical aspect of successful systems and platform is the human interfaces which should prioritize usability, especially for SMEs and global stakeholders, with multilingual support, user-friendly interfaces, and easy learning curves. Currently, no working technical solution exists for interoperability between systems using different data standards. Approaches include storing data centrally, mandating a single standard, or building systems to map data between standards. While central storage is not recommended, combining a single standard with a mapping solution can be effective, with some systems adopting the standard directly and others using adaptors. Resolvers enable navigation within the information system by resolving identifiers or URLs stored on data carriers to the original data source. Resolvers do not address language or format interoperability. Public Key Infrastructure (PKI) and digital signatures can enhance data exchange infrastructure by authorizing parties and ensuring data integrity.

Regarding the legal challenges around the interoperability of data,

- the EU Commission should request that one or more European standardisation organisations (ESOs) draft a European standard under Art. 10 of the Regulation (EU) No 1025/2012 on Eu-ropean standardisation.
- The standard(s) should address interoperability, machine-readability and accessibility via human interfaces.

Data **ownership** is a complex issue with different concepts attributing responsibilities to either the data creator or the product marketer/distributor, yet it remains legally undefined by the EU.

Part C of the report diversely discusses who should bear the ultimate responsibility for availability, correctness, and completeness of product data. Post-sale data additions by users require careful consideration of consumer rights and responsibilities, especially regarding data accuracy. Steps to ensure **data quality** include automatic validation checks, manual verification, and ensuring data integrity through unchangeable data methods like blockchain technology. Encouraging companies to enhance data quality may involve financial incentives, penalties, and regulatory measures, with additional support needed for SMEs and data owners from the global south. Regulation, audits, and certification can hold data owners accountable for data quality, though with associated costs that may impact product pricing unless incentivized through schemes like Extended Producer Responsibility (EPR).

Regarding the legal challenges around the ownership, liability, and data verification,

- The storing of any personal data in a product information system should be governed by the GDPR.
- Access rights and other rights (read, write, delete, retrieve, add etc.) should be specified in applicable European harmonised norms. It is important to track who had access to the system and what changes or additions etc. were made by any actor.
- There should be a framework for the liability of providing accurate data. If there are no consequences for providing inaccurate or insufficient data, it is to be expected that stakeholders, especially consumers, do not / cannot trust the data from the system.
- Consumers should not be liable for adding any data and have either no or very restricted options to add information into the system.

Access management and IP protection can be simplified by defining a dataset of solely publicly available data if it enables all relevant circular economy use cases without revealing sensitive information. If possible, this approach would obviate complex role-based access management. However, it is likely that certain requested information cannot be publicly shared. Claims for secrecy as well as requests for specific details should be reviewed for legitimacy. If some necessary information cannot be publicly disclosed, role-based access management based on the need-to-know principle is advisable. User profiles are the basis for the product information system to deliver relevant information while safeguarding IP. Other solutions like data sharing on request may prove impractical due to time constraints of certain use cases like sorting of discarded products. As bottom-up defined access roles can be expected to lead to complexity and inconsistencies, legislation should determine stakeholders' access rights, considering industry, community, and data owner perspectives. Data owners may voluntarily share additional information under specified conditions, facilitated by fine-grained access rights. Technical solutions for security, authentication, and authorization, including Single-Sign-On (SSO), are readily available. SSO is especially recommended to reduce the burden of managing multiple login credentials for stakeholders.

Regarding the legal challenges around the access management and IP protection,

- Datasets that must be published to the public should not lead to an obligation to disclose trade secrets or information protected under IP rights.

- Access to information that is a trade secret or protected under IP law should, if it cannot be protected otherwise, only be granted to competent Union or Member State authorities fulfilling their duties under Union or applicable national law.
- The EU Commission could draft model clauses that can easily be incorporated between (B2B-) stakeholders for situations where, for example, a repairer, sorter or recycler needs access to information that is considered a trade secret or otherwise protected under IP law.

In order to showcase how a product information system would look from a user perspective, a **frontend-demonstrator** with different role profiles was developed. Customizing information presentation for different user groups, providing abstracted information for consumers compared to other user groups, was considered beneficial. Stakeholders agreed that the chosen format of providing information in different categories was useful for the users. They were able to navigate through the mock-up and find the information that they needed. In the stakeholder interviews, a central registry was suggested for entering product data, allowing the derivation of comparative values for specific product groups.

To support the circular economy through a product information system, **data carriers** need to be included in the product to provide a link to the product information. They must meet various criteria such as durability, storage capacity for a unique identifier, non-interference with product function, ease of reading, personal data protection, and recyclability. Different product subgroups may require different data carrier technologies, and stakeholder preferences also influence data carrier choices. Product-specific requirements are essential. Various product groups have distinct needs, with textiles requiring durability, washability, and support for efficient sorting processes. Optical codes and passive RFID tags are suitable for textiles, with hybrid tags recommended for consumer information and sorting efficiency. However, the current version of the WEEE Directive causes some hurdles for electronic tags (e.g., RFID). Electronics require functional data carriers for reuse and recycling, with durability, design, and metal content influencing the choices. Active RFID and Bluetooth tags are generally unsuitable – optical data carriers such as QR codes and passive RFID HF/NFC tags are preferable. Defining requirements for data carriers rather than mandating specific models can foster innovation. Legislative requirements should include criteria such as durability, process time, storage capacity, readability, privacy protection, and environmental impact. Specifying reading equipment requirements can ensure investment security for data users. A central product list can complement, but not replace, data carriers to meet industry efficiency needs.

Regarding the legal challenges around data carriers,

- The WEEE Directive should be amended to introduce a clear legal exception that clarifies that passive electronic tags which are part of a product group such as textiles under the product information system do not fall into the scope of the WEEE Directive. Member States should not be allowed to introduce stricter rules nationally when transposing this exception of the Directive (full harmonisation).
- Under the current legal framework of the WEEE directive and transpositions into Member States law, it cannot be recommended to use electronic tags (RFID, NFC) in textiles as data carriers for the product information system.
- An electronic tag with a unique identifier can potentially be used as a tracking device. In that case, the entity or person who is responsible for the tracking has to adhere to the GDPR,

including basing the personal data processing on an applicable legal basis (Art. 6 GDPR) and meeting transparency obligations (Art. 12 et seq. GDPR).

An environmental footprint analysis at the example of a smartphone indicates that (1) such a system using electronic data carriers could have a positive environmental impact by prolonging the use phase through more likely repair and (2) it should be avoided to use a new technology, because in particular the production of data reader would entail major environmental impacts. Further analysis of the ecological impacts of the system is advisable.

Identifiers are vital for product information systems because they identify the cloud-stored product data entry and can make it accessible. Identifiers must be globally unique, persistent until the product's end of use, small in size, usable by all necessary stakeholders and resolvable via the internet. Serialized identifiers at the item level are necessary for products with relevant repair, rental, and reuse/recommerce channels to support circular business models. For products without such markets, identification at the variation level is sufficient to support sustainable purchasing decisions and recycling stream decisions. Identifiers at component level can be useful if components are expected to have a dedicated repair or recommerce channel; but not all components need data carriers. A mandated identification scheme could incur high initial costs, so similar to data carriers, defining certain requirements by the legislator is considered beneficial. The resulting diversity of solutions could be resolved by also storing the type of identifier in the product dataset.

Regarding the legal challenges around identifiers,

- To avoid data protection risks, identifiers should generally be limited to model or batch levels instead of the item level. Only in exceptional cases should identifiers be used on item levels.
- RFID tags in products generally store product-related, non-personal data. Nevertheless, their use can lead to personal data protection problems in certain cases if they enable indirect identification of individuals, for example because so many RFID readers are set up in a store that a tracking profile of customers can be created. In such a case, the store or establishment that reads the RFID tags must comply with data protection regulations

Information gaps and barriers identified in Part A of the project primarily concern material composition, product design, service, and circularity information requirements. Overcoming these barriers is crucial for establishing an interoperable, available and usable product information system. Addressing legal information gaps necessitates stricter regulations. Existing information systems cannot replace regulations – for example EPREL and SCIP align conceptually with technical requirements of granularity, accessibility and interoperability, but the information reliably available from these systems is limited to what is legally mandated. However, storing data in existing (voluntary) information systems and platforms today can play a significant role in achieving a comprehensive product information system by showcasing the need for information, providing storage platforms, and assisting in data gathering. In the long term, the required information should be mandated in all qualifying systems in a standardised format and each product must be registered in a single system. While DPP requirements are in development, existing systems can still be used. Adding missing data fields to the existing systems is advisable, but harmonization efforts e.g. on access management should wait for clear requirements.

Conclusion on legal recommendations for the further development of information requirements

Part D of the study presents legal recommendations for a product information system that would facilitate a circular economy within the EU. It underscores the legal information gaps and proposes specific amendments to bridge these. In this summary the legal recommendations are directly allocated to each topic within Part A, B (table 1-3) and C (continuous text).

In conclusion towards the first part of the study (information requirements and gaps): for all legal acts (both existing and upcoming) it is recommended to clearly specify the required information and its meta data (granularity, format, access; see methodology chapter 1.1) as well as to detail within legislation or harmonised standards the necessary infrastructure. Any lack of clear and specific obligations as well as clear exemptions (where needed) can lead to gaps or barriers. Legal acts may need to leave some room for discretion and exceptions for stakeholders, who, for example, may not be able to fulfil all information requirements due to their capabilities. For these companies there should be clear and narrowly defined exemptions or (financial) support/incentives in order to fulfil such requirements.

Looking into detail, the **textiles sector** would benefit from a comprehensive material declaration for fabrics, with a push to eliminate exceptions in current legislation. This could be extended to dyes and chemicals. The implementation of standard sizing systems could reduce online returns. For the **electronics sector**, the analysis focused on improving accessibility to material information for sorters and recyclers under the Ecodesign and WEEE Directives, and addressing consumer confusion caused by the CE mark under the RoHS Directive. The ESPR's upcoming requirements for a digital product passport could also encompass the Ecodesign Commission Regulation for displays, mandating easily accessible and machine-readable data carriers. Cross-Sector: The need for enhanced Safety Data Sheets under REACH, improved CLP labelling, and digitalisation of packaging information was identified. Proposals include stricter enforcement of REACH, digitized labels for substances and mixtures, and QR codes for packaging reuse systems.

In part D also the framework around a proposed product information system (part C) for electronics and textiles was analysed, addressing vocabulary, ontology, and taxonomy to improve legal clarity and coherence. Data storage considerations suggest a central registry for stakeholders with legitimate interests, while data exchange calls for EU Commission-mandated standards to ensure interoperability. Access rights, liability, and data verification within the system should be clearly regulated by law, with a framework to encourage the provision of accurate data. Access management must protect trade secrets and IP rights, and the use of data carriers like RFID in textiles should adhere to WEEE Directive exemptions and be compliant with GDPR.

Finally, the design of an information system is important for usability and easy access to information. However, it is equally important that the information requirements are anchored in the material, product and waste-specific regulations that meet the information requirements of the various stakeholders. Only then it is possible to achieve the environmental goals/objectives for the circular economy.

Zusammenfassung

Hintergrund und Ziel

In den letzten Jahrzehnten haben die Verfügbarkeit und das Spektrum von Produkten durch Fortschritte in der Herstellung und Technologie stetig zugenommen. Diese Zunahme hat eine Vielzahl von Herausforderungen mit sich gebracht, insbesondere im Hinblick auf die Realisierung einer Kreislaufwirtschaft. Neue Trends und individuelle Produktlebenszyklen führen zu einer verkürzten Lebensdauer der Produkte durch vorzeitige Obsoleszenz. Zudem erschweren die zunehmende Vielfalt der Produkte und ihre individuellen Produkteigenschaften (Design, Funktionalität, Reparierbarkeit) die Reparatur. Das Abfallmanagement wird aufwendiger, da die unterschiedlichen Materialzusammensetzungen und Designs der Geräte die Trennung und Gewinnung von Sekundärmaterialien erschweren.

Um die zunehmende Komplexität der physischen und digitalen Produktwelt anzugehen, beabsichtigen die Europäische Union (EU) und das deutsche BMUV, sämtliche produktbezogenen Informationen mit Hilfe eines Digitalen Produktpasses (DPP) zu standardisieren und zusammenzuführen. Vor diesem Hintergrund hat das Umweltbundesamt Anfang 2021 das Projekt „Weiterentwicklung der Informationsanforderungen an Produkte und digitale Umsetzung am Beispiel energieverbrauchsrelevanter Produkte und Textilien (kurz: "Produktinformation 4.0"; Förderkennzeichen: REFOPLAN 372 0363 010) gestartet. Das Projekt zielt darauf ab, die aktuellen rechtlichen Informationsanforderungen hinsichtlich ihrer Eignung zur Erreichung der Ziele der Kreislaufwirtschaft zu bewerten. Teil A und B konzentrieren sich auf die Bewertung der Informationsanforderungen, Teil C bewertet die technische Infrastruktur und schlägt ein Konzept für ein Produktinformationssystem vor, Teil D bietet rechtliche Empfehlungen zu den vorherigen Teilen (Informationsanforderungen und Produktinformationssystemkonzept):

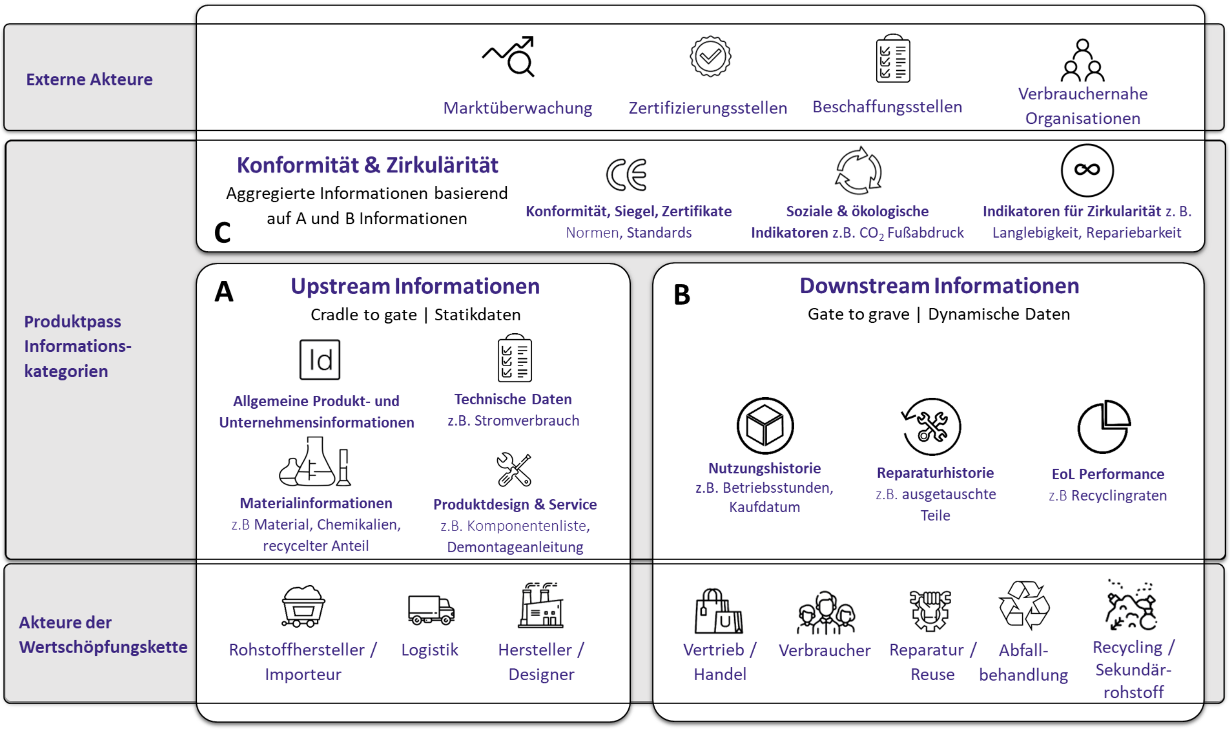
- Teil A: Prüfung und Bewertung der bestehenden verpflichtenden Informationsanforderungen und ob freiwillige Ansätze (Label, Indikatoren) oder aktuelle Aktivitäten die Lücken im rechtlichen Rahmen schließen;
- Teil B: Perspektive der Stakeholder auf die Informationsanforderungen und Bedürfnisse entlang des Produktlebenszyklus;
- Teil C: Empfehlungen und Vorschlag für ein Produktinformationssystem 4.0;
- Teil D: Analyse rechtlicher Lücken und zukünftige Potenziale zur Schließung von Informationslücken.

Die folgende Zusammenfassung beschreibt den Forschungsansatz, die wichtigsten Ergebnisse und Schlussfolgerungen.

Forschungsmethode: Kategorisierung von relevanten Interessengruppen und Informationen für DPP

Bei der Durchführung der Studie ergab sich eine große Herausforderung aus dem Verständnis heterogener Terminologien und Informationsanforderungen in Gesetzgebung, freiwilligen Ansätzen und den Informationsprofilen der Interessengruppen. Daher wurde ein Kategorisierungsschema abgeleitet, das chemische, produktbezogene, abfallbezogene und unternehmensbezogene Gesetzgebung sowie Kreislaufwirtschaftsindikatoren, Zertifizierungen und Informationen widerspiegelt, die von allen Interessengruppen im Produktlebenszyklus erzeugt werden.

Figure 5: Vorschlag für ein Kategorisierungssystem für Produktinformationen



(Quelle: TU Berlin 2022)

Das Kategorisierungssystem ist in zwei Akteurs- bzw. Stakeholdergruppen und drei Informationsgruppen (A-C) unterteilt:

1. **Upstream:** Akteure in der vorgelagerten Wertschöpfungskette und im Produktlebenszyklus (cradle-to-gate) sind in der Regel für das Produktdesign und die Produktionsphase verantwortlich. Diese Akteure erzeugen oder haben Zugriff auf primäre Produktdaten, wie allgemeine Informationen, technische Spezifikationen, Materialzusammensetzung und Informationen zum Produktdesign. Bei Gebrauchsgegenständen sind diese Produktinformationen oft statisch und ändern sich nach der Markteinführung nicht mehr. Als einfache Analogie kann man auch von den "Geburtsdaten" des Produkts sprechen.

2. **Downstream:** Akteure in der nachgelagerten Wertschöpfungskette und im Produktlebenszyklus (gate-to-grave) umfassen Einzelhändler, Verbraucher, Reparaturdienste und weitere Akteure, die in der End-of-Life (EoL)-Phase des Produkts involviert sind. Die in dieser Lebenszyklusphase erzeugten produktbezogenen Daten hängen oft vom individuellen Nutzungsprofil des Produkts ab (z. B. Nutzungsdauer, Reparaturhistorie). Die Produkte verändern ihren physischen Zustand und/oder Eigenschaften, z. B. durch Abnutzung oder Reparatur während der Nutzung. Daher sind die in der nachgelagerten Wertschöpfungskette generierten Daten oft dynamisch und Teil des individuellen Produktlebens. Als einfache Analogie kann man auch von einer individuellen Biografie des Produkts sprechen (vgl. Barata et al. 2020).

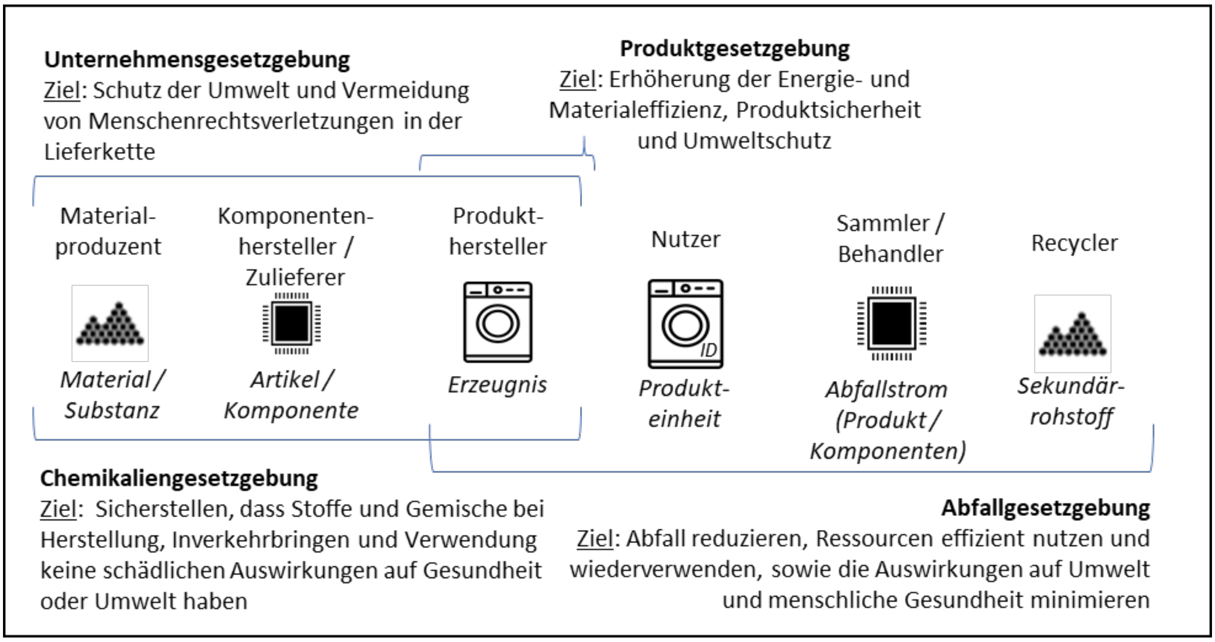
3. **Externe Akteursgruppen und Drittparteien**, die nicht direkt in der Produktions- und Nutzungsphase des Produkts (Produktlebenszyklus) beteiligt sind, nutzen die von den Informationskategorien A und B generierten Produktdaten, um weitere Produktdaten zu generieren. Beispiele hierfür könnten Indikatoren, Umweltlabel, Zertifizierungsschemata oder Produktlebenszyklus-Bewertungen umfassen. Typische Akteursgruppen sind Marktüberwachungsbehörden, Zertifizierungsstellen oder umwelt- und verbraucherorientierte Einrichtungen.

Das Schema dient als Analyserahmen für diese Studie. Es ermöglicht die Strukturierung rechtlicher Akte nach Informationskategorien, zugrunde liegenden Barrieren/Lücken und weiteren relevanten Ansätzen. Teil A dieser Studie untersucht rechtliche Anforderungen, welche hauptsächlich in die Kategorien Upstream- und Kreislaufwirtschaftsinformationen eingeteilt werden können, die für die Produktkonformität erforderlich sind und von Herstellern oder EU-Importeuren bereitgestellt werden müssen. Teil B bewertet aus der Sicht der Akteursgruppen rechtliche Informationsanforderungen und andere wichtige Informationen. Hierbei werden auch Downstream-Informationen von Nutzern, Reparaturdiensten usw. berücksichtigt, wo keine rechtlichen Verpflichtungen zur Datenbereitstellung bestehen.

Forschungsumfang: rechtliche Bereiche, Ziele und Themen

Figure 6 zeigt den Umfang und den Ansatz zur Auswahl rechtlicher Akte. Basierend auf dem Thema und den mit der Kreislaufwirtschaft verbundenen Zielen wurden vier rechtliche Bereiche innerhalb des Umfangs identifiziert: Unternehmens-, Chemie-, Produkt- und Abfallgesetzgebung.

Figure 6: Ziel und Umfang der rechtlichen Bereiche entlang der Wertschöpfungskette (abstrahierte Übersicht)



(Quelle: TU Berlin 2022)

Die Gesetzgebung sieht bereits verschiedene Informationspflichten vor, die eine potentiell Datengrundlage für ein Produktinformationssystem bzw. DPP bieten. Folgende Kriterien wurden verwendet, um relevante Gesetzgebung zu identifizieren:

- **Themengebiet:** Die Informationen müssen sich auf ein Material (Chemikalien, Substanzen, Gemische), ein Produkt (Objekte, Erzeugnisse), Abfall oder ein Unternehmen beziehen.
- **Produktgruppe:** Neben Textilien und energiebezogenen Produkten umfasst das Screening Batterien, Automobil, Verpackungen, Kunststoffe und Software. Dies ermöglicht die Einbeziehung von Erkenntnissen aus Sektoren mit etablierten Informationsanforderungen, die ähnliche Herausforderungen haben könnten.
- **Akteursgruppen:** Die Informationsanforderungen stehen in direkter Beziehung zu einer Akteurs- bzw. Interessengruppe (welche die Daten erzeugen müssen).
- **Bereich:** Eine Informationsanforderung ist zumindest Teil eines der folgenden Domänen der EU-Gesetzgebung und freiwilliger Standards oder Konventionen: Energie; Industriepolitik und Binnenmarkt; Umwelt, Verbraucher und Gesundheitsschutz.

Die relevante Gesetzgebung ist strukturiert auf chemische, produktbezogene, abfallbezogene und unternehmensbezogene Gesetzgebung (Table 5).

Table 5: Liste einschlägiger Rechtsvorschriften, die anhand vordefinierter Kriterien ausgewählt wurden (Gegenstand, Produktgruppe, Beziehung zu den Beteiligten, Tätigkeitsbereich)

Bereich	Kurzbezeichnung des Rechtsakts	Vollständiger Titel des Rechtsakts
Chemikalien-gesetzgebung	„REACH-Verordnung“	Verordnung (EG) Nr. 1907/2006 über die Registrierung, Bewertung, Zulassung und Beschränkung chemischer Stoffe
	„CLP-Verordnung“	Verordnung (EG) Nr. 1272/2008 über Einstufung, Kennzeichnung und Verpackung von Stoffen und Gemischen
Produkt-gesetzgebung	„Textilverordnung“	Verordnung (EU) Nr. 1007/2011 über die Bezeichnungen der Textilfasern und die damit verbundene Etikettierung und Kennzeichnung der Faserzusammensetzung von Textilerzeugnissen
	„Ökodesign-Richtlinie“	Richtlinie 2009/125/EG zur Festlegung eines Rahmens für die Festlegung von Ökodesign-Anforderungen für energieverbrauchsrelevante Produkte
	„Ökodesign-Verordnung PC“	Beispiel: Verordnung (EU) Nr. 617/2013 der Kommission über die Ökodesign-Anforderungen an Computer und Computerserver

Bereich	Kurzbezeichnung des Rechtsakts	Vollständiger Titel des Rechtsakts
	„Ökodesign-Verordnung WM“	Beispiel: Verordnung (EU) 2019/2023 der Kommission mit Ökodesign-Anforderungen für Haushaltswaschmaschinen und Haushaltswaschtrockner
	„Ökodesign-Verordnung Displays“	Beispiel: Verordnung (EU) 2019/2021 der Kommission mit Ökodesign-Anforderungen für elektronische Anzeigen
	„Energiekennzeichnungsverordnung“	Verordnung (EU) 2017/1369 zur Festlegung eines Rahmens für die Energiekennzeichnung
	„ESPR-Verordnung (Entwurf)“	Entwurf zur Festlegung eines Rahmens für die Festlegung von Ökodesign-Anforderungen für nachhaltige Produkte, COM(2022) 142 endgültig, 2022/0095(COD)
	„Strategie für nachhaltige Textilien“	EU-Strategie für nachhaltige und kreislauffähige Textilien (COM(2022) 141 final)
	„Typgenehmigungsverordnung“	Verordnung (EU) 2018/858 über die Genehmigung und Marktüberwachung von Kraftfahrzeugen und Kraftfahrzeuganhängern
Abfall - gesetzgebung	„Batterierichtlinie“	Richtlinie 2006/66/EG über Batterien und Akkumulatoren sowie Altbatterien und Altakkumulatoren
	„Batterieverordnung“	Verordnung (EU) 2023/1542 über Batterien und Altbatterien
	„Altfahrzeug-Richtlinie“	Richtlinie 2000/53/EG über Altfahrzeuge
	„Verpackungsrichtlinie“	Richtlinie 94/62/EG über Verpackungen und Verpackungsabfälle

Bereich	Kurzbezeichnung des Rechtsakts	Vollständiger Titel des Rechtsakts
	„RoHS-Richtlinie“	Richtlinie 2011/65/EU zur Beschränkung der Verwendung bestimmter gefährlicher Stoffe in Elektro- und Elektronikgeräten
	„WEEE-Richtlinie“	Richtlinie 2012/19/EU über Elektro- und Elektronik-Altgeräte
	„Abfallrahmenrichtlinie“	Richtlinie 2008/98/EG über Abfälle
Unternehmens-gesetzgebung	„CSDD-Richtlinienentwurf“	Entwurf für eine Richtlinie zur unternehmerischen Sorgfaltspflicht in Bezug auf Nachhaltigkeit, COM(2022) 71 endgültig, 2022/0051(COD)
	„Konfliktmineralien-Verordnung“	Verordnung (EU) 2017/821 zur Festlegung von Sorgfaltspflichten entlang der Lieferkette für Unionseinführer von Zinn, Tantal und Wolfram, deren Erzen, und Gold aus konfliktbetroffenen und hochrisikoreichen Gebieten

Heterogene Terminologie und Anforderungen führen zu einer Vielzahl von über 122 rechtlichen Produktinformationsanforderungen. Um die Vielfalt der Informationen greifbar zu machen, zeigt die folgende Übersicht die gängigsten Informationsanforderungen, kategorisiert nach den vier Informationskategorien (siehe Figure 6):

Materialbezogene Informationen:

- Gefährliche Substanzen: REACH-Verordnung, RoHS-Richtlinie, CLP-Verordnung, Ökodesign-Richtlinie, WEEE-Richtlinie, ELV-Richtlinie Art. 8(3), Batterierichtlinie Art. 21
- Materialzusammensetzung: Textilverordnung, WEEE-Richtlinie, ELV-Richtlinie
- Mineralien aus Konflikt- und Hochrisikogebieten: Konfliktmineralien-Verordnung
- Materialherkunft: Konfliktmineralien-Verordnung, Entwurf zur CSDD-Richtlinie

Produktdesign-bezogene Informationen:

- Informationen zu Nutzung, Wartung und Aktualisierung: Ökodesign-Richtlinie, Typgenehmigungsverordnung
- Reparaturinformationen (für professionelle Reparatur): Ökodesign-Richtlinie, Typgenehmigungsverordnung

- Demontageinformationen: Ökodesign-Richtlinie, WEEE-Richtlinie, ELV-Richtlinie Art. 8(3) und 8(4)
- Entsorgungsinformationen: Ökodesign-Richtlinie, WEEE-Richtlinie, Batterierichtlinie, Verpackungsrichtlinie, ELV-Richtlinie Art. 9(2)

Funktionale und technische Spezifikationen:

- Informationen zum Energieverbrauch: Energiekennzeichnungsverordnung

Kreislaufwirtschaftsbezogene Informationen:

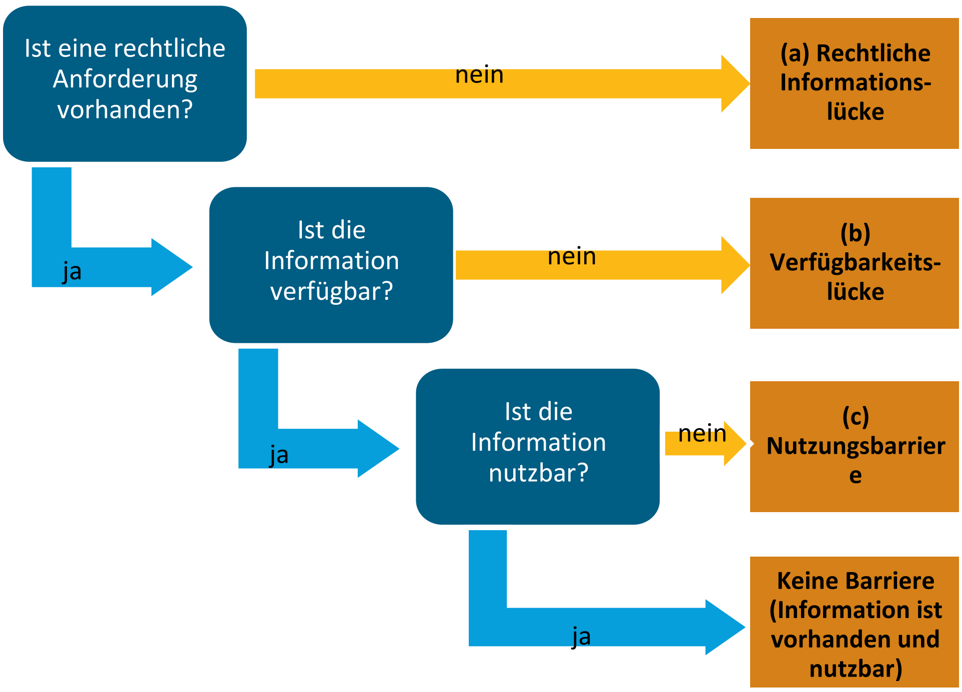
- Informationen zur Umweltauswirkung: Ökodesign-Richtlinie
- Informationen zur sozialen Auswirkung: Entwurf zur CSDD-Richtlinie

Darüber hinaus wurden auch Informationsanforderungen aus freiwilligen Ansätzen (z.B. Label) und rechtliche Entwicklungen in der Analyse berücksichtigt und bewertet.

Informationsanforderungen, Lücken und rechtliche Empfehlungen

Die Analyse umfasst die Identifizierung der in der Gesetzgebung vorhandenen Informationsanforderungen, der vorhandenen, aber mit Ausnahmen versehenen Informationsanforderungen, der nicht vorhandenen, aber von den Stakeholdern geforderten Informationsanforderungen und der vorhandenen, aber nicht durch den Zielstakeholder nutzbaren Informationsanforderungen.

Figure 7: Sukzessive Identifikation von Lücken und Barrieren in der Gesetzgebung. Informationsanforderungen müssen vorhanden sein, Informationen müssen verfügbar sein, Informationen müssen verfügbar und nutzbar sein.



(Quelle: TU Berlin 2022)

Rechtliche Informationslücken (a) wurden hauptsächlich aufgrund von Ausnahmen in der Gesetzgebung gefunden. Verfügbarkeitslücken (b) unterliegen Durchsetzungsdefiziten oder strukturellen Gründen. Nutzungsbarrieren (c) traten aufgrund fehlender oder unangemessener Definition der Zugänglichkeit, des Formats oder der Granularität der Informationsanforderung auf.

Lücken und Barrieren wurden hauptsächlich in drei Kategorien gefunden, die in drei folgenden Tabellen zusammengefasst sind:

- Materialbezogene Informationsanforderungen
- Produktdesign- und servicebezogene Informationsanforderungen
- Kreislaufwirtschaftsbezogene Informationsanforderungen

Für die Informationskategorie „funktionale und technische Spezifikationen“, die rechtlichen Anforderungen zum Energieverbrauch umfasst, wurden keine Barrieren gefunden.

Die folgenden Tabellen bieten einen ganzheitlichen Überblick über die in den Rechtsakten vorhandenen Informationsanforderungen für elektronische und textile Produkte. Darüber hinaus zeigt die Tabelle Kontextinformationen (Metadaten) zur Informationsgranularität, zum Zielinformationsträger, Zugang und Format. Die Zeilen in den Tabellen sind nach Sektor und Zielinformationsträger gruppiert. Die identifizierte Lücke oder Barriere wurde zunächst in Teil A dieser Studie identifiziert und qualitativ durch den Zielinformationsnutzer in Teil B validiert, was in der zweiten rechten Spalte („Bewertung durch die Zielgruppe der Information“) erörtert wird. Die rechte Spalte leitet Empfehlungen ab, um die Gesetzgebung auf Basis der gefundenen Lücke oder Barriere zu erweitern oder anzupassen. Eine qualitative Beschreibung der Lücken und Barrieren sowie weitere Informationsanforderungen über die Gesetzgebung hinaus werden unter den drei Tabellen erörtert.

Anforderungen an materialbezogene Informationen

Table 6: Materialbezogene Informationsanforderungen, sortiert nach Sektor und Informationsnutzer. Identifizierte Lücke und Bewertung der Informationsanforderungen werden in der rechten Spalte dargestellt. Kontextinformationen (Metadaten) für die Bewertung umfassen Zugang/Format und Granularität.

Sektor	Rechtsakt	Informationsanforderung und Granularität	Zielgruppe der Information	Zugang/Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Sektorübergreifend	REACH-Verordnung (Art. 31)	Identifikation von gefährlichen Stoffen und Gemischen	Empfänger des Stoffes/Gemisches	Sicherheits-datenblatt (SDB)	Verfügbarkeitslücke	Informationslücke zwischen Hersteller/Lieferant des Stoffes/Gemisches und dem Hersteller des zusammengesetzten Erzeugnisses, SDB wird nicht übergeben. Validierung der Materialinformation wird als vorteilhaft angesehen. Das SDB wird nur dem professionellen Nutzer, nicht den Verbrauchern oder der allgemeinen Öffentlichkeit zur Verfügung gestellt. *Freiwilliger Ansatz: Informationssysteme wie circularity.ID unterstützen die Sammlung und Verteilung erweiterter Informationen z. B. über Materialinhalte. Freiwilliger Ansatz: Der Internationale Materialdatenraum (IMDS) im Automobilsektor bietet ein modulares System zur Sammlung von Materialinformationen mit Fokus auf Komponenten- und Materiallieferanten.*	Änderung der REACH-Verordnung, so dass (1) Lieferanten (sowohl in der Europäischen Union als auch in Drittländern) allen weiteren Lieferanten entlang der Lieferkette ohne Ausnahmen Informationen über in der Substanz oder dem Gemisch verwendete Chemikalien mittels SDB zur Verfügung stellen müssen, (2) einschließlich der Angabe, ob eine Kumulation von Chemikalien einen (noch zu bestimmenden) Schwellenwert erreicht, der als „riskant“ (z. B. gefährlich) gilt. Diese Informationen sollten zusätzlich in einem digitalen Datenträger enthalten sein. Anfangs könnte das korrekte Ausfüllen der Informationsanforderungen der digitalen Datenträger dazu führen, dass ein korrektes SDB gedruckt werden kann. Über die Zeit könnte die Verwendung des SDB auslaufen, bis nur noch ein digitaler Datenträger verwendet wird.

Sektor	**Rechtsakt**	**Informationsanforderung und Granularität**	**Zielgruppe der Information**	**Zugang/Format**	**Identifizierte Lücke oder Barriere**	**Bewertung durch die Zielgruppe der Information**	**Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen**
Sektorübergreifend	REACH-Verordnung (Art. 33)	Identifikation von Erzeugnissen, die eine SVHC über 0,1 % enthalten, an alle Akteure	Empfänger des Erzeugnisses (Hersteller, Importeur, nach-geschalteter Anwender)	SCIP-Datenbank (Anforderung der Abfallrahmenrichtlinie)	Rechtliche Informations-lücke, Verfügbarkeitslücke	Verbraucher: Informationen nur auf Anfrage und mit einer Verzögerung von bis zu 45 Tagen verfügbar, was für die Kaufentscheidung der Verbraucher nicht ausreichend ist. Informationen über Substanzen zu komplex. Viele Anbieter der Erzeugnisse reagieren nicht auf Anfragen nach SVHC-Informationen von Verbrauchern. *Freiwilliger Ansatz: Smartphone-Apps wie Scan4Chem und ToxFox verbessern die Nutzungshürde, indem sie Verbrauchern helfen, Materialinformationen wie SVHCs anzufordern, aber die Verfügbarkeitslücke (Verzögerung) kann nicht überwunden werden, da sie vom Hersteller des Erzeugnisses herrührt.* *Reparatur und Wiederverwendung könnten betroffen sein, wenn Teile oder Produkte weiterverkauft werden.* *Abfallbehandlung: Zugriff auf Informationen nur über die SCIP-Website möglich und nur für einzelne Erzeugnisse, was in Sortierprozessen nicht effektiv ist. In der Praxis sind Erzeugnisse in SCIP nicht mit dem fertigen Produkt verknüpft.*	Verkürzung der aktuellen rechtlichen Frist von 45 Tagen zur Bereitstellung von Informationen an Verbraucher auf „ohne unangemessene Verzögerung, jedoch mindestens innerhalb von 72 Stunden“. Evaluierung, ob alternativ die relevanten Informationen öffentlich in der SCIP-Datenbank für einen Verbraucher leicht auffindbar sein müssen (z. B. über GTIN oder einen anderen, dem Endverbraucher und/oder Verbraucher bekannten Identifier) und jederzeit zugänglich sein sollen; Zusätzlich sollte die SCIP-Datenbank auf fertige Produkte (mit Seriennummer, z. B. GTIN oder eine andere dem Endverbraucher und/oder Verbraucher bekannte Nummer) erweitert werden und Einträge in der Datenbank sollten maschinenlesbar sein, so dass die notwendige Bereitstellung von Informationen allen relevanten Stakeholdern rechtzeitig gegeben ist, z. B. über eine Schnittstelle (API);

Sektor	Rechtsakt	Informationsanforderung und Granularität	Zielgruppe der Information	Zugang/Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Sektorübergreifend	CLP-Verordnung	Gefahren-piktogramme, Signalwörter, Gefahren-hinweise, Vorsichts-aussagen	Empfänger der Substanz, des Gemisches (einschließlich Verbraucher)	Etiketten	Nutzungs-barriere (Format)	Verbraucher: Kennzeichnungen können von einigen Verbrauchern fehlinterpretiert werden. Für beide Produktgruppen (Textilien und Elektronik) geben Verbraucher an, dass genügend Informationen verfügbar sind und der Aufwand, alle notwendigen Informationen für den Kauf zu finden, sehr gering ist.	Einführung digitaler Etikettenmit zusätzlichen Informationen auf physischen Produkten; Ergänzung von Informationen für Verbraucher, wie sie die Gemische und Substanzen sortieren, recyceln oder entsorgen können; Einbeziehen von Informationen für Sortierer, Recycler und Abfallbehandlungsanlagen ein.
Sektorübergreifend	Verpackungsrichtlinie	Informationen über Rückgabe-, Sammel- und Verwertungs-systeme	Verbraucher	Etiketten	Nutzungs-barriere (Format)	Das Format (Etiketten) legt nicht fest wie oder wo die Informationen den Verbrauchern zur Verfügung gestellt werden sollten, was zu einer heterogenen Überführung der Richtlinie in nationale Gesetzgebung führt. Art. 11 (2) des aktuellen Entwurfs der Verordnung über Verpackungen und Verpackungsabfälle sieht vor, dass solche Informationen digital bereitgestellt werden.	Wechsel von einer europäischen Richtlinie zu einer Verordnung (wie von der EU-Kommission vorgeschlagen); Dem Vorschlag der EU-Kommission, wie in Art. 11 (2) und (4) des Vorschlags für eine Verordnung über Verpackungen und Verpackungsabfälle (COM(2022) 677 endgültig) dargelegt, sollte gefolgt werden.

Sektor	**Rechtsakt**	**Informationsanforderung und Granularität**	**Zielgruppe der Information**	**Zugang/Format**	**Identifizierte Lücke oder Barriere**	**Bewertung durch die Zielgruppe der Information**	**Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen**
Textilien	Textil-verordnung	Textilfasername und Zusammen-setzung jeder Komponente (über 5-15%)	Verbraucher	Etiketten	Rechtliche Informations-lücke	Abfallbehandlung: Wichtige Materialinformationen sind nicht verfügbar, da sie nicht offengelegt werden müssen, wenn ihr Anteil im Produkt unter einem bestimmten prozentualen Schwellenwert liegt. Für Verbraucher gehören Informationen zu den in Textilien enthaltenen Materialien zu den wichtigsten Aspekten. Die meisten Verbraucher gaben jedoch an, dass sie genügend Informationen haben und der Aufwand, alle für den Kauf benötigten Informationen zu finden, gering ist.	Anpassung der Formulierung von Art. 9 (2) und (4) der Textilkennzeichnungsverordnung, Löschung von Art. 9 (5), wie in Teil D vorgeschlagen. Weitere Hauptempfehlungen umfassen: Deklarierung aller Fasern (100%), aber auch Chemikalien und Farbstoffe, die auf Stoffen verwendet werden; dabei könnten Ausnahmen nur für kleine Unternehmen, mit z. B. weniger als 250 Mitarbeitern und zusätzlichen strengen Bedingungen, erwogen werden; Die Informationen müssen in einem digitalen Datenträger enthalten sein, wie z. B. einem digitalen Produktpass.
Elektronik	Ökodesign-Verordnung Computer/ Displays	Identifikation von Quecksilber (Computer); Kennzeichnung von Cadmium und Kunststoff-komponenten (Displays)	Abfall-behandlung	Kenn-zeichnung	Nutzungs-barriere (Zugänglich-keit)	Abfallbehandlung: Die Identifikation von Kennzeichnungen ist nicht effektiv, da möglicherweise Demontagen erforderlich sind, um die Kennzeichnungen optisch identifizieren zu können; Kennzeichnungen sind nicht immer lesbar und die zusätzliche Zeit rechtfertigt nicht die leicht höhere Reinheit.	Einführung (mindestens) einer Verpflichtung, dass die Informationen und/oder Kennzeichnungen nicht nur „klar sichtbar“ (überall, z. B. auch nach Demontage einiger Teile) sein müssen, sondern zum Beispiel „klar sichtbar, ohne dass das Produkt demontiert werden muss“; Einführung einer Verpflichtung, die erforderlichen Informationen auf einem digitalen Datenträger bereitzustellen, der leicht zugänglich, maschinenlesbar ist und die relevanten Informationen digital an alle relevanten Stakeholder, insbesondere an Sortierer und Recycler, bereitstellt.

Sektor	Rechtsakt	Informationsanforderung und Granularität	Zielgruppe der Information	Zugang/Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Elektronik	WEEE-Richtlinie	Informationen über verschiedene Materialien und den Standort gefährlicher Stoffe und Gemische in EAG	Abfall-behandlung	Handbücher, elektronische Medien	Nutzungs-barriere (Zugänglich-keit, Granularität)	Abfallbehandlung: Keine öffentliche Plattform mit zentralisierten Informationen über die Demontage verfügbar. Das Sammeln verteilter Informationen von jedem Hersteller einzeln erfordert hohen Aufwand.	Wechsel von einer europäischen Richtlinie zu einer Verordnung; Einführen einer Verpflichtung für Hersteller, Informationen über spezifische in Teilen von EAG enthaltene Materialien und Informationen darüber, wie EAG demontiert werden können, auf Produktebene bereitzustellen; Ändern der Formulierung von Art. 15(1) der WEEE-Richtlinie, wie in Teil D vorgeschlagen. Hauptempfehlungen umfassen: Entfernen der Formulierungen, die nicht klar sind oder die Verpflichtung für Hersteller zur Bereitstellung von Informationen erleichtern, zum Beispiel „soweit diese für die Einrichtungen […] erforderlich sind“; Informationen müssen in digitaler, maschinenlesbarer Form, auf einem digitalen Datenträger, wie z. B. einem digitalen Produktpass, verfügbar sein; Erwägen, physische Handbücher oder elektronische Medien wie CD-ROMs auslaufen zu lassen.

Sektor	Rechtsakt	Informationsanforderung und Granularität	Zielgruppe der Information	Zugang/Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Elektronik	RoHS-Richtlinie	Bestätigung der Abwesenheit bestimmter gefährlicher Stoffe durch CE-Kennzeichnung	Markt-überwachung	Datenblatt, CE-Etikett	Nutzungs-barriere (Granularität)	Verbraucher: Obwohl die CE-Kennzeichnung sich nicht an Verbraucher richtet, ist sie für die Öffentlichkeit auf Produkten sichtbar. Die Kennzeichnung ist weitgehend bekannt, jedoch mit der Annahme, dass sie Produktsicherheit anzeigt, wegen der Fehlinterpretation als das GS-Zeichen („Geprüfte Sicherheit“). Daher könnte das CE-Etikett entfernt oder mit zusätzlichen Informationen unterstützt werden, wenn Verbraucher angesprochen werden sollen.	CE-Kennzeichnungen sollten von Teilen des Produkts entfernt werden, die für Verbraucher und andere Endkunden von Produkten sichtbar sind; CE-Kennzeichnungen sollten zu einem obligatorischen Teil des digitalen Produktpasses gemacht werden und als solche den relevanten Stakeholdern, wie z. B. Marktüberwachungsbehörden, leicht und sofort zugänglich gemacht werden.
Automobil	Alt-fahrzeug-Richtlinie	Kunststofftyp der Komponente etc.	Abfall-management	Codierung, Etikett	Nutzungs-barriere (Zugänglich-keit)	Siehe Ökodesign-Verordnung Computer/Displays	Siehe Ökodesign-Verordnung Computer/Displays

Anforderungen an produktdesign- und dienstleistungsbezogene Informationen

Table 7: Anforderungen an produktgestaltungs- und dienstleistungsbezogene Informationen, sortiert nach Sektor und Informationsnutzer. Identifizierte Lücke und Bewertung der Informationsanforderungen werden in der rechten Spalte dargestellt. Kontextinformationen (Metadaten) für die Bewertung umfassen Zugang/Format und Granularität.

Sektor	Rechtsakt	Informations-anforderung	Zielgruppe der Information	Zugang/Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Elektronik	Ökodesign-Verordnung Wasch-maschinen	Informationen zu Nutzung, Wartung, Zugang zu professioneller Reparatur, Verfügbarkeit von Ersatzteilen	Verbraucher	Handbuch	-	Verbraucher messen der Wartungsinformation, dem Benutzerhandbuch und den Reparaturservices eine hohe Bedeutung bei	-
Elektronik	Ökodesign-Verordnung Displays	Informationen über Ersatzteile und Reparatur-anleitungen	Verbraucher	Datenblatt, Websites	-	Verfügbarkeit von Ersatzteilen und Reparaturanleitungen, die Selbstreparaturen unterstützen würden, sind für einen Teil der Verbraucher von Relevanz	-
Elektronik	Ökodesign-Verordnung Displays	Verfügbarkeit von Software- und Firmware-Updates, Verfügbarkeit von Ersatzteilen und Produkt-support	Verbraucher	Produkt-informations-blatt	-	Verbraucher messen Informationen über Produktgebrauch und Reparatur eine hohe Bedeutung bei, gefolgt von Informationen über Software-Updates	-

Sektor	Rechtsakt	Informations-anforderung	Zielgruppe der Information	Zugang/Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Elektronik	WEEE-Richtlinie, Batterie-richtlinie	Informationen über Entsorgung, Rücknahme- und Sammelsysteme	Verbraucher	Durch-gestrichenes Mülltonnen-symbol	Nutzungsbarriere (Zugänglichkeit, Format)	Das durchgestrichene Mülltonnensymbol zeigt an, dass Abfall nicht in die reguläre Mülltonne geworfen werden soll, bietet jedoch keine weiteren Informationen über die korrekte Entsorgung, Sammlung und Rückgabe.	Digitale Etiketten mit zusätzlichen Informationen auf physischen Produkten hinzufügen; Informationen für Verbraucher hinzufügen, wie Produkte sortiert, recycelt oder entsorgt werden sollen; Informationen für Sortierer, Recycler und Abfallbehandlungsanlagen einschließen.
Elektronik	Ökodesign-Verordnung Wasch-maschinen/ Displays	Reparatur- und Wartungs-anleitungen (Komponentenpläne, Demontagepläne, etc.)	Reparatur	Handbuch	Nutzungsbarriere (Zugänglichkeit)	Ausschließlich für professionelle Reparateure; die Kompetenz des Reparateurs muss erst nachgewiesen und vom Hersteller akzeptiert werden.	Unabhängige Reparateure kritisieren die Priorisierung von professionellen Reparateuren, da dies den Zugang zu wichtigen Informationen und Ersatzteilen verhindert und letztlich kostengünstigere Reparaturen erschwert.
Elektronik	Ökodesign-Verordnung Displays	Informationen über die Demontage von Produkt-komponenten gemäß Anhang VII WEEE-Richtlinie	Abfall-behandlung	Datenblatt, Websites	Nutzungsbarriere (Zugänglichkeit)	Abfallbehandlung: Keine öffentliche Plattform mit zentralisierten Informationen über die Demontage verfügbar. Das Sammeln verteilter Informationen von jedem einzelnen Hersteller erfordert hohen Aufwand.	Einführen einer Verpflichtung, die notwendigen Informationen auf einem digitalen Datenträger bereitzustellen, der leicht zugänglich, maschinenlesbar ist und die relevanten Informationen digital an alle relevanten Stakeholder, insbesondere an Sortierer und Recycler, bereitstellt.

Sektor	Rechtsakt	Informations-anforderung	Zielgruppe der Information	Zugang/Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Elektronik	WEEE-Richtlinie	Informationen über die Demontage und das Recycling, verschiedene EAG-Komponenten (und Materialien sowie die Lage gefährlicher Stoffe und Gemische in EAG)	Abfall-behandlung	Handbücher oder elektronische Medien	Nutzungsbarriere (Zugänglichkeit)	Siehe WEEE-Richtlinie in Table 5	Siehe WEEE-Richtlinie in Table 5

Anforderungen an kreislaufbezogene Informationen

Table 8: Anforderungen an kreislaufbezogene Informationen mit Kontextinformationen: Sektor, Informationsnutzer. Identifizierte Lücke und Bewertung der Informationsanforderungen werden in der rechten Spalte dargestellt. Metadaten für die Bewertung umfassen Zugang/Format und Granularität

Sektor	Rechtsakt	Informations-anforderung und Granularität	Zielgruppe der Information	Zugang/ Format	Identifizierte Lücke oder Barriere	Bewertung durch die Zielgruppe der Information	Empfehlung zur Erweiterung der rechtlichen Informationsanforderungen
Sektor-über-greifend	Corporate Sustainability Due Diligence Directive (Entwurf)	Informationen zu sozialen Themen	Verbraucher	Bericht	Nutzungs-barriere (Granularität)	Informationen in den Berichten zur unternehmerischen Sozialverantwortung sind für Verbraucher zu komplex und werden vom Hersteller selbst deklariert. *Freiwillige Ansätze: Typ-I-Labels validieren und aggregieren Informationen über die Sorgfaltspflicht, wie z. B. TCO, Blauer Engel, EU Ecolabel, TÜV Rheinland Green Product Mark oder Nordic Ecolabel. Sie werden von 34 % der Verbraucher beim Kauf eines Produkts verwendet.*	Berichte zur unternehmerischen Sozialverantwortung (CSR) erfordern eine umfassende Bewertung verschiedener Aspekte auf Unternehmensebene. Eine klare Produktbeziehung und weniger Komplexität sind nur schwer zu erreichen. Der Verbraucher ist nicht explizit als Zielgruppe der Berichtspflicht definiert, sondern eher die allgemeine Öffentlichkeit. Die EU-Kommission wird in Durchführungsverordnungen Inhalt und Kriterien für die Detailtiefe an Informationen festlegen. Das Vertrauen in die CSR-Berichte könnte durch eine Überprüfung durch unabhängige Dritte erhöht werden.

Anforderungen aus Stakeholdersicht – Datenlücken und Maßnahmen

Identifizierte Informationsanforderungen sowie Lücken und Barrieren (Teil A) wurden in Interviews, Workshops und Umfragen hinsichtlich ihrer Eignung zur Unterstützung der Ziele der Kreislaufwirtschaft (Teil B) bewertet. Jeder Akteur sieht sich mit unterschiedlichen Herausforderungen für Informationen aus dem Upstream-, Downstream- und Circularitybereich konfrontiert:

Materialbezogene Informationsanforderungen kommen hauptsächlich aus der Chemie- und Abfallgesetzgebung. Beide zielen darauf ab, gefährliche Substanzen entweder von Anfang an oder am Ende des Produkt-/Materialzyklus auszuschließen. Die Produktgesetzgebung zielt darauf ab, das Auftreten bestimmter Substanzen und Materialien einzuschränken oder offenzulegen. Produktdesign- und dienstleistungsbezogene Informationsanforderungen, die von der Ökodesign-Gesetzgebung kommen, sind besonders wichtig für die Nutzung, Wartung, Reparatur, Entsorgung und Sortierung von Produkten. Downstream-Informationen sind derzeit gesetzlich nicht gefordert. Unter Downstream-Informationen versteht man beispielsweise Informationen über die Nutzung oder Reparaturhistorie, die von Nutzern oder Reparaturdiensten bereitgestellt würden. Eine Ausnahme sind Informationen über Sammelquoten, welche Behandlungsanlagen der Europäischen Kommission melden müssen. Kreislaufbezogene Informationen sind bislang nur vereinzelt und insbesondere für Verbraucher verfügbar, hauptsächlich im Rahmen der Gesetzgebung zur Sorgfaltspflicht in der Lieferkette (Lieferkettengesetz).

Anforderungen des Herstellers (für die Produktkonformität)

Die Produktkonformität und damit die Verantwortung und der Druck liegen bei den Stakeholdern, die die Produkte auf den EU-Markt bringen. Dies betrifft in der Regel die Hersteller, welche Materialinformationen von ihren Materialherstellern oder -lieferanten sammeln müssen. Solche Top-down-Verpflichtungen stellen auch für Unternehmen eine Herausforderung dar, die intrinsisch motiviert sind und aktiv Transparenz in ihrer Lieferkette anstreben. Lösungen wie das IMDS in der Automobilindustrie sind ein Beispiel für ein gut etabliertes Datenerfassungs- und Berichtstool: Top-down-Datenanfragen vom Hersteller sowie Bottom-up-Datenbereitstellung durch den Lieferanten sind möglich. Lieferanten profitieren von einem kostenlosen System und konkreten, vorgegebenen Materialinformationsanforderungen aus der Automobilbranche der sie entsprechen müssen, ausgehend von dem Hersteller bzw. der Gesetzgebung. Lieferanten können die Daten über ihre Teile an ihren direkten Kunden übermitteln. Eine chinesische Version des IMDS, genannt CAMDS, ermöglicht chinesische Lieferanten, Materialinformationen bereitzustellen, um die chinesische Konformität zu erfüllen. Das System ist interoperabel mit dem IMDS für den Datenaustausch. Für dieses Best-Case-Beispiel muss berücksichtigt werden, das im Automobilmarkt wenige große Hersteller eine Marktmacht und damit wesentlichen Einfluss auf ihre Lieferkette zur Bereitstellung von Materialdaten erzeugen können.

Anforderungen der Verbraucher:innen

Im Kontext der potenziell zunehmenden Verfügbarkeit von Informationen (nicht zuletzt durch den Produktpass) muss das Informationsformat sorgfältig an die Bedürfnisse der Verbraucher:innen angepasst werden. Hochaggregierte Informationen in Form von Piktogrammen und Logos, wie das durchgestrichene Mülltonnensymbol (WEEE-Richtlinie) oder Gefahrenpiktogramme, sind hilfreich, um das Verbraucher:innenbewusstsein für

Recyclingpraktiken oder das Vorhandensein von gefährlichen Substanzen zu schärfen. Logos bieten jedoch häufig nicht die notwendige Informationstiefe für einen korrekten Umgang bzw. Entsorgung. Daher könnten zusätzliche Informationen bei Bedarf digital und auf Anfrage (in einem Produktinformationssystem) verfügbar gemacht werden, um weitere Details online und auf praktische Weise zu erhalten. Solche Bestrebungen werden bereits in der EU-Initiative „Chemikalien – Vereinfachung und Digitalisierung der Kennzeichnungsvorschriften“ vorangetrieben. Weitere Kennzeichnungen für Verbraucher:innen umfassen freiwillige Labels wie TCO Certified, Blauer Engel, EU Ecolabel, TÜV Rheinland Green Product Mark oder Nordic Ecolabel, welche komplexe Informationen zur Kreislaufwirtschaft (z.B. CSR-Berichterstattung) teilweise aggregiert. Jedes Label basiert auf individuellen Kriterien, was zu einer begrenzten Vergleichbarkeit zwischen den Labels führt. Die Umfrage dieser Studie zeigt, dass ein Teil der Verbraucher:innen diesen skeptisch gegenüberstehenden. Bei elektronischen Produkten gaben Verbraucher:innen eine hohe Relevanz von Informationen über die Haltbarkeit, Reparierbarkeit und ob das Gerät Internet benötigt an. Bei Textilprodukten fordern die meisten Verbraucher:innen Informationen über Haltbarkeit und Langlebigkeit. Es sollten somit Standards bereitgestellt werden, um Informationen zu harmonisieren, z.B. gemäß den EN4555X-Normen, die zur Entwicklung von Kreislaufwirtschaftsindikatoren verwendet werden können.

Informationen über Nutzung, Wartung, Reparatur und Entsorgung, wie sie von der Ökodesign-Gesetzgebung gefordert werden, sind für Verbraucher:innen wichtig.

Anforderungen von professionellen Reparateuren

Professionelle Reparateure profitieren von Reparaturinformationen (für bestimmte Produktgruppen), müssen jedoch einen Kompetenznachweis erbringen, der nicht klar definiert ist und somit eine Belastung darstellen kann. Reparateure von elektronischen Produkten weisen auf eine Lücke bei den Downstream-Informationen hin, einschließlich des Kaufdatums, um zu überprüfen, ob das Produkt noch unter Garantie steht, der Nutzungshistorie zur Einschätzung des Zustands und der Reparaturhistorie (z.B. ausgetauschte Teile). Im Textilsektor benötigen Wäschereien, Reparatur- und Verleihdienste Downstream-Informationen über die Historie der Kleidungspflege und -reparatur sowie die Materialzusammensetzung, um einen genaueren Service und Kosten des Services zu gewährleisten.

Anforderungen von Wiederverwendungs- und Aufbereitungsakteuren (Reuse, Refurbishment)

Akteure der Wiederverwendung, Aufbereitung und Vorbereitung zur Wiederverwendung benötigen Informationen, um den Restwert des Produkts zu schätzen, basierend auf den Kosten für Reparatur oder Aufbereitung und/oder den Wiederverkaufspreis des einzelnen Produkts. Für Elektronik umfassen die notwendigen Informationen die Energieeffizienzklasse, den ursprünglichen Verkaufspreis, technische und funktionale Spezifikationen, die meist verfügbar sind. Relevante Downstream-Informationen umfassen die Nutzungshistorie (Nutzungszeit, -zyklen, Alter) sowie die Reparaturhistorie auf Komponentenebene, die in der Regel nicht verfügbar ist oder nur lokal gespeichert wird (z.B. in der Reparaturwerkstatt). Textilspezifische wichtige Informationen umfassen das Kaufdatum oder die Saison, die Materialzusammensetzung, Größen- und Farbspezifikationen, Nutzung (Waschzyklen) und den Zustand (potenzielle Schäden, Zustand des Produkts vor der Aufbereitung). Solche Informationen werden manchmal bereits in professionellen Verleihdiensten gesammelt.

Anforderungen von Abfallbehandlern

Eine der größten Herausforderungen besteht in der Kommunikation von Materialinformationen von Lieferanten am Anfang der Wertschöpfungskette zu den Behandlungsanlagen am Ende. Heute sind Abfallbehandlungsprozesse auf das aktuelle Materialprofil im Abfallstrom zugeschnitten. Daher wurde festgestellt, dass durch zusätzliche Informationen über den Materialinhalt erst die Prozesse ändern müssen und somit nicht unmittelbar nützlich sind. Erstens rechtfertigt die zusätzliche Zeit zum Scannen und Identifizieren jedes einzelnen Geräts, um letztendlich auf spezifische Substanzen zu sortieren, nicht die leicht höhere Reinheit. Für die Zukunft werden Materialinformationen als wichtig erachtet unter der Voraussetzung, dass alle Produkte im Markt bzw. Abfallstrom flächendeckend mit Datenträger (z. B. RFID-Chip) und Materialinformationen ausgestattet sind, was eine gewisse Zeit zur Etablierung erfordern wird. Die Relevanz von Materialinformationen und der Implementierung eines Produkterkennungssystems wird nochmal verstärkt, durch höhere Materialkomplexität in zukünftigen Abfallströmen und zunehmenden Stoffverboten. Die SCIP-Datenbank sammelt strukturierte Materialinformationen (seit Januar 2021) und macht sie öffentlich zugänglich, z. B. für Abfallbehandlungsanlagen. Die Datenbank wird jedoch als noch unvollständig angesehen, nicht leicht zugänglich oder, sofern Erzeugnisse registriert sind, fehlt ihnen eine harmonische Identifizierung und Zuordnung zum Produkt.

Anforderungen von Elektroabfallbehandlungsanlagen

Ähnliche Herausforderungen ergeben sich bei Informationen für die Demontage sowie gefährliche Materialien und deren Lage im Produkt (WEEE-Richtlinie). Es gibt keine öffentliche Website, die solche Informationen zentral für Abfallbehandlungsanlagen bereitstellt. Industrielle Initiativen wie die I4R-Plattform zielen darauf ab, diese Lücken zu schließen, indem sie eine zentrale Plattform für Informationen über Demontage und gefährliche Materialien pro Produktgruppe bereitstellen. Im Allgemeinen konzentrieren sich Produkt- und Abfallgesetzgebung stärker auf Elektronik als auf Textilien.

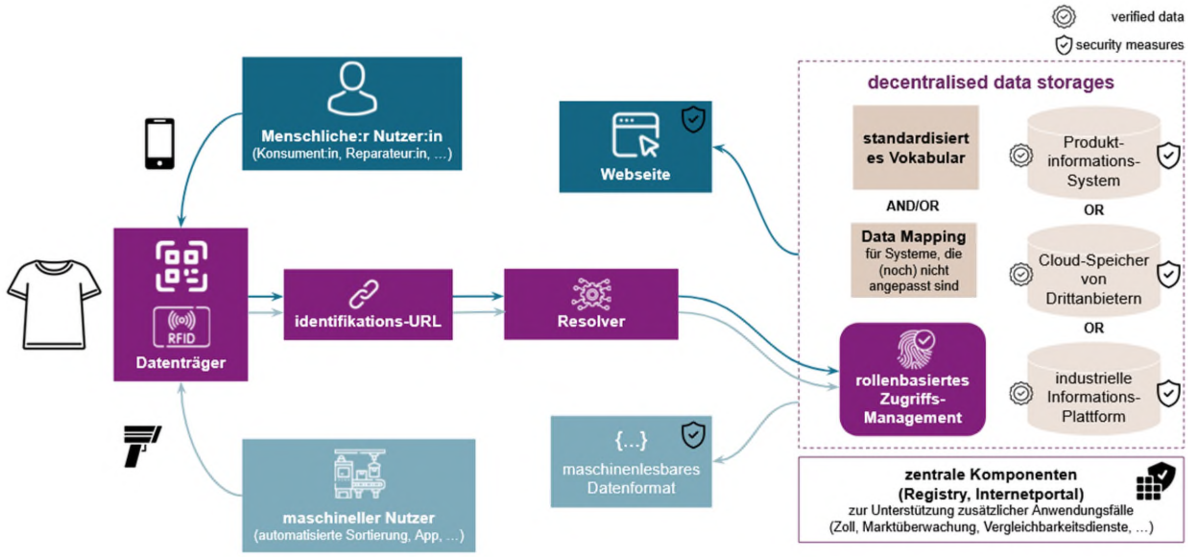
Anforderungen von Textilabfallbehandlungsanlagen

Im Sektor Textilien erschweren Ausnahmen in der Textilverordnung (EU) Nr. 1007/2011 die Sortierung. Wichtige Materialinformationen müssen nicht offengelegt werden, wenn ihr Anteil im Produkt unter einem bestimmten prozentualen Schwellenwert liegt. Die Stapelfaserlänge ist insbesondere für das mechanische Recycling und das Garnspinnen relevant, da sie die möglichen Recyclingzyklen und die Qualität bestimmt (niedrigere Faserlänge bedeutet geringere Qualität). Um sich für einen bestimmten Recyclingprozess zu entscheiden, werden die Faserzusammensetzung und nicht-textile Materialien (z. B. Knöpfe, Membranen) sowie Informationen über Farbstoffe, Anwendungen sowie schadstoffhaltige Materialien als notwendig erachtet. Die Schwellenwerte für die Deklaration des Materialgehalts in der Textilgesetzgebung werden nicht als angemessen betrachtet. Somit muss ein geringer Metallgehalt in Textilien normalerweise nicht deklariert werden, wobei selbst kleine Mengen die Qualität von recycelten Textilien verschlechtern. Die Recyclingtechnologie muss mit solchen Unsicherheiten umgehen können: im mechanischen Recycling werden Informationen über gefährliche Substanzen benötigt, da diese im neuen Material nach dem Zerkleinern und Recycling verbleiben. Das chemische Recycling andererseits kann gefährliche Chemikalien entfernen, aber der anschließende Umgang und die Entsorgung von gefährlichen Chemikalien sind aufwändig.

Produktinformation 4.0 Konzept (technische Infrastruktur) und rechtliche Empfehlungen

Teil C analysiert Aspekte der technischen Infrastruktur, die erforderlich sind, um Produktinformationen für Stakeholder entlang der zirkulären Wertschöpfungskette in einem Produktinformationssystem bereitzustellen: Vokabular, Ontologie und Taxonomien; Datenspeicherung; Datenaustausch; Eigentum und Datenüberprüfung; Zugangsmanagement, Identifikatoren und Datenträger. Bestehende Ansätze und Technologien werden diskutiert sowie die Frage, inwieweit die verschiedenen Aspekte standardisiert werden müssen, um eine nahtlose Interoperabilität zu ermöglichen.

Figure 8: Überblick und Zusammenhänge der technischen Aspekte eines Produktinformationssystems



(Quelle: Circular Fashion 2022)

Standardisiertes Vokabular

Die Standardisierung von Vokabularen, Ontologien und Taxonomien zielt darauf ab, technische Interoperabilität zu erreichen und das Verständnis der Benutzer zu verbessern, insbesondere um Verbraucher:innen fundierte Kaufentscheidungen zu ermöglichen. Idealerweise sollten standardisierte Vokabulare auf bestehenden Standards aufbauen, um die Interoperabilität zu erleichtern. Sie sollten auch erweiterbar, flexibel, skalierbar, konsistent und maschinenlesbar sein. Die Vielfalt bestehender Standards stellt jedoch eine Herausforderung dar, da der Übergang zu einem einzigen neuen Standard aufwendig sein kann. Die sektorübergreifende Interoperabilität ist insbesondere für Zulieferer von Teilen oder Komponenten, die mehrere Branchen bedienen, eine weitere Herausforderung. Pro Sektor müssen eigene Informationsanforderungen definiert werden. Basierend darauf können standardisierte Datensätze erstellt werden, die die Anforderungen branchenübergreifend erfüllen. Obwohl ein vollständig standardisiertes Vokabular wünschenswert ist, erfordern praktische Einschränkungen - jedenfalls zu Beginn - die Arbeit mit standardisierten Mindestdatensätzen pro Produktgruppe, ergänzt durch modulare Datensätze, um sektorspezifische Anforderungen zu erfüllen. Diese Studie schlägt vor, Datenaustausch- ("Data Mapping") tools zu verwenden, und zudem in Ergänzung zu den Mindestdatensätzen auch nicht-standardisierte Daten zuzulassen. Hierdurch wird eine effektive technische Interoperabilität mit einer Balance zwischen Standardisierung und Flexibilität gewährleistet.

Bezüglich der rechtlichen Herausforderungen der Datenspeicherung:

- Stakeholder sollten die Wahl haben, Informationen entweder auf eigenen Servern oder bei einem Drittanbieter zu speichern.
- Neben der dezentralisierten Datenspeicherung sollte ein zentrales Register eingerichtet werden, das von Personen mit berechtigtem Interesse, wie Marktüberwachungsbehörden oder Zollbehörden, zugänglich ist.
- Der rechtliche Rahmen eines Produktinformationssystems sollte auf die Anwendbarkeit der DSGVO verweisen, soweit personenbezogene Daten gespeichert oder anderweitig verarbeitet werden.

Interoperabilität von Daten

Für einen effektiven Datenaustausch ist die Standardisierung sowohl für Mensch-Maschine- als auch für Maschine-Maschine-Schnittstellen entscheidend, um den Zugang und das Verständnis für Verbraucherinnen zu verbessern und gleichzeitig die technische Interoperabilität unter Stakeholdern und bestehenden Systemen sicherzustellen. Ein kritischer Aspekt erfolgreicher Systeme und Plattformen sind die Benutzerschnittstellen, für die die Nutzbarkeit eine hohe Priorität haben sollte. Dies erfordert insbesondere für KMU und globale Stakeholder eine mehrsprachige Oberfläche, benutzerfreundliche Schnittstelle und einfache Lernkurven. Derzeit gibt es keine funktionierende technische Lösung für die Interoperabilität zwischen Systemen, die unterschiedliche Datenstandards verwenden. Ansätze umfassen die zentrale Speicherung von Daten, die Vorgabe eines einzigen Standards oder den Aufbau von Systemen zum Übersetzen von Daten zwischen Standards ("Data Mapping"). Während die zentrale Speicherung nicht empfohlen wird, kann die Kombination eines einzigen Standards mit einer Mapping-Lösung effektiv sein, wobei einige Systeme den Standard direkt übernehmen und andere sogenannte Adapter verwenden. Resolver ermöglichen die Navigation innerhalb des Informationssystems, indem sie Nutzer:innen, die auf Identifikatoren oder URLs zugreifen, beispielsweise aufgrund des Nutzerprofils an entsprechende Datenquellen weiterleiten. Resolver adressieren jedoch nicht die Interoperabilität von Sprache oder Format. Public Key Infrastructure (PKI) und digitale Signaturen können die Infrastruktur für den Datenaustausch verbessern, indem sie Parteien autorisieren und die Datenintegrität sicherstellen.

Bezüglich der rechtlichen Herausforderungen um die Interoperabilität von Daten:

- Die EU-Kommission sollte eine oder mehrere europäische Normungsorganisationen (ESOs) auffordern, eine europäische Norm gemäß Art. 10 der Verordnung (EU) Nr. 1025/2012 über die europäische Normung zu entwerfen.
- Die Norm(en) sollten Interoperabilität, Maschinenlesbarkeit und Zugänglichkeit über menschliche Schnittstellen regeln.

Eigentum, Haftung und Datenverifizierung

Das Eigentumsrecht an Daten ist eine komplexe Angelegenheit mit unterschiedlichen Konzepten, die Verantwortlichkeiten entweder dem Datenschöpfer oder dem Vermarkter des Produktes zuschreiben. Die EU verzichtet bewusst darauf, ein Eigentumsrecht an Daten zu schaffen. Teil C des Berichts diskutiert, wer letztendlich die Verantwortung für Verfügbarkeit, Richtigkeit und Vollständigkeit von Produktdaten tragen sollte. Nachträgliche Datenveränderungen oder -ergänzungen durch Konsument:innen erfordern eine sorgfältige Berücksichtigung möglicher Verbraucherrechte und -pflichten, insbesondere hinsichtlich der Datenqualität. Schritte zur

Sicherstellung der Datenqualität umfassen automatische Validierungsprüfungen, manuelle Überprüfungen und die Sicherstellung der Datenintegrität durch unveränderbare Datenmethoden, wie z.B. die Blockchain-Technologie. Finanzielle Anreize können geschaffen werden, mit denen Unternehmen zur Verbesserung der Datenqualität ermutigt werden, auch können Strafen und regulatorische Maßnahmen getroffen werden. Insbesondere für KMU und Zulieferer aus dem globalen Süden sollten zusätzliche Unterstützungsmaßnahmen getroffen werden. Regulation, Audits und Zertifizierung können Datenquellen für die Datenqualität zur Rechenschaft ziehen, wobei sich allerdings damit verbundene Kosten, auf die Produktpreisgestaltung auswirken könnten, es sei denn, sie werden durch Systeme wie die erweiterte Produzentenverantwortung (EPR) incentiviert.

Bezüglich der rechtlichen Herausforderungen um Eigentum, Haftung und Datenverifizierung:

- Für die Speicherung personenbezogener Daten in einem Produktinformationssystem sollte die DSGVO gelten.
- Zugriffsrechte und andere Rechte (lesen, schreiben, löschen, abrufen, hinzufügen usw.) sollten in anwendbaren europäischen harmonisierten Normen spezifiziert werden. Es ist wichtig, nachverfolgen zu können, wer Zugang zum System hatte und welche Änderungen oder Ergänzungen usw. von einem Akteur vorgenommen wurden.
- Es sollte einen Rahmen für die Haftung bei der Bereitstellung ungenauer oder unzureichender Daten geben. Wenn es keine Konsequenzen für die Bereitstellung ungenauer oder unzureichender Daten gibt, ist zu erwarten, dass Stakeholder, insbesondere Verbraucher, den Daten aus dem System nicht vertrauen können / werden.

Zugangsmanagement und den IP-Schutz

Der Schutz von Geschäftsgeheimnissen und intellektuellem Eigentum (IP) kann durch ein Zugangsmanagement geregelt werden. Ziel sollte es sein, einen Datensatz für die Öffentlichkeit zu definieren, der keine sensiblen Informationen preisgibt und dennoch alle relevanten Anwendungsfälle der Kreislaufwirtschaft unterstützt. Gelingt dies, würde dieser Ansatz ein komplexes, rollenbasiertes Zugangsmanagement überflüssig machen. Es ist jedoch wahrscheinlich, dass bestimmte erforderliche Informationen nicht öffentlich geteilt werden können. Ansprüche auf Geheimhaltung sowie Anfragen nach spezifischen Details sollten auf ihre Legitimität hin überprüft werden. Wenn einige notwendige Informationen nicht öffentlich zugänglich gemacht werden können, ist ein rollenbasiertes Zugangsmanagement basierend auf dem Need-to-Know-Prinzip ratsam. Benutzerprofile sind die Basis für das Produktinformationssystem, um relevante Informationen zu liefern und gleichzeitig den IP-Schutz zu gewährleisten. Andere Lösungen, wie die Datenfreigabe auf Anfrage, könnten aufgrund von Zeitbeschränkungen bestimmter Anwendungsfälle, wie etwa der Sortierung entsorgter Produkte, unpraktisch sein. Da individuell gestaltbare Zugriffsrollen bei Mindestdatensätzen zu Komplexität und Inkonsistenzen führen können, sollte die Gesetzgebung die Zugriffsrechte der Stakeholder festlegen und dabei die Perspektiven von Industrie, Gemeinschaft und Datenquellen berücksichtigen. Das Teilen zusätzlicher Informationen mit bestimmten Nutzergruppen kann durch das Zugriffsmanagementsystem unterstützt werden. Technische Lösungen für Sicherheit, Authentifizierung und Autorisierung, einschließlich Single-Sign-On (SSO), sind leicht verfügbar. SSO wird besonders empfohlen, um den Aufwand der Verwaltung mehrerer Anmeldeinformationen für Stakeholder zu reduzieren.

Bezüglich der rechtlichen Herausforderungen um das Zugangsmanagement und den IP-Schutz:

- Datensätze, die der Öffentlichkeit zugänglich sein müssen, sollten nicht zu einer Verpflichtung führen, Geschäftsgeheimnisse oder unter IP-Rechten geschützte Informationen offenzulegen.
- Der Zugang zu Informationen, die ein Geschäftsgeheimnis darstellen oder unter das IP-Recht fallen, sollte, wenn er anders nicht geschützt werden kann, nur zuständigen Unions- oder mitgliedstaatlichen Behörden gewährt werden, die ihre Pflichten nach dem Unionsrecht oder dem anwendbaren nationalen Recht erfüllen.
- Die EU-Kommission könnte Modellklauseln entwerfen, die leicht zwischen (B2B-)Stakeholdern für solche Fälle abgeschlossen werden können, in denen beispielsweise ein Reparateur, Sortierer oder Recycler Zugang zu Informationen benötigt, die als Geschäftsgeheimnis oder anderweitig unter dem IP-Recht geschützt sind.

Um zu veranschaulichen, wie ein Produktinformationssystem aus der Perspektive eines Benutzers aussehen würde, wurde ein Frontend-Demonstrator mit verschiedenen Rollenprofilen entwickelt. Die angepasste Informationsdarstellung für verschiedene Benutzergruppen, insbesondere die Bereitstellung vereinfachter Informationen für Verbraucher:innen, wurde als vorteilhaft erachtet. Die Stakeholder stimmten zu, dass das gewählte Format der Bereitstellung von Informationen in verschiedenen Kategorien nützlich war. Sie konnten durch den Mock-up navigieren und die benötigten Informationen finden. In den Stakeholder-Interviews wurde eine zentrale Komponente für die Eingabe von Produktdaten vorgeschlagen, welche die Ableitung von Vergleichswerten für spezifische Produktgruppen ermöglicht.

Datenträger

Um die Kreislaufwirtschaft durch ein Produktinformationssystem zu unterstützen, müssen Datenträger im Produkt enthalten sein, die eine Verbindung zu den Produktinformationen herstellen. Sie müssen verschiedene Kriterien erfüllen, wie z.B. Langlebigkeit, Speicherkapazität für einen eindeutigen Identifier, störungsfreie Produktfunktion, einfache Lesbarkeit, Schutz personenbezogener Daten und Recyclebarkeit. Verschiedene Datenträgertechnologien können aufgrund der Produktgruppe oder Präferenzen der Stakeholder ausgewählt werden. Produktspezifische Anforderungen sind wesentlich. Verschiedene Produktgruppen haben unterschiedliche Anforderungen, wobei Textilien Haltbarkeit, Waschbarkeit und Unterstützung für effiziente Sortierprozesse erfordern. Optische Codes und passive RFID-Tags sind für Textilien geeignet, wobei Hybrid-Tags für Verbraucher:inneninformationen und Sortiereffizienz empfohlen werden. Die aktuelle Version der WEEE-Richtlinie bzw. deren Umsetzung in nationales Recht verursacht jedoch einige Hindernisse für elektronische Tags (z. B. RFID). Elektronikgeräte brauchen funktionale Datenträger für die Wiederverwendung und das Recycling, wobei Haltbarkeit, Design und Metallgehalt die Wahl beeinflussen. Aktive RFID- und Bluetooth-Tags sind im Allgemeinen ungeeignet – optische Datenträger wie QR-Codes und passive RFID HF/NFC-Tags sind vorzuziehen. Innovationen können gefördert werden, wenn statt der Vorgabe spezifischer Modelle Anforderungen an Datenträger festgelegt werden. Gesetzliche Anforderungen sollten Kriterien wie Haltbarkeit, Verarbeitungszeit, Speicherkapazität, Lesbarkeit, Datenschutz und Umweltauswirkungen umfassen. Das Spezifizieren von Anforderungen an Lesegeräte kann die Investitionssicherheit für Datennutzer gewährleisten. Eine zentrale Produktliste kann Datenträger ergänzen, aber nicht ersetzen - dies würde den Effizienzbedürfnissen der Industrie nicht entsprechen.

Bezüglich der rechtlichen Herausforderungen um Datenträger:

- Die WEEE-Richtlinie sollte geändert werden, um eine rechtliche Ausnahme einzuführen, die klarstellt, dass passive elektronische Tags, die Teil einer Produktgruppe wie Textilien unter dem Produktinformationssystem sind, nicht in den Geltungsbereich der WEEE-Richtlinie fallen. Den Mitgliedstaaten sollte es nicht erlaubt sein, bei der Umsetzung dieser Ausnahme der Richtlinie strengere nationale Regelungen einzuführen (vollständige Harmonisierung).
- Unter dem aktuellen rechtlichen Rahmenwerk der WEEE-Richtlinie und den Umsetzungen in das Recht der Mitgliedstaaten kann es nicht empfohlen werden, elektronische Tags (RFID, NFC) in Textilien als Datenträger für das Produktinformationssystem zu verwenden.
- Ein elektronischer Tag mit einem eindeutigen Identifier könnte potenziell als Tracking-Gerät verwendet werden. In diesem Fall muss die Entität oder Person, die für das Tracking verantwortlich ist, die DSGVO einhalten, einschließlich der Rechtfertigung der Verarbeitung personenbezogener Daten über eine anwendbare rechtliche Grundlage (Art. 6 DSGVO) und der Erfüllung der Transparenzpflichten (Art. 12 ff. DSGVO).
- Eine Analyse des ökologischen Fußabdrucks am Beispiel eines Smartphones zeigt, dass (1) ein solches System unter Verwendung elektronischer Datenträger eine positive Umweltauswirkung haben könnte, indem es die Nutzungsphase durch wahrscheinlichere Reparaturen verlängert und (2) es vermieden werden sollte, eine neue Technologie zu verwenden, da insbesondere die Produktion von Datenlesegeräten erhebliche Umweltauswirkungen mit sich bringen würde. Weitere Analysen der ökologischen Auswirkungen des Systems sind ratsam.

Kennungen (engl. „identifier")

Kennungen sind für Produktinformationssysteme von entscheidender Bedeutung, da sie den cloudbasierten Produkteintrag identifizieren und zugänglich machen können. Kennungen müssen global einzigartig, bis zum Ende der Nutzung des Produkts beständig, klein in der Größe, nutzbar durch alle notwendigen Stakeholder und über das Internet auflösbar sein. Serielle Kennungen auf Artikelebene (engl. „Item level", erlaubt individuelle Identifizierung) sind notwendig für Produkte mit relevanten Reparatur-, Miet- und Wiederverwendungs-/Recommerce-Kanälen, um zirkuläre Geschäftsmodelle zu unterstützen. Für Produkte ohne solche Märkte reicht die Identifikation auf Modell- oder Batchebene aus, um nachhaltige Kaufentscheidungen und Entscheidungen über Recyclingströme zu unterstützen. Kennungen auf Komponentenebene können nützlich sein, wenn erwartet wird, dass Komponenten einen eigenen Reparatur- oder Recommerce-Kanal haben; jedoch benötigen nicht alle Komponenten Datenträger. Ein vorgeschriebenes Identifikationsschema könnte hohe Anfangskosten verursachen, daher wird ähnlich wie bei Datenträgern die Festlegung bestimmter Anforderungen durch den Gesetzgeber empfohlen. Die daraus resultierende Vielfalt der Lösungen könnte auch dadurch gelöst werden, dass der Typ des Identifiers im Produktdatensatz gespeichert wird.

Bezüglich der rechtlichen Herausforderungen um Kennungen:

- Um Datenschutzrisiken zu vermeiden, sollten Kennungen, statt auf Artikelebene, im Allgemeinen auf Modell- oder Batchebene begrenzt sein. Nur in Ausnahmefällen sollten Kennungen auf Artikelebene verwendet werden.

RFID-Etiketten in Produkten speichern in der Regel produktbezogene, nicht personenbezogene Daten. Trotzdem kann ihre Verwendung in bestimmten Fällen zu Datenschutzproblemen führen, wenn sie eine indirekte Identifizierung von Personen ermöglichen, beispielsweise weil in einem Geschäft so viele RFID-Lesegeräte aufgestellt werden, dass ein Trackingprofil der Kund:innen erstellt werden kann. In einem solchen Fall muss das Geschäft oder die Einrichtung, die die RFID-Tags ausliest, die Datenschutzbestimmungen einhalten.

Informationslücken im Kontext eines Produktinformationssystems

Informationslücken und -barrieren, die in Teil A des Projekts identifiziert wurden, betreffen hauptsächlich Materialzusammensetzung, Produktdesign, Service und Informationsanforderungen der Kreislaufwirtschaft. Das Überwinden dieser Barrieren ist entscheidend für die Einrichtung eines interoperablen, verfügbaren und nutzbaren Produktinformationssystems. Das Überwinden und Schließen rechtlicher Informationsbarrieren und -lücken erfordert strengere Vorschriften. Bestehende Informationssysteme können strengere rechtliche Vorgaben nicht ersetzen – zum Beispiel stimmen EPREL und SCIP konzeptionell mit den technischen Anforderungen an Granularität, Zugänglichkeit und Interoperabilität überein, aber die zuverlässig verfügbaren Informationen aus diesen Systemen sind auf das derzeit gesetzlich Vorgeschriebene beschränkt. Die Speicherung von Daten in bestehenden (freiwilligen) Informationssystemen und Plattformen kann heute jedoch eine bedeutende Rolle bei der Erreichung eines umfassenden Produktinformationssystems spielen. Sie können den Informationsbedarf aufzeigen, Speicherplattformen bereitstellen und bei der Datensammlung unterstützen wird. Langfristig sollten die erforderlichen Informationen in allen qualifizierten Systemen in einem standardisierten Format vorgeschrieben und jedes Produkt in einem System registriert werden. Während DPP-Anforderungen in der Entwicklung sind, können bestehende Systeme weiterhin genutzt werden. Das Hinzufügen fehlender Datenfelder zu den bestehenden Systemen ist ratsam, aber hinsichtlich Harmonisierungsbemühungen, z. B. beim Zugangsmanagement, sollte auf klare rechtliche Anforderungen gewartet werden.

Schlussfolgerung zu rechtlichen Empfehlungen für die weitere Entwicklung von Informationsanforderungen

Teil D der Studie behandelt und entwickelt rechtliche Empfehlungen für ein Produktinformationssystem, das eine Kreislaufwirtschaft innerhalb der EU erleichtern würde. Es unterstreicht die rechtlichen Informationslücken und schlägt spezifische Änderungen vor, um diese zu minimieren oder zu schließen. In dieser Zusammenfassung werden die rechtlichen Empfehlungen direkt jedem Thema innerhalb von Teil A, B (Table 5, Table 6 und Table 7) und C (fortlaufender Text) zugeordnet. In Bezug auf den ersten Teil der Studie (Informationsanforderungen und -lücken): Für alle rechtlichen Akte (sowohl bestehende als auch kommende) wird empfohlen, die erforderlichen Informationen und ihre Metadaten (Granularität, Format, Zugang; siehe Methodik Kapitel 1.1) klar zu spezifizieren sowie innerhalb der Gesetzgebung oder harmonisierten Standards die notwendige Infrastruktur zu detaillieren. Jedes Fehlen klarer und spezifischer Verpflichtungen sowie klarer Ausnahmen (wo nötig) kann zu Lücken oder Barrieren führen. Rechtsakte sollten einen gewissen Spielraum für Ermessen und Ausnahmen für Stakeholder lassen, die beispielsweise aufgrund ihrer Ressourcen und Fähigkeiten nicht alle Informationsanforderungen erfüllen können. Für diese Unternehmen sollten klare und eng definierte Ausnahmen oder (finanzielle) Unterstützungen/Anreize geschaffen werden, um erhöhte Anforderungen zu erfüllen.

Im Detail betrachtet würde der Textilsektor von einer umfassenden Materialdeklaration für Stoffe profitieren. Erreicht werden kann dies mit der Beseitigung von Ausnahmen in der aktuellen Gesetzgebung. Die verpflichtende Deklaration könnte auf Farbstoffe und Chemikalien ausgedehnt werden. Die Implementierung von standardisierten Größensystemen könnte Online-Rücksendungen reduzieren. Für den Elektroniksektor konzentrierte sich die Analyse auf die Verbesserung des Zugangs zu Materialinformationen für Sortierer und Recycler unter den Ökodesign- und WEEE-Richtlinien und den Umgang mit der durch das CE-Zeichen verursachten Missverständnis bei Verbrauchern unter anderem unter der RoHS-Richtlinie. Die bevorstehenden Anforderungen der ESPR für einen digitalen Produktpass könnten auch die Ökodesign-Kommissionsverordnung für Displays umfassen und zur Schließung bestehender Lücken/Barrieren z.B. leicht zugängliche und maschinenlesbare Datenträger vorschreiben. Sektorübergreifend: Es besteht ein Bedarf an verbesserten Sicherheitsdatenblättern unter der REACH-Verordnung, verbesserten CLP-Kennzeichnungen und der Digitalisierung von Verpackungsinformationen. Vorschläge zur Schließung bestehender Lücken/Barrieren umfassen eine strengere Durchsetzung der REACH-Verordnung sowie die Einführung digitalisierter Etiketten für Substanzen und Gemische und QR-Codes für Verpackungswiederverwendungssysteme.

Die Analyse des rechtlichen Rahmen (Teil D) des vorgeschlagenen Produktinformationssystems aus Teil C für Elektronik und Textilien umfasst Vokabular, Ontologie und Taxonomie zur Verbesserung der Rechtsklarheit und Kohärenz. Überlegungen zur Datenspeicherung legen ein zentrales Register für Stakeholder mit berechtigtem Interesse nahe, während der Datenaustausch von der EU-Kommission vorgeschriebene Standards zur Sicherstellung der Interoperabilität erfordert. Zugangsrechte, Haftung und Datenüberprüfung innerhalb des Systems sollten klar geregelt sein, dabei sollte die Bereitstellung präziser Daten gefördert werden. Das Zugangsmanagement muss Geschäftsgeheimnisse und IP-Rechte schützen, und die Verwendung von Datenträgern wie RFID in Textilien sollte den Ausnahmen der WEEE-Richtlinie entsprechen und DSGVO-konform sein.

Schließlich ist die Ausgestaltung eins Informationssystems wichtig für die Nutzbarkeit und den einfachen Informationszugang. Zur Umsetzung der ökologischen Ziele/Ziele für die Kreislaufwirtschaft ist es jedoch mindestens genauso wichtig, dass die Informationsanforderungen in den Stoff-, Produkt- und abfallspezifischen Regelungen verankert werden, welche die Informationsanforderungen der unterschiedlichen Stakeholder erfüllen.

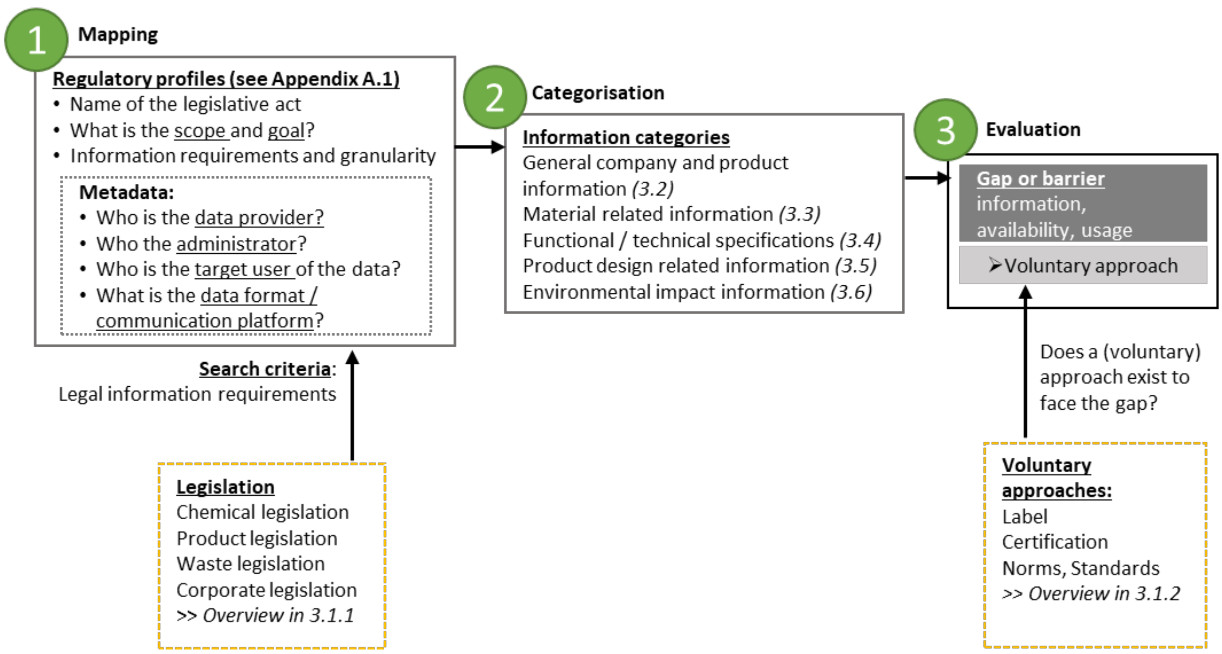
1 Part A – Information requirements for compliance and voluntary approaches

Part A of this study is based on a comprehensive literature and content review that aims to identify and evaluate information that is required for legal compliance or voluntary approaches (e.g., labels, certifications) supporting the general vision and goals of a circular economy (CE). Subsequently, the relevance and implementation of the identified requirements will be evaluated in Part B of this study from a stakeholder perspective.

The evaluation of relevant information requirements is approached in three steps (see Figure 9):

1. Mapping regulatory profiles based on relevant sources (legal acts and voluntary approaches) that address CE goals.
2. Categorisation of information requirements from Step 1 based on the proposed analysis framework from Figure 1 (see summary):
   - General company and product information (see Chapter 1.1.2)
   - Material information (see Chapter 1.3)
   - Functional and technical specifications (see Chapter 1.4)
   - Product design information (see Chapter 1.5)
   - Circularity information (see Chapter 1.6)
3. Evaluation of information gaps and barriers. Identification of (voluntary) approaches that potentially address existing information gaps.

Figure 9: Research approach to identify, map, categorise and evaluate relevant literature



(source: TU Berlin 2022)

1.1 Methodology of the literature review

This study comprises a broad screening of literature and other relevant content on information requirements along the value chain. A value chain is a series of activities that businesses go through to create a product or service. The complexity of the information and data along the value chain can vary greatly depending on the specific industry and the product or service being produced. To reduce the complexity of the screening, the analysis focuses on different scoping criteria:

- Subject matter: the information needs to relate to a material (chemicals, substances, mixtures), product (objects, articles), waste or company.
- Product group: in addition to textiles and energy-related products, the screening includes batteries, automotive, packaging, plastics, and software. This allows the inclusion of learnings from sectors with well-established information requirements, which might face similar challenges.
- Stakeholder relation: a direct relation between a stakeholder (data provider) and the information requirement.
- Operation domain: an information requirement is at least part of one of the following domains of EU legislation and voluntary standards or conventions: Energy; Industrial policy and internal market; Environment, Consumers and Health protection.

The focus of the research is on legislative information requirements and is, if necessary, complemented by voluntary requirements. Voluntary information requirements are criteria or standards that businesses may choose to follow, but are not required by law or regulation. These include industry-specific standards, best practices, and guidelines.

Product information may be documented and disclosed to comply with legal requirements or to obtain voluntary certifications and may either be horizontal or focussed on distinct product groups. Information requirements can thus be defined in legislation or take the form of standards or conventions, the application of which may, again, either be required by law or may be implemented as part of voluntary commitments by companies. The latter is also known as "soft law". In practice, it is not always possible to distinguish between 'hard' and "soft" information requirements, especially with respect to the granularity and accessibility of information. Whether required by law or voluntary, the information requirements analysed must at least be part of an official and binding document that can be referenced and used for the further analysis. Lastly, an information requirement will be defined as relevant if it relates to an existing circular economy goal (see overview in 1.1.1).

In part A of this study the information requirements in the legal acts are described and evaluated towards gaps and barriers, based on objective criteria. The criteria reflect, if the information requirement exists in legislation, if it is made available by the obliged stakeholder and if it is usable by the target stakeholder.

First, legal information gaps are defined as information which does not exist (due to exemptions regarding information requirement in legislation) or which is not available:

- **Legal information gap**: The information requirement <u>does not exist</u>, e.g., due to exemptions. For example, REACH Regulation requires suppliers of articles to identify substances of very high concern (SVHCs), neglecting *other* substances, for example particular substances which constitute impurities within recycling processes.

- **Availability gap**: The information requirement does exist in legislation but is practically not provided or available, e.g., due to a lack of enforcement or structural reasons.

Second, information usage barriers are defined as information that does exist in legislation but is practically not useable by the target information user. The usability depends not only on the existence of the information requirement itself but also the definition of its metadata. The metadata specifies important characteristics how to communicate[3] information between two entities (information provider and target information user). According to ISO/IEC 2382:2015 metadata is defined as: "data about data or data elements, possibly including their data descriptions, and data about data ownership, access paths, access rights and data volatility. Metadata is important for the quality of information because it helps to contextualize the data for example by how it can be accessed or who can access it. It provides additional context for the efficient use of data in practice, which applies to both the analogue and digital world. The four categories of the FAIR principles for metadata (findability, accessibility, interoperability, and reusability) are adapted for this study to identify barriers:

- **Accessibility barrier**: the information requirement exists and is available but can't be accessed, e.g., due to a missing specification of a communication channel (platform, database, peer-to-peer)
- **Format barrier** (interoperability): the information requirement exists and is available but not in a useful format
- **Granularity barrier**: the information exists, is available and can be accessed but is not specified towards its level of detail or can be too detailed or too aggregated.

The findability of the information is arguably most important and similar to accessibility, discussed within chapter 1.1.2 on product and company identification.

For the reusability of information, the stakeholder who is supposed to get the information (data user) needs to be defined. In the screened legislation the target stakeholder is always defined, thus there is no reusability barrier identified.

Validation barrier: some legally required information might be prone to be provided incorrectly. Legislation does generally not require third party validation. Therefore, the validation barrier applies basically to all information requirements. However, for some information the barrier is more relevant and is discussed accordingly in part A (see Chapter 1.3 and 1.6).

For the evaluation of aforementioned gaps and barriers, following aspects were extracted: the name of the legal act, scope and goal, information category, information requirement as well as the metadata including data format, communication medium, information provider, target information user, access rights and period. Using this aspects, regulatory profiles were created for each legal act (see appendix in separate file for all regulatory profiles).

3 See https://www.iso.org/obp/ui/#iso:std:iso-iec:2382:ed-1:v1:en, section code 2121505.

Table 9: Example regulatory profile of the REACH regulation

Legal act	**Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (EC) No 1907/2006 "REACH Regulation"**	
Subject matter and goal	Ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substances, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation.	
Scope	**Art. 31** Substances, mixtures	**Art. 33** Articles as such or complex objects (colloquial term is "products")
Information category	Hazardous substance identification Risk/hazard related information, handling and usage information	Substance identification (SVHCs) Article handling and usage information
Information requirement and granularity	Art. 31 (5) Requirements for safety data sheets Identification of the substance/mixture and of the company/undertaking On request: Identification of non-hazardous mixtures containing hazardous substance (above threshold) Hazards identification Composition/information on ingredients; Physical and chemical properties; Information on handling and storage, toxicological; disposal; transport regulatory; Ecological info. (waste treatment): waste treatment containers and methods physical/chemical properties that may affect waste treatment special precautions for any recommended waste treatment option	Duty to communicate information on SVHCs in articles Identification of the article (name, category, ID) Identification of the substances of very high concern (SVHCs) on the Candidate List in a concentration above 0.1% weight by weight (w/w) and location in that article Other information to allow the safe use of the article, notably information to ensure proper management of the article once it becomes waste.
Data provider	Companies producing and importing chemicals and materials in the EU.	EU producers and assemblers, importers, distributors of articles and other actors in the supply chain placing articles on the market.
Data user	User/recipient of substance or mixture incl. part and product manufacturer;	User/recipient of the article, including consumers and waste operators; ECHA
Validity period of directive	Since 1.6.2007	Since 1.6.2007 (Since 5.1.2021 registration obligation to SCIP based on Waste Framework Directive Art. 5(1)(i) and Art. 5(2))
Access / format of information provision	Safety data sheet (SDS) according to ANNEX II	Art. 33 (1) Paper or electronic format Art. 33 (2) to the consumers (paper or electronic) (Waste Framework Directive requires registration of products with SVHCs > 0.1% in "SCIP" database)

Legal act	**Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (EC) No 1907/2006 "REACH Regulation"**	
Access rights and periods	Art. 31 (1) SDS to be made accessible for the recipient of the substance or mixture	Art. 33 (1) Information on SVHCs > 0.1% must be provided by the supplier to the recipient at the time of delivery Art. 33 (2) To be made accessible to a consumer upon request, free of charge, within 45 days
Administration of data(-base)	Peer to peer information exchange (SDS)	Peer to peer information exchange

All relevant legislative acts were screened systematically in this manner. The texts of EU law, available in the eur-lex website[4], do not follow a standardised structure for the definition of the information requirements and metadata. However, they are mostly explicitly addressed and show a common section or title, for example "Information requirements" or "Material efficiency requirements", which mostly allows a distinct determination of the collected aspects.

Next, the regulatory profiles were used to evaluate the correct specification of the information requirements and metadata. Gaps and barriers were identified based on above criteria. Where necessary, additional literature like position papers from associations were included, in particular to support barriers. Part A therefore is based on literature findings. It is methodologically separated to part B, which will reflect the gaps and barriers with the stakeholder demand, identified in workshops, interview and a consumer survey.

To provide more guidance to readers, each section is structured by an introduction on the information requirement according to the legislation. Barriers and gaps are elaborated in the grey box. Potential voluntary approaches or other activities to close information gaps, in particular voluntary approaches are discussed beneath in the light grey box. Example description:

Description of potential information gaps and barriers of the legal act

► Description of (voluntary) approaches or activities that intend to close the legal information gap

1.1.1 Screened legislation

Regarding the predefined search criteria, the sources in Table 10 on current and upcoming legislation were identified as relevant. Legislation largely stipulates upstream and circularity information requirements, to be provided by upstream stakeholders, mostly manufacturers, EU importers or authorised representatives; therefore, part A refrains from addressing these requirements separately.

Each legal act is clustered into a legal area by its subject matter (chemical, product, waste, corporate) as well as the information requirement by four dimensions as described in the method section.

[4] https://eur-lex.europa.eu/homepage.html

Table 10: Allocation of analysed EU legislation with relevant information requirements into information categories of the analysis framework (see Chapter 1.3).

Legal area	Description	Material information	Functional and technical spec.	Product design information	Circularity information
Chemicals legislation	Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals “REACH Regulation”	x			
	Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures “CLP Regulation”	x			
Product legislation	Regulation (EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products “Textile Regulation”	x			
	Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products “Ecodesign Directive”		x	x	x
	Example: Commission Regulation (EU) No 617/2013 with regard to ecodesign requirements for computers and computer servers “Ecodesign Regulation Computer”		x	x	
	Example: Commission Regulation (EU) 2019/2023 laying down ecodesign requirements for household washing machines and household washer-dryers “Ecodesign Regulation Washing Machines”		x	x	
	Example: Commission Regulation (EU) 2019/2021 laying down ecodesign requirements for electronic displays “Ecodesign Regulation Displays”		x	x	
	Regulation (EU) 2017/1369 setting a framework for energy labelling “EEL Regulation”		x	x	
	Proposal establishing a framework for setting ecodesign requirements for sustainable products, COM(2022) 142 final, 2022/0095(COD) “ESPR Regulation Proposal”		x	x	x
	EU Strategy for Sustainable and Circular Textiles (COM(2022) 141 final) “Circular Textiles Strategy”		x		x
	Regulation (EU) 2018/858 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles “Type Approval Regulation”		x	x	

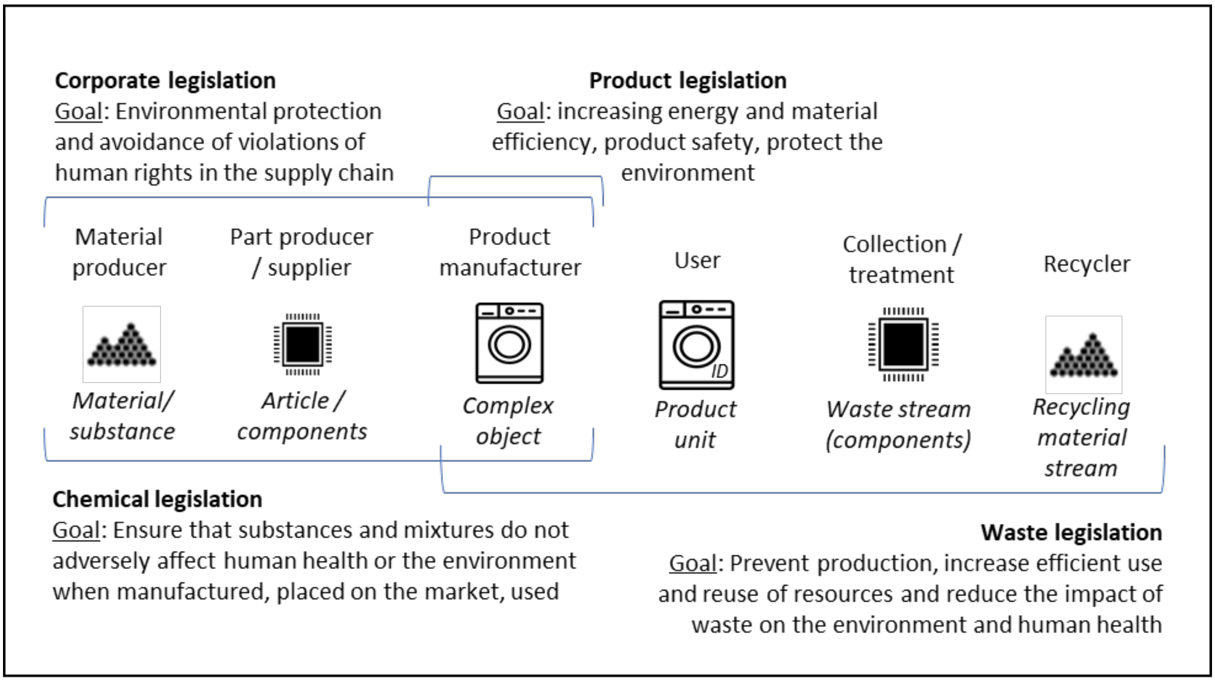
Legal area	Description	Material information	Functional and technical spec.	Product design information	Circularity information
Waste legislation	Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators “Battery Directive”	x			x
	Regulation (EU) 2023/1542 concerning batteries and waste batteries “Battery Regulation”	x	x	x	x
	Directive 2000/53/EC on end-of life vehicles “ELV Directive”	x	x		
	Directive 94/62/EC on packaging and packaging waste “Packaging Directive”		x		
	Directive 2012/19/EU on waste electrical and electronic equipment “WEEE Directive”	x	x		
	Directive 2008/98/EC on waste (Waste Framework Directive) “WFD Directive”	x			x
	Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment “RoHS Directive”	x			
Corporate legislation	Proposal for a Directive on Corporate Sustainability Due Diligence, COM(2022) 71 final, 2022/0051(COD) “CSDD Proposal”				x
	Regulation (EU) 2017/821 on supply chain due diligence “Conflict Mineral Regulation”, “CMR”	x			

Regulatory profiles have been created for these legal acts as shown in the example in Table 9, using the example of REACH Regulation and extracted information.

European legislation – subject matter, goal and scope

This study screened 18 legal acts (including proposals and strategies) with relevant environmental goals. To provide a basic understanding of the legal acts and related information requirements, the illustration in Figure 10 shows a structure where each legal act is clustered by its subject matter: chemical, product, waste and corporate legislation.

Figure 10: Cluster of legal acts by subject matter with summarised goals and scope



(source: TU Berlin 2022)

For each cluster the goals of related legal acts are summarised. Chemical and waste legislation aim to improve environmental protection on material level, while product legislation mostly sets requirements to protect the environment and ensure product safety or is related to the product design. Some requirements overlap between the clusters, for example information on product disassembly are required in waste as well as product legislation.

The scope, indicated by square brackets (see Figure 10), is defined by the stakeholder (and information provider) who has to fulfil the legal obligation. The scope does not include the information user, however from an information perspective these are important as this study aims to identify if information requirements are appropriate and useful. The end-user is within the scope of waste legislation (Directive 2008/98/EC on waste, Waste Framework Directive or WFD), which requires EU member States to set obligations on private entities for a separate collection of waste.

Material related information is provided by GOTS, Blue Angel (textiles) and Nordic Ecolabel (textiles)(chapter 1.3.1.3) including specific information requirements on fibre production, chemicals used in production and coatings, laminates, membranes and adhesives.

Moreover, TCO Certified, EU Ecolabel and the TÜV Rheinland Green Product provide due diligence information in chapter 1.6 including supply chain responsibility, responsibility sourced minerals or on anti-bribery management systems.

Further, Circular Design Criteria and circularity.ID are mentioned in chapter 1.3.1.3. Both initiatives give guidance on product recyclability and circular product design based on their collected information.

The Information for Recyclers (I4R) Platforms provides information for disassembly on legally relevant materials as well as component level to recyclers. Catena-X is a cross-industrial GAIA-X data infrastructure initiative and International Data Space standard which allow secure, sovereign and standardised data exchange, while IMDS provides all the necessary information to comply with national and international standards, laws and regulations.

Lastly, there are Scan4Chem and ToxFox which are smartphone apps that help end-users to get information on the legally required information on the content of SVHCs in various products of daily use.

1.1.2 Screened voluntary approaches

There is a variety of voluntary approaches for the provision of information that follow CE goals and that therefore are potentially relevant to this study. Screened voluntary approaches include labels, initiatives, concepts, norms, standards and projects. They are analysed for their potential to close information gaps in legislation, for example by providing additional information, compliance guidance for manufacturers, or supporting sustainable purchasing of consumers. It was found that in particular information on material identification, social responsibility and circularity (environmental impact) is required by the voluntary approaches. In addition to providing missing information, efforts are also being made to close gaps in the technical infrastructure or visual communication (front-end, websites) through voluntary initiatives and concepts. Appendix A.2.1 provides a table with an overview of DPP-related labels, initiatives and concepts, norms and standards as well as projects that fit the criteria described in the methodology section. The table does not claim completeness, but demonstrates exemplary label used as a basis for analysis. The categorization aims to provide some orientation, but it is important to note that one approach can fit into multiple categories. For example, the project Tex.it can be categorised either as a project or a concept. The Digital Nameplate 4.0 is a standard for information provision and at the same time gives practical guidance similar to a concept.

The following section shows as selection of voluntary approaches that potentially fill particular legal gaps, described accordingly om the following chapters. The voluntary approaches are displayed in a condensed structure as follows: *name, area* and *information requirements* (categories). Each voluntary approach is screened for an information requirement and categories by the four dimensions which were introduced in section

Table 11: Information requirements of voluntary certification and labelling schemes for textile and electronic products

Name	Area	Material information	Functional and technical spec.	Product design information	Circularity information
Blue Angel (computer)	Electronics		x	x	
EU Ecolabel (computer)	Electronics		x	x	x
Nordic Ecolabel (ICT)	Electronics	x			x
TCO Certified	Electronics	x	x	x	x
TÜV Rheinland Green Product Mark (Laptops, ICT, household appliances)	Electronics	x	x	x	x
EU Ecolabel	Textiles	x	x		x

Name	Area	Material information	Functional and technical spec.	Product design information	Circularity information
Nordic Ecolabel	Textiles	x			x
Global Recycled Standard	Textiles	x			
TÜV Rheinland Green Product Mark (Textile)	Textiles	x			x
Blue Angel	Textiles	x	x		x
OEKO-TEX® (ECO PASSPORT)	Textiles	x			
Global Organic Textile Standards	Textiles	x			x
Grüner Knopf	Textiles	x			x
circularity.ID	Textiles	x			x
Circular Design Criteria	Textile	x			x
ToxFox	Cross-sector	x			
Scan4Chem	Cross-sector	x			
I4R-Platform	Electronics				x
IMDS	Automotive	x			
Catena-X	Automotive	x			x

Material related information is provided by GOTS, Blue Angel (textiles) and Nordic Ecolabel (textiles)(chapter 1.3.1.3) including specific information requirements on fibre production, chemicals used in production and coatings, laminates, membranes and adhesives.

Moreover, TCO Certified, EU Ecolabel and the TÜV Rheinland Green Product provide due diligence information in chapter 1.6 including supply chain responsibility, responsibility sourced minerals or on anti-bribery management systems.

Further, Circular Design Criteria and circularity.ID are mentioned in chapter 1.3.1.3. Both initiatives give guidance on product recyclability and circular product design based on their collected information.

The Information for Recyclers (I4R) Platforms provides information for disassembly on legally relevant materials as well as component level to recyclers. Catena-X is a cross-industrial GAIA-X data infrastructure initiative and International Data Space standard which allow secure, sovereign and standardised data exchange, while IMDS provides all the necessary information to comply with national and international standards, laws and regulations.

Lastly, there are Scan4Chem and ToxFox which are smartphone apps that help end-users to get information on the legally required information on the content of SVHCs in various products of daily use.

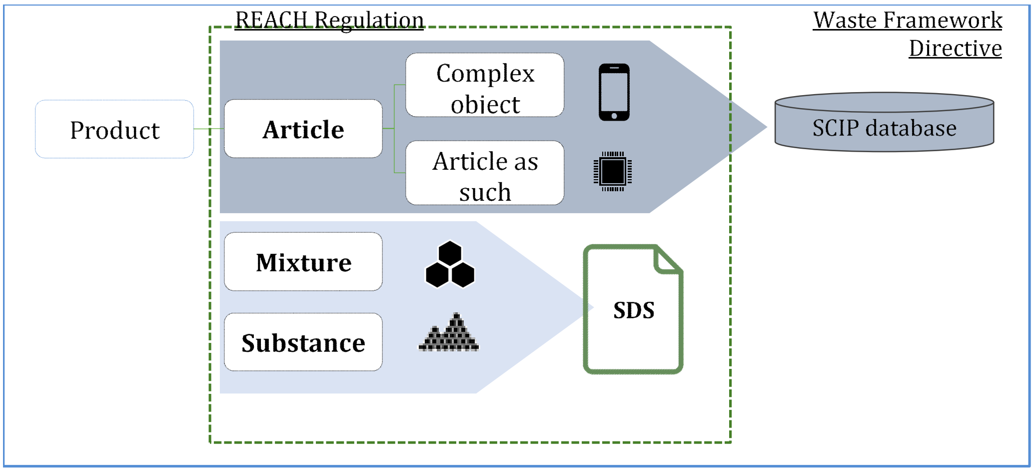
Accessibility (findability) barrier: The identification of products and companies is mostly determined and therefore findable. However, the variety of identification requirements in

legislation results in low accessibility, which entails several challenges (e.g., ambiguity, additional effort, etc.). It does not directly affect CE goals but could increase efforts for market surveillance to identify identical companies or fraud.

- The current proposal of the Ecodesign for Sustainable Products Regulation (ESPR) (COM/2022/142 final) formulates general requirements for the identification of products as well as operators and facilities that should participate as data providers for a Digital Product Passport (DPP). The identifier should be unique and in accordance with ISO/IEC 15459:2015 or equivalent. A technical evaluation of identifiers will follow in the second part of this study.
- Existing systems, such as EPREL or ECLASS classification system use different approaches for the identification (see below), which can be used in further research on the technical development of a DPP concept.

Depending on the regulatory area the subject is identified at substance, mixture or article (product) level. The latter is further grouped by product model, category and type. REACH provides a hierarchical structure, starting from substances, mixtures to articles. A complex object consists of two or more components, each of which is either an article or another complex object (see Figure 11).

Figure 11: Differences in terminology and data format - REACH regulation requires substance and material information to be provided by an SDS. WFD requires product information into the SCIP database



(source: TU Berlin 2022)

As illustrated in above figure, substance and material declarations are required across chemical, product and waste legislation, for different stakeholders and at different levels of detail. Although standards exist to meet the minimum legal information requirements, an extended repository of material information beyond the legal requirements could be useful to address other challenges and provide benefits. Greater detail of information could help, for example, to reduce the administrative burden of information gathering, especially regarding future legal requirements and/or contractual obligations, compliance with industry standards, international trade, communication and product marketing.

The term "product" is not used in the legislation itself, although REACH is officially listed under "product safety" and "chemical product" in the EUR-lex database. The term is commonly used in other regulations, in particular with respect to product legislation, where the term groups complex objects and articles as such. Finally, the harmonisation of terms and identifiers (e.g., regarding the product and the stakeholder) is essential for the implementation of a product passport. Possible ways of identification can be seen in EPREL or the Ecodesign Directive (Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products) (see "digression box" below).

In summary, there are numerous methods of identifying products. GTIN numbers are a global standard, giving rise to product and company information in the retail sector. CAS (Chemical Abstracts Service) registry numbers successfully identify the chemical substances within the product/material mix, although several chemical identification approaches are currently used, e.g., IUPAC (International Union of Pure and Applied Chemistry) -name or CA[5]-index name ("official" name that CAS assigns to a substance). The identification of hazardous or valuable substances in products (i.e., in WEEE) is essential for better recycling. The harmonisation of currently existing terms and identification approaches should be an integral part for the identification of the product and its constituents.

Excursus: Unique product identification approach by EPREL Registration number

Product identification is essential to determine changing characteristics. The EPREL system automatically generates a unique "EPREL Registration Number" per product model registration. The registration number is univocally referring to a specific product model registration. A product is considered a new model if technical parameters change, therefore the term "model" could be misleading and should be seen as the product "version". The QR code that is displayed in Energy Labels (if regulation requires it) univocally points to that record. The registration number is also needed for updating product models in system-to-system mode.

When creating a new model some minimum mandatory data needs to be filled.

- Product group: The product group is automatically determined, based on the data-search screen of that product group (i.e. Electrical lamp).
- Registration number: is unique, automatically generated by the EPREL system per product model registration
- Model identifier: Suppliers freely set a "Model Identifier" of a model (as alphanumeric text). Since this identifier is displayed on both, the Energy Label and the Product Information Sheet, the model identifier is expected to be unique for the same brand/trademark
- Brand/trademark: As explained in Suppliers section, trademarks may be declared at Supplier Organisation level to avoid inconsistencies; Suppliers will be able to choose a trademark from a list of predefined ones if they prefer it, or type a new one.
- The combination "product group + regulation number + supplier name/ trademark + model identifier" has to be unique in the database. Variants of a model, e.g. differing in non-label/Sheet related aspects such as the type of power cable supplied or the colour/finishing, should be considered as equivalent models.

An identifier potentially useful for a DPP needs to be modular in response to changes in the product, its components, chemical composition and stakeholders. For example, it should allow identification of a basic model, but also different versions or batches to reflect changes in

[5] Chemical Abstract

components or materials. It should also allow the identification of the manufacturing company, but also the EU importer. In this logic, an appropriate identifier is similar to the EPREL registration number. It should include: product model identifier + product batch + manufacturer/brand + importer/distributor (+ registration number + administrator). Alternatively, these attributes can be moved from the ID itself to the linked product passport. The ECLASS standard provides further insight into attributes and classes, particularly those used in distribution.

1.2 General company and product information

The identification of the subject (product) and the relevant stakeholder with respect to the product is important for different interested parties, such as for consumers to compare brands and specifications, for repairers to order spare parts based on the product model, or for market surveillance activities. Each legislation stipulates different identification requirements, as shown in Table 12. This constitutes a notable challenge, as identification is essential to merge related product information from different sources. Searchability, accessibility, interoperability and reusability of products and related information can be improved significantly with better data quality, starting with a clear identification of the relevant stakeholder (e.g., a company). General information identifies the company and subject matter (product) can be clustered into:

- Stakeholder identification: in legislation referred to as company, supplier, manufacturer, producer, trademark, distributor, importer, duty holder, authorised representative (of a third country manufacturer). Identification includes, for example, the specification of the name, company address, contact details or UUID (universal unique identifier).
- Subject identification: in legislation referred to as substance, mixture, article, product. Identification means, for example, the material type, model identifier, etc.

Table 12: Overview on company and subject (product) identification requirements in legislation

Legislation	Company identification	Subject identification
REACH Regulation (substances, mixtures)	Identification of the company/undertaking	Substance/mixture identification
REACH Regulation (articles, objects)	Identification of the company/undertaking	Identification of the article (name, category, ID)
CLP Regulation	Name, address, telephone number of supplier	Product identifiers
Textile Regulation	Trademarks or the name of the undertaking	Textile fibre names
Ecodesign Directive	Manufacturer’s name, registered trade name or registered trade mark, and the address	Product type and category, product model number
Energy Labelling Regulation	Name or trademark, address, contact details and other legal identification of the supplier	Model identifier

Legislation	Company identification	Subject identification
WEEE Directive	Name, address, nat. identification code, European or nat. tax number of producer or authorised rep.	Category of EEE, type of EEE
RoHS Directive	Name and address of the manufacturer or authorised representative	Number, unique identification of the EEE
Packaging Directive	/	/
Battery Directive	/	/
Battery Regulation	administrative information about the manufacturer; geographic location of the battery manufacturing plant; battery supplier; name and address of the raw material supplier (Art. 49 (2). (b));	Model identifier; country of origin of the raw material (Art. 49 (2). (c));
ELV Directive	/	Type of vehicle
WFD	Duty holder (legal entity name and UUID)	Article name, primary article identifier type
CMR	Name and address of the supplier to the Union importer	Description of the mineral, including its trade name and type

1.2.1 Classification standards: ECLASS

ECLASS is an example of an industry-led harmonisation approach as a cross-industry classification system for products and related information. It follows the IEC 61360 data standard, which enables the exchange of product information through a universal identification number. The overall goal of ECLASS is to eliminate duplication and data overload for multiple supply chain stakeholders. In addition to manufacturer and supplier identification, ECLASS provides other standardised attributes within the material, product and supply chain domain that can be grouped for the example of a smartphone:

- Manufacturer and supplier identification (brand, URI (uniform resource identifier), GLN (global location number), etc.)
- Material information (CAS, RoHS compliance, certificate, etc.)
- Product information (weight, URI, GTIN, article number, etc.)
- Waste related information (WEEE category, WEEE registry number, etc.)
- Trade/Customs related information (EU customs tariff number TARIC, HS code of the WCO, etc.)

These categories reflect legislative requirements and cover important information categories. The full set of information requirements is listed in Table 18. The ECLASS directory serves with a structured and scalable informational architecture for standardised communication in 38 sectors including textiles, automotives, electronics, logistics, food and more sectors. In this respect, it is highly relevant for the dissemination of information, as it anticipates and reflects practically relevant and standardised information and communication formats on various product groups.

Other parametric classification standards besides ECLASS (industrial) include: EDIBATEC (electronics), EPIC (construction), ETIM (technical data, electronics), GPC (cross-sectoral), Proficlass (cross sectoral), UniClass (construction).

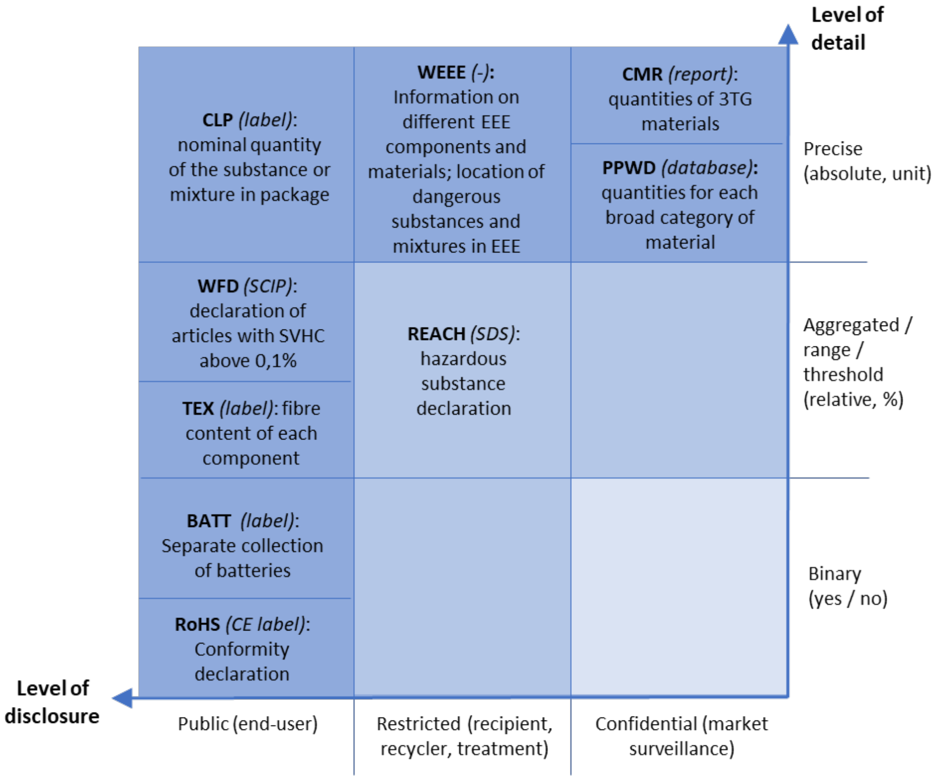
1.3 Material related information requirements

Material related information is mainly required in chemical and waste legislation. The aim of this legislation is to regulate and/or exclude hazardous substances from the product / material cycle. This is, inter alia, achieved by more detailed product legislation which stipulates requirements for specific substances. Detailed information is therefore in particular relevant to manufacturers to adhere to the relevant legal acts and ensure the absence of potential hazardous substances as well as a conflict-free material origin. For consumers, product information is useful to scrutinize the product for materials relevant specifically to them and for sustainable purchasing. For recyclers, detailed product information is useful to reject impurities from waste streams.

1.3.1 Material content

Information requirements on material content vary across the legislation in terms of the level of detail and disclosure obligations, e.g., towards authorities, the public or upon consumer requests, as illustrated in Figure 12. For example, the RoHS Directive does not require information on the exact or absolute amount of materials, but rather a declaration of the absence of hazardous substances (yes/no), which is visible to the public as part of the conformity declaration under the applicable CE marking. It can be seen that aggregated information is more useful for end-users including consumers, while more detailed information is needed for specific stakeholder groups such as the recipient of a substance or professional users, waste treatment facilities, recyclers or market surveillance. The format for the provision of information, indicated in brackets, shows whether the information is made available to the end-user physically (e.g., label, marking) or digitally (e.g., SCIP database). The overview provides a basis for the discussion in the next sections and subchapters whether a particular format might be too aggregated or too detailed for users.

Figure 12: Categorisation of legal acts with information requirements on material content by level of disclosure and aggregation



(source: TU Berlin 2022)

The figure shows the level of disclosure of information requirements as it is accessible in practice to the specific stakeholder group. This practical perspective is important to assess whether the information is accessible and understood by the intended user group. For example, in practice the CE marking is visible on products to consumers, although this information is not specifically intended for consumers, but for market surveillance authorities.

The following sub-chapters identify gaps and barriers in the legislation (dark grey boxes) and describe approaches to address these gaps (green bullet point, light grey box). As stated in the methodology section, there are considerable gaps in the usability of such information, in particular due to the lack of a uniform understanding or a definition for metadata-related aspects.

Availability gap, granularity and validation barrier: A barrier to information availability on material content which is applicable across all legislation arises due to supply chains starting outside the EU. Entities who are not directly addressed by EU legislation, such as material producers or indirect suppliers are not obliged to provide information (in the right format, language or detail) that may be required by EU legislation. However, entities acting in the EU are obliged to gather legally required information.

Private initiatives such as the International Material Data Space (IMDS) in the automotive sector provide a system to gather material information internationally, including a technical infrastructure, central data storage, guidance on the data format, language and level of detail of information. It enables material producers and suppliers to provide all the necessary information to comply with national and international standards, laws and regulations (e.g., REACH Regulation / SCIP and ELV Directive). To note, substantial characteristics of the automotive industry are its long existence as well as the few large companies and few product (car) models that dominate the market compared to e.g. the electronic sector. Thus, the automotive industry creates an enforcement up the supply chain which might contribute to an overall better data collection, while offering support through the IMDS. Currently, "Catena-X" is being developed as an integrated, collaborative, open data ecosystem for the automotive industry by the Catena-X Automotive Network e.V. Compared to the IMDS, Catena-X is based on the cross-industrial GAIA-X data infrastructure initiative and International Data Space standards which allow secure, sovereign and standardised data exchange. An analysis on existing data exchange systems will be available in part C of this study.

In 2014 the **ZVEI "Leitfaden Materialdeklarationen innerhalb der Lieferkette"** specifies three potential stretegies of material disclosure. The technical documentation required to establish legal conformity is contained in the harmonized standard EN 50581: 2012 and updated EC 63000:2019-05 'Technical documentation for the assessment of electrical and electronic devices with regard to the restriction of hazardous substances'. [ZVEI 2014]

- **Level 1** "minimum approach" A supplier's declaration or contractual agreement confirms that the concentrations of the defined substances contained in the material, component or assembly do not exceed the maximum permitted values.
- **Level 2** Material declaration based on a list of substances: e.g. in the IEC 62474 database 'Declarable substances and groups of substances', identifies all substances on the list with an indication of their amount or proportion if they are in the product.
- **Level 3** demand specific material declaration incl. weight like Full Material Declaration (FMD): no standard definition exist. Materials as well as their depth of declaration are individually to specify and not generalizable.

Every strategy comes with benefits and risks or efforts which can be clustered into:

- **IP protection** – risks of disclosing critical information in an FMD are low, as relevant substances can be declared anonym, except restricted, prohibited or declarable substances
- **Effort for declaration** – is low for level 1 and 2. The effort to maintain a FMD in particular for complex parts or products is high.
- **Data availability** – very low on the level of complex parts and therefore a FMD can't be maintained. In the optimal case, the precious supplier provides all necessary declaration for a FMD at the complex product.
- **Assessment of new substances obligations** – FMD allows for an assessment when substance list will be updated.

In IEC-62474 and similar IPC 1752, necessary data point follow the requirements from lists of RoHS substance restrictions, REACH Candidate List SVHC, REACH Substance Restrictions and RoHS Exemptions, which include, if applicable:

- ID, substance group, specific substance, substance clarification, Chemical Abstracts Services (CAS) number, common synonyms
- Typical EEE applications / uses, basis for including, description of basis (specific regulatory citation or specific market demand)
- Reportable application(s), reporting threshold level in product (unless otherwise specified), reporting requirement (whether mandatory or optional), mass information requirements
- First added, last revised, comments / footnotes

Based on the similar minimum-maxium material declaration principle, the Proactive Alliance evualtes different strategies and existing standards for substance and material reporting. The alliance aims to provide recommendations and strategies for "a cross sectoral harmonization on how to report on Substances in Articles along the supply chain on a global level". It is represented by global stakeholders from 12 sectors including automotive, chemicals, electrical and electronic, textiles as well as research and software developers. In 2020 a discussion paper has been published with technical recommendations.

The alliace provides an overview with options and recommendations usable for each sectors to develop their own sectoral Substances Reporting List (SRL) to facilitate the "Substances in Articles" reporting in their supply chain (Table 13). In principle a minimal reporting strategy is possible with low initial effort that foresees a substance reporting which meets legal requirements by current regional law. However to gain flexibility and meet future legal requirments, the list might be extended by all substances that are relvent e.g. to the public or for label, for global trading and reporting which entails the decleration of substance treshold or quantities. The outcome of the discussions of the proactive alliance are recomndations on the right side of the table with a positive (+) recommendation, neutral (0) to be considered in spacific cases or no (-) recommendation. The recommendations can be seen decleration options and discussion basis wihtin the DPP developments.

Table 13: Options and recommendations to determine the Substances Reporting List

Criterion	Option	Description	Rec.
1. Definition of the reporting requirements	a: Hazard based requirements	Only those substances that fulfill the criterion of being "hazardous substances"[1] are included (refers to the respective triggers described in criterion 2a-d).	+
	b: other requirements	Substances are added because of other reporting requirements (e.g. rare earth, conflict minerals, recycling, responsible/sustainable sourcing, etc.)	0
2. Definition of the trigger for substance selection/addition/inclusion	a: Legal approach	Ist he substance regulated[2] globally/regionally (→4) by a governmental agency or authority as a "hazardous substance" [1]? E.g., EU REACH Candidate list (SVHC), California Prop65, China REACH, EU RoHS & China RoHS.	+
	b: Proactive legal approach	Is the substance projected to be regulated[3] globally/regionally (→4) by a governmental agency or authority as a "hazardous substance" [5]?	+
	c: Risk approach	Is the substance associated with a hazard[4] to human health or the environment, and could its presence in a material or part in an assembly create a significant risk[5] to human health or the environment?	+
	d: Hazard approach	Is the substance associated with a hazard[4] to human health or the environment (without currently being covered by 2a-c)?	0
	e: Reputation approach	Is the substance not "hazardous" but associated with a significant public discussion which might endanger a company/sector reputation (applicable only if 1b selected)	0

3. Definition of the threshold	a: Threshold by law	Threshold levels will be based on the global/regional levels required by regulation. The same substance could require different obligations (e.g. thresholds) →Multiple entries/parameters per substance (→4)	+
	b: Threshold by own/external data	Threshold levels will be reasonably required by scientific evaluation of own/external data. The same substance could have different requirements (e.g. thresholds) → Multiple entries/parameters per substance (→4)	0
4. geographic scope of the jurisdiction	a: Global scope (Best in Class)	If a substance is regulated differently in individual regions it results in one SRL entry following the most stringent requirement that is globally applicable.	+
	b: Regional scope	If a substance is regulated differently in individual regions, it results in several SRL entries for each individual requirement.	-

(Pro-active Alliance 2021)

The alliance further states the need for a harmonised "Material Reporting Standard" compatible with the Full Material Declaration (FMD) that shall be able to handle all types of information levels, support data collection for conformity along all industries, refer to unique identifiers (e.g. substance lists/CAS numbers) and needs to be future-proof. Industrial material reporting standards to be considered for harmonisation include IPC 1752A and B, IEC-62474 and other (proprietary) formats and tools like the IMDS or chemSHERPA. The IPC 1752A and IEC-62474-2 are mostly aligned towards interoperability and a translator tool available. Revised IPC 1752B supports ECHA SCIP reporting and new automotive requirements.

1.3.1.1 Cross sectorial requirements

Material related information for the recipient of the substance or mixture

According to the **Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals** (REACH Regulation) substances or substances in mixtures produced or imported in the EU in quantities over one tonne per year have to be registered in the ECHA database in the form of a registration dossier. The latter comprises, where applicable and amongst other, information on intrinsic properties, toxicological potential and the substance's hazard classification. In certain cases manufacturers or suppliers have to pass on a safety data sheet (SDS) in the industrial or commercial supply chain (recipient of the substance or mixture) in paper or electronic format. The information is important for transmitting safety information on hazardous substances and mixtures (see Appendix A1 table "REACH", Art. 31 for details). The SDS is in many cases based on the information from the registration.

Availability gap: studies[6] [7] show a low data quality or the absence of required information in the registration dossier and safety data sheets. A whitepaper from the European Chemical Industry Council[8] points out that the process to prepare a registration dossier is burdensome for affected

[6] Project F2415: From registration dossier via safety data sheet to workplace risk assessement – Data availability and quality between REACH and Occupational Safety – ongoing study till 2023-02-28 (planned)

[7] REACH Compliance: Data availability in REACH registrations Part 2: Evaluation of data waiving and adaptations for chemicals ≥ 1000 tpa. Final Report. Umweltbundesamt 2018

[8] What it takes to prepare and maintain a REACH registration dossier - FACTSHEET. European Chemical Industry Council (Cefic) 2019

stakeholders. There is also a risk of missing or incorrect information in the SDS provided to the next stakeholder. After all, the stakeholder placing the product on the EU market and it's supplier are legally obliged to comply with the applicable articles of the REACH Regulation and may be subjected to fines for non-compliance. However, it might be difficult for the actor who places the product on the market to trace back or validate the required information with the supplier ex post e. g. in a compliance check.

Information for consumers and users

The REACH Regulation (Art. 33) requires EU manufacturers and assemblers, importers, distributors of articles and other stakeholders in the supply chain who place articles on the EU market to make information on articles with SVHC content above 0.1 weight percent available to consumers upon request within 45 days in paper or electronic format (known as the "right to know").

Accessibility barrier: The potential delay of 45 days and the associated effort to obtain information contradicts certain objectives, e.g., for consumers at the point of sale to make an informed purchase. The information is generally available, but not provided in a practical way, thus constitutes an indirect legal gap.

- Voluntary approaches such as **Scan4Chem** (developed within the AskReach project), and **ToxFox** are smartphone apps that help end-users to get information on the ingredients, composition and content of SVHCs in various products of daily use (cosmetics, textiles, toys, do it yourself articles, sports articles, electronic devices, furniture etc.) by scanning their barcode. The information about SVHCs is provided by a database which is voluntarily filled by product suppliers. If information is not yet available in this database, suppliers are asked to provide it. Scan4Chem and ToxFox offer several functionalities and options to product suppliers that aim to simplify and make the process of providing the requested data to consumers more convenient. These include a (data) supplier front-end, notification of changes to candidate SVHCs and bulk upload (REACH 2018). Finally, the app supports the end-users: they can see the information from the database directly in the app, but for information that is not yet available in the database the apps unfortunately cannot speed up the waiting period granted by the REACH Regulation, which is the main barrier. In addition to information about SVHCs in articles the ToxFox also provides information about SVHCs and other substances in cosmetics. The app CodeCheck mainly provides information about chemical mixtures like cosmetics, detergents etc. which is already available on the packaging of the products.

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) provides a specification standard for the safety data sheet (SDS) at UN level. It became binding in the EU through the CLP Regulation (**Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures**). The CLP Regulation imposes obligations on "manufacturers, importers, downstream users and distributors, as well as producers and importers of certain specific substances and mixtures, to communicate the identified hazards to the other actors in the supply chain, including to consumers." The required communication tool to consumers is a label with information on hazards containing hazard pictograms, signal words, hazard statements, precautionary statements and supplemental information (Art. 17 of the CLP Regulation). Such labels are commonly found on chemical products, cleaning agents, and potentially dangerous goods.

The information required is in line with **Art. 31 of the REACH Regulation** and includes the identification of the supplier and the substance/mixture by an SDS and a label on the packaging of the mixture or substance. Private entities or consumers usually do not have access to the SDS unless suppliers make it publicly available, e.g. in the internet.

Granularity barrier: The required labelling under the CLP Regulation applies for all substances and mixtures, include those for consumers such as cleaning products. It is stated that label is the only tool for consumers, while recital 40 of the CLP Regulation notes that the label "may also serve to draw the attention of workers to the more comprehensive information" in the SDS. However, also the consumer might require more comprehensive information (more granular information or other format). Furthermore, consumers are confronted with a variety of existing markings and pictograms (see Appendix A.1.2).

- The legislative initiative "Chemicals – simplification and digitalisation of labelling requirements"[9] evaluates the introduction of digital labelling for everyday products covered by REACH Regulation, the Detergents Regulation and the Fertilising Products Regulation. It states that consumer protection could be further improved by avoiding that labels are overloaded with information.

Additionally, under Art. 13 of the **Packaging Directive 94/62/EC**, member States shall take the necessary measures to ensure that users of packaging and consumers are provided with information (inter alia) about

- "the return, collection and recovery systems […],
- their role in contributing to reuse, recovery and recycling of packaging and packaging waste,
- the meaning of markings on packaging existing on the market,
- the appropriate elements of the management plans for packaging and packaging waste […]".

Accessibility barrier: The Packaging Directive does not define the format or platform how to access the information as a user.

- The 2022 Proposal for a Regulation on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, states, that packaging would have to be marked with a label containing information on its material composition (Art. 11 (1)). Packaging which is subject to deposit and return systems also needs to be marked with a specific label (Art. 11 (1)). For its implementation the potential for compatible national deposit return schemes should be explored while at the same time cross-border coordination of such systems is proposed. Packaging would have to bear a digital data carrier (such as a QR code) providing information on packaging reusability and facilitating the tracking of the packaging (Art. 11 (2)).

Information for recycler

The information required by the REACH Regulation (Art. 33 (1)) may also be helpful for waste operators to identify impurities in the waste stream. The REACH Regulation does not specify the

[9] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12992-Chemicals-simplification-and-digitalisation-of-labelling-require-ments/public-consultation_en

format and communication medium for information on articles containing SVHCs (Art. 33 (1)). The Waste Framework Directive (WFD) aims to fill this gap by establishing the SCIP database (see Chapter 1.1.1), which provides the technical infrastructure to collect and make available information under the REACH Regulation (Art. 33). Since January 2021, articles with an SVHC concentration above 0.1% (weight/weight) placed on the market have to be registered in the SCIP database.

Legal information gap: The REACH Regulation shows two information gaps. First, it does not require the disclosure of SVHCs in articles below 0.1 % by mass. Second, some materials (and related information on identity, uses, physical, chemical and hazardous properties) are exempt from the registration and evaluation, including polymers (Art. 2 (9))[10], additives and impurities [11]. Other regulations do not set any information requirements, e.g., on paints, varnishes, drugs, cosmetics, foods, cleaning agents[12]. Therefore, relevant information is missing, especially for consumers and waste treatment facilities.

The information accessible through the SCIP database could support the separation of waste containing substances on the REACH candidate list (SVHCs) during collection, disassembly, and sorting of waste. In addition, it could enable to identify material-based streams that could be affected by these substances in articles when they become waste.

Accessibility barrier: The information is provided on an article basis and can only be accessed via the SCIP website. The website requires a manual search process for the articles and may therefore not be effectively accessible in sorting processes.

Information for member states

The **Directive 94/62/EC (as amendment by the Directive 2018/852/EC) on packaging and packaging waste** aims to reduce packaging waste by increasing its reusability, recyclability and other forms of recovery with the help of an extended producer responsibility. Member States need to collect information (through databases) on the "magnitude, characteristics and evolution of the packaging and packaging waste flows [...] at the level of individual member States, including information on the toxicity or danger of packaging materials and components used for their manufacture" (Art. 12 (2)) from all economic operators (defined in Art. 3 (11) as "suppliers of packaging materials, packaging producers and converters, fillers and users, importers, traders and distributors and statutory organizations"). Economic operators must (under the national implementation act, e.g., in Germany "Gesetz über das Inverkehrbringen, die Rücknahme und die hochwertige Verwertung von Verpackungen (VerpackungsG)) register with the relevant database (e.g., in Germany the register "LUCID") and provide information on quantities of packaging consumed (produced + imported - exported), reused, recycled, and recovered[13].

[10] https://echa.europa.eu/documents/10162/23036412/polymers_en.pdf/9a74545f-05be-4e10-8555-4d7cf051bbed

[11] https://echa.europa.eu/documents/10162/2324906/annex_v_en.pdf/8db56598-f7b7-41ba-91df-c55f9f626545

[12] https://www.askreach.eu/right-to-know/

[13] 'recovery` shall mean any of the applicable operations provided for in Annex II.B to Directive 75/442/EEC (energy recovery, component recovery)

1.3.1.2 Electronics-specific requirements

Information for market surveillance

The **Directive 2011/65/EU on the restriction of hazardous substances (RoHS)** regulates the use of 10 hazardous substances in electrical and electronic equipment to protect human health and the environment, including recovery and disposal of electronic waste (Art. 1 RoHS Directive). Member States shall ensure that manufacturers, where applicable, are obliged to declare conformity on the absence of hazardous substances or presence of such or below a tolerated value (Art. 7, Art. 4 and ANNEX II of the RoHS Directive) by affixing the CE label on the product (Art. 14 et seq. RohS Directive) which is therefore visible to the consumers. The technical documentation and the EU declaration of conformity have to be accessible to market authorities for 10 years after the electronic product has been placed on the market (Art. 7 (b) RoHs Directive).

Granularity barrier: Although the CE marking does not specifically address consumers, studies show that CE-label can be misinterpreted by consumers, who are not aware of the intended meaning. Consumers may misinterpret it for the safety label "GS" (tested safety, in German: "Geprüfte Sicherheit") and are confronted with information overload[14] (see Appendix A.1.6 for an overview of mandatory markings). It is therefore questionable, if this information is essential to be affixed on the product or packaging or can be digitised and made accessible for market surveillance. Furthermore, the CE marking does not indicate with which legislation the product complies.

- ► With the objective to reduce the complexity and digitalise information, digital labelling is discussed within the industry-led "e-labelling initiatives"[15] and the EU initiative "Chemicals – simplification and digitalisation of labelling requirements". Digital labelling is adopted in several countries, such as Canada, USA, China, Australia.

The regularity conformity is based on a self-declaration basis by manufacturers with the visual CE-marking but does not require independent certification of compliance. As an example, some online platforms offer products from outside EU which do not conform to EU legislation[16]. In one occasion, this resulted in an official order to delist the website from search engines in France due to concerns of product safety[17]. Thus, the lack of validation gives room for fraud and can be seen as a barrier to achieve an EU market with compliant products.

To note, the CE marking not only related to RoHS legislation but rather a mandatory conformity marking for certain products sold within the European Economic Area (EEA). It indicates that a product complies with EU health, safety, and environmental protection standards. The CE marking is required for a wide range of products, such as electronics, toys, machinery, medical

[14] https://www.anec.eu/images/documents/CE_Marking_Leaflet_final.pdf
[15] https://www.elabellinginitiative.org//docs/eng/MWF_E-labelling%20White%20Paper_Mar2022.pdf
[16] https://www.chip.de/news/Wish-Produkte-als-Gefahr-Erstes-europaeisches-Land-verbietet-den-Shop_183962640.html
[17] https://www.reuters.com/technology/france-take-steps-against-online-retail-site-wish-protect-consumers-2021-11-24/

devices, and personal protective equipment. Manufacturers are legally required to affix the CE-marking on most products covered by the respective legislation (e.g., RohS Directive).

Information for re-use, treatment and recycling facilities

The **Directive (2012/19/EU) on waste electrical and electronic equipment (WEEE)** aims to prevent or reduce environmental impacts of WEEE by setting obligations for member States to take the necessary measures for separate collection, treatment, recycling, reuse and recovery of electrical and electronic equipment (EEE). It provides a framework on the extended producer responsibility (EPR) principle with the goal to improve the "design and production of EEE, to facilitate re-use, dismantling and recovery of WEEE, its components and materials" (Art. 4). "Member States shall ensure that producers are obliged to provide information to re-use, treatment and recycling facilities on different EEE components and materials as well as the location of dangerous substances and mixtures in EEE" (Art. 15). This has to be realised by manuals or electronic media one year after the EEE was placed on the market.

Granularity and accessibility barrier: The WEEE Directive does not specify to which granularity information on "materials" or the concentration of "dangerous substances" should be provided. Further it specifies the format "in the form of manuals or by means of electronic media (e.g., CD-ROM, online services)" which could imply a bilateral exchange instead of a more generally accessible provision to relevant stakeholders (e.g., a database comparable to EPREL, that may be reached via an API). Considering a bilateral exchange and the large number of re-use, treatment and recycling facilities, the effort for distributing information could theoretically be relatively high.

- The Information for Recycler (**I4R**) and Recycler Information Center[18] (RIC) platform are provide disassembly information on materials as well as component level to recyclers. The information is provided per product group and therefore give guidance on the disassembly, material composition and value. Although both platforms conceptually show relevant information categories and allow the distribution of the respective information, not all information is available or is of generic character. Furthermore, the platforms must be accessed manually. An indication of materials contained in parts and the necessity for its disassembly on product model level would allow for a selective treatment and potentially increase economic viability.

The POP Regulation and WEEE Directive state general requirements to separate products or components with specific materials. The following section elaborates on such material information which are relevant in waste treatment. The cross-sectorial **Regulation (EU) 2019/1021 on the use of persistent organic pollutants (POPs)** Art. 7 sets obligation to waste treatment operators to avoid the contamination of waste with POPs (substances are listed in Annex IV of the POP Regulation).

- pesticides (such as DDT);
- industrial chemicals (such as polychlorinated biphenyls, widely used in electrical equipment)

[18] https://ric.werecycle.eu/

- unintentional by-products formed during industrial processes, degradation or combustion (e.g., dioxins and furans).

The **Commission Regulation (EU) 2019/2021 laying down ecodesign requirements for electronic displays** sets information requirements on dismantling (dismantling steps, tools or technologies) needed to access any of the products components according to ANNEX VII WEEE Directive 2012/19/EU) on a free-access website. **ANNEX VII of the WEEE Directive** sets out general requirements on the selective treatment of specific substances and parts:

- polychlorinated bi-/ter-phenyls (PCB) /PCT)
- mercury containing components
- batteries
- printed circuit boards of mobile phones generally
- toner cartridges
- plastics with BFRs
- asbestos waste
- cathode ray tubes
- chlorofluorocarbons (CFC), (HCFC), (HFC), (HC)
- gas discharge lamps
- LCDs
- External electric cables

The WEEE Directive does state explicit information requirements on these substances and parts. The WEEE Directive rather sets general information obligations on producers who are responsible for the product (e.g., manufacturer) to provide dismantling and recovery instructions for re-use, treatment and recycling facilities. This includes information on different EEE components and materials as well as the location of dangerous substances and mixtures in EEE in the format of manuals or electronic media one year after the EEE was placed on the market[19]. Dangerous substances are not further specified. Dangerous substances (and components) could be interpreted as those which need separate treatment according to ANNEX VII of the WEEE Directive.

Accessibility, granularity gap: The Commission Regulation (EU) 2019/2021 laying down ecodesign requirements for electronic displays sets explicit information requirements which are product specific to electronic displays. Horizontal information requirements that apply to all

[19] Similar defined in WEEE Directive (26): Information on component and material identification to be provided by producers is important to facilitate the management, and in particular the treatment and recovery or recycling, of WEEE.

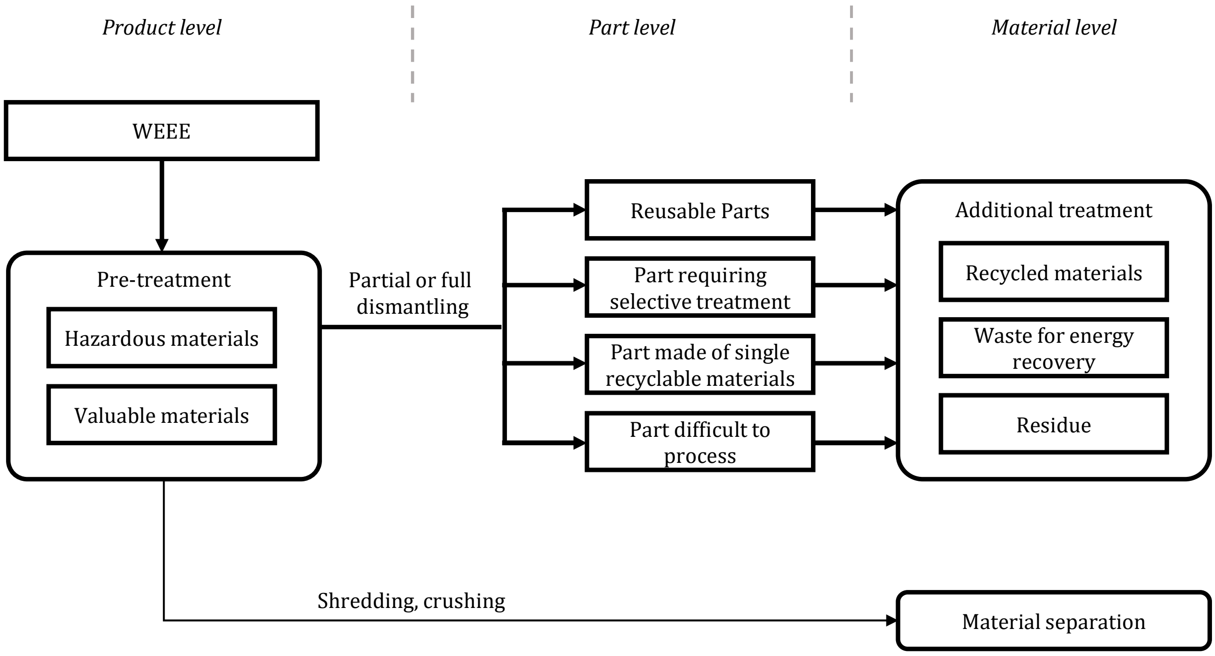
electronic waste for their selective treatment of specific substances according to ANNEX VII WEEE Directive 2012/19/EU are missing in the WEEE Directive.

- The I4R "Information 4 Recycler Platform" was launched in 2018 by industrial associations[20] as a communication tool between EEE manufacturers and waste operators to meet information obligations by WEEE Directive. Information is provided to waste operators on different EEE components and materials and location of dangerous substances and mixtures in EEE. Five product groups are in focus: large household appliances, small appliances, IT equipment, cooling and freezing appliances, screens. The information is not product-specific but shows material content per product group and dismantling information is shown exemplarily by a specific product, which might be not sufficient in granularity (see stakeholder evaluation in part B).

Further potentially relevant information is derived in following section, using the basic waste treatment process, shown in Figure 13.

In its basic principle, WEEE can be itemized in 5 categories: ferrous metals, non-ferrous metals, glass, plastics and other materials. Literature subdivides possible treatments for WEEE into four different groups: pre-treatment of products and parts, material separation, energy recovery, disposal of residuals. Within the pre-treatment stage, products are dismantled and parts are extracted that need to be treated selectively.

Figure 13: Steps in waste treatment of electronic products with potential information demand



(source: adapted from (JRC 2012))

Specific information requirements are not stated in the norm, for example on additives and fillers for plastic components or composites. The norm mentions that those parts should be assessed by recyclers (see part B).

[20] WEEE Forum, APPLIA and Digital Europe

Similar to the WEEE Directive, Ecodesign legislation requires information as physical markings on some product groups to facilitate the correct and environmentally sound treatment at end of life. For example, the **Commission Regulation (EU) 2019/2021 of 1 October 2019 laying down ecodesign requirements for electronic displays** pursuant to Directive 2009/125/EC requires a marking on devices with cadmium content (above 0,1%, as defined in the RoHS Directive) and on plastic components heavier than 50 g and components containing flame retardants (Annex II). The **Commission Regulation (EU) No 617/2013 of 26 June 2013 implementing Directive 2009/125/EC with regard to ecodesign requirements for computers** and computer servers requires products with an integrated display (notebooks) containing mercury to be identified with total content of mercury (in mg) (Annex II).

Accessibility barrier: Physical markings on products or component need to be identified within waste treatment (e.g., sorting) process which requires time. Markings on plastic components might not be visible from the outside. Therefore, products have to be disassembled first to retrieve the markings. The impact assessment study on the Proposal Regulation on packaging and packaging waste, amending Regulation (EU) 2019/1020, and repealing Directive 94/62/EC states that "there is no evidence alphanumeric coding has ever been used in any meaningful way by consumers, neither is it used by the waste sorters. New packaging labelling requirements to facilitate smarter sorting in the waste management sector would be mandated. Apart from the already widely applied optical sorting (NIR), digital watermarking55 and serialisation56 have demonstrated to be technically viable labelling technologies, but they are not yet rolled out. Also integration of information into a Digital Product Passport57 could be an option ".[21]

1.3.1.3 Textile-specific requirements

For textiles, information on fibres is in particular relevant to consumers and recyclers. Textile production and finishing processes have a high environmental impact and entail health concerns, correlated to the used pesticides and fertilizer for natural fibres. In the life cycle of garments the highest CO2 emission and energy use occurs during initial fibre extraction, in particular for synthetic fibres [Niinimäki et al. 2020, Koszewska 2018, Ellen MacArthur Foundation 2017]. For consumers, it may be important to know what kind of fabric their clothes are made of and what environmental impact resulted from making the clothes. Recyclers need to know about the fibres of textiles to process them accordingly for reuse or material recovery.

Information for consumers

The Regulation **(EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products ("Textiles Regulation")** aims to improve the functioning of the internal market and to providing accurate information to consumers to make informed choices (Art. 1). Information requirements (described in Chapter 2 of the EU Textiles Regulation, as "textile fibre names and related labelling and marking requirements") include textile fibre names and fibre composition of textile products as well as non-textile parts of animal origin, which need to be made available before the (online) purchase.

[21] COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT REPORT Accompanying the document Proposal for a Regulation of the European Parliament and the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020, and repealing Directive 94/62/EC https://data.consilium.europa.eu/doc/document/ST-15581-2022-ADD-2/EN/pdf

This can either be done by a label or a marking visible to all stakeholders including consumers when placing a textile product on the market.

Legal information gap: The Textiles Regulation requires the identification of fibres but does not require to indicate chemicals used in the production process or the environmental impact, which could be useful for consumers. The current regulation furthermore does not cover information about the country of origin (e.g., "made in"), size or a care/wash labelling.

- Labels like the GOTS, Blue Angel and Nordic EcoLabel aim to reduce adverse effects of textile production on environment and health. Besides overarching requirements (e.g., usage of best available technologies, compliance with UN labour standards, etc.) the labels set specific information requirements on fibre production, chemicals used in production and coatings, laminates, membranes and adhesives. The labels partly exceed REACH requirements by defining an extended set of substances, restricted due to certain properties under certain thresholds or completely according to a predefined list (restricted substance list). To be compliant with the requirements of a label, such information has to be provided (at least to the certification body) and might close the legal information gap.

- In March 2022, the Commission adopted the EU Strategy for Sustainable and Circular Textiles (COM/2022/141 final). The Commission will introduce mandatory disclosure of information beyond the current Textile Regulation, such as sustainability and circularity parameters, products' size, the country where manufacturing processes take place ("made in"). The Commission will also consider the possibility of introducing a digital label.

- Other proposals are planned that effect textile products within current legislative revisions. This includes addressing the presence of hazardous substances in the revision of the REACH Regulation (2023), harmonising EU extended producer responsibility (ERP) for textiles in the revision of the Waste Framework Directive and developing criteria for distinguishing waste from second hand textile products.[22].

Information for waste treatment and recyclers

To note, the Textile Regulation states to providing accurate information to consumers, while waste treatment operators are not mentioned. The current Textiles Regulation includes several exemptions for certain fibres which do not have to be declared. This represents a challenge to assess the actual fibre composition of a product which is in particular crucial to waste treatment operators. Examples of relevant cases include the following exceptions:

Legal information gap:
For Multi-component textile products, labelling or marking is not required for textile components that are not the principal lining materials and constitute less than 30 percent of the total weight of the textile product.
Fibres accounting for up to 5 % of the total weight of the textile product, or fibres accounting for up to 15 % of the total weight of the textile product, may be designated as 'other fibres'.
Textile products whose composition is difficult to determine at the time of manufacture may be described on the label or marking as 'miscellaneous fibres' or 'product of indeterminate composition'.
Visible and isolable fibres intended to obtain a purely decorative effect and representing not

[22] https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-eu-textiles-strategy

more than 7 % of the weight of the finished product do not need to be included in the fibre compositions.
Metallic fibres and other fibres added to obtain an antistatic effect and which do not exceed 2% by weight of the finished product need not be included in the fibre composition.

- Strategies like the "Global Fashion Agenda's Circular Design Toolbox" or the Ellen MacArthur Foundation's "Make Fashion Circular" share sustainable design guidelines from a general perspective. However, they do not provide detailed recycling requirements or criteria granular enough to enable designing products with high quality recyclability. Holistic information transparency systems like the Circular Design Criteria and the circularity.ID provide guidance on product recyclability and circular product design, based on their collected information e.g., on material (feedstock) requirements of recyclers. The circularity.ID system collects and stores all relevant product data for recycling such as a full declaration of the fibre composition and provides it to sorters and recyclers. See chapter 4.3.1.1 for a detailed description of the circularity.ID.

1.3.2 Material origin

Existing corporate due diligence legislation and several legislative proposals require disclosure of information on material origin and related social and environmental conditions. The following section elaborates on information requirements in existing and proposed due diligence legislation. A comprehensive comparison of voluntary approaches and legislation acts can be found in the paper of Scherf et al. (Scherf et al. 2019).

1.3.2.1 Overview: Due diligence acts in Europe

Due diligence as defined in the Ruggie-Framework[23] in 2008 describes the ambition towards a responsible business conduct. Guidelines like the Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises or UN Guiding Principles on Business and Human Rights (UNGP) recommend enterprises to conduct risk-based due diligence to "identify, prevent, mitigate and account for how they address actual and potential adverse impacts". These guidelines are taken up by legislation on national level for example in France, Netherlands and most recently Germany to provide for a legal foundation for the responsibility of companies to ensure social and environmental standards in the supply chain. On EU level a Proposal for a Directive on Corporate Sustainability Due Diligence was adopted in February 2022. A brief overview of selected related legal acts, validity period and obligated stakeholders is given in Table 14.

Table 14: Exemplary EU due diligence legislation

	EU	Germany	France
Legislative act	Working title: "Proposal for a Directive on Corporate Sustainability Due Diligence"	„Lieferkettengesetz" Gesetz über die unternehmerischen Sorgfaltspflichten zur Vermeidung von Menschenrechts-verletzungen in Lieferketten	„Loi de vigilance" Loi relative au devoir de vigilance des sociétés mères et entreprises donneuses d´ordre

[23] John Ruggie, Special Representative to the Secretary-General of the United Nations on Business and Human Rights

	EU	Germany	France
Validity period	Legislation proposal early 2022, introduction likely starting 2024	Gradual introduction from 2023	Since 2017
Obligated stakeholder (company size)	Companies with 500+ employees and €150 million worldwide turnover for EU-companies and EU-wide turnover for non-EU companies. In the defined high-impact sectors agriculture, textiles, and extraction of minerals, companies with 250+ employees and over €40 million turnover are also obligated, but only 2 years after rules are applicable to the larger companies.	German companies from 2023: with 3000+ employees; from 2024: 1000+ employees and their direct suppliers (in some cases also indirect suppliers)	French companies with 5,000 employees; international companies with 10,000 employees; including subsidiaries, subcontractors and suppliers

(adopted overview from (Quentic 2022))

The table shows the different applicability of the respective legislation by company size. In general, the laws do not explicitly define information requirements, but rather sets obligations to report and act within five key topics of the due diligence process: human rights statement, assessment of actual and potential adverse impacts, ambitions to measure and mitigate those impacts and risks, reporting and the implementation of complaints mechanisms. Depending on the degree of involvement, the company identifying rising or causing negative impacts is obliged to take measures to avoid, mitigate or cease those risks or impacts. Depending on the legislation, the scope of risk evaluation might affect different sectors, materials, sustainability aspects as well as the entire value chain including own operations and business operations (direct and indirect suppliers, corporate customers and subsidiaries). The EU Proposal for a Directive on corporate sustainability due diligence defines a duty to act, which comprises "identifying, bringing to an end, preventing, mitigating and accounting for negative human rights and environmental impacts in the company's own operations, their subsidiaries and their value chains". The recently adopted Battery Regulation aims to reduce social and environmental impacts throughout the battery's life cycle by defining due diligence rules for operators. These must "establish and operate a system of controls and transparency regarding the supply chain, including a chain of custody or traceability system, identifying upstream actors in the supply chain;" Further information on the source of raw materials used for batteries placed on the market need to be collected.

Granularity barrier, validation barrier: Corporate sustainability information provided, e.g., as a corporate sustainability report might be too complex for consumers. Furthermore, CSR reporting information is not always trusted by consumers [Bögel 2016]. An independent (3rd party) validation might overcome this barrier.

- Labels provide information on due diligence, such as TCO Certified, EU Ecolabel, TÜV Rheinland Green Product Mark or Nordic Ecolabel. First, they aggregate i.e. due diligence practices into one comprehensive label. Second, they act as independent certifier for due diligence ambitions including supply chain responsibility, responsibly sourced minerals or anti-bribery management systems. However, also certification bodies set different degrees of requirements for their label towards the rendered due diligence ambitions of companies.
- The Proposal for a Directive on Corporate Sustainability Reporting (April 2021) introduces requirement on improved accessibility and the disclosure of relevant, comparable and reliable sustainability information.

Looking into an industrial use case, Fairphone aims to provide full supply chain transparency on material sourcing within its report “Fairphone 4 Suppliers, Smelters and Refiners”[24] using the five steps of OECD’s “Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas”. Within this process Fairphone reported on the following information categories, declared publicly on their website:

- Material suppliers (Smelter ID, Standard Smelter Name, Country location, RMAP[25] Conformant) per mineral/material in particular 3TG - gold, tin, tungsten, tantalum.
- Component suppliers (name, address, website) per component category, e.g., semiconductors, passive components, connectors, clips, etc.

The report shows supplier information at component level allowing for a product allocation. Furthermore, material level information is provided which might result from previous reporting obligations set by the Conflict Mineral Regulation (CMR). Similar to the corporate social responsibility report, the information might result in improving the environmental and social impacts and increase credibility, but more aggregated information is more useful to consumers.

1.3.2.2 Conflict Minerals Regulation (CMR)

The **Regulation (EU) 2017/821 laying down supply chain due diligence obligations for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas** lays down information requirements for the aforementioned importers in Art. 4. Union importers are required to operate a chain of custody or supply chain traceability system, supported by documentation. The required information comprises (inter alia) the metal/mineral (description, trade name, type), the name and address of the supplier, the country of origin of the minerals, the name and address of the smelters and refiners in the supply chain of the Union importer, the quantities and dates of extraction, if available, in volume or weight. These information have to be made available to Member State competent authorities, downstream purchaser and to the public in form of a DD report.

Information for downstream purchaser

The CMR further states, that “Union importers of minerals or metals shall make available to their immediate downstream purchasers all information gained and maintained pursuant to their supply chain due diligence with due regard for business confidentiality and other competitive concerns.”

The Conflict Minerals Regulation has no (direct) product relation. However, the required supply chain traceability system and included information for conflict minerals could be taken as an example to define product group specific information requirements or a product information system in other legislation, as done in the new Battery Regulation.

1.4 Functional and technical specification

A distinctive category of product related information is functional and technical specifications. Technical specifications are results of standardised measurements which are determined by the product design, its components and materials, e.g., the weight or capacity of a washing machine or fridge. Functional specifications describe product-specific behaviours or features, for example

[24] Fairphone: Supply Chain Engagement: from Risk to Impact. Fairphone 4 Suppliers, Smelters and Refiners. May 2022.
[25] Responsible Minerals Assurance Process: Assessment approach for responsible mineral procurement.

the water column of water repellent jackets. They are mostly standardised and broadly available, provided by the manufacturers on a voluntary basis as a selling argument ("features").

Some information obligations are set out in product legislation, in particular for energy-related products (e.g., Ecodesign Directive, Energy Labelling Regulation) on aspects related to the environmental impact like the power demand. Waste legislation requires specifications on product weight (WEEE Directive) or packaging quantities by weight and percentage (Packaging Directive).

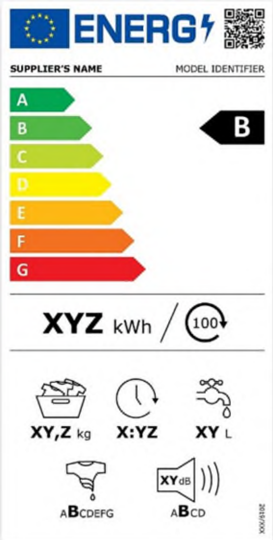
1.4.1 Electronic-specific requirements

Electronic-specific information requirements can be found in legislation for ecodesign and energy labelling. Both areas outline requirements for individual product groups under a legislative framework. The ecodesign framework directive (Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products) covers 31 product groups, while the energy labelling framework regulation (Regulation (EU) 2017/1369 setting a framework for energy labelling) is applicable to 15 of the product groups.

Energy labels are mandatory for appliances such as refrigerators, washing machines, dishwashers, and televisions. They provide information on energy efficiency, helping consumers make informed choices and encouraging energy-saving practices. According to the Energy Labelling Regulation, suppliers[26] have to provide product information regarding energy efficiency, the consumption of energy and of other resources by the products during use. Dealers are obliged to provide information on the physical product's energy efficiency label on technical and functional specifications, supported by the energy efficiency class and graphical icons. For some product groups[27] a rescaled label was made mandatory in 2021, which provides more detailed information via the QR code on the top right of the label as seen in Figure 14. The QR codes are linked to a central database, the European Product Registry for Energy Labelling (EPREL), developed under the Energy Labelling Regulation. EPREL is operational since 2019. Since then, affected product groups must be registered with related information.

[26] Suppliers are manufacturer established in the Union, the authorised representative of a manufacturer who is not established in the Union, or an importer, who places a product on the Union market
[27] (1) washing machines and washer-driers, (2) dishwashers, (3) electronic displays (scope is larger than for TV screens), (4) refrigerators, (5) light sources

Figure 14: QR-code links dynamic information in online product database (EPREL)



(source: EPREL 2021)

Besides the label in electronic format, dealers are obliged to provide the information on the product information sheet to the customer as well as in the public part of EPREL. The information is supposed to enable customers to choose most efficient products and thus incentivise manufacturers to use more energy efficient technologies. Furthermore, the technical documentation and test reports must be provided in a compliance part of the database, with access for market surveillance (see Table 15) (EPREL 2022).

Table 15: Information requirements according to the Energy Labelling Regulation, to be stored in the central online database EPREL

Public part (Annex I, 1 of the Energy Labelling Regulation)	Compliance part (Annex I, 3 of the Energy Labelling Regulation)
Name or trademark, address, contact details and other legal identification of the supplier	Identifier for all equivalent models that are already placed on the market
Model identifier **Label** in electronic format Energy efficiency class(es) and other parameters of the label Parameters of the **product information sheet** in electronic format incl. duration of guarantee given by the supplier	**Technical documentation** as specified in Art. 12(5) Energy Labelling Regulation: (a) General description of the model, sufficient for it to be unequivocally and easily identified; (b) References to the harmonised standards applied or other measurement standards used; (c) Specific precautions that need to be taken when the model is assembled, installed, maintained or tested; (d) The measured technical parameters of the model; (e) The calculations performed with the measured parameters; (f) Testing conditions if not described sufficiently in point (b). The supplier may upload additional parts of the technical documentation on a voluntary basis into the database.

EPREL serves three purposes according to Recital 29 of the Energy Labelling Regulation. Firstly, it should serve as a "useful tool for consumers", who can digitally review the energy label and compare products. Machine readable data with an API[28] is foreseen to access and further process data e.g. for comparing products. Secondly, dealers may receive product information sheets via EPREL, which can help dealers to make available the information to customers (an obligation under Art. 5(1)(b) of the EEL). Thirdly, the database supports market surveillance activities.

To note, other information may be relevant or of strong interest for the consumers while comparing products, but that do not relate to reducing the environmental impact. For example, information on the colour or specific functionalities. Such information is not covered by the Energy Labelling Regulation. Voluntary approaches such as the TCO Certification for Laptops include further specifications like the display resolution, colour, luminance, contrast, keyboard gloss or easily accessible connectors. This is not considered an information gaps, as that information cannot be linked to sustainability.

1.4.2 Textile-specific requirements

For textiles, technical or functional specifications are not mandatory in the Textile Regulation. Though voluntary approaches like the Blue Angel and EU Ecolabel set technical and functional criteria on colour resistance to perspiration, washing, wet and dry rubbing and light exposure. Technical textiles and high-end fashion are voluntarily provided by the manufacturers with information such as size and fit, application area, wind resistance, water repellent or impregnation.

1.5 Product design-related information

In this study, product design-related information is defined as properties, composition and arrangement of parts on a product level that determine how to install, maintain, repair or dispose the product. Related information for energy-related products is specified across product and waste legislation, namely the Ecodesign Directive, Energy Labelling Regulation and WEEE Directive.

1.5.1 Electronic-specific requirements

The Ecodesign Directive defines a framework for setting ecodesign requirements for energy-related products to increase energy efficiency and environmental protection. The framework is the basis for the implementation measures and proves horizontal information requirements:

- For consumers: information on installation, use and maintenance, return options at the end-of-life (EoL), period of availability of spare parts, possibilities of upgrading products.
- For consumers: information on the significant environmental characteristics and performance of a product, accompanying the product when it is placed on the market to allow consumers to compare these aspects of the products.
- For treatment facilities: information on disassembly, recycling or disposal at end-of-life.

[28] Application Programming Interface

The horizontal information requirements are to be specified per product group, based on the way the product is handled, used or recycled by parties other than the manufacturers (Ecodesign Directive ANNEX I part 2).

Information for users and professional repairers

The recent implementing measure **Commission Regulation (EU) 2019/2023 lying down ecodesign requirements for household washing machines and household washer-dryers** requires the manufacturers to provide the user with an online user manual including information on use, maintenance, access to professional repair, spare part availability. Repair and maintenance information has to be provided to professional repairers after a period of two years after the placing on the market of the first unit of a model until 10 years after placing the last unit of the model on the market.

Further exemplary information requirements are specified in the **Commission Regulation (EU) 2019/2021 on ecodesign requirements for electronic displays**. End-users and professional repairers are to be provided with information about spare parts and repair instructions via a user manual or the manufacturer website. In addition, professional repairers are intended to get repair and maintenance information that allows to identify the error, open the product and change internal components e.g., disassembly map or exploded view, list of necessary repair and test equipment, component and diagnosis information, wiring and connection diagrams, diagnostic fault and error codes, data records of reported failure incidents stored on the electronic display.

In order to obtain repair information guaranteed by the ecodesign requirements, professional repairers are required to register on a website of the manufacturer, importer or authorised representative. For some product groups such as washing machines they may be required to demonstrate their technical competence to repair the respective appliances. A reference to an official registration system as professional repairer, where such system exists in the member States concerned, should be accepted as proof of compliance of the applicable regulations for repairers of electrical equipment in the member States where it operates.

Accessibility barrier: although information requirements exist, the process to gain the information might be a barrier. In a position paper of a German repair association, the vague definition of "professional competence" as well as the option for manufacturer to not accept the proof of verification is seen critical[29].

Annex II E. 1.(b) of **Commission Regulation (EU) 2019/2021 of 1 October 2019 laying down ecodesign requirements for electronic displays** sets information requirements on the minimum guaranteed availability of software and firmware updates, availability of spare parts and product support which should be indicated in the product information sheet available to consumers and professional repairers.

Granularity barrier: indicators and ratings like the energy efficiency class are important information to gain an objective evaluation of a product and allow comparison between products without extensive research. Information on the duration of the availability of updates and spare parts is important to estimate how long the product can be used. However, without a

[29] https://runder-tisch-reparatur.de/wp-content/uploads/2021/03/rtr_repair_registry_germany_2103010.pdf

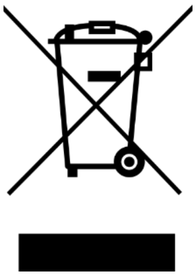
comparison to an average duration or benchmark (like the energy efficiency rating), it can be difficult for consumers to determine if an absolute value (e.g., 2 years updates for displays) is good or bad, and to make informed choices.

- In 2021 France implemented a repairability index for five product categories of electronic products (based on law 2020-105 Regarding a Circular Economy and the Fight Against Waste). It shows how well a product can be repaired considering the availability of repair information, spare parts and (for smartphones, laptops and TVs) software aspects within a one-score rating. To note, software updates are often seen as a repair measure, as they extend the lifetime with external support, while durability reflects the ability of the product to be functional without external intervention (like repair). Promoting only one circularity strategy like repairability through the instrument of a repairability index might result in a e.g. less durable or recyclable product. In the same law (2020-105), France introduced a durability index for 2024 for which a preparatory study is available[30].

Information for users

The **WEEE Directive** states that a success of WEEE collection can only be achieved when users of EEE are made aware not to dispose WEEE to unsorted municipal waste by the crossed-out wheeled bin marking (Recital 25 and ANNEX IX). Users should be informed about collection and return options, e.g., available collection points. According to WEEE Directive Art. 14 users are to be provided with information to not dispose the WEEE to municipal waste and to collect WEEE separately in form of a symbol, the crossed-out wheeled bin.

Figure 15: Symbol for the marking of WEEE



(source: WEEE Directive ANNEX IX)

Furthermore, the WEEE Directive requires producers to make users aware of return and collection systems available to them as well as their role in contributing to re-use, recycling and other forms of recovery of WEEE.

Format barrier: The crossed-out wheeled bin label serves as a visual cue for consumers to handle electronic waste responsibly and indicates not to dispose WEEE to the regular waste bin. Due to the aggregated format, the symbol does not provide information about designated collection and return options. Though it might encourage consumers to seek out such options.

[30] https://librairie.ademe.fr/consommer-autrement/4853-preparatory-study-for-the-introduction-of-a-durability-index.html

Information for re-use, treatment and recycling facilities

According to Art. 15 of the **Directive (2012/19/EU) on waste electrical and electronic equipment (WEEE)** producers are obliged to provide information on different EEE components and materials as well as the location of dangerous substances and mixtures in EEE (further details of the WEEE Directive are described in chapter 1.3.1.2) to re-use, treatment and recycling facilities. The information has to be provided in the form of manuals or electronic media one year after the EEE was placed on the market.

Automotive-specific requirements

The **Directive 2000/53/EC on end-of life vehicles (ELV)** sets obligations for the prevention and reduction of waste by reuse, recycling and recovery of end-of life vehicles and their components. In this manner, member States are obliged to take measures to ensure that "relevant economic operators to publish information on:

- the design of vehicles and their components with a view to their recoverability and recyclability,
- the environmentally sound treatment of end-of life vehicles, in particular the removal of all fluids and dismantling, (…)

The producer must make this information accessible to the prospective buyers of vehicles. It shall be included in promotional literature used in the marketing of the new vehicle." (Art. 9 (2)). Producers have to provide information to treatment facilities on dismantling for each type of new vehicle within six months after the vehicle is put on the market (Art. 8(3) ELV Directive). Furthermore, member States must take the necessary measures to ensure that manufacturers of vehicle components make available appropriate information concerning dismantling, storage and testing of components which can be reused to authorised treatment facilities (Art. 8(4) ELV Directive).

The "**Type Approval Regulation**" (Regulation (EU) 2018/858 amending Regulations (EC) No 715/2007 and (EC) 595/2009) Motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles obligates manufacturers to share information about On-Board-Diagnosis as well as information on maintenance and repair. It requires repair information (Art. 61-66 and Annex X) to be provided from the manufacturer to the consumer and especially the repairer in the form of machine-readable and electronically processable datasets. Therefore, the SERMI website was introduced to simplify the process for professional repairer. A launch for the platform is planned for late 2023.

For passenger cars the **Regulation (EU) 2023/851** of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2019/631 as regards strengthening the **CO2 emission performance standards for new passenger cars and new light commercial vehicles (**initital Directive 1999/94/EC [31]) suggests the Commission should review Article 15 (6) by 31 December 2024, towards the requirement to provide consumers with accurate, robust and comparable information on the fuel and energy consumption, CO2 emissions and air pollutant emissions of new passenger cars placed on the market. Furthermore, the review

[31] Directive 1999/94/EC of the European Parliament and of the Council of 13 December 1999 relating to the availability of consumer information on fuel economy and CO2 emissions in respect of the marketing of new passenger cars

should include an evaluation of "options for introducing a fuel economy and CO2 emissions label for new light commercial vehicles".

Accessibility barrier (see also 1.3.1.2): the WEEE Directive specifies that information has to be provided "in the form of manuals or by means of electronic media (e.g., CD-ROM, online services)" which could imply a bilateral exchange instead of a more generally accessible provision to relevant stakeholders (e.g., a database comparable to EPREL, that may be reached via an API). Considering a bilateral exchange and the large number of re-use, treatment and recycling facilities, the effort for distributing information could theoretically be relatively high. The ELV Directive does not specify how the information can be accessed.

- (See also 1.3.1.2) The I4R "Information 4 Recycler Platform" provides information to waste operators on different EEE components and materials and location of dangerous substances and mixtures in EEE. The information is not product-specific but shows material content per product group and dismantling information is shown exemplarily by a specific product, which might be not sufficient in granularity (see stakeholder evaluation in part B).

- In the automotive industry the International Dismantling Information System (IDIS) provides a platform for information provision by car manufacturers on safety information like airbag deployment, dismantling information (e.g. of EV batteries) and potentially recyclable parts. Similar to the SCIP database the usability of such platforms in practice might be limited towards the provided information and functionality. E.g. information on relevant materials such as the type of cooling liquid for the air condition or neodymium magnets might be useful. Search and filter functions might help for a more efficient use of the information.

- Within the current Proposal for a Regulation on circularity requirements for vehicle design and on management of end-of-life vehicles32 the current barriers are addressed. A Circularity Vehicle Passport as well as specific information requirements are introduced: According to Art. 11 and 13 the Circularity Vehicle Passport shall contain information on batteries, e-drive motors, components containing liquids, critical raw materials and/or code as well as other parts (Annex VII Part C). A breakdown of the material composition of the components is not planned but a declaration on the recycled content of certain materials (Art. 10). The passport is well defined to be broadly available, accessible and usable – it should be based on open standards, interoperable format, a data exhchange network within vendor lock-in and machine-readable, structured and searchable information. The Circularity Vehicle Passport should contain information on batteries, e-drive motors, components containing liquids, critical raw materials and/or code as well as other parts (Annex VII Part C). A breakdown of the material composition of the components is not planned but a declaration on the recycled content of certain materials (Art. 10).

1.1.1 Textile-specific requirements

There are no textile-specific legal information requirements on product level. However, Duhoux et al. (Duhoux et al. 2021) identify unwanted soft and hard accessories and items for the manual or automated sorting process of textiles. This indicates an information gap on the location of such accessories or parts. Hard parts include all metals as they might generate sparks in contact with machineries, thus ignite with cotton and constitute a risk of fire. Remaining hard parts in

[32] Proposal for a Regulation on circularity requirements for vehicle design and on management of end-of-life vehicles, amending Regulations (EU) 2018/858 and 2019/1020 and repealing the ELV Directive 2000/53/EC and Type Approval Directive 2005/64/EC

fibres are problematic when respinning. Soft parts to be avoided include prints, coatings and labels which can hinder the processing, lower the quality or cause visual variations. In automated sorting processes, in particular performed in EU countries, machine readable information is beneficial on specific textile parts including hard parts (e.g., buttons) and trims as well as on material level the material (composition, exclusion of certain dyestuffs or finishes). Furthermore, information on material level, namely the nature of contamination of textiles is useful, as textiles are cleaned or sanitized accordingly during pre-treatment with specific methods (e.g., detergents, liquid CO2, ozone).

1.6 Circularity information

This study defines product circularity information as aggregated information such as indicators or labels which express sustainability aspects of the product design (e.g., repairability indicator) and/or value chain (e.g., environmental impact).

Information for consumers and users

The **Ecodesign Directive** outlines in Art. 14 ("consumer information") that manufacturers "are required to ensure, in the form they deem appropriate, that consumers of products are provided with information on the consumers role in the sustainable use of the product and the ecological profile of the product and the benefits of ecodesign". Further information requirements are outlined in ANNEX I 2. (b) for consumers on the significant environmental characteristics and performance of a product, accompanying the product when it is placed on the market to allow consumers to compare these aspects of the products. Similar qualitative statements can be found in the **WEEE Directive**, Art. 14 ("information for users") (d) according to which users in private households should be provided with information on "the potential effects on the environment and human health as a result of the presence of hazardous substances in EEE." However, these requirements are not adopted in national law (WEEE Directive) or through implementing measures for the specific product groups (Ecodesign Directive). In Germany, for example, the respective implementing measure (§ 3 Energieverbrauchsrelevante-Produkte-Gesetz – EVPG (act governing the environmentally sound design of energy-using products) authorises the federal German government to determine by legislative decree (Rechtsverordnung) when consumers must be informed about the ecological profile of a product by the manufacturer, its authorized representative or importer. However, until now, a legislative decree establishing such an obligation does not exist in Germany. Nonetheless, the Ecodesign implementing measures on washing machines requires "information that the most efficient programmes in terms of energy consumption are generally those that perform at lower temperatures and longer duration" (Regulation 2019/2023 Art. (9) 1b). Such information do not provide information on the impact as such but reflect the environmental characteristics within the suggestion for sustainable use by consumers.

The potential reason for the missing information requirements in the EU Ecodesign implementing measures on environmental impacts is the complexity to calculate environmental impacts. Two of approaches for calculating the environmental footprint of products are the Life Cycle Assessment (LCA) and the LCA-based Product Environmental Footprint (PEF).

LCA is a widely used methodology for evaluating the environmental impact of products. Depending on the scope it considers the entire life cycle of a product, from raw material extraction, manufacturing, use, and disposal. It takes into account environmental impacts such as energy consumption, water use, greenhouse gas emissions, and the depletion of natural resources. The results of an LCA can be used to identify areas where a product's environmental impact can be reduced. PEF is a methodology that was introduced by the European Commission in 2013. PEF is designed to provide a harmonised method for measuring the environmental impact of products. It focuses on specific environmental indicators such as climate change, water use, and resource depletion. PEF is intended to be a more consistent and comparable method for measuring the environmental impact of products.

In general, comparing the environmental footprints of different products is a challenge. One of the main reasons is that different approaches use different indicators and metrics to measure environmental impact. Some only consider the production and distribution, other include the use and end-of-life phase. Another challenge is the lack of standardisation and quality of the data used to calculate environmental footprints. Different companies and organizations may use different data sources, different use or recycling scenarios and assumptions, which lead to differences in the results obtained.

Availability gap: requirements for environmental information are defined in the EU directives. Some are adopted or implemented e.g. on the sustainable use while others e.g. on the environmental impact (carbon footprint, repairability index) are not. The reason for those missing impact information might be the complexity and various ways of calculating environmental or circularity impact, which leads to low comparability and contradicts the goal of the Ecodesign Directive to allow consumers to compare the environmental aspects of the products.

- The Ecodesign for Sustainable Products Regulation (ESPR) Proposal lists in the ecodesign requirements Art. 5 (1) (m) environmental impacts, including carbon and environmental footprint. These need to be adopted into secondary legislation by means deligated acts. In the deligated acts the PEF approach needs to be individually defined per product group.
- The PEF approach is frequently mentioned33 in the current ESPR Proposal as an example for a potential calculation method, but not (yet) defined as a horizontal requirement. A legally harmonised usage of a calculation approach might improve the comparability. Further does the PEF approach forsee category rules (PEF-CR) per product group that should harmonise the calculation.
- Voluntary metrics exist that reflect circularity or environmental impacts (see below “label and indicator”)

Label and indicator (for consumer)

Sustainability indicators and labels can help to close information gaps by reducing the demand for extensive data collection and analysis required for LCAs. The voluntary standards ISO14024, ISO14021 and ISO14025 provide guidelines for the development and implementation of environmental labels, varying in the effort to generate the information, the ease of understanding the information (to overcome the granularity barrier) and its credibility (to overcome the validation barrier). Such labels can provide guidance on criteria for sustainable purchasing. The study "Basic Concepts on Ecodesign Unit 10: Introduction to Ecolabelling" (Fernández 2018) provides an overview and evaluation of the three types of ecolabels from the ISO 14020 series, shown in Table 16.

[33] PEF is mentioned i.a. in ESPR Article 2 Definition (23) ‘environmental footprint’ and ESPR preamble (19)

Table 16: Overview on types, principles and aspects of ecolabels (source: (Fernández 2018))

ISO Ecolabel type I – III	Description, Example and Trade-off (benefits vs. disadvantages)	User friendly (Granularity)	Credibility (validation)	Effort
ISO 14024 Ecolabel Type I: "Label declaration"	An independent certification body (third party) verifies the claims and provided information from the manufacturers, e.g., by audits and product tests. **Example**: TCO, Blauer Angel, GOTS **Trade-off**: high credibility and reliability, but high effort.	+	+	-
ISO 14021 Ecolabel Type II: "Self-declaration"	The standard provides guidance on the indication of particular product aspects (e.g., repairable, recyclable) by a logo or text, self-declared by the manufacturers or packagers. **Example**: H&M conscious foundation, Zara Join Life, Vaude Green Shape **Trade-Off**: more economical but less credible and confusing to consumers due to high variaty of self-declared label.	0	-	+
ISO 14025 Ecolabel Type III: "Product declaration"	Standardised technical documentation (Environmental Product Declarations) which includes an inventory of environmental product data. The data is quantified with standardised method and certified by third parties. **Example**: EPD (environmental product declaration) **Trade-off**: it provides information that are third party verified, objective, reliable and comparable but the technical document is not conveniently usable as an indicator for consumers.	-	+	-

Type 1 labels (ISO14024) are awarded by an independent third party and indicate that a product has met specific environmental criteria. The benefits of Type 1 labels are that they provide a clear indication of a product's environmental performance and can help consumers make more sustainable choices. However, the certification process can be costly and time-consuming.

- Type I Ecolabel provide multi-criteria sustainability certification in the form of a label. For example, the label TCO Certified defines eight main categories with several sub-criteria for IT products. These include product life extension, material recovery, user health and safety, reduction of hazardous substances and product performance. Sustainable performance indicators include information on recycled materials, replaceable components and PCF availability. Significant sub-suppliers must be identified. Information provided by the manufacturer or brand owner is verified through factory audits and product testing by independent certification bodies.

- Although Type I Ecolabels aim to provide independent certification and validation of information through audits, a report by the Clean Clothes Campaign in 2019 showed that such external audits “protect brands and fail workers”[34].

Type 2 labels (ISO14021) are self-declared environmental claims made by the manufacturer. The benefits of Type 2 labels are that they can provide useful information for consumers and can be less expensive than Type 1 labels. However, due to the low barrier of applying such labels, a broad variety of logos exists. Furthermore, they may not be independently verified, which can lead to scepticism about their accuracy.

- The quantity of available label and underlying sustainability criteria might be a burden to consumers, due to limited comparability . The website www.siegelklarheit.de makes existing label comparable for various product groups, including Type 1 and Type 2 label.

Type 3 labels (ISO14025) provide information about a product's environmental impact throughout its entire life cycle. The pros of Type 3 labels are that they require an independent verification and provide detailed information about a product's environmental impact, allowing consumers to make informed decisions. However, the cons are that the process can be complex and expensive, making it less accessible to smaller manufacturers.

Major differences in existing labels can be seen between the textile and the electronic sector in particular for Type 1 and Type 2 labels.: a majority of 32 labels are available for textile products, compared to 7 labels for electronics (Siegelklarheit 2022). Type 3 label are less commonly used in the electronic or textile sector, rather in the construction sector.

Accessibility and granularity barrier (of labels and indicators): Labels and indicators potentially close the information gap on environmental impacts. However, the proliferation of existing labels and indicators with different underlying criteria reduces comparability and increases the effort for consumers to evaluate the actual sustainability of the product and its manufacturing process and finally purchase a sustainable product. Moreover, as most labels aggregate information, they do not give any background information towards their rules and governance, e.g. how many criteria must be met to be awarded for the label. These barriers are not related to a specific legal act.

- Siegelklarheit.de is an initiative of the German government, which potentially overcomes both barriers. It provides an central overview of existing labels and shows the criteria and content of the label itself. For example, labels for textile products include often chemical thresholds while electronic product information include lifetime extension and recycling friendly design. Furthermore, the platform compares the label by three main categories: the criteria on ecological and social impacts well as the credibility of the labels itself (Siegelklarheit 2022). All labels are evaluated by these criteria, which guides the consumers towards a label, but does

[34] https://cleanclothes.org/file-repository/figleaf-for-fashion.pdf

not compare the products. To note, although the platform provides the information in one single place and makes them comparable by centrally defined criteria, the information still require the search through the website and are not available on the point of sale (on the product), which might be critical for consumers.

While there are more labels in the textile sector, norms and standards dominate for electronic products, in particular for material and environmental declarations to support compliance. As with labels, indicators and indices are commonly used for electronic products to aggregate information, particularly for consumers, to enable quick comparison of product performance and informed purchasing. Table 17.**Fehler! Verweisquelle konnte nicht gefunden werden.** provides an overview of several approaches and standardisation activities that are underway to develop or apply such indicators.

Table 17: Overview of approaches and standards to calculate circularity indicators

Year	Name	Durability	Repairability	Recycling	Energy Efficiency	Critical Materials used	Recycled content
2021	French durability index	X					
2021	French repair index		X				
2020	EN45552-durability	X					
2020	EN45554-repair reuse and upgrade		X				
2020	EN45555-recoverability and recyclability			X		X	
2020	EN45557-recycled material content						X
2019	EN45558-critical raw materials					X	
2021	Telekom Ecorating	X	X	X	X		
2021	Circularity Transition Indicator			X		X	X
2015	MCI Material Circularity Indicators			X			X
2020	PCDS Product Circularity Data Sheet		X	X		X	X

Most indicators do not reflect the environmental impact of the entire product lifecycle, but rather single circularity aspects, for example the durability, repairability or recyclability. The mandatory energy efficiency label expresses e.g. energy efficiency class. Other circularity indicators such as the repairability indicator are not yet mandatory in German legislation (unlike, for example, in French legislation). The ESPR Proposal lists in Art. 7 (b) information requirements on the performance of the product in relation to the product parameters, such as durability, reliability, repairability, etc. which still need to be adopted in the delegated acts.

In summary, for the missing adoption and implementation of legal information requirements on environmental impacts, various voluntary approaches exist that calculate and communicate such information. Due to the complexity, the comparability of those information is very limited. Harmonising the information requirements by law could result in the necessary environmental information to steer consumers purchase decisions. However, the selection of one particular calculation method on the environmental footprint, but also durability and recyclability indicators as well as the approach to calculate and validate the recycled content is a major challenge.

1.7 Summary part A

The literature analysis in part A provides an overview of 29 identified legal information requirements with gaps and barriers in current EU legislation. To identify if voluntary approaches might fill legal gaps, the screening is complemented with the description of such voluntary approaches and current legal developments. Five main information categories are identified and used as a research structure: General and company information, material information, functional and technical specifications, product design information, circularity information.

Methodologically it was evaluated whether the information requirement itself is existing in legislation (legal information gap), if the information is available (availability gap) and if it is usable (usage barriers). Usage barriers occur if an information requirement is not specified by its metadata by means of granularity, accessibility and format. In general metadata is essential as it describe how the information is transported from one stakeholder to the next.

In summary, the following gaps and barriers have been identified in legislation.

Legal information gaps result mainly from the exemptions from or the missing of information requirements in legislation.

- The Textile Regulation does not require to identify textile fibres below a specific threshold (depending on the fibre, 5-15%). This excludes information on materials which might be important for waste treatment, as already small amounts of some materials can result in low-quality recycled material. Product design related information is completely missing, such as information on the location of accessories, zippers, buttons, etc.. Furthermore, waste treatment operators are not addressed as recipients of information. Voluntary approaches such as the circularity.ID fill the legal gap if they are voluntarily implemented by manufacturers by collecting extended material information and provision to waste treatment operators (see description in chapter 4.3.1.1 in part C).
- REACH Regulation Art. 33 shows two legal information gaps. First, it does not require the disclosure of SVHCs in articles below 0.1 % (w/w). Second, some materials are excluded from the requirement, including polymers and by-products.

Availability gaps appear if information which is required by law is not provided or available.

- In particular material legislation shows availability gaps. Especially when upstream stakeholders (e.g. producers of materials, substances etc.) do not act in the European market and are therefore not directly addressed by EU legislation, it is difficult to collect and validate information. Unwittingly, stakeholders covered by EU legislation may not provide sufficiently accurate information (in the right format, language or detail) as required by EU legislation. For example, a safety data sheet (REACH Regulation Art. 31) with the respective substance related information is not obligatory for articles.

- The Ecodesign Directive requires information on the environmental profile of a product to consumers. Some information requirements are adopted e.g. on the sustainable use of products while e.g. information on the environmental impact (carbon footprint) are not.
- The WEEE Directive sets out the general requirement for selective treatment of specific materials and parts according to WEEE Directive ANNEX II. No explicit information requirements exist to identify such materials in the WEEE Directive. Though the product specific Ecodesign Regulation (EU) 2019/2021 on Electronic Displays requires dismantling information for such materials.

Usage barriers (granularity, accessibility, format)

A **granularity barrier** is present if legislation defines general information requirements but does not specify the (proper) level of detail.

- The CLP Regulation requires hazard pictograms, signal words, hazard statements and precautionary statements. These are highly aggregated which might result in misinterpretation by users. A combination of current aggregated information accompanied with more detailed online information, conveniently accessible on the product (e.g. QR-code) might be an useful approach. This circumstance is addressed by the EU initiative "Chemicals - simplification and digitalisation of labelling requirements initiative". The initiative aims to simplify and make additionally relevant information digitally available.
- The crossed-out wheeled bin label serves as a visual cue for consumers to handle electronic waste responsibly and indicates not to dispose WEEE to the regular waste bin. Due to the aggregated format, the symbol does not provide information about designated collection and return options. However, it might encourage consumers to seek out such options.
- The WEEE Directive does not specify the level of detail for information on hazardous or dangerous substances as well as information on different EEE components and materials.
- The Energy Labelling Regulation for Electronic Displays requires information on the frequency of updates and duration of spare part availability. For consumers, the absolute value of the update availability (e.g., 7 years) without any relation to a benchmark or further explanation might not be helpful for making an informed purchasing decision. To evaluate repairability, the French repairability index might be helpful.

An **accessibility barrier** is present where information is available but not readily accessible or requires some effort to be obtained.

- Under some implementing acts of the Ecodesign Directive (e.g., Commission Regulation (EU) 2019/2021 on ecodesign requirements for electronic displays) professional repairers may be required to individually register and verify their competence by each manufacturer to gain repair information. Therefore, an accessibility gap can occur if manufacturers do not accept the proof of competency. Repair associations see this regulation unprecise about how professional competence is defined and that manufacturer can decline the proof of verification.
- Further accessibility obstacles occur due to the missing specification of a **communication medium.** For example, the WEEE Directive requires information on dangerous substances, instructions on dismantling and recovery which have to be made available to re-use, treatment and recycling facilities in form of manuals or electronic media. This implies usually a bilateral (peer-to-peer) exchange of information between the manufacturer (data

providers) and treatment facilities (data users). Collecting information from each manufacturer entails effort and might not be effectively usable in the sorting process. This barrier is partially tackled partly by the I4R platform, which has been established as an industry initiative to provide a central storage and communication infrastructure for effective distribution of information. Similar legal requirements and barriers are found in the ELV Directive. Here, the International Dismantling Information System (IDIS) provides dismantling and other information for the recycler and waste treatment operator within the automotive secotor. Both platforms allow to meet the legal requirements but are limited in their practical usability towards functionality and contained information. The ELV Regulation Proposal introduces a Circularity Vehicle Passport with new requirements on relevant information, which might close the current barriers.

- The Ecodesign Regulations for computers (PCs) and displays require physical/ alphanumeric markings that identify, e.g., cadmium, mercury, plastic components for waste treatment operators. The markings on components inside a product may require the dismantling and are thus not accessible coviently. There is no requirement for machine readable markings, therefore such information needs to be manually identified in the sorting process which further slows down the waste treatment process.
- The REACH Regulation enables consumers to request information about substances of very high concern (SVHCs) above 0.1% (w/w) present in articles ("right to know"), as specified under Art.s 57 and 59. The information delivery is allowed to take up to 45 days.
- The SCIP database provides information on articles with SVHC content above 0.1 % (w/w) which can be accessed through the website. This requires a manual search which is not effective within the waste treatment or sorting process.
- Data accessibility is further limited due to the heterogenic **identification of stakeholders** (manufacturer, producer, supplier, organisation, company, etc.) and **products** (article, component, material) throughout legislation. Furthermore, the terminology used in legislation and voluntary approaches is heterogenic. The fact that a common taxonomy has not yet been established is a major gap in the first place and poses a barrier to successfully bringing together data from different stakeholders within a DPP.

The **validation** of information by third parties is generally not required in legislation. All recipients of information therefore have to trust or rely on the self-declaration of the correctness of information, similar to the example of declaring CE conformity (when demanded by applicable legislation) or due diligence reporting by companies. Information on dismantling or disposal might be less prone to be false than information which is more complex, such as material information (RoHS, REACH Art. 31) and corporate legislation (Corporate Sustainability Due Diligence Directive Proposal). The European Chemical Industry Council points out the effort for generating the SDS, indicating a risk for incorrect information.

Missing information (legal information gaps) for consumers is partly provided by voluntary approaches. This information might then typically be available for some products of companies who participate in the voluntary approaches, but not for the majority of products available on the market.

Voluntary approaches might be usefull to provide missing information (legal information gap), make the information accessabile on the product in form of a label (accessability gap) and make the information more comprehensible (usage barrier). However, the quantity of existing label with different underlying criteria might result in the contrary effect, hindering the comparability of products. The analysis of voluntary approaches shows information gaps and general **sectorial differences** between electronics and textiles:

- Voluntary labels for textile products focus on chemicals used and labour conditions within production, which are only partially covered by legislation.
- For electronic products, voluntary approaches in terms of label rather provide information on functional and technical specification, product design and circularity information beyond legislation. There are reporting strategies and recommendations from industrial associations or initiatives (ZVEI and Pro-Active Alliance) towards the disclosure of material information beyond legislation, though not through a label but rather for own voluntary data gathering to be e.g. future proof for compliance. Further label and indicator are currently developed by several initiatives in the electronic sector addressing information provision on the quantity of pre/post-consumer recycled content of EEE and product circularity (durability, repair, recycling, recycled content, critical materials).

The literature analysis serves as a comprehensive overview of information requirements, gaps and potential usage barriers which will be evaluated in part B by the stakeholder. For this task Table 18provides an overview of information requirements, clustered by each stakeholder group and information category. It shows the data providing stakeholder (>>) as well as the target user (x) and related gaps and barriers per information requirement and legal act. A selection of voluntary approaches which try to close some information gaps are indicated. It should be noted that cluster terms like “material” include substance and mixtures and “waste treatment” includes sorting (see Chapter 7).

Table 18: Overview of legal information requirements and barriers for the data provider (>>) and target user (x). Where available, potential approaches to overcome the gap are provided.

Information category	Legal acts	Information requirement (grouped)	Access / format	Material producer	Supplier of articles	Manufacturer	Distribution /	User / Consumer	Professional	Reuse	Waste treatment	Recycling	Market	Gap / barrier	(Voluntary) Approach
Product and company identification	All	Identification of subject	See legal act		x	x	x	x	x	x	x		x	Accessibility barrier: identification is not harmonised across legislation	Standardised format, e.g., according to ISO/IEC 15459:2015, EPREL or ECLASS classification system
	All	Identification of stakeholder	See legal act		x	x	x	x	x	x	x		x		
Functional and technical specifications	Energy Efficiency Regulation	Functional/technical specification (product information sheet)	Product information sheet, EPREL		>>	>>	x	x					x	-	Additional functional and technical properties are provided by label such as TCO certified
		Technical documentation (test reports)	Technical documentation, EPREL		>>	>>							x	-	
Material information	CSDD Directive Proposal	Origin of material	Non-financial statement	>>	>>	>>							x	-	
	Conflict Mineral Regulation	Material quantity (for tin, tantalum and tungsten) and origin by means of the address of the EU importer	report, audits	>>	>>	>>							x	?	

Information category	Legal acts	Information requirement (grouped)	Access / format	Material producer	Supplier of articles	Manufacturer	Distribution /	User / Consumer	Professional	Reuse	Waste treatment	Recycling	Market	Gap / barrier	(Voluntary) Approach
	Textile Regulation	Textile fibre name and composition of each component	Label		>>	>>		x				x	x	Legal information gap: fibres below 15% -5% and chemicals used in production do not have to be declared. Waste treatment operators are not addressed.	Labels like GOTS, Blauer Angel, Nordic EcoLabel include more detailed information, e.g., on fibre production, chemicals used in production and coatings, laminates,membranes and adhesives.
	REACH Regulation	Information on hazardous substances and mixtures to the recipient (Art. 31)	Safety data sheet	>>	x	x	x	x						Availability gap (SDS might not be available or complete or show false information)	Information system like the circularity.ID supports to gather and distribute extended information i.a. on material content
	REACH Regulation	Identification of articles containing an SVHC above 0.1% (w/w) to all actors (Art. 33)	Registration in SCIP database (according to waste frame-work directive)		>>	>>	x	x	x	x	x	x	x	Legal information gap: does not require the disclosure of SVHC in articles below 0.1 % by mass. Second, some materials are excluded from the requirement, including by-products Accessibility barrier for consumers (deadline for reply to information request 45 days; SCIP: website access only) Accessibility for waste treatment: SCIP requires a manual search on the website, not effectively usable in sorting processes. No always linked to final product.	Smartphone apps like Scan4Chem, and ToxFox provide or help consumers to request information about SVHCs in articles. ToxFox (cosmetics) and codecheck provide information about ingredients in chemical mixtures.

Information category	Legal acts	Information requirement (grouped)	Access / format	Material producer	Supplier of articles	Manufacturer	Distribution /	User / Consumer	Professional	Reuse	Waste treatment	Recycling	Market	Gap / barrier	(Voluntary) Approach
	CLP Regulation	Hazard pictograms, signal words, hazard statements, precautionary statements	Label		> >	> >	> >	x						Granularity barrier (physical logos are highly aggregated, might be misinterpreted by consumers)	The EU initiative "Chemicals - simplification and digitalisation of labelling requirements initiative" aims to simplify and make additionally relevant information digitally available
	RoHS Directive	Confirmation of absence of certain hazardous substances by CE marking	Datasheet, CE marking		> >	> >							x	Granularity barrier (misinterpreted by consumers)	
	Ecodesign Regulation PC/ Display	Identification of mercury (ErP PC), marking of cadmium and plastic components (ErP Disp)	Marking		> >	> >					x			Accessibility barrier (physical/ alphanumeric markings/ logos are not machine readable and need to be identified manually in the sorting process which slows down the waste treatment process)	
	Packaging Directive	Information on the toxicity or danger of packaging materials and components	Database, marking	> >	> >	> >	> >						x		
	Packaging Directive	Information on return, collection and recovery systems	-	> >	> >	> >	> >	x						Accessibility barrier (the format or platform how to access the information is not defined)	

Information category	Legal acts	Information requirement (grouped)	Access / format	Material producer	Supplier of articles	Manufacturer	Distribution /	User / Consumer	Professional	Reuse	Waste treatment	Recycling	Market	Gap / barrier	(Voluntary) Approach
	WEEE Directive	Information on different materials and location of dangerous substances and mixtures in EEE	Manual or electronic media		> >	> >					x	x		Accessibility barrier (high effort for data access by "electronic media"); Granularity barrier (no particular materials defined)	Industrial initiatives (e.g., Information for Recycler platform; Recycling Information Center platform) provide information on product group level.
	WEEE Directive	Quantity of waste of EEE separately collected, recycled, recovered and disposed	Report								> >	> >	x		
Product design related information	Ecodesign Directive	Information on installation, use and maintenance, return options at End of Life (EoL), period of availability of spare parts, possibilities of upgrading products.	-			> >		x							
	Ecodesign Directive, WEEE Directive	Information on the consumers role in the sustainable use of the product and the ecological profile of the product and the benefits of ecodesign	-											Availability gap: directive sets goals on information, but these are not adopted or implemented in national legislation. The overarching directive does not result directly in any specific information requirements.	Labels and indicators exist, e.g., on the carbon footprint or single circularity aspects such as durability or repairability
	Ecodesign Directive	Disassembly, recycling or disposal at end-of-life.	-			> >					x	x			

Information category	Legal acts	Information requirement (grouped)	Access / format	Material producer	Supplier of articles	Manufacturer	Distribution /	User / Consumer	Professional	Reuse	Waste treatment	Recycling	Market	Gap / barrier	(Voluntary) Approach
	Ecodesign Regulation WM	Information on use, maintenance, access to professional repair, spare part availability	Manual			> >		x							
	Ecodesign Regulation Display	Information about spare parts	Datasheet, website			> >		x	x					?	
	Energy Labelling Regulation Display	Availability of software and firmware updates, availability of spare parts and product support in the product data sheet	Datasheet, website			> >		x						Granularity barrier (absolute specification of availability of updates, no reference for consumer)	
	Ecodesign Regulation WM/ Display	Repair and maintanance instructions (Component maps diagrams, disassembly map, etc.)	Datasheet, website			> >			x				x	Accessibility barrier (proof of competence is not clearly defined, imposing a barrier to access repair information)	
	Ecodesign Regulation Display	Information about dismantling needed to access any of the products components according to ANNEX VII WEEE Directive	Free-access website			> >					x	x		Accessibility barrier (free-access website with dismantling information not effectively usable)	The platform "Information for recyclers" (I4R) provides dismantling and material information on product group level
	ELV Directive	Information about dismantling and end of life	Datasheet, website			> >					x	x		Accessibility barrier (website with dismantling information not effectively usable) Information on brominated flame retardants and rare earth magnets missing, because there is no dismantling obligation yet.	International Dismantling Information System (IDIS) provides dismantling and other information for cars

Information category	Legal acts	Information requirement (grouped)	Access / format	Material producer	Supplier of articles	Manufacturer	Distribution /	User / Consumer	Professional	Reuse	Waste treatment	Recycling	Market	Gap / barrier	(Voluntary) Approach
	Battery Directive / Battery Regulation	Circularity: Carbon footprint Material: recycled content, Hazardous substances, cricital raw materials, material composition; Functional: expected lifetime, state of health, rated capacity, etc. (see Annex XIII); Product design: Dismantling information incl. safety measures and detailed composition of the battery model		>>	>>	>>	X	X	X	X	X	X	X	-	
	WEEE Directive, Battery Directive	Information not to dispose of WEEE as unsorted municipal waste and collect WEEE separately and about the collection systems and their role in the management of WEEE	Crossed-out wheeled bin			>>		x						Accessibility/format barrier (e.g., crossed out wheelie bin logo does not provide information about collection and return options)	

Information category	Legal acts	Information requirement (grouped)	Access / format	Material producer	Supplier of articles	Manufacturer	Distribution /	User / Consumer	Professional	Reuse	Waste treatment	Recycling	Market	Gap / barrier	(Voluntary) Approach
	WEEE Directive	Information about preparation for re-use and treatment in respect of each type of new EEE, different EEE components and materials, as well as the location of dangerous substances and mixtures in EEE	Manuals, electronic media			> >					x			Accessibility barrier (high effort for data access by "electronic media"); Granularity barrier (no threshold for materials defined);	Industrial initiatives (e.g., I4R, see above)
Circularity information	Ecodesign Directive	Ecological profile of the product and the benefits of ecodesign	in the form manufact urer deem appropria te			> >		x						Availability gap (directive sets goal on information, but is not implemented)	Label and indicator provide information on CO2 or circularity aspects (e.g., durability, repairability, etc.)
	CSDD Directive Proposal	Information on social issues (minerals originating from conflict-affected and high-risk areas)	Report		> >	> >		x					x	Granularity (CSR reports might be too complex for consumer); Validation (manufacturer claims on sustainability are self-declared)	Type I labels validate and aggregate information on due diligence, such as TCO, EU Ecolabel, TÜV Rheinland Green Product Mark or Nordic Ecolabel.

2 Part B – Evaluation of stakeholder requirements

The central task of part B is the validation of information gaps described in part A and the identification of further needs of stakeholders that are deemed to be necessary to effectively implement and use digital product information to contribute to Circular Economy goals. In addition, confidentiality and availability aspects are considered to explore potential data gaps. The analysis covers a wide range of stakeholders using a multi-method approach. To reduce the complexity and heterogeneity the results are presented in an aggregated form, which will be based on the analysis framework already introduced in the previous chapter (see 1.3).

Part B is structured as follows:

- ► Section 2.12.1 presents the multi-method approach.
- ► Section 2.2 - 2.4 elaborates for each product group and stakeholder category:
  - all relevant information requirements from stakeholder perspective (bottom-up) in the sub-chapter "relevant data".
  - the stakeholder evaluation on legal information and metadata related requirements as well as on potential (voluntary) approaches in "evaluation of data gaps and remedies".

2.1 Methodology of the analysis of stakeholder requirements

The stakeholder consultation aims to identify information gaps in legislation and exploration of potentially data that is considered relevant from the perspective of different stakeholder groups regarding the effective implementation of a digital Circular Economy. For this purpose, the European Commission (EC 2022) intends to increase the availability and accessibility of digital product data. However, as with all standardization projects on this scale there are several challenges that need to be addressed in advance.

Therefore, it is important to identify and understand the requirements of various stakeholder groups that already provide and use product-related data. Furthermore, it is necessary to examine current data gaps and further data potentials that can contribute to a CE and might need legislative intervention. This includes not only content-related data aspects such as the information content, quality or granularity of data points, but also more practical aspects, such as the technical capabilities, legal considerations, or business concerns of specific stakeholders. The following analysis will therefore address a series of stakeholder-specific and cross-cutting questions, which are presented in Table 19.

Table 19: Stakeholder-specific and cross-cutting questions on data needs and requirements

Stakeholder category	Stakeholder group	Research questions
All	▪ All	Are you currently obliged by law to provide information? OR if not: Which information are you currently working with? Is the mandatorily provided information suitable to achieve political targets/CE goals? OR: What are data gaps for the effective implementation of CE goals? Which information might be relevant in future? What are current barriers? (potential barriers might be: level of detail, interface to write and read product-related data, technical infrastructure (i.e., central, decentral), effort, etc.) What are potential benefits from a DPP?
Upstream value chain (A)	▪ Material producer and importer ▪ Product manufacturer ▪ Product developer and designer ▪ Distributor and retailer	What are your current data gaps regarding the material composition of products and pre-products? Is data availability (from indirect supplier) a challenge? For which information do you see data validation necessary? What are your business and legal concerns regarding the provision of confidential data? How could you benefit from reverse information flows from the downstream supply chain?
Downstream value chain (B)	▪ Remanufacturer, Reuse, Repair ▪ Refurbishment / washing and textile services ▪ Collection and treatment ▪ Sorter ▪ Recycler ▪ Recycling distributor and retailer ▪ Manufacturer of waste treatment technology ▪ Manufacturer of secondary raw materials	What are your current data gaps regarding the availability and accessibility of data relevant for repair, remanufacturing, reuse and collecting/ sorting of products? What type and quality of data quality (granularity, validity) do you need to increase the product recycling rates (quality/quantity)? Which type of data carrier do you prefer to identify used products and product-related data (e.g., QR codes, barcodes)?
Consumers (B)	▪ Consumers	What product information do consumers need to make an informed and sustainable purchasing decisions? How should information be provided to consumers (e.g., accessibility, availability)?

Stakeholder category	**Stakeholder group**	**Research questions**
External stakeholder (C)	▪ Certification bodies ▪ Consumer protection associations ▪ Consumers ▪ Public procurement entities ▪ Government institutions ▪ Market surveillance authorities	What are current data gaps regarding the availability and accessibility of data relevant for market surveillance (e.g., CE marks, compliance statements, safety sheets, etc.)? What level of detail and data reliability do you need for certain data points? How important is the validation of information, e.g., by 3rd party audits?
Technical experts (A-C)	Technical experts/developers (front-end, back-end) Product identification and data exchange expert Circular Economy and interdisciplinary experts Product information system expert	What are current approaches to implement and connect digital product databases? Would you recommend central or decentral technical approaches? What are lessons learned from previous projects? Which semantic systems (ontologies, taxonomies) for product data exist and are used on the market?

The consulted stakeholders have been selected by the following criteria: They operate in different market settings, have different interests (i.e., demand-side, supply-side, market surveillance) and/ or work at different touchpoints with data (i.e., physical/digital, etc.). Many of them already use IT systems to manage product-related data or a part of existing data networks (e.g., IMDS, EPREL). Due to the heterogeneity of stakeholders, the study used a combination of quantitative and qualitative approaches to tailor the methods used to different needs and interests: desk research, semi-structured expert interviews, a quantitative consumer survey and a series of stakeholder workshops (see detailed descriptions in Figure 16 and Table 20). Regarding the scope of products, many research questions relate to general aspects of product data. Where necessary, the survey scope was limited to electronic consumer goods and textiles (i.e., clothing, fashion products).

Figure 16: Schematic illustration of the research design for the exploration of stakeholder requirements

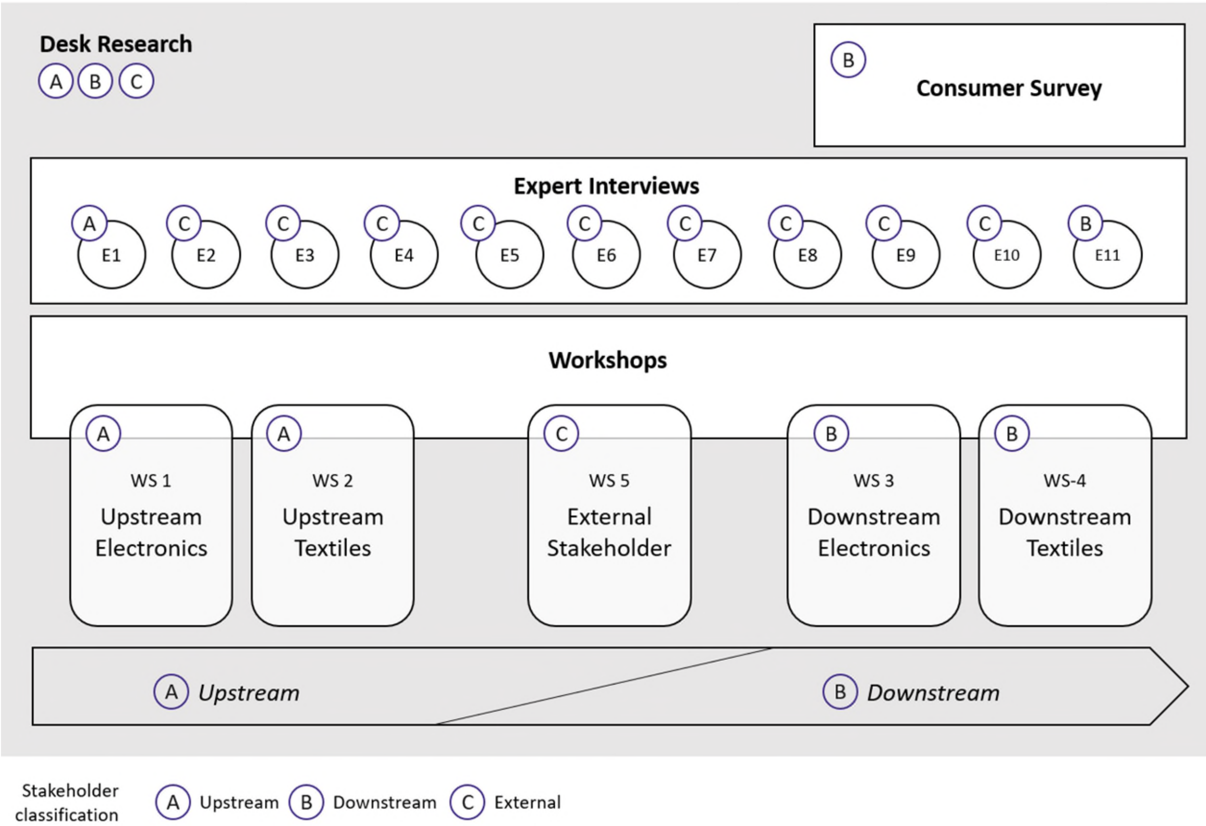


Table 20: Survey methods used for the exploration of data requirements of stakeholders

Method	Description	Stakeholder group	Number of stakeholders	Analysis
Desk research	Research and explorative review of documents or publications by stakeholders regarding the provision of product data, the implementation of a DPP or studies on stakeholder perspectives (e.g., blogs, websites, whitepapers, official statements, brochures)	All	*	Qualitative content analysis

Method	Description	Stakeholder group	Number of stakeholders	Analysis
Expert interviews	Scoping interviews with semi-structured questionnaire	All (excl. consumers)	26	Qualitative content analysis
Expert workshops	Five interactive online workshops on: Textile (up- and downstream) Electronics (up- and downstream) External stakeholders	All (excl. consumers)	53	Mixed-method content analysis
Consumer survey	Representative online survey with structured questionnaire	Consumers	1.001	Descriptive statistical analysis

* The desk research was a horizontal task that overlapped with the literature review in Part A of this study.

The next sections (2.2 - 2.4) present for each sector the different stakeholders' information requirements, clustered according to the three stakeholder categories. For both sectors (electronic and textile) distinct upstream and downstream stakeholder requirements are presented. Data requirements of external stakeholders are cross-sectorial, regardless of where they operate in the product lifecycle, thus presented in a separate chapter, independent from the sector. Stakeholders often have a dual role as data provider and receiver, which makes it hard to identify, map and assess the relevant data channels distinctively. In the following results are presented per sector, structured within two main areas:

- **Current data practices and requirements**: What relevant data is already used by stakeholders on a regular basis? What further data is required?
- **Data gaps and remedies**:
  - Are the information requirements identified in legal documents sufficient for stakeholders to achieve circular economy goals? Which other gaps or barriers exist?
  - Can the data gaps be closed by existing measures, e.g., voluntary approaches? What further measures or information is necessary?

The consumer information requirements were gathered with the help of a representative survey and pre-set questionnaire. A 20-minute online survey was conducted with a sample of 1,001 participants between the ages of 18 and 75, representative of gender, age, education and income in Germany. The survey took place in January 2022. For the report the survey questions and results were translated from German to English. The questionnaire consisted mainly of closed questions with additional options to add individual comments. The focus of the survey was to gather information requirements and preferences of customers along the different product lifecycle stages of electronic appliances and clothing. Electronic products and clothing include a vast variety of different products regarding price, branding, functionality and other product-related aspects. The survey did not further specify the two product groups for participants, which can bias the results. In addition to product-related aspects, relevant preferences and expectations about the implementation and usage of a digital product passport had been collected. The collected data was mainly analysed descriptively.

2.2 Information requirements: electronic sector

2.2.1 Upstream stakeholder requirements

2.2.1.1 Current data practices and requirements

The majority of product-related data has currently its origin in the upstream value chain of products (see Part A). This includes general product and company information, technical and functional specifications, material compositions and information on product design that can typically be provided by manufacturers and product dealers[35].

Information requirements identified in the expert consultation (workshop 1 and interviews) are presented in an aggregated form in Table 22 differentiated for upstream stakeholders within the electronics value chain. During the workshops the participants were asked to rate the relevance of several information aspects, which were then quantified.

Although the participants represented different stakeholders such as manufacturers, component suppliers or retailers, a shared relevance of specific data points could be identified. This includes data on material compositions and characteristics, which are necessary for the design and manufacturing of products, but also relevant to comply with existing market rules and reporting requirements (e.g., CE marking, REACH). Furthermore, detailed supplier information (e.g., components, pre-products) is seen relevant to stakeholders in the upstream value chain, which might also include information on the sustainability and CSR-engagements of the supplier. In relation to upstream data, downstream data seem less important but still relevant for stakeholders in the upstream value chain. This includes condition data on the usage and repair history of products, and also customer feedback.

The last column in Table 21 indicates if the data point is already covered by legislations as an information requirement. It has to be mentioned that the data points specified by the workshop participants do not always match entirely the wording of the information requirement in legislation. Thus, the symbol "~" indicates, that the information requirement in legislation does not fully match the stated information demand by the stakeholder or is subject to interpretation. For example, the information demand "Material composition per component" could match the requirement in the WEEE Directive on "information on different EEE components and materials". Requirements with a relevance over 60% and not covered by legislation are highlighted in bold.

During the workshop the stakeholders were asked to visually rate the information aspects above from relevant to not relevant. The results of each stakeholder were coded. Based on the responses, a weighted relevance score was calculated as the proportion of all counted responses (yes, no) and all possible responses (N = total sample size), including abstentions. The color coding indicates the relevance from red (important) to green (less important) based on the amount of responses (counts). Due to the heterogeneity of the stakeholders the relevance of single information aspects can differ between the participants. (N=9). Source: Technical University Berlin 2022.

[35] 'Dealer' is defined as a retailer or any other natural or legal person who offers products for sale, hire or hire purchase, or displays products to customers in the course of a commercial activity, whether or not in return for payment (COM(2022) 142 Art. 1 paras. 46.)

Table 21: Relevant information aspects in the upstream value chain of electronics

Data providing stage	Information category	Data point	N	No	Yes	Counts	Relevance	Covered in legislation
Upstream Data (A) General info., Tech specs, Materials level, Product level,	General product & company information	Registered WEEE/fee paid	9	0	6	6	67%	n
		Original sales price	9	2	5	7	56%	n
		Component supplier company details	9	0	9	9	100%	y
		Supplier sustainability info	9	0	9	9	100%	n
	Technical specifications	**Main functionalities as advertised**	9	0	8	8	89%	n
		Technical parameter	9	0	9	9	100%	y
		Material composition of dismantled fraction	9	2	3	5	33%	~
		Material composition of shredded fraction	9	2	4	6	44%	~
	Material & composition	**Material origin**	9	1	7	8	78%	~
		Hazardous substances	9	0	9	9	100%	y
		Material composition per component	9	0	9	9	100%	~
		Material composition of product	9	0	9	9	100%	y
		Recycled content per material	9	0	9	9	100%	n
		Recycled content per product	9	0	8	8	89%	n
		Recycled material origin	9	0	1	1	11%	n
	Product design & Service	Repair information (spare part availability, documentation, component map, dismantling instructions)	9	0	8	8	89%	y
		Design for reuse/refurbishment/repair	9	0	7	7	78%	n
		Component map (name/ID)	9	0	7	7	78%	n
		Durability test results	9	0	9	9	100%	n
		Design for longevity/durability score	9	0	9	9	100%	n

Data providing stage	Information category	Data point	N	No	Yes	Counts	Relevance	Covered in legislation
Downstream Data (B) Usage, Product History, End of Use		**Usage (hours of use, washing cycles)**	9	1	6	7	67%	n
		Repair history (exchanged parts)	9	2	6	8	67%	n
		Purchase date	9	2	7	9	78%	n
		Feedback from users	9	0	8	8	89%	n
		Product condition when recycled	9	0	5	5	56%	n
		Product condition when repaired	9	1	7	8	78%	n
		Product condition when reused/resold	9	1	6	7	67%	n
		Date of recycling	9	1	5	6	56%	n
		Recycling performance	9	0	8	8	89%	n
Circularity Social Impact, Environmental impact, Certifications		Digital receipt (for warranty)	9	0	1	1	11%	n
		LCA of goods/services	9	0	7	7	78%	n
		Sustainability certificates	9	0	9	9	100%	n
		Biodegradability	9	2	5	7	56%	n
		Recyclability score	9	0	1	1	11%	n

The analysis shows a particularly high relevance of data about the durability and longevity of products or components, which is associated by the stakeholder with consumers' information demands and corresponds to the results of the consumer survey (see Chapter 2.2.3). The relevance of this type of information is also confirmed by the expert scoping interviews. Moreover, detailed data on the material composition as well as recycled material content was mentioned to be important for all economic operators in the upstream value chain. Major gaps prevail in downstream data, including usage and repair history, purchase date and product condition. This dynamic data from downstream stakeholders (consumers, repairers etc.) is not covered by legislation, as legal requirements mostly address manufacturers, EU importers or authorized representatives who place products on the market. The same applies to circularity information, in particular on LCA of goods/services and sustainability certificates.

Although the information on detailed material compositions is seen as very important by manufacturers, suppliers and other economic operators in the upstream value chain, not all of them are willing to disclose such information. During the workshop, participants mentioned major concerns about the disclosure of critical and confidential business information such as supplier contacts, the origins of components or detailed data on material compositions. They also pointed out, that the level of detail is an important aspect which determines the sensitivity and confidentiality of information. It was mentioned, that it makes a huge difference, if for example companies have to declare the existence of a hazardous substance in a product with a binary coding such as "yes/no", or if they need to give detailed information on the location and concentration of the substance.

If data is relevant, it does not automatically mean that it is accessible and available to the respective stakeholders. Table 22shows that a lot of important data are already available and not confidential. These include product quality and performance aspects such as price, information on functionalities and features, compliance certificates and conformity statements or information about hazardous substances and recycled content.

Workshop participants voted if a data point is available and not confidential on a scale from 0 - 3 (see caption). Bold indicates the top five data points, that are not available / confidential (equal ranking might increase the number of total marked data points). The table shows averaged results from workshop 1 with stakeholders in the upstream value chain of electronics (manufacturing to retail) (N=9).

The ranking is scaled as follows (see also caption below the table): Confidential: 0 = not confidential, 1 = partly confidential, 2 = mostly confidential, 3 = confidential; Available: 0 = available, 1= mostly available, 2= partly available, 3 = not available.

Table 22: Availability and confidentiality of data within the value chain of electronics from upstream stakeholder perspectives.

Data point	Confidential	Available
Biodegradability of product	0,4	**1,375**
Circularity indicator (e.g., French repair index)	0,4	0,875
Compliance tests (for legislation, standards)	1,4	0,375
Instructions for waste treatment	0,8	0,625
LCA or CO2 footprint of product	0,8	1
Main functionalities as advertised	0	0,375
Original sales price	0,4	0
Presence of hazardous substance + location in product	0,8	0,625
Number of products put on the market	0,4	1,125
Repair cost estimations (e.g., based on failure)	**1,8**	**1,375**
Repair history	**1,8**	**1,875**
Recycled content per material	1,6	1
Recycled content per product	0,4	0,75
Critical raw material type + amount in product	1,4	**1,375**
Materials type + amount per component	1,6	**1,375**
Materials type + amount in product	**1,8**	1,125
Material origin	**2,4**	2

<table>
<tr><th colspan="3">Data point</th><th>Confidential</th><th>Available</th></tr>
<tr><td colspan="3">Tier 1 company data (e.g., product/ system assembly)</td><td>1,8</td><td>0,5</td></tr>
<tr><td colspan="3">Tier 2 company data (e.g., components)</td><td>2,4</td><td>0,75</td></tr>
<tr><td colspan="3">Tier 3 company data (e.g., parts)</td><td>2,4</td><td>0,875</td></tr>
<tr><td colspan="3">Tier 4 company data (e.g., material producer)</td><td>2,4</td><td>2</td></tr>
<tr><td colspan="5">Caption</td></tr>
<tr><td>Confidential</td><td>0 = not confidential</td><td>1 = partly confidential</td><td>2 = mostly confidential</td><td>3 = confidential</td></tr>
<tr><td>Available</td><td>0 = available</td><td>1= mostly available</td><td>2= partly available</td><td>3 = not available</td></tr>
</table>

Source: Technical University Berlin 2022.

Low data availability in combination with confidentiality particularly occurs at the top of long value chains (Tier 4). Even though, data from suppliers on components and parts is still available, it is often confidential (e.g., exact material composition of plastics and other compounds). Stakeholders that are obliged to provide information for compliance are therefore faced with the problem that they are not always able to access accurate information on the materials used.

2.2.1.2 Data gaps and remedies in the upstream value chain

Manufacturers, designer, brands

In the interviews and workshops, manufacturers stated a high relevance for information on the material composition. While they have good access to information from their (direct) suppliers of tier 1 and 2, they have limited access to material information from the top of the supply chain, namely tier 3 and 4 although the latter cover suppliers of substances and mixtures who have certain information duties under REACH. For example, they have to pass safety data sheets (SDS) to the next user of the substance/mixture, if it meets the criteria for classification as hazardous (REACH, Art. 31). However, the SDS does not have to be passed on once the substance or mixture becomes an article (e.g. an additive in plastic material). Suppliers or producers of articles like intermediate products are mainly obliged to register articles with SVHC content above 0.1% (w/w) to the SCIP database and prefer to provide material compliance declarations which aggregate the material composition to their buyers (e.g., manufacturer of finished products). Furthermore, it was mentioned that suppliers often do not provide proof or validation in form of compliance test reports, increasing the manufacturer's effort to identify potentially false information or changes of material properties, e.g., by retesting production batches. Tracing information back to determine the material composition of supplied intermediate products (articles) is currently seen as a major challenge towards material compliance. Therefore, they stated the demand for validated compliance tests to be provided by suppliers. Several existing sources of data were discussed:

- The mandatory registration of articles with SVHC content above 0.1% (w/w) in the SCIP database was seen as a useful approach to trace substances. However, the usefulness of information in the SCIP database is limited, as everyone can enter data without validating the own identity. The EPREL database was mentioned as an example how a validation process could work. The international material data space (IMDS) in the automotive sector was mentioned as an example to establish a flow of detailed information (material declaration, BOM) from the beginning of the value chain.

- The IEC 62474 standard was mentioned to be sufficient to meet legal obligations for the electronic industry. But, the standard is of limited use for cross sectorial suppliers, e.g., on electronic and car manufacturers, because it ends with the thresholds in their substance lists for electronic products and does not consider requirements from other sectors.

Besides the material composition, also information on the origin of materials is a legal requirement for particular companies, e.g., in due diligence legislation. Such information entails the same gaps and barriers. First, tracing the intermediate products and materials back to their origin in long supply chains is considered to be challenging, causing low data availability and data gaps. Second, if data are available their validity is questionable, in particular if coming from actors located outside the EU.

Retail and distribution

Retailers state an overload of information including certificates, labels and logos in general. They fear that customers are distracted by too much and possible unimportant information in their purchasing decision. From their perspective it is a challenge to understand product data or compare products to each other without external support like smartphone apps or comparative product tests. Detailed material information is of less relevance to them and they prefer more aggregated information which is tailored to the consumers' information demands. A future demand was stated on information on the design, e.g., for longevity, durability or repairability which they think will be gaining importance for consumers. In this regard, recycled content and material composition can be of increasing interest as well.

2.2.2 Downstream stakeholder requirements

2.2.2.1 Current data practices and requirements

Information requirements of downstream stakeholders in the electronic value chain (excl. consumers) were revealed in workshop 3, complemented by interviews. Here again, after a discussion of required types of data and possible information gaps, the participants were asked to rate the relevance of different types of information. The results are presented in an aggregated form in Table 23. Requirements with a relevance over 60% and not covered by legislation are highlighted in bold.

During the workshop the stakeholders were asked to visually rate the information aspects above from relevant to not relevant. The results of each stakeholder were coded. Based on the responses, a weighted relevance score was calculated as the proportion of all counted responses (yes, no) and all possible responses (N = total sample size), including abstentions. The color coding indicates the relevance from red (important) to green (less important) based on the amount of responses. Due to the heterogeneity of the stakeholders the relevance of single information aspects can differ between the participants. (N=12). Source: Technical University Berlin 2022.

Table 23: Relevant information aspects in the downstream value chain of electronics

Data providing stage	Information category	Data point	N	No	Yes	Counts	Relevance	Covered in legislation
Upstream Data (A) General info., Tech specs, Materials level, Product level	General product & company information	Identical products with diff. branding (white label products)	12	4	6	10	50%	n
		Field of usage	12	2	9	11	75%	n
		Registered WEEE/fee paid	12	4	5	9	42%	n
		Manufacturer name	12	4	7	11	58%	y
		Company information	12	7	3	10	25%	y
		Product name/identifier	12	1	9	10	75%	y
		Original sales price	12	8	2	10	17%	n
		Product category and type	12	1	10	11	83%	y
		Product dimensions (size/weight)	12	0	11	11	92%	y
		Energy consumption / class	12	0	0	0	none	y
	Technical specifications	Product information sheet EPREL	12	1	6	7	50%	y
		Warranty information	12	1	8	9	67%	y
		Product photos	12	5	4	9	33%	n
		Performance (e.g., cooling, washing program)	12	0	2	2	17%	y
		Carbon footprint	12	0	1	1	8%	n
	Material & composition	Material Value	12	0	1	1	8%	n

Data providing stage	Information category	Data point	N	No	Yes	Counts	Relevance	Covered in legislation
		Material origin	12	2	10	12	83%	3GTs impor ter
		Recycled/renewable content (percentage)	12	4	7	11	58%	n
		Full material declaration of chemicals	12	2	10	12	83%	n
		Hazardous substances	12	0	12	12	100%	y
		Component weight	12	2	9	11	75%	n
		Chemical content	12	0	12	12	100%	~
		Location of hazardous substances in product	12	2	10	12	83%	for waste treat ment
		CMR content	12	0	1	1	8%	n
	Product design & Service	Modularity/upgradeability and software update	12	0	1	1	8%	some produ ct group s
		Repair information (spare part availability, documentation, component map, dismantling instructions)	12	4	7	11	58%	for prof. repair
		Disassembly instructions	12	2	10	12	83%	for waste treat ment
		Component location and types	12	0	2	2	17%	for waste treat ment
		Potential treatment strategy/process	12	3	6	9	50%	n
		Design for reuse/refurbishment/ repairability	12	2	8	10	67%	n
		Maintenance instructions	12	3	9	12	75%	y

Data providing stage	Information category	Data point	N	No	Yes	Counts	Relevance	Covered in legislation
		List of product components	12	0	12	12	100%	some product groups
		Repair instructions	12	0	2	2	17%	some product groups
Downstream Data (B) *Usage, Product History, End of Use*		**Usage (hours of use), (washing cycles)**	12	1	10	11	83%	n
		Repair history (exchanged parts)	12	2	10	12	83%	n
		Condition (state of product prior to refurb for second hand market, potential damage)	12	3	7	10	58%	n
		Purchase date	12	3	9	12	75%	n
		Instructions for disposal/takeback	12	2	10	12	83%	y
		Number of different users	12	0	1	1	8%	n
		Prior owners/anti-theft protection	12	0	2	2	17%	n
Circularity *Social Impact, Environmental impact, Certifications*		LCA of goods/services	12	6	2	8	17%	n
		Availability of recycling/waste streams	12	4	5	9	42%	n
		Sustainability certificates	12	4	6	10	50%	n
		Biodegradability	12	3	8	11	67%	n
		Durability indicator	12	3	6	9	50%	n
		Repairability indicator	12	2	8	10	67%	n
		Recyclability score	12	2	7	9	58%	n
		Reusability indicator	12	0	1	1	8%	n

Despite the heterogeneity of stakeholders (ranging from recyclers, trading platforms for secondary materials, repair services, research institutes, to recycling technology providers) they converged on a need for information on material compositions (i.e. hazardous substances, list of components, chemical content, material origin) and other characteristics of a product like its configuration (i.e. dimension) and maintenance requirements. Furthermore, the downstream stakeholders deemed individual product-lifecycle data (i.e. repair history, usage hours) and information on certificates related to the sustainability, durability, biodegradability and other environmental aspects as relevant. The next section discusses the information requirements alongside different circular practices in the downstream value chain.

2.2.2.2 Data gaps and remedies in the downstream value chain

Reuse, refurbishment, preparation for reuse

The general aim of reuse and refurbishment operators is to sell products for second use by repairing broken or exchanging worn out parts. Similarly, preparation for reuse operators aim to extract valuable products or parts from the waste stream to sell or for reuse, in general. Reuse operators expressed a demand for information on the residual monetary value, based on costs for repair or refurbishment (for products) and/or the resell price of a product at hand. It was mentioned that a mix of upstream and downstream (including usage) information allows to determine the residual value. Most important upstream information comprises the energy efficiency class, original sales price, technical and functional specifications as well as durability and repair information (e.g., spare part lists, software update availability). Relevant downstream information includes the usage history (usage time[36], cycles, age) as well as the repair history on component level. Exemplarily, the refurbishment website "Buyback" (Buyback 2022) offers an integrated website tool that estimates the residual value. It reflects the statements given by the reuse operators on necessary information from a process point of view exemplified here for the case of smartphones:

- product model and version (colour, year, storage/capacity, power, etc.),
- existence of a sim-lock or activation lock (smart devices)
- usage history / current condition
  - can it be switched on, does the monitor work?
  - are there visible damages (big scratches, strong wear out)?
  - are there internal damages (water damage, can it be charged, are the main functions working)?

The stakeholders argued that 2nd hand and repaired products are still not popular among consumers which might be tackled by better information on the second hand quality, for example in the form of second hand labels. For both product groups (electronics and textiles) it would present a potential barrier if users have to provide data manually.

Repair (non-professional and professional)

Repair actors are differentiated into two categories: The respective implementation measures of the Ecodesign Directive defines "professional repairer" as actors who provide services of repair and professional maintenance of electronic displays. Only professional repairers are ensured access to detailed information relevant for repair after registration and verification at the manufacturer's website (at least for some product groups like displays). The consulted repairers assessed the provided information as sufficient to conduct necessary repairs. The other form of

[36] The term „usage time" is used equivalent to „service life"

repair actors that are those who are not authorised by the product manufacturer (which are called non-authorised, non-professional or independent repairers). They criticise that information is exclusively provided to authorised (professional) repairers, which prevents affordable repair. Some professional repairers criticised that the registration can be refused by manufacturers.

Repairers stated a demand for information on the purchase date of products (to check if the broken product could be treated as a warranty case), on the usage history and the current condition of the product and possibly its repair history (e.g., exchanged parts). This information would have to be provided by the product user and possibly the repairers, thus seen as beneficial to use but at the same time associated to costs for providing this information.

It was also discussed if a product passport could meet some product model specific requirements like a list of necessary repair skills, the economic feasibility of a (professional) repair, disassembly instructions or spare part availability. This type of information could facilitate all sorts of repairs, particularly of product groups with a low repair success rate. Some repairers were also willing to provide feedback to manufacturers, e.g., on failure statistics to facilitate repair friendly design.

Waste treatment - collection and sorting

The collection and sorting of waste separates hazardous materials from waste streams for separate treatment, as defined by the WEEE Directive. This process can include a pre-sorting step to separate products with high material value, while a separation on component level is considered in the consecutive sorting step.

From the recycler's point of view most products containing hazardous substances are usually identified by experienced collection staff to a sufficient degree for further treatment and high-quality recycling. Product information mainly becomes relevant if a product technology changes which might result in the need for separate collection. Technological changes need to be communicated, for example as a notification within a document issued by the manufacturers (product change notification) which is currently already done in the semi-conductor industry. Furthermore, the recyclers would benefit from the information if the EEE is registered and the "EPR[37] fee" has been payed.

The sorting processes generally aim to separate products and components with target materials of value from those containing hazardous substances at an early stage. In principle, information in the SCIP database could support the separation of waste or identify material-based streams with these substances. However, such information is not accessible at the product in the waste stream. The information can only be accessed via an internet browser and only one article at a time. An effective access to product model specific information within the collection and sorting process is hindered by the fact that products lack an individual identifier. For some product groups, mandatory physical markings currently indicate the presence of cadmium, mercury or plastic parts. However, it was argued, that even with this information accessible on the product, the additional time needed for the (dismantling and) sorting is not justified by the slightly higher purity of the waste streams. Here, automated sorting has to be distinguished from manual sorting. The reading speed of the data carrier (e.g., RFID) is an important criterion in particular for automated sorting to be economically viable. In manual sorting, a standardised location of the data carrier is essential. Further it is required that the material information is always

[37] Extended Producer Responsibility

available to not interrupt the waste treatment process, which might require the information to be stored locally at the waste treatment plant.

The I4R platform has been mentioned to be useful for some product groups to provide material information on product group level where hazardous materials are to be expected on the same components across different products. At the same time information on product model level is necessary for other product groups that differ in technology, used hazardous materials and their location.

In future, information on the material composition was seen to play a major role. Some recyclers highlighted the necessity for a declaration of material type, amount, grades, additives and pollutants in products to optimise the recycling process, particularly in the case of plastics recycling. For other products and recycling facilities a disclosure of a full SVHC inventory per product group placed on the market would suffice. Valuable materials could be disclosed by the share of technical materials as well as critical raw materials per product model.

Considering the number of products and related data it was suggested by waste treatment operators to make information available on valuable and hazardous materials per main component with a high weight or value relative to the overall weight. Some information can be disclosed on a voluntary basis, for example on technical components or materials which might be subject to intellectual property (IP) interest. At the same time, this aggregated approach of disclosure would meet potential IP interests and limited data availability from manufacturing. Sorting stakeholder confirmed that material information is necessary not directly when the product is placed on the market, but at the earliest after approximately half of the expected lifetime of the product group (or after one year, according to WEEE legislation) and should not be limited in the duration of availability. In this manner, relevant product groups per sector should be specified with respect to the necessary information and aggregation (product, component and material value and recycling processes).

The implementation to establish a sorting system or adapt material streams is linked to financial investments by waste treatment operators. To provide added value for reading DPPs of products in the waste stream it is required that a large number of products in the market/waste stream with an identifier (e.g. NFC chip) and material information exist, which can be seen as a structural requirement

A deep dive into technical requirement, for example on the reliability and robustness of the identifiers can be found in part C of this study (4 – Part C).

Early sorting of products or components by their material content is seen favourable in comparison to sorting of materials as flakes after shredding. Shredding of components might destroy or blend valuable and hazardous materials, which then could not be (efficiently) recovered or removed. Furthermore, the identifier will be destroyed after shredding, which requires to read all necessary information at component or product level.

Current research on augmented sorting and automated dismantling would profit from dismantling instructions as well as information on materials and their location in the product in a machine-readable way.

Waste treatment - crushing, shredding, sorting, recycling

Crushing or shredding electronic waste results in fractions consisting of small heterogeneous material flakes that are further sorted. The consulted stakeholders expressed information requirements on the types of metals, polymers (e.g. PET, PP as well as homo-/copolymer) and plastics with information requirements on specific additives like flame retardants and fillers. This information is of particular relevance for post-consumer plastic waste due to the heterogeneity of the waste. Information on the waste source was mentioned to be relevant for product-to-product recycling (e.g., food contact grade). Further information requirements could be derived from the target fractions to be separated, in particular wires (insulated copper wires, etc.), technical plastics (with specific properties), BFR (brominated flame retardant) plastics and black plastics. Material level information was also seen relevant for recyclers. In the recycling step, the sorted materials are processed and compounded into secondary materials, preferably in a high quality for the target application. Therefore, information on the material profile of the input fraction is relevant comprising the material composition and substance of concern content of the shredded fraction coming from the previous stage.

Barriers to use the material information are missing common standards and terminology. This includes cross-sector quality standards for recyclers as well as definitions of “technical material”-types in many sectors (like, e.g., plastics). Recyclers recommended that information on possible processing methods could be specified instead of declaring the material composition, as too much information would require additional effort for processing and extracting the relevant information.

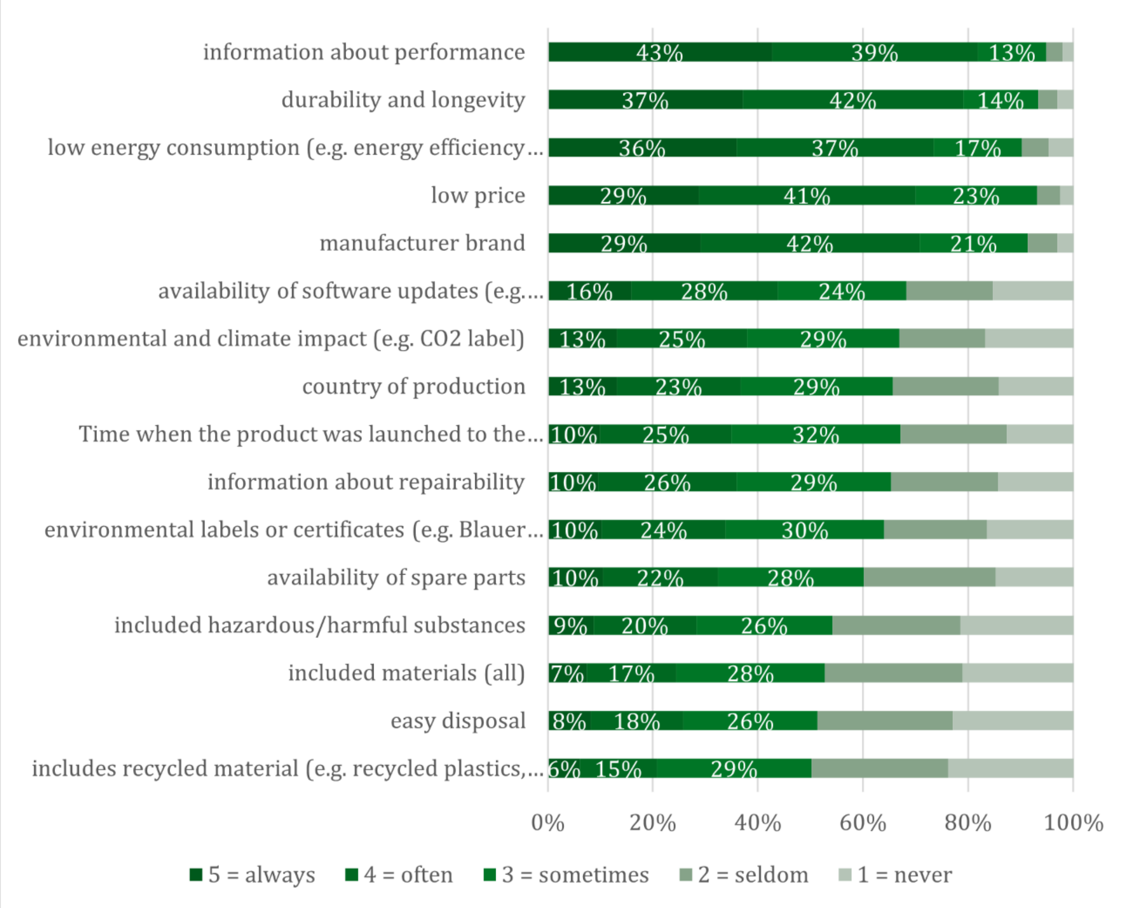
A technical barrier to the accessibility of information to recyclers was seen in the shredding process which will likely destroy the product identification interface**.** Therefore, recyclers are rather in favor of DNA markers that persist on material level and can be read by optical detection (see Chapter 2.2.2).

2.2.3 Downstream stakeholder requirements - consumer survey

2.2.3.1 Current data practices and requirements

The participants of the consumer survey were asked to rate how often they considered different information aspects when buying an electrical appliance on a scale from 1 (never) to 5 (always). The results show that information about the performance is most frequently considered: 82 percent of respondents consider this information always or often when buying a product. This is followed by information about durability and longevity (79%), energy efficiency (73%) and brand information (71%) and low price (70%). Although a low price features among the important aspects less than a third of respondents reported to always consider it in their purchase decision.

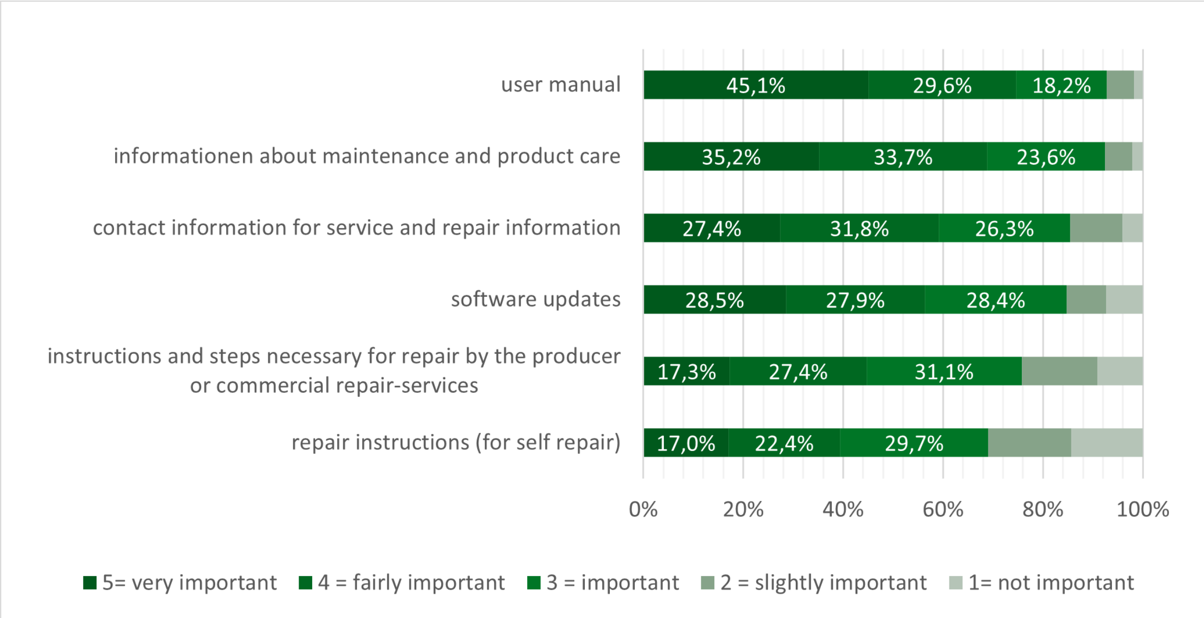
Figure 17: Consumer survey responses to the question on the "frequency of considering different information aspects when buying an electrical appliance". From dark green ("I always consider this information") to light green ("I never consider this information").



Relative distribution and relevant information aspects when buying electronic products; Question: "How frequently do you take the following aspects into consideration when buying electrical appliances?" (n=1001). Multiple answers are possible.
Source: Technical University Berlin 2022

When asked about which information is important during the use phase of a product, the majority of respondents assessed the user manual (75%), information about maintenance and product care (69%) and contact information regarding service and repair (59%) as important or very important.

Figure 18: Consumer survey responses to the question "What information is important to you when using an electronic product?". From dark green ("Very important") to light green ("Not important").



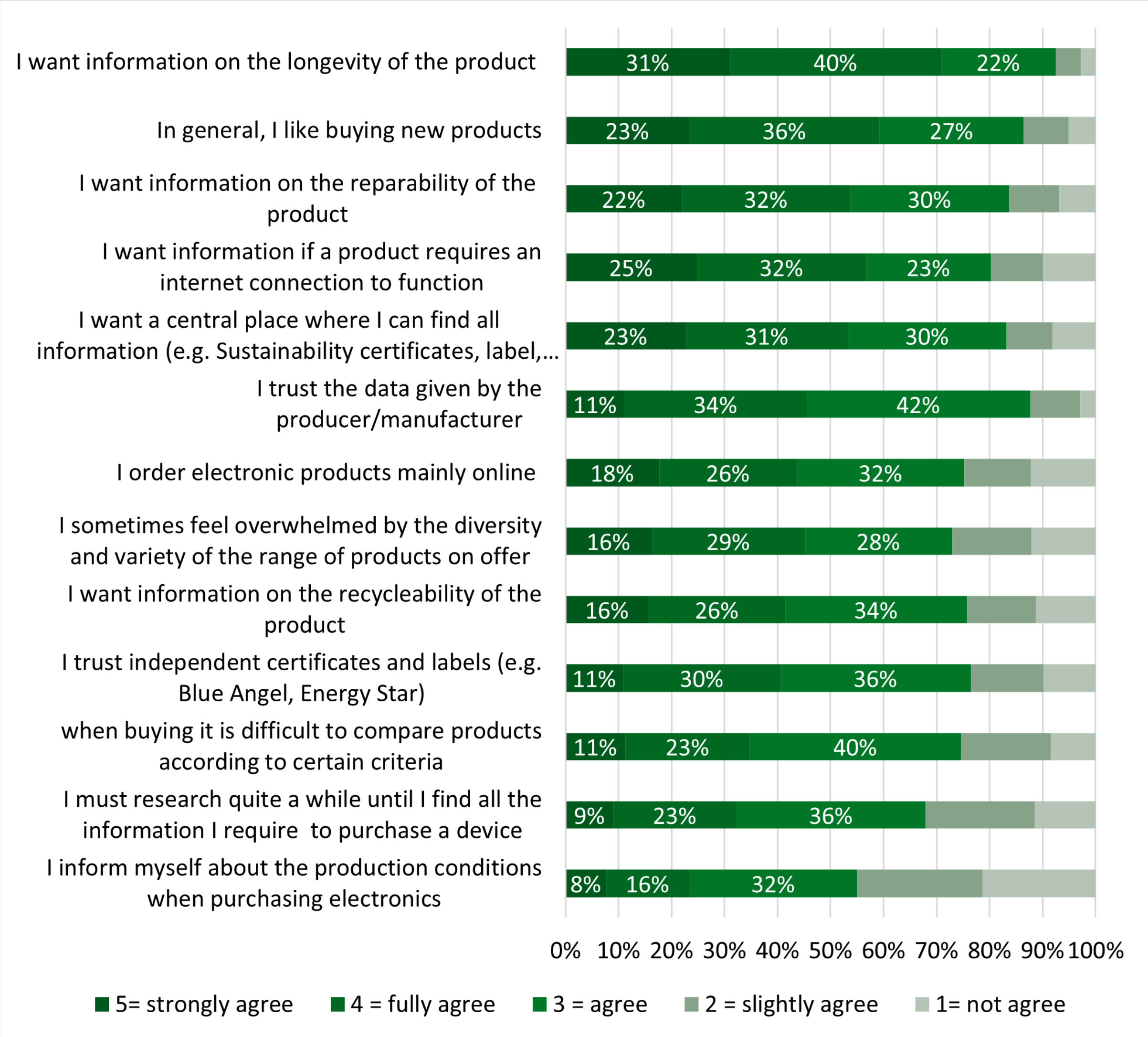
Relative importance of information regarding the use phase of an electronic product (n=1001). Multiple answers are possible. Source: Technical University Berlin 2022

Information about the availability of software updates was of high importance to the majority (56 % very important or important). Repair related information was seen less important, but still a significant number of respondents assessed repair information for professional repair (44%) and self-repair (39%) as important or very important.

The respondents were asked to agree or disagree to predefined statements about their shopping expectations and behavior regarding electrical appliances. Figure 19 shows an overview of responses to the 16 statements. The most significant results are that:

- 71% agree or mostly agree with the statement that they would like to see information about the longevity and lifetime of products.
- a significant part of respondents agrees or mostly agrees to want more information on the repairability (54%) and recyclability of a product (42%).
- many consumers agree or mostly agree on the demand for information if a product requires an internet connection to function (57%).
- a majority (54%) would like to see a central place for all product-related information (e.g., sustainability certificates, label, materials, etc.)

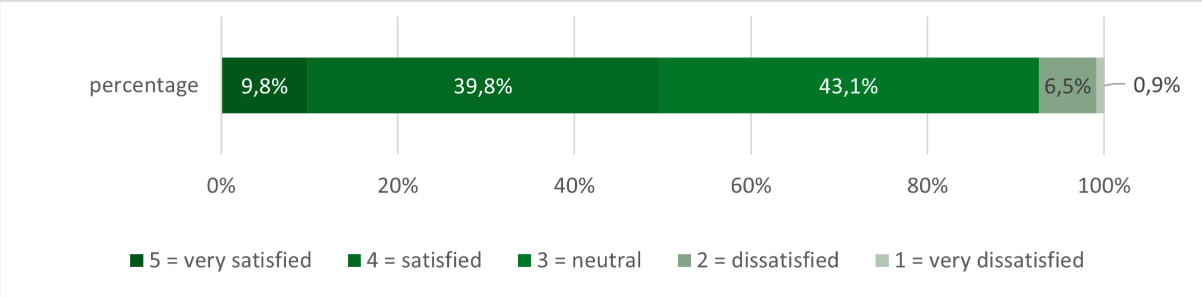
Figure 19: Consumer survey responses "to general statements about shopping practices and related information requirements". From dark green ("I strongly agree") to light green ("I do not agree").



Relative distribution of attitudes and behaviors when buying electronic products, Question: "How strong do you agree with the following statements about yourself?" (n=1001). Source: Technical University Berlin 2022

Contrary to other surveys, e.g., (Bögel 2016) respondents in this survey state a slightly higher trust in information provided by manufacturers (45%) than by independent bodies or labels and certificates (41%). It indicates the necessity to differentiate the type and source of information. Social and environmental claims are less trusted than product performance characteristics.

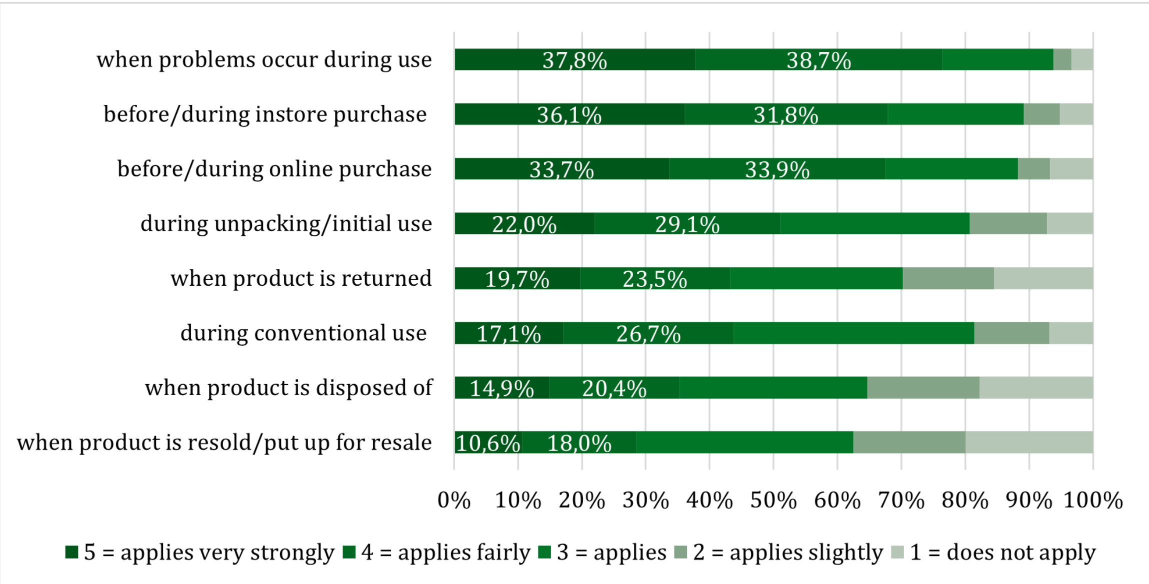
Figure 20: Consumer survey responses to the question "Overall, how satisfied are you with the information you receive for electrical appliances before, during and after purchase?". From dark green ("Very satisfied") to light green ("Very dissatisfied")



Relative satisfaction with product information during the life cycle of electronics (N=1001; M=3,51; MD=3; SD=0,79). Multiple answers are possible. Source: Technical University Berlin 2022

When asked about their overall satisfaction with all product-related information, most consumers indicate that they are very satisfied or satisfied (50%), while only 7% indicate that they are dissatisfaction or very dissatisfied. A significant part of consumers (43%) is neither satisfied nor dissatisfied.

Figure 21: Consumer survey responses to the question "At what point would you like to get more information regarding electrical appliances?". From dark green ("Applies very strongly") to light green ("Does not apply")



Relative distribution and missing information points within the product lifecycles of electronic devices from consumer perspective (N=1001). The participants had the opportunity to list additional points in the category "others" which is not presented in the chart above. Approx. 5% of the respondents used this option and wrote additional comments in a text field. Source: Technical University Berlin 2022

Regardless of their general satisfaction, consumers were also asked specifically where they needed more information. Consumers especially demand more information when problems occur during use (77%). More than 50% of the respondents state to want more information before and in-store or online purchases and during unpacking and the initial use.

2.2.3.2 Data gaps and remedies in the downstream value chain

The consumer survey shows a mix of information demands for information that are already available (e.g. user manual) as well as information that are not available respectively information gaps (e.g. durability and longevity). The Ecodesign Regulation (EU) 2019/2021 for electronic displays obliges manufacturers to provide information on updates and repair for consumers, which were both assessed as important for a significant part of the respondents in this survey. Information requirements for software updates are particularly important given the increasing number of digital and smart devices (Jeager-Erben et al. 2021). The fact that information on repair services as well as the repairability of the product were seen as important indicates a demand for professional product repairs. Even though information relevant for private repairs of products is less relevant than other aspects, this could be interpreted as an indicator that almost a third of the representative sample is interested in this option.

Information on the production conditions are of comparably lesser interest for the respondents when purchasing an electronic product. This might be due to the fact value chains for electronics are complex and globalised and almost incomprehensible for most consumers. Thus, aggregated information that are comprehensible (e.g. traffic light system) for consumers are important. Another reason could be an ambiguity towards different types of information providers. It seems astonishing that a majority of respondents (55%) neither clearly trust the information provided by the manufacturers nor by independent certification bodies and labels. This shows gaps not only in the need for information itself but also in the educational and confidence building activities of information providers.

Product performance information (technical and functional specifications) is considered highly relevant with the energy label as third most important information. Such information is already required by the Energy Labelling Directive.

In specific hazardous substances are considered relevant by 54% and in general all materials included in electronics are relevant to 53% of consumers in the purchase process. In interviews, consumers stated that they felt safe about products in the EU.

When using products, consumers stated a need for the user manual as well as information on product maintenance and care. Such information is usually provided with the product inbox documentation or are available online.

Qualitative interviews with consumers on mandatory labels and markings revealed barriers on the granularity of information. Markings and pictograms that indicate hazardous substances (as required by CLP Regulation) were commonly associated with dangerous content by the consumers, but they didn’t know the details. Similarly, the crossed-out wheeled bin (as required by the WEEE to indicate separate collection requirements for EEE) was often recognised as an indication to separate the product from the regular municipal waste. However, it was not known where to dispose such products correctly, making extended information on the correct disposal necessary. Another marking visible to the consumers is the CE marking. Although it does not target the consumers, it was the most known marking, while its meaning was unclear. Some consumers assumed the CE marking as a safety indication or confused it with the GS label (a German label indicating approved safety). In summary the consumer responses indicate that markings require additional information to be fully comprehensible which confirms the barrier identified in Part A. Making additional information digitally available and accessible, e.g., through a product information system might be an approach to overcome these barriers.

Overall, consumers of electronic products are satisfied with the information they receive before, during and after purchase. At the same time, asking consumer needs for specific situations they wish more information e.g. during instore purchase or when a product is broken. Further some information that are important (e.g. durability, longevity, product requires internet connection) are not yet available. Thus, for some information there are gaps between is the required and available information in the case of consumers of electronic products. Highly aggregated information (markings and labels) might be better understood if more information would be available, e.g., through a DPP. It seems important to respond to the fact that consumers somehow lack trust in information providers. Given that 57% of respondents would also appreciate a central location for all sorts of information around their products, a DPP provided by a trusted legal body would address several challenges.

2.3 Information requirements: textile sector

2.3.1 Upstream stakeholder requirements

2.3.1.1 Current data practices and requirements

In a textile-specific workshop, stakeholders from the upstream textile value chain were asked to state if the information is important to them (yes/no), shown in percent as the relevance of several information aspects which are presented as an aggregated result in Table 24. Focusing on data point which are at least 60% relevant to participants, the analysis shows, that in particular material compositions and characteristics, especially information on hazardous and critical substances and biodegradability are important. Requirements with a relevance over 60% and not covered by legislation are highlighted in bold.

During the workshop the participating organizations were asked to visually rate the information aspects above from relevant to not relevant. The results from each stakeholder were quantified and averaged. Due to the heterogeneity of the stakeholders the relevance of single information aspects can differ between the participants. The color coding indicates the relevance from red (important) to green (less important) based on the amount of responses (counts). Due to technical problems only 11 of 13 participants could vote for the relevance of the above items (N=11).Source: Circular Fashion & Technical University Berlin 2022.

Table 24: Relevant information aspects in the upstream value chain of textiles

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance	Covered in legislation
Upstream Data (A) General info., Tech specs, Materials level, Product level,	General product & company information	Field of usage	11	0	6	6	55%	n
		Manufacturer name	11	0	2	2	18%	y
		Product name/identifier	11	1	7	8	64%	y
		Original sales price	11	2	4	6	36%	n
		Product category and type	11	0	6	6	55%	
		Product attributes (size/weight/color)	11	1	5	6	45%	n
		Component supplier company details	11	1	4	5	36%	y
		Supplier sustainability info	11	1	6	7	55%	n

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance	Covered in legislation
	Technical specifications	Product description	11	0	6	6	55%	n
		Warranty information	11	0	7	7	64%	n
		Product photos	11	0	6	6	55%	n
	Material & composition	**Material origin**	11	1	7	8	64%	~
		Recycled/renewable content (percentage)	11	0	6	6	55%	n
		Component weight	11	0	6	6	55%	n
		Location of hazardous substances in product	11	0	8	8	73%	n
		Staple fibre length	11	1	7	8	64%	n
		Material properties	11	0	6	6	55%	n
		Material functional properties	11	1	6	7	55%	n
		Material composition per component	11	0	7	7	64%	~
		Material composition of product	11	0	7	7	64%	y
		Recycled content per material	11	0	2	2	18%	n
		Microfibre release	11	2	5	7	45%	n
		Material quality information	11	0	7	7	64%	n
		Finishes & treatments	11	0	6	6	55%	~
	Product design & service	Repair information (spare part availability, documentation, component map, dismantling instructions)	11	1	5	6	45%	n
		Design for reuse/refurbishment/repair ability	11	0	6	6	55%	n
		Maintenance instructions (textile: care instructions)	11	0	7	7	64%	n
		Design for transformability	11	2	4	6	36%	n

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance	Covered in legislation
		Design for recycling (mono.cycle / disassembly)	11	0	4	4	36%	n
		Durability test results	11	0	7	7	64%	n
		Design for longevity/durability score	11	0	3	3	27%	n
Downstream Data (B) Usage, Product History, End of Use		**Usage (hours of use), (washing cycles)**	11	0	8	8	73%	n
		Repair history (exchanged parts)	11	0	7	7	64%	n
		Condition (state of product prior to refurb for second hand market (storage / transport condition, potential damage)	11	0	6	6	55%	n
		Feedback from users	11	1	6	7	55%	n
		Date of return from user	11	0	6	6	55%	n
		Possibility to buy back for re-commerce	11	0	6	6	55%	n
Circularity Social Impact, Environmental impact, Certifications		LCA of goods/services	11	1	6	7	55%	~
		Availability of recycling/waste streams	11	1	6	7	55%	n
		Sustainability certificates	11	1	7	8	64%	n
		Biodegradability	11	0	8	8	73%	n
		Recyclability score	11	1	6	7	55%	n
		Restricted substances lists (e.g., AFIRM)	11	0	7	7	64%	~

Upstream value chain stakeholders were also asked to rate specific data points according to their confidentiality and availability (see Table 25). In contrast to the electronics sector, most data point are available and not confidential in the upstream value chain of textiles. Commercial product information such as images, descriptions, care instructions or warranty information is usually both available and generally accessible (or at least not confidential) to all users. The fact that the material composition is rated as highly available is likely due to the requirement for its mandatory disclosure. Further investigation would be valuable to determine whether the high availability of material composition relates to the legally required declaration of composition (i.e., the main material and lining) and if the result would be different in non-mandatory areas (i.e., components that make up <30% of the product).

The ranking is scaled as follows (see also caption below the table): Confidential: 0 = not confidential, 1 = partly confidential, 2 = mostly confidential, 3 = confidential; Available: 0 = available, 1= mostly available, 2= partly available, 3 = not available. Bold indicates the top five data points, that are not available / confidential (equal ranking might increase the number of total marked data points).

Table 25: Availability and confidentiality of data within the value chain of textiles from upstream stakeholder perspectives. Workshop participants voted if a data point is available and not confidential on a scale from 0 - 3 (see caption).

Data point	Confidential	Available
material composition	0.08	0.04
staple fibre length	**1.18**	1
LCA / footprint of goods or services	0.83	**1.54**
instructions for disposal / take back	0	0.96
product photos	0.08	0
care instructions	0	0.04
warranty information	0.18	0.05
design strategy (for reuse, refurbish, repair, ...)	0.09	0.82
material components (e.g., yarn, zipper, button, ...)	0.33	0.71
alignment with restricted substances list	0.91	0.54
commercial information (descriptions, ...)	0.42	0.17
durability test results	1.04	0.5
disassembly instructions	0.27	**1.05**
hazardous substances	0.68	0.45
component weight	0.83	0.42
material origins	**1.08**	**1.08**
biodegradability	0.27	1
recycled content	0.17	0.38
material properties (pattern, dyeing, printing, color...)	**1.45**	0.45
chemical content	**1.55**	0.85
Tier 1 company data (e.g., cutting, sewing)	0.83	0.33

Data point	Confidential	Available
Tier 2 company data (e.g., weaving, knitting)	**1.08**	0.92
Tier 3 company data (e.g., spinning, dyeing)	1.04	**1.71**
Tier 4 company data (e.g., farm, oil drilling)	0.92	**2**

Caption

Confidential	0 = not confidential	1 = partly confidential	2 = mostly confidential	3 = confidential
Available	0 = available	1= mostly available	2= partly available	3 = not available

Averaged results from the workshops with stakeholders in the value chain of clothing (manufacturing to retail) (N=11, excluding abstentions). Source: Circular Fashion & Technical University Berlin 2022.

The surveyed stakeholders mentioned some product attributes that are not particularly confidential but are subject to data availability issues (e.g., material components like yarns or zippers, biodegradability or disassembly instructions). The availability of those information is mostly related to the material or component supplier. In such cases, the information could be made available on a voluntary basis if it exists (i.e. if respective tests have been conducted) and can be accessed by the companies themselves. Experience shows that companies often do not have access to their suppliers' information for a variety of reasons beyond confidentiality concerns, which need further investigation.

Some attributes are available to organizations but should rather not be made public in their opinion. This is true, e.g., for tier 1 supplier company data, durability test results or the alignment with restricted substances lists. Nevertheless, they would allow certain user groups to access them, given there is a good access management, which would require to define and create access permission based on different user roles. For information that should not be made available in detail even to specific user groups (some stakeholders mentioned chemical content or material origin, for example), the information could be made available at a different information level (e.g., by a threshold value) or in an abstracted form (e.g., by means of certificates)

In addition, there is information that the organizations do not have themselves, nor should it be shared with other stakeholders based on the opinion of the workshop participants. Tier 2, 3 and 4 company data and LCA information are most commonly named along this category.

2.3.1.2 Data gaps and remedies in the upstream value chain

Compared to the electronics sector, upstream stakeholder in the textile sector are confronted with fewer legal obligations. However, voluntary approaches like sustainability labels are available more frequently. Entailed information requirements are reflected in the following statements of stakeholder groups.

Producer of material

Material producers are mostly providing information by the requirements of their customers (manufacturers and brands). They stated the goal to provide circularity information and guide customers to choose sustainable materials. In this context, they are interested to share useful and detailed information about materials and their sourcing. As mentioned in the methodology section, the statement might not be representative for the entire stakeholder group.

Manufacturers, designer, brands

The surveyed group stated that detailed material information is not always accessible or provided by the suppliers, in particular on restricted substances. It is therefore sometimes challenging to comply with chemical legislation (REACH Regulation) or specify information on material proportions (Textile Regulation). It was stated by this stakeholder group that information coming from supplier are prone to be false, which can be seen as a validation barrier. Technical specifications as well as product design related information are of less importance given the rather aesthetic character of clothes compared to highly functional oriented electronic products.

Retail and distribution

Retailers and distributors are defined as stakeholders selling new textiles, while 2nd hand retail is discussed in the paragraph "reuse" (downstream stakeholder, 2.3.2.2). Brands with direct sale or own stores can also act as retailer. They mention a legal gap as well as barrier on the availability of upstream information, which results in the demand to extend obligations within the due diligence act towards upstream suppliers. In particular material composition, recycled, renewable content as well as location of hazardous or restricted substances in the product are mentioned to be important. Transparency along the entire value chain on all sustainability and circularity information including sustainability certificates is usually missing. Furthermore, information on buy back option for recommence (from sorter) and biodegradability were stated as an information gap.

2.3.2 Downstream stakeholder requirements

2.3.2.1 Current data practices and requirements

During the workshop, a group of stakeholders from the downstream value chain (excl. consumers) was asked to rate the relevance of data points from different information categories. The group consisted of representatives for different EOL solutions like sorting and recycling as well as repair service providers, research technology providers and a trading platform for secondary materials. They were asked to visually rank the information points between "relevant" and "not relevant". The aggregated results of the workshop question are presented in Table 26. Requirements with a relevance over 60% and not covered by legislation are highlighted in bold.

During the workshop the participating organizations were asked to visually rate if an information aspect is relevant or not (yes/no). The results of each stakeholder were coded. Based on the responses (counts), a weighted relevance score was calculated as the proportion of all counted responses and all possible responses (N = total sample size), including abstentions. The color coding indicates the relevance from red (important) to green (less important) based on the amount of responses. Due to the heterogeneity of the stakeholders the relevance of single information aspects can differ between the participants (N=12) and the variation of the answers was higher than in the upstream stakeholder group. This results in a high relevance if most stakeholder see this information relevant. However, an on average low relevance still indicates the importance of information to a few particular stakeholder groups. Source: Circular fashion & Technical University Berlin 2022.

Table 26: Relevant information aspects in the downstream value chain of textiles

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance
Upstream Data (A) General info., Tech specs, Materials level, Product level,	General product & company information	Field of usage	12	4	4	8	33%
		Manufacturer name	12	3	7	10	58%
		Company information	12	3	6	9	50%
		Product name/identifier	12	5	4	9	33%
		Original sales price	12	5	3	8	25%
		Product category and type	12	2	9	11	75%
		Product attributes (size/weight/colour)	12	1	10	11	83%
		Product description	12	4	6	10	50%
	Technical specifications	Warranty information	12	4	6	10	50%
		Product photos	12	6	4	10	33%
		Performance (e.g., hydrostatic head)	12	0	2	2	17%
	Material & composition	Material origin	12	3	5	8	42%
		Recycled/renewable content (percentage)	12	0	1	1	8%
		Hazardous substances	12	0	8	8	67%
		Component weight	12	3	6	9	50%
		Chemical content	12	1	8	9	67%
		Location of hazardous substances in product	12	0	1	1	8%
		Staple fibre length	12	6	3	9	25%
		Material properties	12	2	8	10	67%
		Material composition per component	12	0	10	10	83%
		Material composition of product	12	2	8	10	67%
		Recycled content per material	12	3	5	8	42%
	Product design & Service	Repair information (spare part availability, documentation, component map, dismantling instructions)	12	2	7	9	58%
		Durability indicator - (Expected life time/extended free warranty or other durability performance)	12	2	7	9	58%

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance
		Disassembly instructions	12	4	5	9	42%
		Available recycling/waste stream	12	0	1	1	8%
		Design for reuse/refurbishment/repairability	12	2	7	9	58%
		Maintenance instructions (textile: care instructions)	12	3	5	8	42%
		Professional care labelling	12	0	1	1	8%
Product lifecycle data Usage, Product History, End of Use		Usage (hours of use), (washing cycles)	12	1	7	8	58%
		Repair history (exchanged parts)	12	3	5	8	42%
		Condition (state of product prior to refurb for second hand market (storage / transport condition, potential damage)	12	2	7	9	58%
		Instructions for disposal/takeback	12	0	8	8	67%
Circularity Social Impact, Environmental impact, Certifications		LCA of goods/services	12	5	3	8	25%
		Availability of recycling/waste streams	12	2	6	8	50%
		Sustainability certificates	12	3	7	10	58%
		Biodegradability	12	5	2	7	17%
		Recyclability score	12	2	6	8	50%
		Restricted substances lists (e.g., AFIRM)	12	3	6	9	50%

Nevertheless, a shared need for information could be identified. These include material compositions (i.e. composition of product and used materials, hazardous substances, chemical content, material properties) which are especially important for the recycling process in order to achieve high quality outputs without contaminations. For this reason, such information become important to sorters that sell pre-sorted products or waste fractions to the recyclers. Repair services use this information in order to find suitable repair materials.

Other product attributes (i.e. size, weight, colour, product type) have also been marked highly relevant by almost all stakeholders. This group of data points covers a wide range of attributes. Since these are data that are commonly used for commercial purposes and therefore usually publicly accessible, there is no need for a more detailed analysis of which exact data points are relevant to which stakeholders in the scope of this project.

Furthermore, some individual product-lifecycle and service data (i.e. product condition, washing cycles, instructions for disposal and takeback) is considered relevant by the representatives of most organisations. This information can be used to assess the current condition and thus the value of the garment which is crucial to take sorting decisions and to resell the product.

Sustainability certificates are of high relevance especially to second hand retailers and therefore also to the sorters that sell garments to them.

Some data points are considered relevant only by certain parts of the stakeholder group (e.g., the care instructions are relevant to laundry, rental and repair services but not to recyclers, the biodegradability is only relevant to some sorters that also deal with waste management).

2.3.2.2 Data gaps and remedies in the downstream value chain

Downstream stakeholders in the textile industry mostly do not only act in one field but rather offer, for example, laundry, repair and rental services combined. The following stakeholder cluster reflect common fields of activity and information requirements. Due to the few information obligations for textile products, most of the following information requirements can be seen as gaps.

Laundry, repair and rental service stakeholder

Textile rental services usually perform laundry and repair of their rented inventory. Product information on material composition and reprocessing of textiles (washability, longevity, repairability) was stated to help service providers to calculate more accurately the business model and predict operations and costs of services. Furthermore, downstream information on the history of garment care and repair (how the garment has previously been cared for) are of interest. It was stated that information of proper disposal facilities with respect to the textile specific material composition are necessary for proper recycling.

Waste treatment - collection, sorting

Stakeholders in the waste management often combine collection and sorting. Specifically, for textiles, the aim of sorting is mostly to identify reusable items. Important information which are missing today to identify and separate valuable textiles from waste include purchase date or season, material composition, size and colour specifications, usage (washing) cycles and the condition (potential damages, state of product prior refurbishment). Such information is sometimes already collected in professional rental services. It was considered relevant to provide information to the consumers on reuse and recycling options. When redesigning clothes, it was seen very helpful to know about the production or the quality of the fabrics by the fibre length and composition. Such information is mostly not available today. Information on the unique identification was seen as helpful to prevent counterfeit.

As a general remark it was mentioned that information from an product information system (such as the DPP) could lower the necessary knowledge to identify valuable textiles which enables inclusion and employment initiatives within sorting facilities. Furthermore, data-driven sorting supports local reuse in smaller sorting facilities without major identification or sorting technology. Finally, a better sorted feedstock for recycling increases qualities and potentially receive value.

Reuse (resale)

Reuse operators can be seen as retailers of second hand textiles with residual economic value for resale. Similar to electronic products, the residual value of textiles is calculated. The resell price is calculated by taking into account detailed information from upstream and downstream, including the brand, original sales price, age and usage history or condition (purchase date, season, usage/wear cycles). Such information is usually not available today. Reuse operators do not take hazardous materials into account as they are sorted out in the previous stage (sorting).

Repair or refurbishment is usually not performed. Durability information for clothes are not available, but can be important to estimate the residual usage cycles or lifetime. Functional specification or product description can be important as commercial information.

Waste treatment - shredding, sorting, recycling

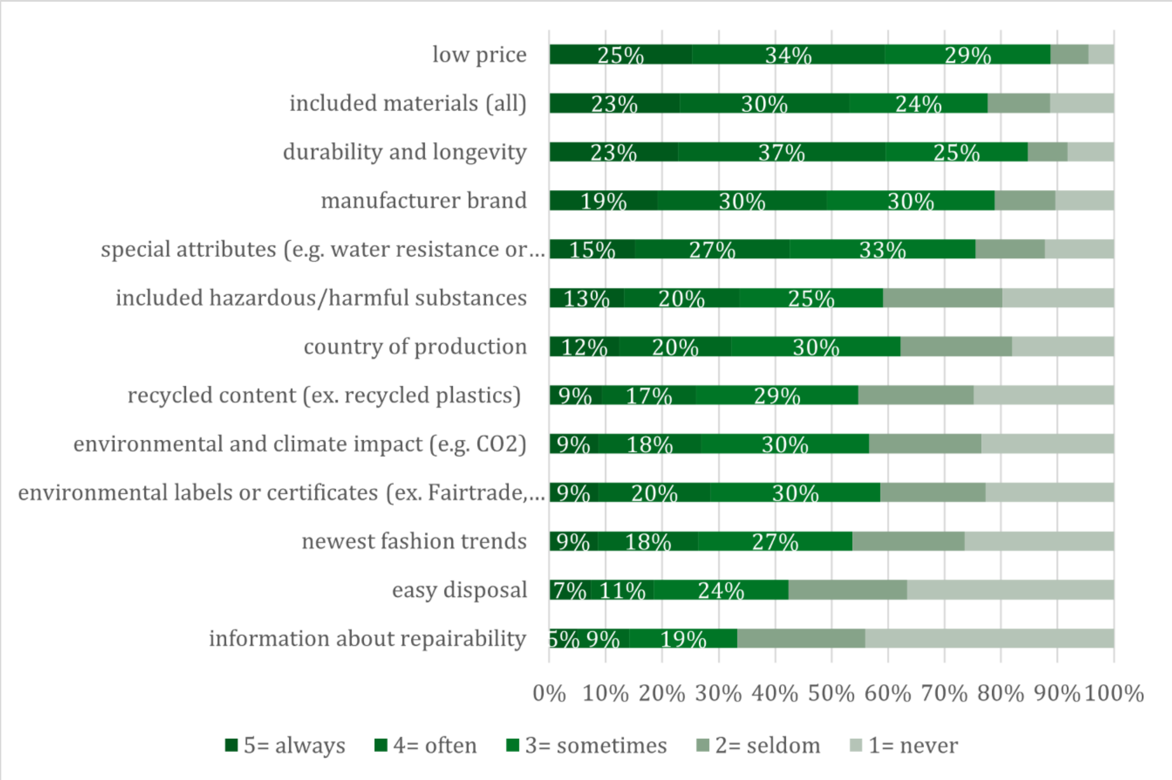
This stakeholder group performs automated shredding, sorting and recycling on material level. The aim is an output of high-quality material, which is homogeneous and contains intact (long) fibres. An information gap for some materials was mentioned due to the exemptions in the Textile Regulation on several textile fibres up to a specific threshold. Currently this results in a downgrade of fibres after recycling with a drastically decrease of quality. Product information such as fibre composition and non-textile materials present (i.e. buttons, membranes etc.) need to be accessible to increase efficiency and quality of the sorting process and decrease cost of recycling. This statement was underlined by producers of sorting technology, which further set the demand for an identification system. The staple fibre length is in particular relevant for mechanical recycling and yarn spinning as it determines the potential recycling cycles and quality (lower fibre length means lower quality). Sorting technology provider further stated, that information on dyes, applications as well as polluting material content are necessary for the recycling process but currently exempted from legislation. As one particular problem it was stated, that low metal content in textiles is usually not declared but even small amounts are degrading the quality of recycled textiles. The recycling technology has to cope with such uncertainties - mechanical recycling needs information on dangerous substances as they stay in the new material after shredding and recycling. Chemical recycling on the other hand can remove hazardous chemicals but requires more energy and the subsequent handling and disposal of hazardous chemicals is effortful.

2.3.3 Downstream stakeholder requirements - consumer survey

2.3.3.1 Current data practices and requirements

The participants of the consumer survey were asked to rate the relevance of several information aspects when buying clothing on a scale from 1 (never) to 5 (always). The chart in Figure 22 shows that consumers consider always or often a low price (59%), the included materials (53%), durability and longevity (60%), manufacturer brand (49%) and special attributes of clothing (42%) as important aspects.

Figure 22: Consumer survey response on the question of the "frequency of considering different information aspects when buying clothing". From dark green ("Always") to light green ("Never")

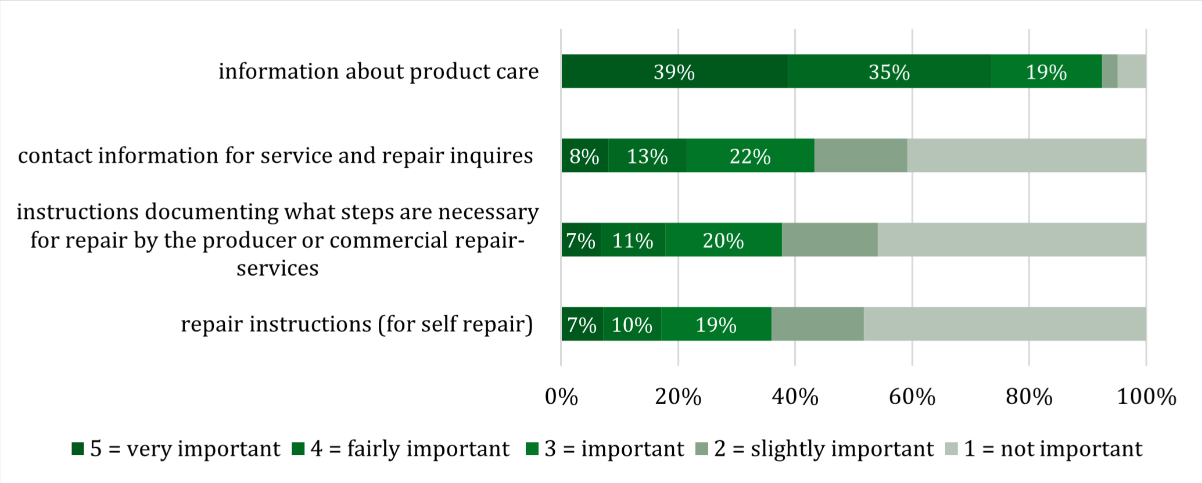


Relative distribution and relevant information aspects when buying clothing (N=1001). Multiple answers are possible.
Source: Technical University Berlin 2022

When asked for important information aspects during the use phase of a product on scale from 1 (not important) to 5 (very important), the respondents stated a higher relevance of information on product care then information on product repair. This might result from the fact, that textile repair today is still not as common and related information not as relevant while care instructions are.

Information about product care are considered very important or important (74%). Contact information on service and repair indicate a relevance for some consumers (21% very important or important). Repair instructions for self-repair is less relevant compared to the other information but still very important or important to 17% of respondents.

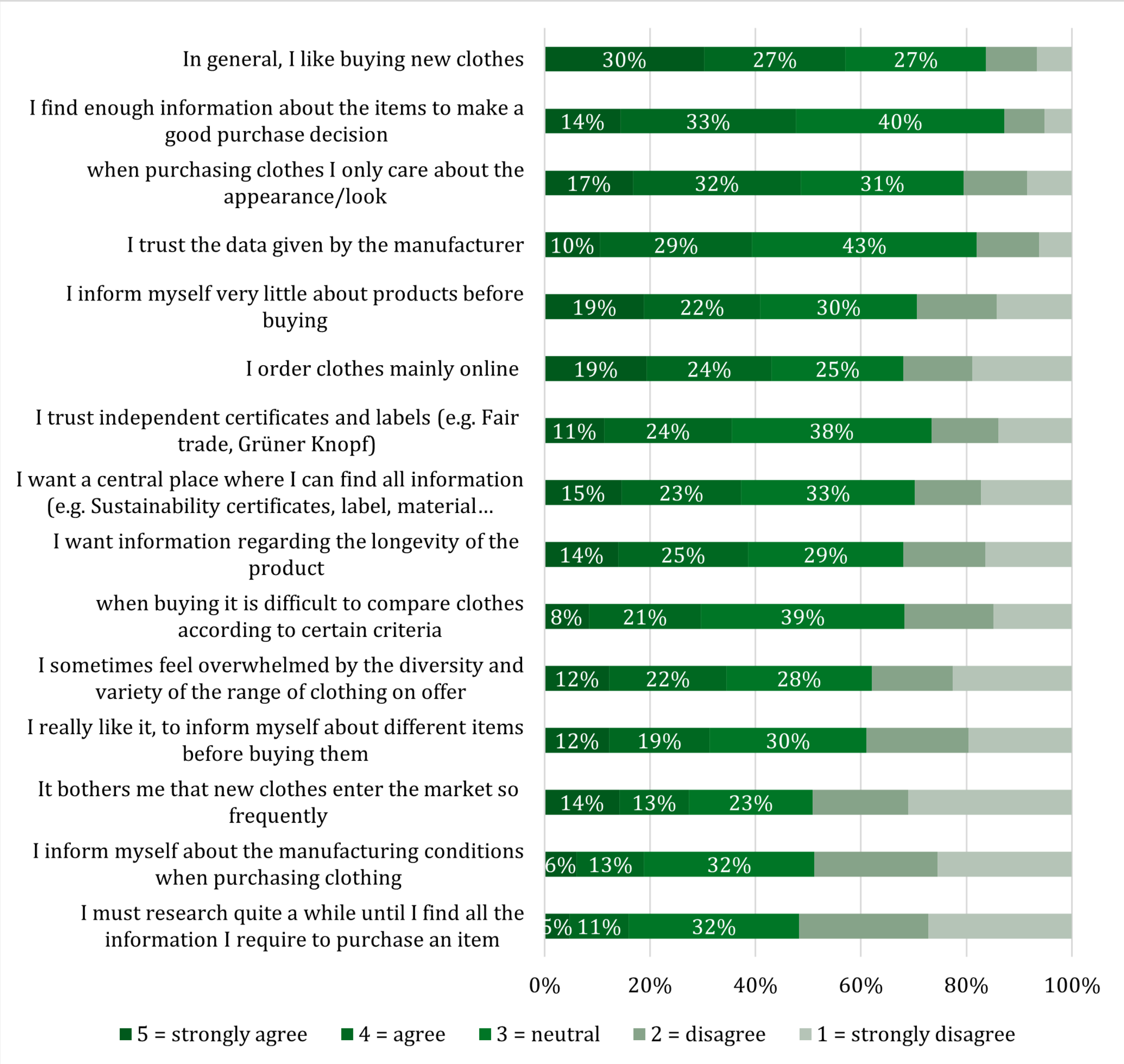
Figure 23: Consumer survey response on the question "What information are important to you when using clothing?". From dark green ("Very important") to light green ("Not important")



Relative importance of information regarding the use phase of clothing (N=1001). Multiple answers are possible. Source: Technical University Berlin 2022

For a deeper analysis of customer types, the respondents were asked to agree or disagree to predefined statements about their shopping expectations and behavior regarding clothing.

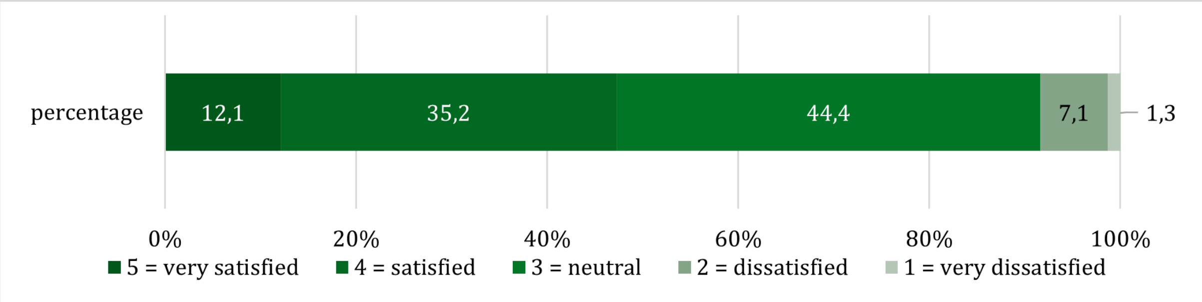
Figure 24: Consumer survey response on the question to general statements about shopping practices and related information requirements. From dark green ("I strongly agree") to light green ("I strongly disagree")



Relative distribution of customers' attitudes and behaviors when buying clothes (N=1001). Multiple answers are possible.
Source: Technical University Berlin 2022

From a set of 15 opinion poll questions, which are shown in Figure 24, most respondents (47%) agree or mostly agree with the statement that they find enough information to make a good purchase decision. A majority of 51% of consumers disagree or mostly disagree to have problems finding all the necessary information to purchase an item. In general, a significant part of consumers (39%) agrees or mostly agrees to want more information on the longevity the product. With 38% a significant part of consumers agrees or mostly agrees to want a central place for all product-related information (e.g., sustainability certificates, label, materials , etc.).

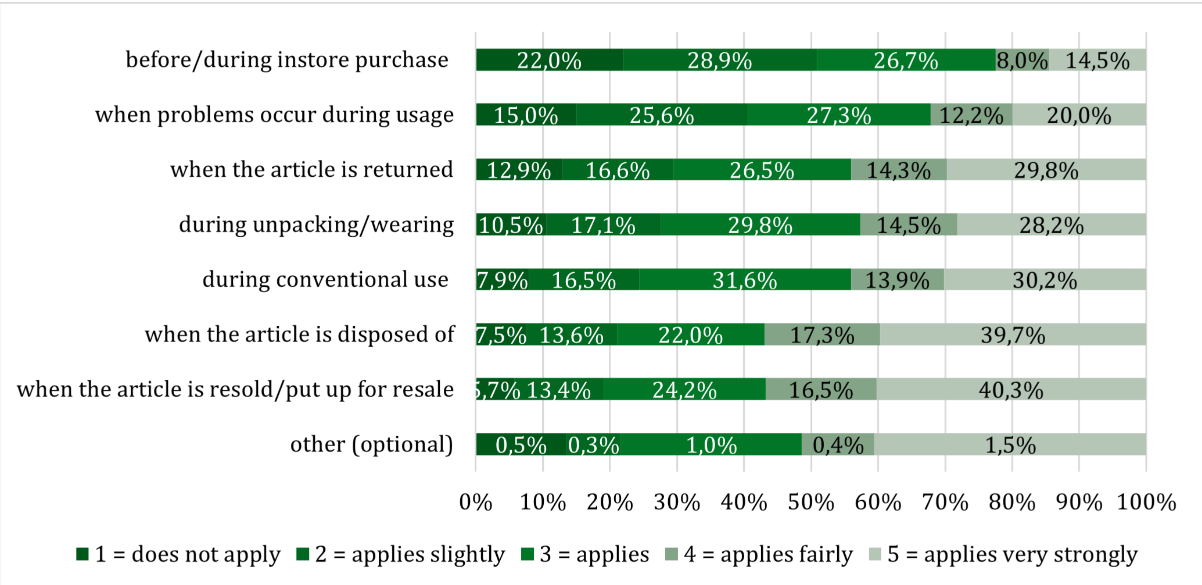
Figure 25:Consumer survey response on the question "How satisfied are you in general with the information you get about a piece of clothing before, during and after the purchase?". From dark green ("Very satisfied") to light green ("Very dissatisfied")



Relative satisfaction with product information during the life cycle of clothing (N=1001). Multiple answers are possible. Source: Technical University Berlin 2022

When asked about their overall satisfaction with all product-related information, most consumers indicate that they are satisfied (47%), while only 8% indicate dissatisfaction. A significant part of consumers (44%) is neither satisfied nor dissatisfied.

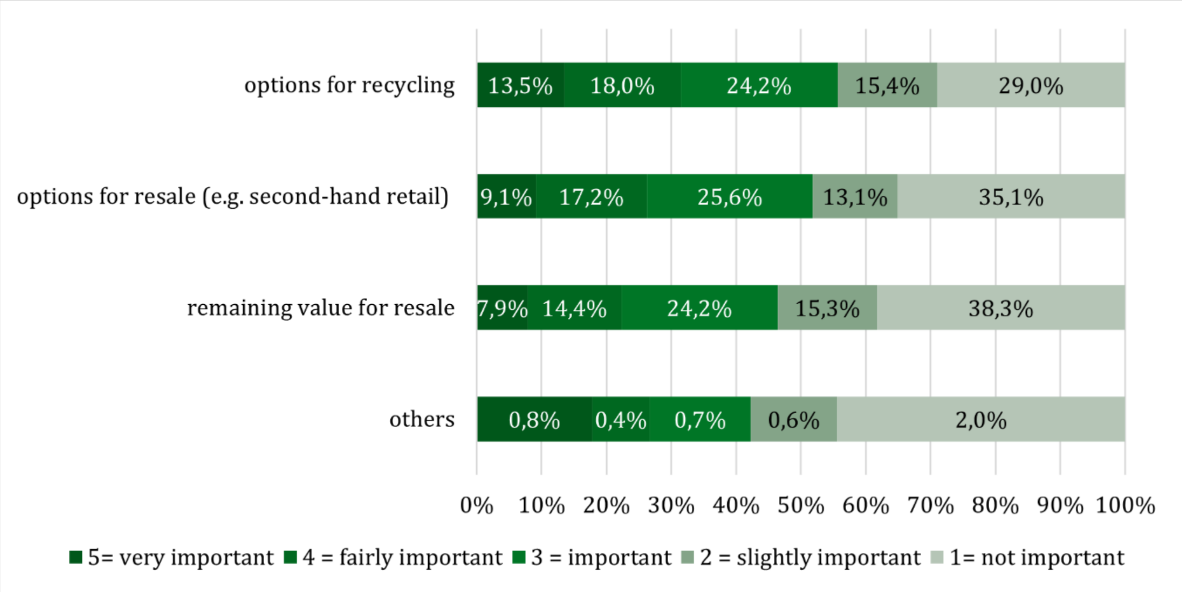
Figure 26:Consumer survey response on the question "at what point would you want more information regarding clothing?". From dark green ("Applies very strongly") to light green ("Does not apply")



Relative distribution and missing information points within the product lifecycles of clothes from a consumer perspective (N=1001). Multiple answers are possible. The participants had the opportunity to list additional points in the category "others" which is not presented in the chart above. Source: Technical University Berlin 2022

Consumers were also asked specifically where they needed more information. Consumers especially demand more information when problems occur during use (51%). More than 27% of the respondent's state to want more information before an in-store or online purchases and during unpacking and the initial use. However, a majority of consumer don't need more information regarding the return, resale or disposal of an article.

Figure 27: Consumer survey response on the question "What information is important to you after use and for the disposal of clothing?". From dark green ("Very important") to light green ("Not important")



Relative importance of information regarding the end-of-life of clothing (N=1001). The participants had the opportunity to list additional points in the category "others" which is not presented in the chart above. Source: Technical University Berlin 2022

In addition to the previous life-cycle stages consumers were further asked about important information regarding the end-of-life and disposal of clothing. A significant proportion of the respondents quote information on options for recycling (41%) as important. Further important aspects are option for resale (26%) and the remaining value for reselling the products (22%). However, a large part of respondents (44-53%) indicates that none of the predefined information aspects are important for them.

2.3.3.2 Data gaps and remedies in the downstream value chain

The survey reveals insights on the current purchase behavior and required information of consumers. The price (59%) and manufacturer brand (49%) are seen amongst the most important information, which are assumingly always available at the point of sale and therefore are not considered a data gap.

In general, consumer want more information before or during instore purchase, followed by information during use, when problems occur. Contact information on service and repair that were quoted in the survey also indicate the need for professional repair for some consumers (>20% very important or important). Repair information for self-repair might seem of low relevance. However, these number gains more weight considering that most textiles can be repaired rather simply and do not require instructions, at least compared to electronic products with specific requirements and interfaces (screws, disassembly, technical parameter, etc.). This indicates the information needs coming from both, a particular group that prefers professional repair as well as those who like to perform self-repair.

Furthermore, information on all included materials in textiles as well as hazardous substances and recycled contend in textiles are considered important aspects in the purchase decision for consumers. In part A it was shown, that the Textile Regulation does not require to identify materials if they are below a specific threshold (mostly 5-15%). While this is an information gap for recycler, for consumers the availability of information is seen less of a problem with 47% of consumers stated to have enough information, 41% inform themselves very little before buying clothes and 16% need to search for information until all information is found for the purchase. This might be supported by the availability of sustainability label for textiles or smartphone apps which allow consumers to get further information, e.g., on material content. Nonetheless, some specific stakeholder groups, e.g., babies, allergy sufferers require more detailed information of materials of lower quantities.

2.4 Information requirements: external stakeholder

2.4.1 Current data practices and requirements

During the workshop the participants were asked to rate the relevance of several information aspects, which are presented as an aggregated result in Table 27.

The participants consisted of stakeholders from different organizations with a focus on market surveillance and governance including policy makers, public authorities, NGOs, consumer entities, public procurement and certification/ labelling bodies.

During the workshop the stakeholders were asked to visually rate the information aspects above from relevant to not relevant. The results of each stakeholder were coded. Based on the responses, a weighted relevance score was calculated as the proportion of all counted responses (yes, no) and all possible responses (N = total sample size), including abstentions. The color coding indicates the relevance from red (important) to green (less important) based on the amount of responses (counts). Due to the heterogeneity of the stakeholders the relevance of single information aspects can differ between the participants. (N=6). Source: Technical University Berlin 2022.

Table 27: Relevant information aspects for the market surveillance and others.

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance	Covered in legislation
Upstream Data (A) General info., Tech specs, Materials level, Product level	General product & company information	Product sales numbers (products put on the market)	7	0	3	3	43%	n
		Identical products with diff. branding (white label products)	7	0	1	1	14%	n
		Place of production and assembly	7	0	1	1	14%	not SMEs
		Date of placing on market	7	0	2	2	29%	n
	Technical specifications	Product performance /characteristics/abilities (e.g., energy consumption)	7	0	5	5	71%	y (electronics)

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance	Covered in legislation
	Material & composition	Material type/category	7	0	2	2	29%	y
		Material origin	7	0	2	2	29%	3GTs importer
		Recycled/renewable content (percentage)	7	0	4	4	57%	n
		Full material declaration of chemicals	7	0	4	4	57%	n
		Hazardous substances	7	0	4	4	57%	y
		Ingredients in products, ideally with comprehensive BOM, but with phasing in stages, starting with most important data	7	0	2	2	29%	if hazardous
	Product design & Service	Alternative ways to identify products in waste stream (for AI recognition/marker)	7	0	2	2	29%	n
		Modularity/upgradeability and software update	7	0	2	2	29%	some product groups
		Recycling potential	7	0	2	2	29%	n
		Repair information (spare part availability, documentation, component map)	7	0	3	3	43%	for prof. repair
		Target collection/waste stream	7	0	1	1	14%	n
		Fitness for use	7	0	1	1	14%	n
		Disassembly instructions	7	0	2	2	29%	for waste treatment
Downstream Data (B) *Usage, Product History, End of Use*		Usage (hours of use), (washing cycles)	7	0	2	2	29%	n
		Repair history (exchanged parts)	7	0	2	2	29%	n
		Create new product for upcycling products	7	0	1	1	14%	n
		Condition (state of product prior to refurb for second hand	7	0	1	1	14%	n

Data providing stage	Information category	Data point	N	no	yes	counts	Relevance	Covered in legislation
		market (storage / transport condition, potential damage)						
		Sorting efficiency	7	0	1	1	14%	n
		Digital receipt (for warranty)	7	0	1	1	14%	n
		Recycling rates	7	0	3	3	43%	to EC
Circularity *Social Impact, Environmental impact, Certifications*		Norms, Standards, Regulations	7	0	3	3	43%	n
		Expected life time/extended free warranty or other durability performance	7	0	2	2	29%	n
		Compliance with labour rights	7	0	2	2	29%	not SMEs
		Environmental footprinting (e.g CO2-emissions) of goods/services	7	0	2	2	29%	n
		Energy Efficiency Indicator	7	0	2	2	29%	y
		Circularity Performances: durability, repairability, recyclability (KrwG)	7	0	3	3	43%	n
		Due diligence info	7	0	2	2	29%	not SMEs

The majority of stakeholders share a common information requirement for data on product performance (i.e. energy efficiency, functional characteristics), which are not covered in legislation for textiles. In particular, the full material declaration of chemicals, recycled content and product-assessment (i.e. product durability, repairability) are seen to be relevant. This level of information detail on material related information is not covered in current legislation.

2.4.2 Data gaps and remedies with value chain external stakeholder

Certification bodies

Certification and labelling bodies state a high demand on information to perform their tasks. This stakeholder group sees the highest relevance in information on material composition and origin, recycled and renewable content, product performance and sustainability and circularity related information. Particular information requirements are on the fitness for use[38] and place of production and assembly. Latter is already done on a voluntary basis ("made in") but not legally required. The exact information requirement depends on the verification approach and the subject (material, component, product and/or process). The verification on social and environmental production processes requires information of material and component supplier.

[38] Describes that the customer requirements and expectations fit the product or service

As usually product manufacturer commission certification bodies as a trusted, independent 3rd party to verify the product and process related information and specifications, all information is collected and streamlined at the manufacturers. Necessary resources for verification include mainly product test reports (product safety), chain of custody (paper trail) evidence or physical products for material testing in laboratory. However, within the certification process, the validation of the provided information is not always required or certification companies might evaluate in favour of the manufacturers who commissioned them. Static information (e.g., product performance specification, energy efficacy) are easier to verify compared to information like changes on the product (design), production batch (material) or production process (e.g., a change of material or part supplier will result in changes in production environment and LCA data). Paper trail evidence is not always reliable or verifiable and information infrastructure often poor, done via e-mail communication. In particular LCA data (material and energy flows) of upstream stakeholders is relevant but barely available. In case of missing data, a positive certification can already be given if a specific threshold of transparency can be assured, e.g., 85% or tier 2 (component supplier) of the value chain.

Market surveillance

Market surveillance aims to ensure that products coming on the European market are compliant and fulfil the legal EU market requirements. Current legal information requirements are seen to be sufficient for this purpose with some limitations. Information is mostly provided as reports or documentation. Although the reporting of recycling rates to the European Commission are legally required, it was mentioned that better monitoring of goods from the point of being sold to recycled would improve the tracking of EEE exports outside member States and WEEE ending up in unofficial channels. For this purpose, the information demand was mentioned on product sales numbers or sold goods, more detailed information on material composition beyond hazardous substances and recycling rates. Regarding material information it was stated that supplier do not have an interest to hide information on critical materials but rather for substances of concern which might not pass compliance tests. As a barrier it was mentioned, that even if mandatory information is captured, they may be provided in different formats or not the required language. The increasing number of product groups and functional as well as material complexity in the past years is seen challenging. As a result, compliance test got more complex but also more room for interpretation is present. Other important barriers are of technical nature, described in the chapter 2.2.2.

Public procurement

Information requirements from public procurement align with current existing guidelines for green public procurement (buying green 2016). Circularity information is of major importance, including information on environmental footprint, energy efficiency, durability, repairability, presence of substances of concern, recycled content and recyclability. These information requirements are not legally required and therefore not or only provided on a voluntary basis leading to heterogeneity. In order to be useful and comparable, they need to be harmonised and applied to a broad range of products, which is currently seen as a major barrier.

3 Summary and discussion of information requirements and gaps (part A and B)

Part A and B of this study aim to evaluate information requirements in legislation and supportive voluntary approaches towards their eligibility to foster Circular Economy goals. In this process not only missing information were identified, but further gaps, which prohibit the use of such information. The next sections include a discussion on the main outcomes:

- Chaper 3.1: Suitability of legal information requirements to support the circular economy in terms of
  - Legal gaps and barriers
    - Legal information gap in terms of missing definition of requirements or exemptions in legislation
    - Availability gap
    - Usability barrier (missing definitions towards the format, granularity or accessibility)
  - Stakeholder evaluation of identified information gaps and barriers
- Chapter 3.2: Bottom-up identification of information demands beyond legislation and
- Chapter 3.3: Comprehensive evaluatuion of information requirements and gaps
- Chapter 3.4: Recursive derivation of an information categorisation system

It has to be mentioned that the evaluation by stakeholders is of qualitative nature, providing indications on the suitability of information. Even within one stakeholder group several different and sometimes contrary information demands where found. Therefore, these results do not claim representativeness but are basis to further research.

The results from workshops and interviews were gathered in the fourth qauter of 2021 and first quarter of 2022. At this time, the concepts of an product information system like the DPP was vague and abstract. It was sometimes difficult to comprehend the concept, potentially necessary or usefull information from other stakeholder and based on this the identification of gaps. Thus the relevance for some specific information was seen different across stakeholder (from the same group).

3.1 Overview of suitability of legal information requirements

Identified information requirements as well as gaps and barriers (part A) were evaluated within interviews, workshops and surveys towards their suitability to support Circular Economy goals (part B). Table 28

provides a list of legal information requirements with an aggregated visualisation on the suitability of such information by stakeholders.

Table 28: Overview of legal information requirements and evaluation on their suitability by stakeholder group. The table shows data provider (>>) and data user (x). The green marking indicates that information can be provided or used, while the red colour indicates the contrary.

Information category	Legal acts (acronym)	Information requirement (grouped)	Supplier, manufacturer	Consumer, user	Repair, reuse	EoL	Market surveillance
	All	Identification of subject	>>	✓	✓	X	x

Information category	Legal acts (acronym)	Information requirement (grouped)	Supplier, manufacturer	Consumer, user	Repair, reuse	EoL	Market surveillance
General product and company information	All	Identification of stakeholder	>>	✓	✓	X	x
Functional and technical specifications	Energy Efficiency Regulation	Product information sheet (functional/technical specifications)	>>	✓			x
		Technical data sheet (test reports)	>>				x
Material information	CSDD	Origin of material	>>				x
	CMR	Material (3TG) origin (address) and quantity	>>				x
	REACH	Identification of hazardous substances and mixtures to the industrial/commercial recipient (Art. 31)	>> X				
	RoHS	Confirmation of absence of certain hazardous substances by CE marking	>>				x
	PPWD	Information on the toxicity or danger of packaging materials and components	>>				x
	TEX	Textile fibre name and composition of each component	>>	✓		X	x
	REACH	Identification of articles containing an SVHC above 0.1% to all actors (Art. 33)	>>	X	~	X	x
	CLP	Hazard pictograms, signal words, hazard statements, precautionary statements	>>	X			
	Ecodesign Computer/ Display	Identification of mercury (Ecodesign Regulation Computer), marking of cadmium and plastic components (Ecodesign Regulation Display)	>>			X	
	WEEE	Information on different materials and location of dangerous substances and mixtures in EEE	>>			X	

Information category	Legal acts (acronym)	Information requirement (grouped)	Supplier, manufacturer	Consumer, user	Repair, reuse	EoL	Market surveillance
	WEEE	Quantity of waste of EEE separately collected, recycled, recovered and disposed				>>	x
Product design related information	WEEE, BATT	Information on disposal, return and collection schemes	>>	X			
	PPWD	Information on return, collection and recovery systems	>>	X			
	Ecodesign WM	Information on use, maintenance, access to professional repair, spare part availability	>>	✓			
	Ecodesign Display	Information about spare parts and repair instructions	>>	✓	✓		
	Ecodesign Display	Availability of software and firmware updates, availability of spare parts and product support in the product data sheet	>>	✓			
	Ecodesign WM/ Display	Prof. repair and maintenance instructions (Component maps diagrams, disassembly map, etc.)	>>		✓		
	Ecodesign Display, ELV	Information about dismantling and end of life	>>			X	
	WEEE	Information on dismantling and recycling, different EEE components and materials, as well as the location of dangerous substances and mixtures in EEE	>>			X	
Circularity information	Ecodesign Directive	Ecological profile of the product and the benefits of ecodesign	>>	X			
	CSDD	Information on social issues (minerals originating from conflict-affected and high-risk areas)	>>	X			x

3.2 Overview of information requirements beyond legislation

The goal of the multi-stakeholder analysis was to gather different insights and requirements of stakeholders along the value chain of textiles and electronics. A major part of the analysis was to conduct several interviews and workshops for specific stakeholder groups that operate along upstream stakeholders (manufacturer to retail), downstream stakeholder (repair, reuse, recycling) and third parties (market surveillance, certification bodies and public procurement).

In the workshops over 50 participating organizations have been involved. The workshops and interviews were largely qualitative in nature and some results were later quantified. The results are not representative as only a very limited number of organizations per stakeholder group have been involved, but should help to identify further information gaps and barriers. It must be highlighted that the goal of the workshops was to evaluate the legal information requirements (top-down) as well as to gather further relevant information and technical requirements (bottom up) of different stakeholders. Not all stakeholders were aware of all legal (information) requirements that applied to them to identify or validate gaps. Furthermore, not all stakeholder had a clear opinion about the relevant information which might be useful for them. The relevance (reflecting if an information is important or not) reflects the average of votes for all workshop participants of the particular upstream or downstream stakeholder. Thus some information that are not seen by the majority might still be important for a few stakeholder.

In following a summary of evaluated legal requirements and relevant data of electronic and textile products is presented per information category.

Table 29 gives an overview of the information which are seen relevant by stakeholders (relevance over 60%) and not covered by legislation. For each information the goal is specified by the according stakeholder. Manufacturers additionally stated relevance if they have to provide information which is demanded by others.

Table 29: Overview of the information (beyond legal information requirements) which are seen relevant by stakeholders

Data providing stage	Information category	Textile/ electronic	Information requirements of stakeholders	Stakeholder groups and goal
Upstream Data (A) General info., Tech specs, Materials level, Product level	General product & company information	Electronic	**Component supplier details and sustainability info**	Manufacturer: Validation/proof of (material) compliance, sustainability reporting and certification
		Textile	**Product category and type**	Sorter, resale: automated identification and sorting for improving recycling rates
		Textile/ electronic	**Field of usage**	EoL (sorting): Product-to-product recycling for improving recycled material quality
	Technical specifications	Textile	**Product description**	Retail: fit for use to consumers to avoid retour or misuse and reduce transport
		Textile	**Product attributes (size, weight, colour)**	Repair/reuse, brands, retail: fit for use information for consumers EoL: determine material composition and recycling volumes to optimise sorting processes and increase recycling rates
	Material & composition	Electronic	**Recycled content**	Manufacturer: Communication to consumers (for sustainable purchasing)
		Textile	**Material properties (e.g., colors, prints)**	Repair, rental services: e.g., washing instructions for proper treatment Sorter, resale, recycler: for resale or recycling to prepare feedstock
		Textile/ electronic	**Full material declaration of chemicals (per component and product)**	Manufacturer: (future) compliance, sustainability reporting EoL: SVHC removal to improve recycled material quality
		Textile	**Staple fibre length**	EoL: important to mechanical recyclers to determine the quality and improve the recycled material
		Textile	**Material quality information (e.g., durability)**	Manufacturer: quality information for consumers and sustainable product design Rental services: business planning based on product lifetime / durability
		Textile/ electronic	**Biodegradability**	EoL (sorter): separate collection and determination of waste stream

Data providing stage	Information category	Textile/ electronic	Information requirements of stakeholders	Stakeholder groups and goal
		Textile	**Restricted substances lists (e.g., AFIRM)**	Manufacturer: pro-active consideration of substances that might become legally regulated or for voluntary compliance
		Electronic	**Component weight**	EoL textile (sorter): increase purity
		Textile/ electronic	**Material origin (source)**	EoL (recycling): Contamination, determination of grade, product-to-product recycling
	Product design & Service	Textile/ electronic	**Design for reuse/refurbishment/repairability**	Manufacturer: design information handed over to consumer for sustainable purchase decision Repair/reuse: Increase pressure to manufacturer; estimation on repairability (repair success, repair guide, spare part accessibility)
		Textile/ electronic	**Durability test results**	Manufacturer: Increase durability of supplier components and parts to increase and evaluate product durability; Communication to consumers and certification bodies
		Textile/ electronic	**Design for longevity**	Consumers: sustainable purchase of durable products
		Textile	**Maintenance instructions**	Consumers: care and washing instructions (not mandatory by legislation yet)
		Textile/ electronic	**Instructions for disposal/takeback**	Consumers, reuse, repair: correct disposal
		Electronic	**Disassembly instructions**	Reuse/repair, EoL: Reversible disassembly for reuse
Downstream Data (B)	Usage, Product History, End of Use	Textile/ electronic	**Usage (hours of use), (washing cycles); repair history (exchanged parts)**	Manufacturer: design improvements, service offers Repair/reuse: maintenance and residual value
		Textile/ electronic	**Purchase date**	Repair/reuse: determination of age/season and residual value

Data providing stage	Information category	Textile/ electronic	Information requirements of stakeholders	Stakeholder groups and goal
		Electronic	**Feedback from users**	Manufacturer: design improvements, service offers
		Electronics	**Product condition when repaired, reused, resold**	Manufacturer: design improvements
		Electronics	**Recycling performance**	Manufacturer: design improvements
External data (Circularity)	Circularity indicator, social and environmental impact, label, certifications	Textile/ electronic	**Footprint, LCA of goods/services, sustainability certificates**	Manufacturer: footprint/certificates of components from supplier; Certification bodies: certification of products
		Electronics	**Repairability indicator**	Repair/reuse: increase pressure on manufacturer to improve repairability

3.3 Evaluation of information requirements and gaps

The following sections presents findings and discusses information gaps and barriers identified in Part A (literature analysis) and further identified stakeholder information requirements from Part B (interviews, workshops, consumer survey) are discussed in following sections, clustered by information category and (where applicable) stakeholder group.

To note, this study and carried out workshops differentiates by textile and electronic products. However, diverging requirements arise within each product group e.g., due to different material composition or size of waste products. Each product group comes with individual requirements which might requires a more differentiated analysis.

3.3.1 Company and product identification

Company and product identification are a prerequisite to make any information identifiable and thus available. In particular EoL stakeholders face major gaps to access and effectively use available information, e.g., from SCIP database. Besides a harmonisation of information on product and stakeholders, the technical infrastructure by means of an identifier on the product is necessary.

3.3.2 Material information

The evaluation of **material information requirements** shows several gaps, starting with a lack of availability of information on materials like by-products which are exempt from REACH regulation but relevant for treatment facilities and recycling. An accessibility barrier was found for manufacturers, consumers and treatment facilities towards information on the SVHC content in articles (REACH). Reasons are complex and interdependent:

Supplier of articles, product manufacturer and distributor see an information gap on material information coming from tier 3 and 4 suppliers. Necessary material information is provided by stakeholders at the beginning of the value chain, often outside the EU and therefore not directly affected by EU compliance obligations. Liability and pressure are on the stakeholders who place the products on the EU market, usually manufacturers, to gather upstream material information from their material producer or supplier. Such top-down obligations are challenging, even for who are intrinsically motivated and actively pursue transparency in their supply chain. In particular due to the fact, that suppliers of articles are not obliged to hand over the security data sheet with material information to the manufaturer of the finished product. Ideally, each material producer and supplier provides pro-actively a full material declaration (bottom-up) from which their customers/ target stakeholders can pick the necessary information to meet compliance. SCIP can potentially be seen as a bottom-up approach where each article manufacturer can provide information to comply with the REACH Regulation and further use for manufacturer of complex products. The SCIP database is not useful as a material information source due to various reasons, for example outside EU actors are not allowed to provide information to or do not understand the system. The search functionaly of SCIP is limited and does not lead to expected rseults[39]. Furthermore, such approaches are regulation-specific or too generic, because each product group and stakeholder is affected by very particular constellations of information requirements from various laws. Hybrid solutions like the IMDS demonstrates a working approach specifically for the automotive industry. Supplier benefit from a free of charge system and a given set of automotive specific

[39] A comprehensicve overvie is given in the study "SCIP Database - Does it enhance transparency on Substances of Concern in a Circular Economy?“, October 2023

material information requirements, which have to be provided in a resolution of 1 gram or better. They can submit the data about their parts to their direct customer. A Chinese version of the IMDS, called CAMDS[40], addresses Chinese supplier to provide material information to meet Chinese compliance. The system is interoperable to the IMDS for data exchange. However, the convincing power of the few car manufacturers has to be taken into account, generating supply chain control and pressure to provide material data, at least to a remarkable extend, considered 2300 tier 2 and 3 suppliers for raw materials and intermediate products[41].

Consumers

For consumers of textile products information on hazardous substances or included materials (TEX Regulation) are among the most important aspects. For electronic products on the other hand, information on included materials and hazardous substances are considered less relevant. The majority of consumers are satisfied with the available information, according to the consumer survey. However, asking for the demand of information before purchase during and after use consumer want more information prior purchase and during use (when a product is broken). Smartphone apps already support consumers to gain extended material and hazard information, but as long as it is voluntary for suppliers to make their SVHC information available in the app-associated database, the apps in many cases still face the barrier of an information availability delay up to 45 days, which is not sufficient to support the consumers, e.g., with their purchase decisions.

Some material information are communicated through aggregated, physical markings. In context of the potentially increasing information available (not at least due to the planned product passport), the format of information has to be carefully adapted to consumer needs. Pictograms and logos (EDD, WEEE, CLP, PPW) which are addressing consumers are not always understood or can be misinterpreted. Such highly aggregated formats might be supported by digital labelling or the product passport with convenient on-demand access to obtain further details online, already pushed forward in the EU initiative "Chemicals – simplification and digitalisation of labelling requirements." Complex circularity information (e.g., CSR reporting) on the other hand are partially aggregated by labelling organisations, although not all consumers have trust in them. Interestingly, for textile products consumer see recycled content information as important, while upstream stakeholder such as manufacturer did not, according to the responses in the workshop. This might become a future requirement, as recycled content currently becomes more important e.g. in the ESPR, Battery Regulation and in general EU's sufficiency and green transition strategy[42].

EoL operator

One of the biggest challenges is seen in the communication of information from suppliers at the beginning of the value chain to treatment facilities at the end. Waste treatment operators of both product groups state a demand on a full material declaration. Textile sorter and recycler further require information on the staple fibre length, and biodegradability. Such information are currently not legally required.

Due to established sorting and recycling processes, material information needs to be available on a broad amount of products and quickly accessible to be economically effective. In this context, the additional time to scan, identify and eventually sort out hazardous WEEE does not justify the slightly higher purity. Ambitions to establish platforms like the SCIP database

[40] China Automotive Material Data System, it is interoperable to the IMDS
[41] https://www.welt.de/wirtschaft/article207263407/Zulieferer-Die-verletzliche-Lieferkette-der-Autoindustrie.html
[42] https://commission.europa.eu/system/files/2023-07/SFR-23-beautified-version_en_0.pdf

providing information on products containing SVHCs is seen to be incomplete or not effectively accessible via the website as no automated interface is provided. Aggregated and data quality checked material information on product level is required. If articles are registered, they miss a harmonic identification and allocation to the product which makes the identification of the components or products and allocation to the according SCIP article registration burdensome or not possible. Similar challenges arise for information for disassembly as well as hazardous materials and their location in products (WEEE Directive). This information is not readily accessible, even not at industrial initiatives like the I4R platform that aim to fill this gaps. In general, product and waste legislation have a stronger focus on electronics rather than textiles. Specifically, for textiles, sorter suffer from exemptions in the regulation on textile fibres. Important material information does not need to be disclosed if their proportion in the product is below a specific percentage threshold.

For electronics, physical markings, e.g., on cadmium, mercury or plastic components (Ecodesign Directive) are of less relevance in the sorting process, as dismantling is required and markings are not always readable. Overall the additional time necessary for the localization of markings or identifier is not justified by the slightly higher purity. This is stated with respect to today's recycling processes, while future waste stream might require a more granular identification of materials and substances used in products.

The Battery Regulation addresses information and usage barrier as it requires information accessible through the battery passport on various relevant information such as the recycled content, hazardous substances, cricital raw materials, material composition.

Market surveillance stated a demand on the tracking of products to monitor exports and material flows. Here, information on sold goods are seen relevant together with collection and recycling rates.

3.3.3 Product design related information

Consumers

By law consumers are provided with information on use, maintenance, access to professional repair (Ecodesign Directive,) as well as information on disposal and return (WEEE Directive, Battery Regulation). This information is the most required during use and end-of-use according to the consumer survey. They might be available in the product manual or on the packaging. However, these paper documents might be thrown away, indicating the requirement for convinient on-demand support towards the specific problem, such as the contact to a repair serveice for the repspective product accessible via an QR-code on the product. This was emphesised by the majority of consumers of electronic products who prefer information on professional repair services.

The demand on information for disposal during use are less necessary to consumers. There are physical markings indicating not to dispose the product in to municipal bin (crossed out wheeled bin). Consumers are familiar with the markings but its meaning is not always understood or misinterpreted because it does not inform about the correct disposal.

Repair

Professional repairer of electronic products reqiure information on repair incl. component maps, disassembly instructions, wiring diagrams and spare part availability. For these information repairer see progress in the current legal developments of the Ecodesign Directive. The registration process to verify professional repair competence in order to gain such information is not seen as a major barrier. However, independent repairers deprecate the prioritisation of professional repairers, as this prevents access to important information and spare parts and finally cheaper repairs.

In the textile sector, laundry, repair and rental service are often offered together. Important for this stakeholder group are information on the history of garments care and repair as well as material composition to give a more accurate service and cost of service. This information are not legally required (legal information gap).

Reuse and refurbishment stakeholders are not specifically addressed by legal information requirements. However, information demands where stated regarding the residual value, based on costs for repair or refurbishment (for products) and/or the resell price of the individual product. Information comprise the energy efficiency class, original sales price, technical and functional specifications as well as durability and repair information (spare part lists and software update availability).

EoL operator

Legally mandatory information about dismantling, end-of-life, different EEE components and materials as well as the location of dangerous substances and mixtures in EEE as specified in the WEEE Directive and ELV Directive are not provided via a central public database like EPREL or SCIP. Industrial initiatives like the I4R (Information for Recycler) and IDIS which aim to close this gap are mentioned to be good approaches e.g., for training purposes for employees of sorting stations though of limited use, because they can not be effciently used within the sorting process. The current Proposal for a Regulation on circularity requirements for vehicle design and on management of end-of-life vehicles introduces a Circularity Vehicle Passport as well as specific information requirements, which address current barriers. Similar, the Battery Regulation might tackles some of these barriers by providing information on material composition, hazardous substances and dismantling information incl. safety measures and detailed composition of the battery model through the Battery Passport. Furthermore, a product change notification would be beneficial, indicating if relevant (hazardous and valuable) materials and separate sorting is necessary, e.g., due to a new technology.

Common information requirements from the stakeholder group of **crushing, shredding, sorting** are on shredded fraction level, including the types of polymers (homo-/copolymer), plastics (specific types of polymer), metals, additives, e.g., flame retardants and fillers. Information demand from **recyclers** on material level includes material composition and substance of concern of the shredded fraction. However, any data carrier such as a QR-code is shredded and thus not readable on shredded flake level. Thus information have to be read by sorters and handed over with the batch of flakes to recycler. Further barriers to use the material information are missing common standards and terminology.

Certification bodies are missing information on the fitness for use, place of production and assembly. Other important information within the certification process are available, however these are provided by the manufacturers on a self-declaration basis, which lacks validation.

3.3.4 Circularity related information

For electronics, consumer staated information needs on durability, repairability and whether the device requires internet, which are partially defined as information requirements by some implementation measures of the Ecodesign Directive. Although information on spare part or update availability were in part A identified as a granularity barrier (due to the missing comparison to an average duration or benchmark) the consumer survey showed that these information are seen sufficient.

For textile products most consumers demand information on durability and longevity. Such information are not legally required (legal information gap). Product care information is highly relevant during use, which are also mostly available, provided by manufacturers on a voluntary basis. However, the trustworthiness of information provided by the manufacturers as well as label are of average relevance.

Sustainability reports (required by due dilligence legislation) are rather complex, thus not effectively usable for sustainable purchasing. However, several labels, in particular for textiles are available with consumer friendly, aggregated information. When purchasing a product, the majority of consumers do not or seldom consider label or certificates (electronic: 36%; textiles: 42%). This aligns with consumers trust: generally speaking, type I eco-label are trusted but only used by 34% of consumers when purchasing a product. This might resullt from the heterogenity of labels and included information which are not standardised, thus resulting in limited comparability. Legislation is in duty to give harmonised guidance or provide information requirements on EU level, e.g., according to the EN4555X standard which can be used to develop circularity indicators or label such as the draft Regulation (EU) 2017/1369 with regard to the energy labelling of smartphones and slate tablets.

Public procurement stated a demand on harmonised circularity information including environmental footprint, durability, repairability and recyclability. The Battery Regulationsets information requirements on the carbon footprint.

3.3.5 Downstream information

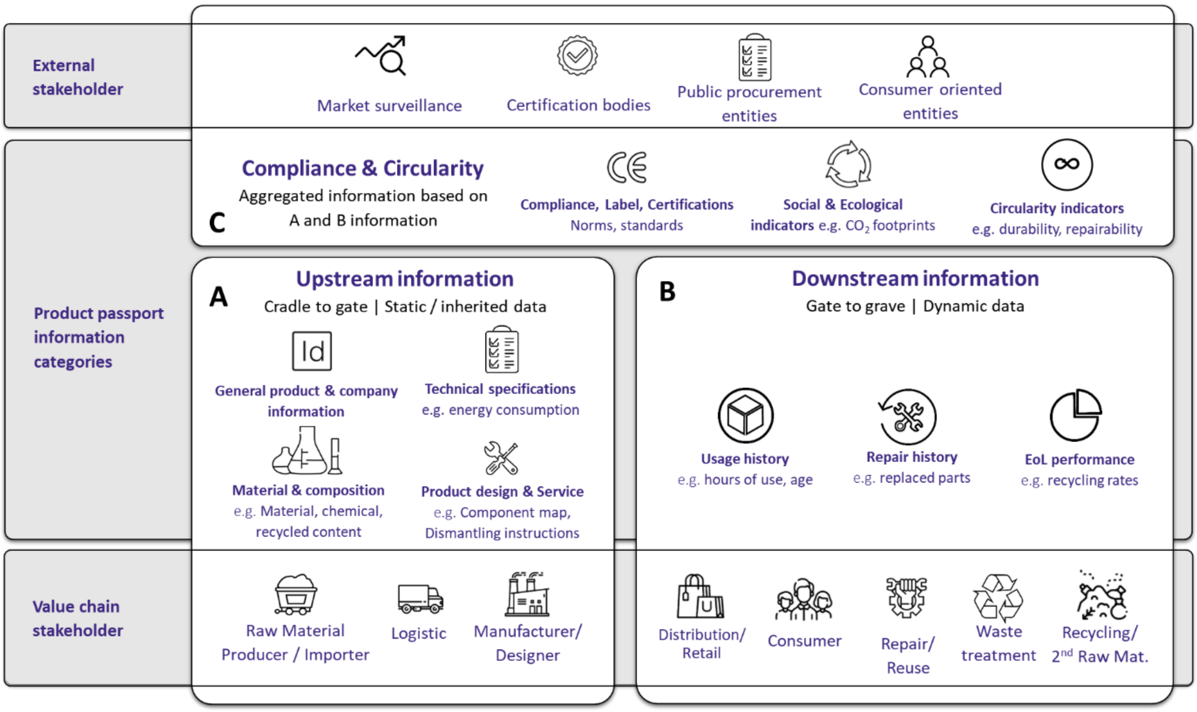
Manufacturers mainly demand downstream data on the usage and repair history as well as recycling performance. Reuse and refurbishment stakeholders stated a similar need for information on the the usage history (usage time, cycles, age) as well as the repair history on component level. Repairers of electronic products require informaton on the purchase date to check for warranty case, usage history to estimate the condition and repair history (e.g., exchanged parts). Such downstream information is currently not required in legialstion (legal information gap).

The WEEE directive requires the provision of downstream information on collection rates to the European Commission, to be reported by treatment facilities. In this context proper incentives for data provision should be discussed - it was mentioned by sorters, that a notification to the previous owner when the product unit arrived at sorting and being reused or recycled would be beneficial as this could indicate environmental value and therefore incentivise users to recycle more. In general, the traceability of the own product assures ownership (e.g., in case of theft) or that it is being destroyed/recycled.

3.4 Information model and categorisation system

As identified in previous chapters, stakeholders, legislation and voluntary approaches provide a variety of information which is needed by other stakeholders. However, due to their heterogenic character, a common semantic as well as their classification is necessary to understand, describe and derive relevant information. In general, a data classification system (see research framework in Figure 1, chapter summary) aims for unambiguous identification of classes and properties, and their relations. This study derived such classification system which incorporates results from previous analysis including requirements from (chemical, product, waste, due diligence) legislation, voluntary certifications (label, circularity indicators) as well as stakeholder generated data, in particular by consumers.

Figure 28: Categorisation system for product information and their relation to stakeholders along the entire product life cycle



The categorisation system was recursively used to structure the study and report. It comprises two stakeholder groups and three (A-C) information groups in relation. It can be seen as the basis to establish a data model with classes, attributes, data types, etc. The classification is split into dynamically and static generated on product model or batch level. It shows primary and secondary generated information and according stakeholder groups. Upstream data includes mostly the product birth certificate with information that are static for the product model or batch, mostly provided by manufacturers or importers. Downstream information is dynamically generated during the use and EoL-phase per product model or batch. This primary generated information is used to calculate information within the third group on product circularity.

4 Part C - Concepts for product information systems and technical realization (front-end demonstrator)

4.1 Analysis of available technical and informational aspects in existing concepts and technologies

4.1.1 Introduction

Part C of this report has the objective to analyse and trial technical requirements for capturing, linking, saving and exchanging product data.

The part is separated into seven subchapters. In the first chapter, the methodological approach for Part C of the project is explained in detail. Chapter two is divided into sections that provide an overview of different aspects that are relevant to the technical infrastructure for a product information system. Concepts and technological approaches for the different aspects as well as expert opinions are presented. The third chapter analyses a selection of product information systems in greater detail. In the fourth chapter, the options to fill information gaps identified in Part A with information from existing voluntary product information storages are assessed. Chapter five introduces a proposal for an access management concept which is used as the basis for the front-end demonstrator presented in chapter six. In chapter seven, the findings are summarised to form a concept description for the product information system. Furthermore, limitations of the findings are indicated, and conclusions drawn.

4.1.2 Methodology

This chapter describes the methodology of Part C of the project. The aim of Part C of the project is to develop a concept how all information necessary for a circular economy can be digitally compiled and provided to the respective users. For this purpose, technical requirements for the collection, linking, storage and dissemination of product information were to be analysed and tested. Different approaches were combined to gain an insight into the topic from different perspectives. Thereby, differentiated answers to the questions should be found how a system has to be designed in order to close existing information gaps and to cover the information needs as well as the technical, data security and liability requirements of the different stakeholders. The results from this part will serve as the basis for Part D, where legal recommendations for action will be developed.

To develop a product information system, various technical and informational aspects must be considered. The following list of aspects has been identified based on the industry experience of the researchers. The list has been used as a basis to structure the findings of this report.

1. Vocabulary, Ontology, Taxonomy and Standards
2. Data Storage and Exchange
3. Ownership, Liability and Data Verification
4. Access Management and IP Protection
5. Identifiers and Data Carriers

Although the list was originally intended to be a first draft and could have been adjusted during the research based on the findings, no changes have emerged from them except that standards have been moved out of the “Vocabulary, Ontology, Taxonomy” aspect and instead are being separately examined because they are overarchingly relevant for all aspects. Apart from that, data storage and data exchange have been separated to two aspects due to the amount of information found.

The first part of this report (Chapter 4.2) describes the results of a desk research, a workshop and interviews that were conducted with several technical experts in the field of digital product information systems. These approaches were chosen due to the novelty of the topic and the lack of sufficient published research sources. The aim of combining these approaches was to provide a broad overview of possible solutions for each of the aspects listed above and to assess and validate them from different perspectives. The focus is on the analysis of available concepts and technologies that are potentially useful for a product information system. Based on the findings for each aspect, conclusions and recommendations are made for concepting a product information system to enable circular economy. These are presented in a subchapter at the end of each aspect chapter and summarised in "take away" boxes to provide an overview of the relevant recommendations similar to an actionable summary.

In the second part (Chapter 4.3), existing systems and present solutions are analysed for the different aspects listed above and evaluated on pre-defined criteria to exemplarily assess their usability, showcase suitable solutions and highlight possible issues.

Independently of the conclusions and recommendations from above analysis, existing voluntary product information sources were identified and analysed based on a set of criteria to assess whether they are suitable sources to fill information gaps (Chapter 4.4).

Based on the requirements of the different data users, a concept was developed how information gaps as identified in Part A of the project can be closed (Chapter 4.5). The chapter also describes the development of a demonstrator frontend with the aim of verifying the suitability of some of the concepts developed and to revise and validate the information needs and corresponding user profiles in the active use of the tool.

Subsequently, results, conclusions and recommendations are summarised in chapter 4.6.

4.1.2.1 Initial research

To kick off the evaluation and analysis of possible solutions for a product information system, the researchers started with an initial online research and investigation. In this research, relevant state-of-the-art approaches and solutions were identified for the different aspects of the product information system as listed below. The aim of this analysis was to provide an overview of where sufficient solutions already exist and where there is an increased need to develop further approaches. The analysis was not intended to result in a complete list of all approaches currently in use.

4.1.2.2 Expert opinions

To gain an overview of the field and identify relevant approaches and well-working systems for the different aspects, expert opinions have been collected within the framework of a workshop and six semi-structured interviews. The focus included different approaches and requirements of a product information system. The participating parties and the outcome are documented below.

The workshop was conducted on March 9th, 2022, with 15 representatives of 12 organisations involved with the different aspects of developing product information systems. The agenda of the workshop covered:

- Check-in and introduction
- Short presentation of the "Product Information 4.0" project
- Interactive workshop using the tool Miro (https://miro.com/)

Subsequently, six semi-structured expert interviews were conducted to query specific and concentrated knowledge of selected persons on the narrowed topic area of product information systems and clarify open questions from the workshop. The information collected include subjective assessments, interpretation patterns and action orientations. General statements about product information systems are to be derived from the individual observations and their plausibility checked by means of comparisons.

The experts are knowledgeable persons who, as insiders of the field of investigation of product information systems, possess subject-specific action and investigation knowledge.

Questions, hypotheses and theoretical explanations can be explored, answered and clarified from the experts' point of view, making them suitable for the broad field investigation of product information systems.

The interviews are then categorised into text segments. In doing so, the textual material of the interviews is systematically worked through to interpret the content of the categories and define the most important aspects of the product information systems.

4.1.2.2.1 Workshop

The aim of the expert workshop was to clarify the following questions in reference to each of the defined aspects:

- Which aspects need to be defined by standards, laws and other guidelines?
- Which (kind of) organisation should be responsible for the standards, laws and guidelines?
- Which barriers and pitfalls are to expect?

Above that, a list of examples for well-working solutions was collected. The results of the workshop have been categorised systematically to the aspects described above and used as part of the basis to develop the questions for the expert interviews and to investigate certain barriers and solutions further. Relevant results, including especially well-working solutions for the different aspects, are summarised in the aspect chapters of the report.

For the technical expert workshop, the following twelve organisations participated.

Slides and workshop results can be found in the Annex 8 and Annex 9.

4.1.2.2.1.1 Avery Dennison Inc. (Avery Dennison)

Avery Dennison is a global company producing and developing branding- and information labelling solutions. They integrate the design and manufacturing of labelling materials to improve packaging and enhance carrying and displaying information which creates a connection between the physical and digital world. They are specialised in high-quality pressure sensitive adhesives and radio-frequency identification (RFID) inlays and tags. The applications are used in the building and construction industry, automotive-, electronics-, textiles-, logistic-, food- and grocery- as well as pharmaceutical- and other general- and personal care sectors. They employ 36.000 people in 50 different countries.

4.1.2.2.1.2 Deutsches Institut für Normung e.V. (DIN) (German Institute for Standardization e.V.)

The DIN is an independent organisation working and supporting innovative solutions through standardisation (DIN 2023a). It is also the acknowledged standardisation organisation that represents Germany in international standardisation groups such as ISO. Germany is an ISO member. The DIN integrates every sector and field of technology. The DIN is globally recognized as the German national and international non-governmental standards organisation. 36.000 experts from various fields of the industry, research and public organisations work together on standardisation projects defining requirements for products, services and processes. Currently there are 34.000 German standards published by the Beuth Verlag GmbH.

4.1.2.2.1.3 Deutsches Forschungszentrum für Künstliche Intelligenz GmbH (DFKI) (German Research Centre for Artificial Intelligence)

The DFKI is a non-profit public-private research centre (Deutsches Forschungszentrum für Künstliche Intelligenz GmbH 2023b). The 27 research departments, nine competence centres and eight living labs are located in Germany (Deutsches Forschungszentrum für Künstliche Intelligenz GmbH 2023a). DFKI is performing application-oriented research in all areas of Artificial Intelligence with a "human-centric view". They develop product functions and solutions in the field of information and communication technology, focussing on scientific excellence and socially relevant topics. At DFKI, 890 qualified researchers and 610 graduate students are working on 390 research projects.

4.1.2.2.1.4 Datamars Inc. (Datamars)

Datamars is a global supplying company for RFID (Datamars 2022a). Through research and development, they offer solutions for electronic IDs, simplifying the management of information. Through the production of data carriers and suitable IT solutions data can be displayed and shared. The sectors of focus are on livestock management, animal health delivery, pet identification, -reunification and textile identification. In these sectors, Datamars enhances traceability to fasten informed processes. In total there are 1900 people working at Datamars across 28 sites in 21 countries over the world (Datamars 2022b).

4.1.2.2.1.5 European Commission

The European Commission is the executive body of the European Union responsible for shaping the overall strategy, the EU budget, proposing new EU laws and policies and monitoring their implementation (European Commission 2023a), (European Council 2023)

Moreover EU-relevant-policies and regulatory frameworks are implemented, valid for each member state and EU citizen. The head of the EU operates as a cabinet government with 27 Commissioners, led by the president, who is currently Ursula von der Leyen (European Commission 2023b).The cabinet is re-elected every five years. One important priority for the 2019-2024 Commission is the "European Green Deal", with the aim of the EU becoming a modern, resource-efficient economy.

4.1.2.2.1.6 Fashion Cloud GmbH (Fashion Cloud)

Fashion Cloud is a company which has built a platform for fashion brands and retailers to exchange information through their software (Fashion Cloud 2022c). Their cloud system is specified on supply chain management and logistics. Previously defined data can be accessed and exchanged by retailers and brands. Stock management is improved by an interactive interface e.g., with the possibility for retailers to make immediate orders. Their service integrates different web applications and apps. 17.000 retailers and 500 brands participate in 85 countries and over 35.000 marketing materials and 15 Mio data points are stored on their platform (Fashion Cloud 2022a) (Fashion Cloud 2022b).

4.1.2.2.1.7 Global Textile Scheme GmbH (GTS)

The GTS is a standardising industry initiative establishing easy communication through a standardised industry language (GTS 2023a).

The goal is to develop transparent data, exchanged between all parties along the supply chain. The data can be uploaded to the GTS-CAT platform as uniform master data in the form of a catalogue with specifically set characteristics. There the data can be exchanged with all stakeholders in the same consistent language, machine-readable and multilingual. Different standardised packages can be booked by a stakeholder. In total there are 29 members and partners working together in the standard including associations, brands, retailers and suppliers and IT partners.

4.1.2.2.1.8 +ImpaKT SàrL (+ImpaKT)

+ImpaKT is a consulting company specialised in material and information flows in complex systems (+IMPAKT 2023b). The overall goal is to move towards a circular economy respecting the planet's boundaries. Therefore, consulting includes raising awareness about resource scarcity, promoting innovative concepts, building a community network, and specifically helping organisations and enterprises to meet their C2C challenges. Different trainings are offered to include, apply and improve circular concepts. Together with the European Commission they are working on several European innovation projects. They have developed the Product Circularity Data Sheet (PCSD) which can be used by every stakeholder along the supply chain (+IMPAKT 2023a). The data sheet includes standardised product information for circulatory properties. Circular properties of products can be monitored, and resources be handled more effectively with traceable and transparent data.

4.1.2.2.1.9 World Wide Web Consortium (W3C)

In the W3C[43] member organisations together with a working staff build an international community to develop leading web standards with long term growth (W3C, 2021a 2023a). Their work includes research and development of protocols, guidelines and web applications as well as public relations and mainly “making the World Wide Web work”. Their vision is that everyone can share with multiple devices information around the world building trust. It is hosted in 4 universities around the world, USA, France, Japan and China.

4.1.2.2.1.10 Wuppertal Institut für Klima, Umwelt, Energie gGmbH (Wuppertal Institute for Climate, Environment and Energy), (Wuppertal Institute)

The Wuppertal Institute is a research and development institute focused on climate-friendly and resource-efficient solutions (Wuppertal Institut 2022b)

The framework set for its research activities are the planetary boundaries leading to a “climate-neutral and resource light society by 2050”. Therefore, research topics are e.g., the digital-, energy and mobility transition, resource circulation and consumption strategies, climate-friendly primary industry and changing cities. In the year 2021 over 300 experts have worked on around 200 projects in 70 countries worldwide. There have been 200 scientific publications, 5000 media reports and 50 currently ongoing dissertations.

4.1.2.2.1.11 Spherity GmbH (Spherity)

Spherity is developing decentralised identity management solutions for enterprises, machines and other entities (Spherity 2022b). They enhance digital solutions creating compliance setting standard processes interacting with researchers, industry and developers. Their focus is set on data management including secure systems with identity and access management and supporting interoperability and exchange of data (Spherity 2022c). Fields they are working on include Blockchain, Industry 4.0, Internet of Things, Digitals Twin, Cloud Identity Wallet, Digitally Identity, IT Compliance, Audit Trail and Enterprise Identity. They are collaborating with several different organisations around the world. One of their main focuses is set on the new battery regulation (European Commission 2020; Spherity 2022a). Spherity is currently engaged in defining technical concepts for a digital, decentralised battery product passport. The

[43] W3C is not an incorporated organisation, but an international organisation administered via a joint agreement by the "Host Institutions": MIT, ERCIM, Keio University, and Beihang University)

decentralised information storage system can store battery product information including sustainability information and certifications.

4.1.2.2.1.12 United Nations Economic Commission for Europe (UNECE)

UNECE was founded in 1947 to strengthen pan-European integration and cooperation in the EU and outside (UNECE 2017b). It is one of five regional commissions of the United Nations Economic and Social Council. UNECE integrates 56 member States from Europe, North America and Asia and moreover 70 international organisations are working within the cooperation. Head is the Executive Secretary of United Nations Economic Commissions for Europe Ol'ga Algayerova (UNECE 2017b). Their work includes policy dialogue, setting legal frameworks as rights and regulations, integrating technical cooperations, exchanging best practices and leading international economic negotiations.

4.1.2.2.2 Expert interviews

In addition to the expert workshop, interviews with six technical expert groups were conducted. These interviews were used to clarify unanswered questions from the workshop and to go into greater depth.

4.1.2.2.2.1 Susanne Guth-Orlowski (Spherity GmbH) (Spherity)

Susanne Guth-Orlowski is the Chief Innovation and Solution officer at Spherity, which offers digital trust products and Digital Product Passport solutions. She also founded the firm 4TheRecord and works as an international independent external expert for the European Commission. She is an expert in digital contracts, blockchain, cryptography and security technology. Currently, she is engaged with the development for a digital, decentralised battery product passport.

4.1.2.2.2.2 Katie Shaw and Natalie Grillon (Open Supply Hub, Inc., formerly the Open Apparel Registry) (OS Hub)

Katie Shaw and Natalie Grillon have been involved in the development of Open Supply Hub (formerly the Open Apparel Registry) (Open Supply Hub 2023). OS Hub is an accessible, collaborative, supply chain mapping platform, used and populated by stakeholders across sectors and supply chains. Katie Shaw is the Chief Programme Officer and an expert in sustainability and supply chain transparency. Natalie Grillon is Executive Director at Open Supply Hub. She is an expert in supply chain transparency, open data, and interoperability.

4.1.2.2.2.3 Thibaut Wautelet (+ImpaKT SàrL) (+ImpaKT)

Thibaut Wautelet is a consultant in circular economy and a project manager at +ImpaKT which is a private consulting company with the mission to raise awareness and help organisations move towards a circular economy. Together with the Ministry of the Economy of Luxembourg and a group of more than 50 organisations, they have developed the Product Information Data Sheet (PCDS) standard which is a basic source of verifiable data. The PCDS contains statements describing the circular properties of products (on how they were designed and manufactured for). The PCDS data can be used to assess circular products. Thibaut Wautelet is an expert in the fields of circular economy, supply chain transparency and standardisation.

4.1.2.2.2.4 Phil Archer and Sandra Hohenecker (GS1 AISBL) (GS1)

Phil Archer and Sandra Hohenecker are working with the collaboration platform GS1 that develops standard-based solutions for data exchange (GS1 2023b). Phil Archer is the director of web solutions at the GS1 global office. He is working to improve eCommerce and online product data through web technologies and dereferenceable persistent Uniform Resource Identifiers (URIs) for every barcode. Sandra Hohenecker is a senior manager for identification and data carriers at GS1 Germany GmbH. She is focused on identification, barcodes, Electronic Product Code (EPC)/RFID and Privacy Impact Assessments.

4.1.2.2.2.5 Dieter Wegener (Siemens AG) (Siemens)

Dieter Wegener is the Head of External Cooperation at Siemens Corporate Technology and a professor for management and sustainability at the RWTH Aachen University. He is also the speaker of the German Electro and Digital Industry Association ZVEI e.V. (ZVEI) and the speaker of the advisory board "Standardization Council Industrie 4.0 (SCI.40)". In the context of his work for ZVEI, he deals with the development of the Asset Administration Shell and digital twins.

4.1.2.2.2.6 Gerhard Heemskerk (UNECE)

Gerhard Heemskerk is an independent business consultant and consultant at the United Nations Economic Commission for Europe (UNECE). He is an expert within several domains of the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) and involved in different projects. The UN/CEFACT works on traceability of sustainable supply chains amongst other projects, and has developed a recommendation, guidelines and an electronic business standard on traceability and transparency in support of more responsible production and consumption patterns (UNECE 2023c).

4.1.2.3 In-depth analysis of product information systems

Based on the results of the initial online research and the expert interviews, a list of particularly relevant systems was identified to be investigated in more detail in chapter 4.3. Systems for different product categories with different focus were chosen in order to incorporate the resulting different findings to the development of the concept.

To evaluate the selected product information systems, the researchers defined the following different aspects:

- **Data security**
  How is the data in the system technologically and conceptually secured? How is intellectual property protected from third parties?
- **Modularity**
  Can information be added in a modular form? Are information requirements flexible?
- **Interoperability**
  Are adequate interfaces to established systems e.g., consumer apps or information portals available? Are interfaces and data formats documented and accessible?
- **Applicability to other product groups**
  Is it possible to use the approaches in the described system for other product groups?
- **Data quality**
  How is data quality ensured? Are there algorithmic and/or manual review/verification processes?
- **Granularity**
  Is the data in the system attached to product model, variation, batch, or item?
- **Accessibility**
  How can data in the system be accessed? Are interfaces documented?

4.1.2.4 Development of the front-end demonstrator

The demonstrator was intended to help evaluate how real users and representatives of important stakeholder groups would interact with a product information system. The focus of the development was on the information to be shown to the different user profiles and its presentation to the users. The technical backend architecture was disregarded at this point. The mock-up is however designed to be usable with a system as described in the following chapters.

4.1.2.4.1 Creation of the user profiles

In a first step, the results of Part A of this project were taken as a basis to develop a first version of user profiles. All the information requirements of all stakeholder groups were gathered in a table (see Annex 10). Additionally, a survey was conducted with stakeholders from different groups, both for the electronics and textile sector. In a heuristic approach, the results were checked and supplemented by the researchers to fill in probable gaps, based on other existing product information systems mentioned in Chapter 4.3 analysis and the industry experience of the researchers. This first version of the user profiles was subsequently put to test using the front-end demonstrator mock-ups.

4.1.2.4.2 Development of the mock-ups

The user profiles created in the previous step were used to create the initial design for the front-end demonstrator and create a mock-up. The overall design approach was to ensure good navigation of the interface for all stakeholders involved. The data presented for the product types tested should be applicable and appropriate for the user profiles. After sketching potential layouts, the final layout was decided in collaboration with internal feedback. Hi-fidelity mock-ups of the screens were then created in Figma, an interface design tool (www.figma.com). After internal review of these mock-ups, a clickable prototype of the demonstrator was created using the same tool.

4.1.2.4.3 Stakeholder workshops

The researchers have designed the stakeholder workshops with the aim of testing the mock-ups of the front-end demonstrator and reiterate on the information requirements and user profiles. The workshops were to be used as a kick-off to the testing phase, to demonstrate the mock-ups and let participants navigate through them. A combination of applied user experience (UX) research methods aimed at providing insights for future design decisions were undertaken. The approach included a remote prototype usability test combined with a survey to gather observational data and qualitative feedback from users. Heatmap analysis[44] was used to identify patterns in user flows and assess navigation as well as identify potential areas for improvement. Qualitative data was collated and synthesised to uncover trends, insights, and core themes. The feedback was collected using the tool useberry (https://www.useberry.com/), giving the participants enough time to test the mock-ups. During the testing period, time for questions and discussions was scheduled.

The research questions were not intended to yield quantitative results and therefore, no statistical conclusions should be made. The survey sample size was too small and not representative of the overall industry to make definitive judgements based on the number of responses. The purpose was to gain insights from relevant users to evaluate the current state of

[44] Heatmap analysis is an approach from the field of user experience to review user behaviour on a software. The user behaviour is presented through images that show a view of the software with an overlay that represents the clicks or mouse positions of the users. Different colours indicate the frequency and length of the interactions – red colour usually indicates a frequent/long interaction while green or transparent colour indicates an infrequent or short interaction.

the interface and inform future iterations. Nonetheless, in the future, decisions should be validated through both representative quantitative analysis and further qualitative research.

In November 2022, 4 workshops with a duration of approx. 60-90 minutes took place. The workshops were divided as follows:

- 07.11.2022: **Certifiers, market surveillance etc.** - 13 participants
- 14.11.2022: **Supply Chain & Retail** - 8 participants
- 23.11.2022: **Reverse Supply Chain** - 10 participants
- 28.11.2022: **Consumers** - 18 participants

The following agenda was used for all four workshops.

1. Introduction round
2. Update on project status, content and objectives
3. Introduction/repetition of selected product information system aspects
   a) User profiles and access management
   b) Information needs
   c) Data carriers and connection to 3rd party services
4. Description and demonstration of the demonstrator mock-ups and presentation of the feedback process
5. Q&A
6. Conclusion and checkout

Results on information access and coverage are used to revise the information requirements and user profiles. The workshop results as well as the updated user profile proposals are documented in this report. In the subsequent course of this project, both are used as a basis to further develop the front-end demonstrator. In particular, the comments of the users regarding the division of the information categories as well as the usability of the tool are also incorporated in the further development.

4.1.3 Parallel and related developments

The concept of storing digital information about physical products is being explored from different points of view in the industrial, the academic and the legislative worlds. This section provides examples of parallel developments that contain similar aspects and approaches. A comparison and delimitation are beyond the scope of this project.

The EU is in the process of outlining the concept of the Digital Product Passport (DPP). The Ecodesign for Sustainable Products Regulation published in March 2022 establishes the framework to set ecodesign requirements for specific product groups and introduces DPPs for this purpose. It defines a DPP as follows:

"Tool that can significantly enhance the end-to-end traceability of a product, complementing information provided in product manuals or labels. It should help consumers make informed choices by improving their access to product information, allow repairers or recyclers to access relevant information, and improve enforcement of legal requirements by authorities".

Several research projects are ongoing to develop technical infrastructure concepts for DPP:

- **CIRPASS** (The Ecosystem Digital Product Passport)(CIRPASS 2023)
- **Onto-DESIDE** (Ontology-based Decentralized Sharing of Industry Data in the European Circular Economy)(Onto-Deside 2022)
- **SCIRT** (System Circularity & Innovative Recycling of Textiles)(Scirt 2023)
- **CISUTAC** (Circular and Sustainable Textiles and Clothing) (CISUTAC 2023)
- **CircThread** (Circthread 2023)
- **CE-RISE** (Circular Economy Resource Information System) (Cordis 2023)

The Battery Passport is invented to scale a sustainable, responsible, and circular battery to meet the goals of the Paris Agreement based on the EU's proposal for a regulation of the European parliament and of the council on batteries and waste batteries (European Commission 2020). It aims to map the whole lithium-ion battery chain from mining to recycling. Furthermore, the Battery Passport framework is designed to increase the transparency by including a digital twin of the physical battery. Data can be collected, exchanged and reported among the stakeholders throughout the lifecycle. (Global Battery Alliance 2022)

Digital Twins are a concept that gains interest both in the academic and the industrial world. The Digital Twin is defined as a virtual representation of a physical product through descriptive product information that is accurate on micro and macro level. The concept was later expanded to include the bi-directional data connections between physical and virtual representation where data can be exchanged between the real and the virtual space. Nowadays there are a variety of definitions, some of which also consider information about the product lifecycle. (D. Jones et al. 2020).

4.2 Analysis of concepts and technological approaches

To describe possible technical solutions for a product information system, different existing systems have been analysed. Approaches and solutions used for the different aspects identified have been gathered from these systems and within an expert workshop. Afterwards, they were discussed and complemented within the framework of expert interviews. This chapter provides an overview of the state-of-the-art used in product information systems, broken down according to the individual aspects.

In all of the identified aspects of a product information system, the questions of how standards should be developed and refined and who should be responsible for the standards are relevant. Therefore, standards are discussed in the following separate chapter.

4.2.1 Standards

Standardisation is an important tool to benefit from progress, safety, orientation and clarity (DKE 2020; ISO 2023d). The structure of standards simplifies the integration and diffusion of new innovations (DKE 2020), like all of the technical innovations of product information systems analysed in the report. Distributed knowledge is brought together and documented in writing. The standards should be accessible by everyone to improve understanding throughout the globally connected industry. Standards enables stakeholders to have confidence in the safety, reliability and quality of products (ISO 2023d). In Industry 4.0, standards can increase automation and strategic employment of data and improve daily digital and analogue processes (Hashemi 2022). Collaboration to improve the processes throughout the industry is key and beneficial to all stakeholders. Technical specifications in the context of Industry 4.0 'increase reliability, predictability, inter-compatibility, consistency and efficiency' (Hashemi 2022) https://flowcate.com/industry-40-standards/. Furthermore, standardisation contributes to a more resilient and sustainable use of resources along the value chain (UNECE 2023d).

The DKE/AK STD_1941.0.2 committee is dealing specifically with these questions in relation to the Digital Product Passport - the participants could certainly also be consulted on the product information system (DKE 2023).

All experts interviewed emphasise that standards are a useful tool to harmonise all different aspects of a product information system. They also shared requirements for the hosting bodies and their processes which are summarised in the next subchapters.

4.2.1.1 Hosting body of the standard

Besides developing the actual standard, an organisation needs to be selected to host the standard and the adaptation processes. This could be the European Commission, but also other types of organisations such as standardisation organisations (e.g., ISO/IEC/ITU, CEN/CENELEC/ETSI, DIN/DKE/VDI, UNECE), non-profit organisations (e.g., GS1, W3C, IRMA, Textile Exchange), or industry platforms or associations (e.g., Euratex, Platform Industrie 4.0, SCI4.0).

In the expert interview, Guth-Orlowski emphasises the importance of the organisation hosting the standard to be considered neutral and thus able to take on the role of a mediator.

There are various suggestions for organisations that could be suitable to host the standard. Several experts advocate for businesses or non-governmental organisations to host the standard rather than governmental organisations due to a more flexible adaptation process (Wautelet T., Interview 2022) and a better representation of industry requirements. (Heemskerk G., Interview 2022)

Other experts consider that public and governmental organisations such as DIN or ISO would be better suited to host the standard (Grillon N., Interview 2022, Guth-Orlowski S., Interview 2022, Wautelet T., Interview 2022 or that new organisations might need to be formed (Guth-Orlowski S., Interview 2022). Grillon points out that private organisations have no incentive to cooperate with their competitors, currently resulting in multiple standards in circulation without interoperability or true standardisation.

Archer mentions that in his opinion, the bigger question is what community within the industry is represented by the standard body than what the maintenance and processes will be like, because he considers the differences here as rather minimal. For some standards, different organisations are involved, for example the GS1 identification standards are based on ISO norm 15459 (ISO/IEC 15459-1:2014). There's also a possibility for a standard that originates from a private organisation to become a DIN or ISO norm (Archer P, Interview 2022). This can be seen in the example of the cooperation between the PCDS Initiative and ISO, launching a future ISO/NP 59040 standard[45]. (ISO 2023a)

Grillon and Shaw advocate for free and accessible solutions (e.g., open-licensed). Grillon mentions the concern that private standardisation companies may commercialise data as part of their business model. Data quality requires unpaid solutions with regular updates and access to multiple databases to get the most accurate solution (Grillon N., Interview 2022). Often, a fee is charged for either creating an entry, accessing information, or both. This disincentivises, in her opinion, both the data owner to keep the data updated and the data user to cross-check different data sources. Therefore, she advises against relying on private organisations to host the standard. ISO, CEN and DIN standards for example are currently not available free of charge. To

[45] A pilot version is already available here https://gd.lu/8HNg7F.

use a standard, it must be purchased. If a standardisation initiative was responsible for developing a standardised product information system, it can be assumed that the standard (or a newly developed standardisation package with many subordinate standards) would have to be purchased. Private systems that are linked to a standard, such as GS1, also provide their manuals as a paid service. The manuals are not free of charge. With so many small companies in a product information system, the question arises as to who should pay for the purchase.

One question that has been raised is whether the hosting organisation should depend on the stakeholders involved (Archer P, Interview 2022) and/or the use cases the standard is designed for (Grillon N., Interview 2022). There could for example be different organisations for identification standards and circularity datasets (Grillon N., Interview 2022).

4.2.1.2 Standard development / adaptation process

When asked how the standard should be adaptable to changing stakeholder requirements, many experts agree that existing development processes could be used from existing standardization organizations such as ISO, UNECE, W3C or GS1. (Archer P, Interview 2022, Heemskerk G., Interview 2022)

Development and refinement processes are usually quite similar for any standard body (Archer P, Interview 2022). There needs to be a community interested in the standard and a consensual demand within this community to create a change, such as developing new terms. When these conditions are met, a working group is formed to jointly develop the desired changes (Archer P, Interview 2022, Guth-Orlowski S., Interview 2022).

Grillon addresses that a consensus approach involving multiple stakeholders takes time and could become a “death by committee” process where you work on a standard for years. In contrast, W3C addresses the concern that a top-down approach for a standard could lead to a lack of community engagement.

Any stakeholder that is affected by the standard should be allowed to propose and work on changes (e.g., recyclers are involved in standardisation processes for batteries formed (Guth-Orlowski S., Interview 2022). For example, UN/CEFACT uses an open development process where changes to a particular standard can be started by a project description including data requirements. The changes can be submitted for inclusion in their data structure library. The only way to make changes to the standard is through this feedback process. Once confirmed, the elements become available to the data structure that is to be adapted. This process takes place twice a year. Heemskerk mentioned that in a world of Application Programming Interfaces (APIs) where requirements change frequently, it might also be recommendable to go into more rapid development. The UN/CEFACT has also been working on such a process for the development of their open API specifications. They have also created rules on how to give feedback for UN/CEFACT data models, keeping the standards stable without too many new versions. (Heemskerk G., Interview 2022).

Another example for a standard development process is GS1’s GSMP (Global Standards Management Process) (GS1 2023f). Anyone can propose a change here. Whether this is implemented depends on how large the community is that supports the proposed change (GS1 2023e).

In order to provide incentives for different stakeholders to use the standard, Grillon states that the process must be consensus driven, open, transparent and includes multiple stakeholders (Grillon N., Interview 2022). Therefore, the Open Supply Hub is advocating for open data standards to be included in the Corporate Due Diligence Legislation.

Further open issues about standards that need to be solved in the development are (Wautelet T., Interview 2022):

- When a new version of the standard is published, how does that affect the existing product data?
- Is there a need to update the product data to adjust to increased information requirements? If so, for how long should data be maintained and updated? Who is responsible for the maintenance?
- If a product is compliant with regulations at the moment of production and the regulation is changed later on, does the product need to be checked for compliance again?
- What are the existing gaps in terms of data requirements vs. assessment methods?

4.2.1.3 Regional versus global approaches

To achieve true interoperability, Heemskerk suggests aiming for a global coverage for the standards. This requires the standards to be in line with all national regulations. Especially the exchange of data elements should be standardised, in his opinion, by a single law respected by all countries.

Grillon, on the contrary, considers the expectation for a single standard to be set and adhered to worldwide to be illusionary. She refers to innovations taking place too fast for that. For example, China, where a large part of textile production takes place, could simply set its own standard resulting in everyone who collaborates with Chinese producers having to comply with it. She emphasises that for this reason it is particularly important that standards, especially national standards, are open and accessible. This way, a dominant standard does not necessarily have to prevail, but interoperability can be improved on an ongoing basis.

Interoperability along with machine-readability of the standard also simplifies the process of providing data to compliance partners and research institutions responsible for ensuring that laws and regulations are followed, and progress is made (Grillon N., Interview 2022).

4.2.1.4 Legislative vs. voluntary approaches

It is very rare that a certain standard is mandated by law (Archer P, Interview 2022). It occurs that legislation cites norms or standards[46]. If such a reference is made, the legislation usually leaves room for different approaches providing solutions based on this standard. All the standards from GS1 are on a voluntary basis, because making them compulsory would be out of market adjustments (Hohenecker S., Interview 2022). It is also not necessary to make them compulsory, because business partners usually make agreements involving standards. If one of the partners does not comply with this standard, the others will hold this partner accountable. In the International Material Data System (IMDS) for example, manufacturers can state data requirements for specific projects that their suppliers then need to comply with. The IMDS is the material data system of the automobile industry. It has become a de-facto global standard that is used by most automobile manufacturers. (IMDS 2023b)

Wautelet considers that legislation should rather create specifications for the overall interoperability and exchange than specifying the details of data formats or protocols. For example, for the unique ID, governance, semantic and syntax rules should be set based on

[46] e.g., the Proposal for a Regulation establishing a framework for setting ecodesign requirements for sustainable products (COM(2022) 142 final) refers to the ISO/IEC 15459

existing standards (e.g., ISO/IEC 15459). The definition of such rules enable multiple different service providers to create and manage unique identifiers (UIDs). (Wautelet T., Interview 2022)

However, to pave the way for the industry to develop towards a circular economy, Grillon thinks mandating the standard may be necessary (Grillon N., Interview 2022). Therefore, the Open Supply Hub is pushing for open data standards to be included in the Corporate Due Diligence Legislation (Grillon N., Interview 2022). This approach is also supported by GTS who state that voluntary standardisation would take too long, and therefore standardisation should be stipulated by law (GTS, Workshop 2022).

Shawn adds that while organisations are moving faster than the legislative curve, the legislation could stay optional for an interim phase to get to higher speed legislation processes. This would allow progressive organisations to move into this direction ahead of legislation. She sees that currently, organisations are waiting for clarity from the regulations and pause their efforts to become more circular. However, the standards cannot be voluntary infinitely.

Further examination of advantages and disadvantages of legislative and voluntary approaches will be conducted in Part D of this project.

4.2.1.5 Implementation of standards

Most user organisations (such as industry associations) create an implementation guide and/or profile of a standard such as the UN/CEFACT standard (Heemskerk G., Interview 2022). Validators will be applied that check whether or not the exchanged information complies with the industry standard. Those checks can be made either with regard to the format of the information and/or with regard to the business rules. Different profiles can be created for different industries and/or different stakeholders within those industries. Industry associations or the EU could provide validation tools that check whether or not the exchanged data complies with the European norm. These potential validation tools can check on the restrictions made in the profile(s).

4.2.1.6 Challenges

Challenges that experts foresee in terms of standards include the updating process, i.e. the process of adapting the product information systems and the product data within these systems after a change has been made to the standard (Wautelet T., Interview 2022).

An example for this challenge is the SCIP database for information on substances of concern in articles as such or in complex objects (products) established under the Waste Framework Directive (WFD) (ECHA, 2023; Wautelet T., Interview 2022). When information requirements change for a specific product (e.g., material composition or compliance with a declarable substance list), it would be helpful if every stakeholder that is using this product is notified so they can update their data and add missing information. Additionally, it should be defined whether information for products that are already on the market should also be updated. This would come with considerable costs and may not be economically feasible. Instead, different versions of the standard could co-exist, and information could be linked to a certain version.

Another challenge currently arises in the context of conformity if a product information system requires specific values, e.g. on recycled content (Wautelet T., Interview 2022). Material and chemical information is usually varying over production batches. This means that the composition of the individual instance of a product might differ from the information given in the information system for a production batch, especially when batches of the same product model are produced in different facilities. The question of whether the information should be saved on product model or batch level will be discussed in chapter 4.2.8.2.2.

4.2.1.7 Discussion and conclusions

In this chapter the authors of this report discuss the arguments which have been described in the chapters before about standards and draw conclusions.

Standardisation of product information systems is in theory desirable and recommended, because it makes it cheaper and easier for all stakeholders to collaborate and participate to the system. In praxis this ideal scenario faces many challenges. The extend and granularity for which standardization is necessary needs to be negotiated. Lock-in effects need to be considered because stakeholders are already using very different systems and a change to another standard could be expensive for them. In some cases, it can have economic advantages when tools for adapting between different standards are used instead of forcing all stakeholders to be align with one global standard.

It has been discussed whether specific standards should be mandated by law. So far this is rare but there are exceptions where it is already done. The authors of this report recommend defining clear requirements within legislation which standards must fulfil to be compliant. Additionally, certain standards that are aligned with the requirements can be named. That can support stakeholders to identify relevant standards to be compliant. Compared to the law, standards are more specific about how something is ultimately implemented.

There are many different organizations that are developing and maintaining standards and different opinions which organizations are suitable for such a task. It is important that they have a well-structured process for the development and updates of the standards. Furthermore, it will increase the chance that standards are accepted and widely used if standard organisations include a strong community including all relevant stakeholders to develop and maintain standards in a consensus-driven way. It helps to avoid that important requirements are overlooked. To the authors' knowledge, there are several organizations that fulfil these requirements.

As interoperable product information systems (such as the Digital Product Passport on EU level) are a new development, frequent update cycles to react to changes of requirements from the industry are recommended in the beginning. Over time the systems will be more established and less updates will be needed.

Globally applicable standards would be ideal. However, regional standards such as on EU level could be helpful to be more agile in the beginning of such a system. The stakeholder group is more homogenous, and the EU has the possibility to create the same law for all stakeholders who are affected. Therefore, the involvement of a relevant share of the affected stakeholder groups is easier on EU level. Even if this does not result in a globally applicable standard, regional standards can pave the way for adaptation tools to map standards between these regions (e.g., European standards and Chinese standards).

In general, it is fine when standards are not free of charge as the organization who maintains the standard needs to cover their costs. However, when governments would make standards mandatory by law, they need to make sure that they are free of charge. In this case, the government could cover the costs for the standard development and maintenance.

A process needs to be established regarding how organisations should adapt their data storage systems after changes to the standards have been made. However, the adaptation of all product data of products that are already on the market would result in a massive amount of effort. To avoid this, it could be a feasible solution to allow several versions of the standard to be run in parallel. The data should be marked with the standard version used. This way, new data would need to follow the new standard, while legacy data could remain unchanged.

Takeaways for standards

- Standardisation of product information systems in theory is desirable and recommended.
- Legislations should define requirements that applied standards must fulfil and optionally can mention examples of aligned standards.
- Standard organisations should include a strong community including all relevant stakeholders to develop and maintain standards in a consensus-driven way.
- There should be frequent update cycles to react to changes of requirements from the industry.
- Access and usage should be free of charge when mandated by law.
- Globally applicable standards would be ideal but to start with regional standards can be a way forward.
- A process needs to be established regarding how organisations should adapt their data storage systems after changes to the standards have been made. Legacy data should not be updated to a new standard version.

4.2.2 Vocabulary/Terminology

To communicate data and information between different parties, it is necessary to agree on a set of words to be used as well as on the meaning behind these words and how to use them to create understandable and useful information.

The challenge of communicating understandable and useful information occurs universally in almost all aspects of cooperation between organisations and stakeholders - regardless of which medium (e.g., product information system) is used for communication. However, there are established terms and fundamental concepts with corresponding solutions to approach the communication problems. It should be noted that these fundamental concepts defined below are often used interchangeably because the definitions are not clearly delineated. Vocabulary describes a set of common words for communication (datos.gob.es 2021). An ontology provides the background information for a certain domain, in the form of definitions for terms, classes and relations between them (Gruber 2009). Syntax allows to put words in a meaningful order, while semantic provides the meaning of the language (Georgieva; Kubicek et al. 2019). A taxonomy refers to a classification of terms. (Georgieva) Combining these concepts in a standard allows all stakeholders of the data infrastructure to participate in an aligned way of communication. This gives clarity about the definition and meaning of the data as well as its organisation.

4.2.2.1 Standards, laws or guidelines

As discussed in chapter 4.2.1, the standardised datasets for the product information system should be based on existing industry standards (e.g., DIN/CEN/ISO) to minimise the efforts for affected stakeholders to adapt to the standard. It should furthermore be available to all relevant actors. Additionally, the standardised dataset should be adaptable to requirement changes in a transparent and accessible process, e.g., when technology evolves in the recycling industry and more or other information becomes relevant. Furthermore, it has been mentioned by representatives of the EU commission that a DPP system ideally would be based on CEN standards (European Circular Economy Stakeholder Platform 2022).

Existing software already uses standardised datasets of different standards and companion specifications (Datamars / DIN, Workshop 2022). This variety leads to confusion between different systems (Wuppertal Institut, Workshop 2022) and therefore efforts need to be made in order to align and harmonise the standards used.

In the framework of the expert workshop, participants emphasised the need for standardised semantics (DIN, Workshop 2022) and for terminology to remain consistent within a sector throughout the lifecycle of a product; from the raw material to the introduction and reintroduction of the final product into the circular economy (GTS, Workshop 2022). Technical requirements mentioned by the experts include the need for extendibility, flexibility, scalability (Wuppertal Institut 2022b) and interoperability (W3C, Workshop 2022). Interoperability also includes reference models and frameworks for existing standards (DIN). However, the participants representing the Wuppertal Institute point out that the classical standardisation of vocabulary or ontologies hinders the flexibility and scalability of product information systems.

Apart from the standardisation of vocabulary, ontology and taxonomy, the protocols to share and exchange information will also need to be standardised (Datamars, Workshop 2022) (DIN 2022). When asked for their experiences with developing the Open Supply Hub, Shaw and Grillon mention that their most serious challenge from a data perspective was the initial data quality, data being stored in various sources and formats - none of which was machine readable. A clear syntax for data formats was a limitation. This led to a lack of interoperability and high number of duplicates within these datasets.

Possible solutions could be based on the following formats for data notation (W3C, Workshop 2022). These formats have been mentioned in the expert workshop as suitable formats to provide a machine-readable syntax. In this syntax, metadata and standards can be described in a standardised way. The list is not exhaustive.

- **JSON-LD** (W3C JSON-LD Community Group 2023)
  JavaScript Object Notation for Linked Data is a lightweight linked data format that is based on the JSON format. JSON is a widely adopted way of expressing data that is both human and machine readable. JSON-LD is a specification for encoding contextualised meaning into the JSON documents that allows the inclusion of standardised vocabulary for the keys.(W3C 2004)
- **RDF-star** (W3C, 2004 2022c)
  The Resource Description Framework (RDF) is part of the semantic web, an extension to the world wide web through standards set by the W3C. As a directed, labelled graph data format, it provides a framework for representing information on the web in a flexible way and is built on an abstract syntax. Amongst other things, it is often used to represent personal information or metadata about digital artefacts.
  RDF-star (RDF*) is an extension of RDF, providing a concise way to make statements about statements.
- **OWL2** (W3C 2017)
  The OWL2 Web Ontology language is designed to formally define meaning for the semantic web. The information should be stored as semantic web documents and can be used in combination with information written in RDF. OWL2 provides ontologies, syntaxes and semantics.
- **SPARQL** (W3C 2013)
  SPARQL is the query language for RDF. It can be used to express queries across diverse data sources that use RDF either directly or through middleware.

4.2.2.2 Interoperability - sectoral vs. cross-sectoral approaches

Interoperability describes the possibility of data exchange between different information systems (Weiß 2018). This includes a technical interoperability as well as a syntactic and semantic interoperability of the data stored. Interoperability should be distinguished from compatibility, which merely describes the possibility of exchanging data between two systems. Only when all systems are compatible with each other one can speak of interoperability. Apart from the interoperability between the different information systems within a certain sector, Wautelet also points out that a structure may be needed to provide for interoperability between sectors. He considers this to be especially important when it comes to manufacturers supplying partners from different sectors. These need to adjust their data exchange interfaces to meet all the requirements from their different partners. Currently, there is a challenge for suppliers when stakeholders e.g., from different countries request different data and data formats. For example, a company working with a PCDS data infrastructure would request different information (and formats) compared to a company that uses the circularity.ID Open Data Standard. The closer the requested datasets are aligned, the less complications the manufacturers encounter with sharing data. The potential of harmonising datasets between branches is also emphasised by Datamars in the workshop.

Wautelet emphasises that harmonisation of data requirements across sectors should be pursued as much as possible, but he also believes that specific requirements for individual sectors are needed. A bottom-up approach should be taken to identify larger sets of commonalities of properties that should be harmonised across sectors, and then add more specific requirements for each sector. Additionally, existing standards, such as the PCDS or ISO norms can provide a basis for a cross-sectorial dataset (+ImpaKT, Workshop 2022, Wautelet T., Interview 2022). Archer assumes that interoperability between standards and vocabularies will be a never-ending problem that needs to be worked on continuously by different parties.

4.2.2.3 Knowledge graphs and the semantic web

A possible implementation of the database is knowledge graphs. Unlike traditional relational databases, information is stored in a graph structure. In practice, graph databases are usually modelled using the W3C Resource Description Framework (RDF) (W3C 2023b). In this framework, data is modelled as sets of two nodes and a directed, labelled edge between them. These sets are called triplets, each consisting of a subject (node), a predicate (edge) and an object (node). Each component of the triplet can be either a literal (e.g., text, number, or date) or a URI that identifies an object.

Although in theory graph databases can exist without a standardised schema, standardisation is just as important for applicability and interoperability, especially for large databases, as it is for relational databases.

The Web of Data was mentioned by W3C. This is a development with the objective to create an environment built on knowledge graphs that applications can query and draw inferences from. It aims to not only standardise the data themselves but also the relationships between them. (W3C 2023b)

4.2.2.4 Example solutions

When asked for example solutions from the field of data standards, the participants put together lists of relevant vocabularies, ontologies and taxonomies for textiles, electronics, other products and cross-sectorial data standards. Since the definitions overlap, no demarcation of the categories vocabulary, taxonomy and ontology is undertaken here. The findings have been complemented with standards that the researchers encountered during the investigation. The list is not exhaustive and is recommended to be considered a first insight rather than a comprehensive overview. For a more detailed evaluation of different standards which could be used for a Digital Product Passport see the Circular Economy Normungsroadmap by DIN, DKE and VDI (DIN 2023b).

4.2.2.4.1 Textiles

- **Textile Exchange Standards - Materials, Processes, & Products Classification V1.1.**
  Standardise the classification of raw materials, process categories, product categories, and product details for GOTS and Textile Exchange's standards.(Textile Exchange 2020)
- **circularity.ID - Open Data Standard**
  The circularity.ID Open Data Standard is an ontology designed to meet the information requirements of sorters, recyclers and consumers in the textile industry. (circularity.ID 2023)
- **UNECE BUSINESS REQUIREMENTS SPECIFICATION (BRS) - Traceability and Transparency in the Textile and Leather Sector**
  The UN/CEFACT Textile & Leather Process and Data Model supports business processes to improve traceability and sustainability in the garment and footwear sector.
- **Global Textile Scheme (GTS) Language**
  The GTS Language is a multi-language vocabulary for textiles that is built with the intention that multiple platforms can use this vocabulary across the value chain. (GTS 2023b)
- **Fashionpedia**
  Fashionpedia is a visual fashion dictionary covering all the technical terms from style to material to production with illustrations and infographics. It is not a standard which can be used for data exchange but other standards build up on the vocabulary and taxonomy defined in Fashionpedia. (Fashionary 2023)
- **Circular Product Data Protocol**
  Circular Product Data Protocol is an identification system for textile products, enabling recyclers and reusers to digitally identify products and access material information. (Circular Protocol 2023)
- **ISO/FDIS 5157 Textiles — Environmental aspects — Vocabulary**
  This draft ISO standard shall provide general terms and definitions used in the textile value chain related to environmental aspects including design, production, retail, use and reuse, recycling processes and disposal. It is supposed to improve communication between stakeholders addressing issues related to environmental aspects of textile products and processes. It is currently still in development. (ISO 2023e)

4.2.2.4.2 Electronics

- **European Technical Information Model (ETIM)**
  An international taxonomy with the objective to be a sustainability classification standard for all technical products. It uses classes, features, values and keywords to classify products. (ETIM International 2022)
- **ISO/IEC 22603-2 - Information technology — Digital representation of product information — Part 2: Requirements for electronic devices with integral display** (ISO 2022)
  ISO/IEC 22603 defines requirements for electronic product labelling for all types of

products. It is a method using an electronic system to communicate product compliance information in conjunction with existing labelling practices or as an alternative to them. Among other things the standard defines structure, content, data carrier and machine-readable codes. ISO/IEC 22603-2 is specifically for electronic devices with an integral display.

- **EDIBATEC**
  EDIBATEC is a classification standard for technical information of industrial products. The areas include generators (heating, hot water, air conditioning), systems, control, etc.

4.2.2.4.3 Cross-sectorial

- **EPCIS-CBV (Electronic Product Code Information Services - Core Business Vocabulary)**
  EPCIS is a global GS1 standard for creating and sharing visibility event data. The Core Business Vocabulary is a companion standard that defines data values to populate the EPCIS structure. (GS1 2023a)

- **PCDS Dataset**
  The Product Circularity Data Sheet is a document stating a methodology for circular economy related information. It is supposed to improve the accuracy and completeness of the data. It provides requirements for organisations using the data. It also includes a guide to define and share the data in an interoperable way between systems. The ISO norm ISO/WD 59040.2 is under development. (ISO 2023c).

- **RAMI 4.0 - Asset Administration Shell**
  The asset administration shell is a standardised digital representation of an "asset" which is a physical or logical object owned by an organisation. RAMI 4.0 provides a structured view of the main elements of an asset (see chapter 4.3.1.2) Every Industry 4.0 asset should be enclosed by an asset administration including a sufficient description according to the Industry 4.0 use cases. (ZVEI 2017, 2020)

- **ECLASS**
  The ECLASS standard is a global, cross-sectorial reference data standard for the classification and unambiguous description of products and services. (Eclass 2023). It allows classifying assets into segments (e.g., laboratory material), main groups (e.g., laboratory utilities), groups (e.g., manual devices) and commodity classes (e.g., spatula spoons).

- **UN/CEFACT**
  UN/CEFACT (United Nations Centre for Trade Facilitation and Electronic Business) is a subbody of the UNECE (United Nations Economic Commission for Europe) focusing on electronic commerce to simplify international trade. Their work includes setting electronic business standards and trade facilitation recommendations.

  1. **The UN/CEFACT EDIFACT** (United Nations Electronic Data Interchange for Administration, Commerce and Transport) is one of the recommended standards for electronic data interchange. It includes a set of agreed standards, directories, and guidelines for the electronic exchange of structured data between independent computer-based information systems. The information system is used in most of the national customs administrations and major international logistic systems. (UNECE, 2023a 2023b)
  2. The **Reference Data Model** (RDM) is a model to manage the aggregated business information focused on the subset of a specific segment such as the supply chain

information management. The model aims for interoperability between different segments. (UN/CEFACT 2016)

3. Apart from the possibility to use UN/CEFACT semantic standards for the development of APIs, UN/CEFACT is also working on the technical specifications for a **UN/CEFACT standard API.** This API is developed to retain the richness of information available in the Reference Data Models (RDM) that are currently used. It includes the definition of a JSON Schema. (GitHub 2022; UNECE 2022a)

- **ITC (International Trade Center) Standards**
  The International Trade Center supports the implementation of sustainability standards by creating a connection between trade and sustainability. These standards are important to protect the environment and people interacting in production, manufacturing, trading, and consumption. To find information about standards for environmental protection, labour rights, due diligence, and traceability they have implemented a database on sustainability standards. More than 300 standards are integrated in the standards map 4.0. (ITC, 2023a 2023b)

- **ISO/IEC AWI 30173 - Digital twin — Concepts and terminology**
  A concept for a digital twin is currently being developed including a terminology. The terminology refers to the definitions of a digital twin, the concepts such as the ecosystem, life cycle processes and classifications, it also integrates the stakeholders. Communication is supposed to be improved between the stakeholders and parties working with the digital twin.(ISO 2023f)(DBA 2022; Digital Twin Hub 2021)

- **ISO/IEC 19762:2016 Information technology — Automatic identification and data capture (AIDC) techniques — Harmonised vocabulary**
  The standard provides general terms and definitions in the field of automatic identification and data capture techniques and essential terms for non-specialists (ISO 2016)

- **GS1 Web Vocabulary**
  The GS1 Web Vocabulary collects terms defined in various GS1 standards and data systems and made available for general use following Linked Data principles. It is designed as an extension to schema.org. Where relevant, mappings and relationships arising from that vocabulary are made explicit. The initial focus of the GS1 Web Vocabulary is consumer-facing properties for clothing, shoes, food beverage/tobacco and properties common to all products. (GS1 2023d)

- **GS1 Global Traceability Standard**
  The GS1 Global Traceability Standard is intended to be used for data that is exchanged across supply chains. It includes master data that provide descriptive attributes of real-world entities identified by GS1 identification keys. Furthermore, it consists of transaction data (e.g., ordering the product or final settlement) and visibility event data that provide details about steps along the supply chain. (GS1 2017)

- **EANCOM** (European Article Number (EAN) + Communication) is a sub-application under the UN/CEFACT EDIFACT standard. It creates a connection between GS1 standards for trade items (GTIN) and Global Location Numbers (GLNs) as logistic units providing information about trading partners. (GS1 2023c)

- **Schema.org**
  The Schema.org vocabulary can be used with many different encodings, including RDFa, Microdata and JSON-LD. These vocabularies cover entities, relationships between entities

and actions, and can easily be extended through a well-documented extension model. (Schema.org 2022)

4.2.2.4.4 Other products/materials

- **MSDS for chemical substances**
  A MSDS (material safety data sheet, also safety data sheet (SDS) or product safety data sheet) is a document listing different health and safety information on specific (mostly hazardous) substances in a standardised way to facilitate a structured exchange of this information. The chemical composition and different chemical characteristics are described. Different organisations define different requirements for the MSDS.
  (CCOHS, 2023; Chemical Check 2023; ChemSafetyPRO 2015; ECHA 2020)

- **ISO 11014:2009 - Safety data sheet for chemical products**
  The safety data sheet (SDS) for chemical products gives information on the safety, health and environmental protection aspects of these substances or mixtures. National Material Safety Data Sheet standards are based on this standard. Interoperability can be achieved for chemical aspects. (ISO 2009)

- **ISO/TR 13329:2012 Nanomaterials**
  As a supplement for ISO 11014, this standard provides guidance on the development of content for, and consistency in, the communication of information on safety, health and environmental matters in safety data sheets (SDS) for substances classified as manufactured nanomaterials and for chemical products containing manufactured nanomaterials. (ISO 2012)

4.2.2.4.5 Additional concepts for standardising vocabulary, ontology and taxonomy

The KEEP Electronics system, a traceability system designed for electronic and electrical products to trace items throughout their life cycle from production and to material recycling. is aiming for a joint information-sharing standard with pre-defined options for data entry (Liljestrand et al. 2023). IMDS (the material data system of the automobile industry) uses pre-defined Material Data Sheets for data sharing. For more flexibility, it additionally provides the possibility for suppliers to add customised data. Manufacturers can also add information requirements for industry-specific information they need. (IMDS 2023b)

4.2.2.4.6 Discussion and conclusions

A standardised vocabulary, ontology or taxonomy should be based on existing standards to ease interoperability. There is a wide range of existing standards available for different sectors and cross-sectorial. An alignment and harmonisation of datasets can be beneficial. However, it is not very likely. Standards have already been used in IT systems and it can be expensive to change this. A potential workaround could utilize data mapping tools to facilitate the mapping of data between different data standards. The precondition for this is that the standards are based on the same data set. They should be extendable, flexible, scalable, consistent, and machine-readable. Next to the vocabulary also exchange protocols need to be aligned to facilitate interoperability.

Knowledge graphs and the semantic web are a technology that could be used to model the databases. Though in theory, knowledge graphs can exist without a standardised data format, standardisation is inevitable to make these graphs interoperable and usable. Therefore, the decision whether to apply such a structure does not affect the requirement for standardisation.

Additionally, cross sectoral interoperability needs to be considered. Especially low tier suppliers whose products can be used in various industries would profit from aligned data requirements.

However, experts highlighted the challenge to achieve such an interoperability. To cater to the unique demands of various industries, it is essential for each industry to define their specific information requirements. Subsequently, additional data expert committees should develop standardized datasets. This collaborative effort should aim at meeting information requirements across multiple industries. This would remove the burden on suppliers who would otherwise need to provide data in different formats multiple times. Harmonized wording would also improve the user experience for consumers.

Takeaways for vocabulary, ontology and taxonomy

- A standardised vocabulary, ontology or taxonomy should be based on existing standards to ease interoperability.
- Instead of implementing a single data standard, data mapping can facilitate interoperability.
- Requirements for vocabulary, ontologies and taxonomies include extendibility, flexibility, scalability, consistency and machine-readability.
- The interoperability of data standards across the value chain as well as cross-sectoral interoperability needs to be considered.

4.2.3 Data storage

To make data accessible via a digital product information system, the storage and exchange of data must be considered. The requirements for the data storage and exchange include **security, reliability, and availability** of the data as well as **interoperability** with existing systems. Since products, especially from the textile and electronics sector, can be kept in use for a period of several years after manufacturing the information on these products might only become relevant for certain actors (e.g., sorters, recyclers) after this period. Therefore, the **long-term usability** of the data must be ensured. Additionally, some of the data users such as sorters may have the requirement to **access data in real time**, so the access of the data will not slow down their processes too much.

4.2.3.1 Standards, laws and guidelines

Avery Dennison Inc. representatives state that developer advocacy is crucial to enable and accelerate adoption across participants. They stress the importance of minimising technical entry barriers by offering tools for all stakeholders to ease the start and providing a clear adoption and implementation roadmap.

Encryption, and the security and reliability of the used technology and interfaces are other aspects of data storage and exchange that will need to be standardised (W3C, Datamars). Furthermore, the independence of the infrastructure concept chosen is essential to create a safe and well thought-out concept of the technological infrastructure (Hohenecker S., Interview 2022).

An additional aspect of standardisation is the timespan for which product data needs to be available via the system. Wautelet suggests standardising the minimum number of years to save the data per product group and whether and how the data should be archived afterwards. In this case, also the archive infrastructure including all interfaces needs to be standardised as well as access rights to the archived data.

4.2.3.2 Centralisation and decentralisation in information systems

Centralisation of IT systems is defined as the degree to which a certain element plays a dominant role in the operation of the system (Ein-Dor & Segev 1978). Two major elements that are relevant to IT systems are the data control and the data storage. Data control refers to the organisation that is responsible for the decisions around the information system, including planning the information system, providing organisational and computational infrastructure and data management as well as training (Heeks 1999). Data storage refers to the physical technical infrastructure, such as the server.

Control can be handled centrally by a single entity in the system, or it can be distributed decentrally among several parties. Data storage, in turn, can also be solved either centrally, on a single server in a single physical location, or distributed or decentralised. In the latter case, data is distributed to several servers, in decentralised locations.

Data storage and data control are not independent, however, there can be some variety. While centralised data control is often connoted with centralised data storage, there are numerous examples where storage is distributed in centralised systems; for example, to achieve better robustness and fast response times especially when it comes to big data applications (Thusoo et al. 2010). Decentrally controlled systems usually use decentralised storage, but could also rely on a central data store, e.g. on a cloud server, where several different organisations can store data they control in their preferred way.

In this report, the discussion of centralisation vs. decentralisation mainly refers to data control. The physical storage of the data is then defined by the controlling organisation.

4.2.3.3 Data control - centralised versus decentralised

Centralised data control means that decisions are taken by a central authority. Decentralised data control distributes the responsibility amongst several parties. (Heeks 1999)

Benefits of a centralised data control system include good data integration with accurate and consistent data and easy management of transactions. Centralised data control can help to avoid redundancies and create reproducible, consistent data for all stakeholders through a central administration and orchestration of the data. It can also facilitate data portability. Unauthorised access can be more easily prevented by a central access management system. Also, a centrally controlled system can apply stricter rules for atomicity, consistency, isolation and durability (known in information technology as “ACID”).

Constraints to a central system include technical barriers when migrating data to the system and interconnecting existing systems. Additionally, there may be cultural, political and perceptual constraints (Heeks 1999). Cultural barriers are due to the different modes of communication, mentalities and stylistic jargon. This complicates cooperation and can lead to insufficient trust towards a central system controlled by a third party. Political barriers can arise from the allocation of resources such as who is responsible for investing money, equipment, and staff. Moreover, placing information in a central system is associated with the loss of control. Perceptual constraints arise by the individual perception of the importance of an information for decision making. For some stakeholders it might be highly sensible information and the need for a clear management is important. However, for the public sector who might manage the data it can be perceived differently leading to discussion and barriers.

The continued conceptual and technical development of governmentally hosted systems is dependent on the allocation of public resources like money, equipment, and staff. This may lead to a limited ability to meet user needs and a general inflexibility of the system. (Heeks 1999)

Decentralised systems provide the benefits of more flexibly fitting user needs and faster system development. They can also allocate the costs of enhancements to those who request or need certain features without requiring public resources, so that in the public opinion they are perceived to have lower cost. (Heeks 1999)

A disadvantage of decentralised data storage with the control of every stakeholder is the additional effort for the stakeholders, often also resulting from duplicated efforts when e.g., features are developed in multiple organisations. Maintaining their own data responsibly and guaranteeing data requirements is an investment of extra cost and work. All manufacturers in the supply chain would need a digitised infrastructure. In the case of interlinked product information entries, interoperability and harmonisation are particularly important so that information is usable for all users. (Heeks 1999)

Heeks et al. conclude their analysis of centralised and decentralised data control by introducing the concept of a so-called “core-periphery approach” where the control is split between a central authority and the stakeholders. This involves a separation of the responsibilities and data management, where for example generic data lies with the central authority and additional data can be hosted in decentralised storage. (Heeks 1999)

Regarding long-term usability within a centralised system, care should be taken to ensure that long-term maintenance and control of the data can be guaranteed by the authority. In the case of a decentralised system, care would also have to be taken to ensure maintenance, management, and continued operation, especially when patching security gaps and when an organisation no longer exists.

4.2.3.4 Approaches for data storage

The following approaches for storing data on centralised versus decentralised systems have been presented and discussed in the workshop:

- **Self-hosting by data source**
  Data owners can host data in a decentralised manner on their own premises. An example for this would be the decentralised storage approach presented in the Gaia-X project (see chapter 4.2.4.7.4.1) (gaia-x 2023). The interfaces between the systems need to be standardised so information is accessible. (DFKI, Workshop 2022, Spherity, Workshop 2022)

- **Private service providers**
  Third-party platform providers could store the data in their information systems. Each data owner would choose a service provider to host their data. The interfaces between the systems need to be standardised.

- **Trusted data platforms - certified by EU**
  Third-party platform providers that are certified by the EU (based on defined minimum requirements) as suitable data platform providers store the data in their information systems and make them available through standardised interfaces.

- **Centralised platform**
  An alternative approach is to provide a central platform for the data. The host and controller of this platform would be the EU or the corresponding country[47]. Data would be copied to this central platform and can be distributed from there (e.g., SCIP/EPREL).

[47] The corresponding country would be the country responsible for its own centralized system if an EU wide system will not be implemented but the obligation for a nation-wide system is set.

- **Mix of approaches**
  A decentralised solution is necessary to enable a combination of a decentralised system and a centralised system. The mix of approaches could enable that organisations with limited IT capacity could use a centralised system while other ones create their own solutions or use third party platforms to provide the data.

- **Hybrid cloud**
  Cloud computing is, according to the US National Institute of Standards and Technology (NIST) definition (Mell & Grance 2011), a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. There are different approaches to deploying cloud storage:

  1. ***Private cloud****:* The cloud infrastructure is provisioned for exclusive use by a single organisation comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organisation, a third party, or some combination of them, and it may exist on or off premises.
  2. ***Community cloud****:* The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organisations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organisations in the community, a third party, or some combination of them, and it may exist on or off premises.
  3. ***Public cloud****:* The cloud infrastructure is provisioned for open use by the public. It may be owned, managed, and operated by a business, academic, or government organisation, or some combination of them. It exists on the premises of the cloud provider.
  4. ***Hybrid cloud***: The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardised or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds)." (Mell & Grance 2011) The DFKI uses a hybrid cloud to host their Digital Lifecycle Passport (Plociennik et al. 2022)

In a centralised database the data is mostly stored on a single physical server which can be accessed by users in the network (Iacob & Moise 2015). There is a single point of failure. It is crucial that a centralised database is protected by technical measures, such as regular backups. If the original database is lost due to hardware failure or hacking, this could potentially lead to a complete loss of the database without a backup if the security measures taken are not sufficient. (Iacob & Moise 2015)

In contrast to a central database, a distributed database describes an aggregation of data storage with the data spread out across multiple computers (nodes). It enables the usage and management of information from different sources within the same information set by linking it across different databases. (Datamars Inc. 2022) With very few exceptions, these systems are built as peer-to-peer networks. Peer-to-peer refers to a network where two or more equal parties (peers) can collaborate spontaneously without needing central coordination. In contrast to client/server networks, the benefits of peer-to-peer networks include improved scalability, greater fault tolerance and lower cost of ownership (Schoder & Fischbach 2003).

In the KEEP traceability system for electronic and electrical products, decentralised data storage and control is planned. It allows either the producer of the data or a traceability system provider to store the data (see chapter 4.3). For PCDS, distributed data storage on site of the stakeholders is planned. The circularity.ID system uses a centralised data storage for its product data but is preparing to become a service provider in a decentralised system. IMDS also utilises centralised data storage.

4.2.3.4.1 Distributed ledger technology and blockchain

Distributed ledger technology (DLT) is a concept in decentralised technology that refers to multi-party systems that function in an environment without a central authority, despite the presence of unreliable or malicious parties. This is usually realised by using an append-only chain of cryptographically-linked 'blocks' of data. This chain is referred to as "ledger". It is maintained and updated by a decentralised network, where participants are encouraged by economic incentives to maintain and secure the system. Blockchain technology, which is a type of DLT, is specified by its use of a chain of hash-linked blocks of data as its underlying structure. However, it's important to note that there is no universally accepted definition of DLT or blockchain. This chapter is designed to give a short introduction of the technology in order to facilitate understanding of the expert statements. A broader introduction to DLT and blockchain technology, including technical explanations can be found in (Rauchs et al. 2018).

To store data on a blockchain, it can be added in the form of a transaction, which is then sent to all the nodes of the network. An algorithm within every node evaluates and verifies the block. If the block is authenticated, it is accepted to the ledger and added to the blockchain. After this process the ledger cannot be changed anymore (Altaf et al. 2022).

4.2.3.4.2 Sustainability of blockchain technology

As one of the main goals of the introduction of a product information system for the circular economy is to reduce environmental impacts of products, careful consideration should be given to the environmental impact of the technologies used. There are several studies that examine the environmental impact of blockchain. Blockchain technology, especially bitcoin, is associated with excessive energy consumption resulting from the consensus algorithms that require mining by multiple participants. Mining in the context of blockchain is a process where participants compete to solve complex mathematical puzzles, a fundamental aspect of consensus algorithms. This mining process requires substantial computational power, resulting in heightened energy consumption, a critical point frequently emphasized in discussions about blockchain and sustainability. Mora et al. come to the conclusion that with the projected usage of blockchain, based on the rate of adoption of other broadly adopted technologies, it could alone produce enough emissions to push global warming above the 2°C mark. (Mora et al. 2018) It can be however assumed that with the technology evolving and more efficient algorithms, the environmental footprint will be reduced over time to some extent. (Esmaeilian et al. 2020) Especially the energy intense consensus algorithms are already being replaced by a new generation of algorithms that instead of mining require a pre-defined number of validators. Depending on the number of validators, these systems can have a significantly lower energy consumption (Platt et al.). However, also the mining of the minerals needed for the hardware to support a blockchain, including aluminium, copper and gold, has a high ecological impact. (Krause & Tolaymat 2018)

Other studies have addressed the impact on the sustainability of supply chains that blockchain has. These often come to the result that "blockchain data" (product or supply chain data stored on a blockchain) would improve the sustainability of the supply chain over not having the data (Park & Li 2021) or that blockchain provides the means to offer further incentives for sustainable behaviour. (Esmaeilian et al. 2020)

To assess whether or not blockchain technology is in fact beneficial for the product information system, an investigation is needed that goes beyond the scope of this project. Since different implementations of a blockchain come with different environmental impacts, first, an implementation needs to be selected. Then, a comparative life cycle assessment needs to be conducted comparing blockchain to the alternative solutions of a centralized database and decentralised databases. Finally, the environmental savings expected from the product information system must be estimated. These must be compared. Based on our initial broad research, it could be assumed that the blockchain performs inferior to already existing information systems.

4.2.3.5 Integration of existing systems

Currently, product data is owned by a variety of different stakeholders and is stored in numerous places, sometimes referred to as data "silos" because the systems are not interoperable. This neither corresponds to a centralised nor a decentralised system. In fact, it is rather a multitude of systems. To integrate the data repositories to a single system, the interfaces need to be harmonised. Additionally, a uniform access management system is needed so that a single point of access to the system is sufficient to obtain all relevant data.

This can be implemented in a way that leaves the data in the current information platforms. If this is the case, the evolving system can be classified as decentralised. Several platform providers remain in this system that can host data and make it accessible to the relevant stakeholders in a uniform way. Alternatively, all data could be copied to and managed by a single organisation. In this case, the system would be centralised.

Careful consideration should be given to the extent to which current processes for different parties need to be changed to store data in a central system instead of how data from the current systems can be made accessible in a decentralised system in the future. Many of the existing solutions currently offer to store data in a central database which is designed to become part of a decentralised system (Global Textile Scheme GmbH 2022) , while others rely on distributed data storage directly on premise of the data sources (TrusTrace, TrueTwins). The battery passport (Proposal for a Regulation **concerning batteries and waste batteries**, COM(2020) 798 final 2020/0353(COD)) is also designed to be decentralised with a distributed data storage. In theory, the approaches can be combined to a "hybrid" system where the data storage solutions can remain while the access and interfaces are standardised.

4.2.3.6 Expert opinions on decentralised versus centralised data storage

All experts interviewed advocate for decentralised storage. Fashion Cloud states that there are philosophies that handle ownership here like 'data mesh'[48]. Guth-Orlowski, Hohenecker, Wegener and Archer independently raise the question whether companies would be willing to store their data in a central database unless it is clear who has or can get access to the data. The concern of the commitment of actors was also raised in the workshop (Wuppertal Institut, 2022b). Some of the organisations may not want to reveal their product components or supply chain data (Heemskerk G., Interview 2022, Spherity, Workshop 2022). A central platform in particular is expected to be boycotted by the industry (Spherity, Workshop 2022;, Avery Dennison, Workshop 2022). Heemskerk points out that it may be hard to establish a single entity to host a central server and force all the different stakeholders to use it. The companies might

[48] Data mesh is a decentralised data architecture to perform cross-domain data analysis. It follows the domain ownership principle which transforms the data flow into serving data at the source. The data mesh architecture was designed for sharing data across different domains within a company, but the principles used could be transferred for a cross-sectorial product information system. Data Mesh (2023); OCI (2023)

feel safer storing the data on their own premises and administering access (Hohenecker S., Interview 2022, Archer P., Interview 2022) (Archer P., Interview 2022) and thereby keeping control over their data formed (Guth-Orlowski S., Interview 2022). Archer raises the concern that a central approach could lead to the companies reluctance to fill in data without further incentive than being legally obliged. Guth-Orlowski mentions that self-directed management of data on the other hand could also help product owners be more aware of their responsibility for the data and the product.

This is also closely related to the concern of data availability and trustworthiness of the database. This can only be achieved if the database providers stay up to date with technological progress. Wautelet sees a high risk in using one central database because the whole responsibility for the data is on one organisation. In the event of an error, the entire system would be shut down and this one entity alone is positioned to solve the problem for everyone involved. If each stakeholder is responsible for storing and maintaining their own data in a decentralised product information system, the risk of disclosure can be minimised as attackers would need to gain access to many different systems as opposed to one central system (Wautelet T., Interview 2022).

For these reasons, a decentralised solution is favoured (Archer P, Interview 2022; Guth-Orlowski S, Interview 2022; Heemskerk, Interview 2022; Hohenecker S., Interview 2022). In fact, Archer and Guth-Orlowski consider a decentralised system as the only concept to cover the requirements of the complex value chains. Grillon adds that decentralised systems have advantages in terms of mechanisms that allow the system to be secured in such a way that stakeholders throughout the circular economy can make contributions to complement the data profile of the product (Grillon N., Interview 2022).

While Heemskerk explicitly suggests a blockchain solution, Grillon assumes that there are several possible approaches to building a decentralised data system.

In different industries, centralised data storage systems already exist. Guth-Orlowski assesses that they are not accepted by the industry. Wegener mentions that the EU had initially also planned a centralised system, but the industry demanded a decentralised system.

The easy accessibility of centrally stored data is beneficial (Archer P, Interview 2022). However, Archer also sees the possibility here of achieving accessibility through a standardised URI-based identification system similar to the GS1 Digital Link.

Instead of developing a system that is usable for all the different products on the market, Grillon brings in the idea to allow for different storage possibilities depending on the product category. Fashion Cloud in general questions the necessity to design the overall system architecture if the data is interchangeable.

In the case of a centralised database, one organisation has control over all the data. This makes it easier for all stakeholders because the data is maintained for them. Errors can be found more easily. However, the entire responsibility is with a single organisation. If an error occurs, it may affect all the data in the system.

4.2.3.6.1 Complementing central server

The decentralised system architecture could be complemented by a central registry to ensure an overview of which products are currently on the market and to provide tools for customs and market surveillance. This central registry could be a collection of identification links to each product model on the market. The detailed product information could then still be loaded from the respective decentralised data storages (Wegener D., Interview 2022). Wautelet suggests that this may also be a good option for SMEs to store their product data if they do not have the capabilities to host data themselves.

Another possibility is to create a central backup storage for product data of companies that no longer can or want to host the data themselves (Wautelet T., Interview 2022, Wegener D., Interview 2022). This could also be used for archiving data if required (Wautelet T., Interview 2022).

4.2.3.6.2 Real time data processing

Wegener states that the product information system as described cannot be utilised with either a centralised or decentralised structure to process data in real time or even live. To ensure this reliably, the data would have to be located on the computer where it is processed. He suggests that in time-sensitive systems, certain data should be downloaded before processing so that it can be available in real time.

4.2.3.7 Discussion and conclusions

The project team advises for a system with decentralised data control where each stakeholder can decide whether they would like to store information on their own premises or with a third-party platform provider. This is align with the opinion of the interviewed experts. The data storage is decentralised because the different storage providers store data in different physical places. This can involve several local 'central' storages for single platforms as well as distributed systems where each dataset is stored in a different location. To provide interoperability for these different players in the same system, the identification, interfaces and access management need to be standardised.

For SMEs it may be particularly relevant to use a third-party database where access management, data safety and similar aspects are covered in the service and do not need to be taken additional care of.

Adapting existing systems for data storage, including data platforms as well as PLM systems to these standards is an effort that needs to be considered; forcing a centralised storage instead however can be expected to result in transformation processes that involve a much higher effort. Additionally, a centralised system could result in lower acceptance of the system by the industry, slower development and a higher risk due to the single point of failure.

No concrete implementation is advised. Different players may implement the system differently as long as they meet the interoperability and security requirements. Environmental impacts should be included in the considerations when comparing different technological solutions.

A central registry can be established which complements the system with a single place to look up certain information. This enables access to product data without the data carrier of individual products at hand. It can be used to store solely the product identifiers and product categories, linking to the original source of the full product information set or to store a minimal dataset. It can, amongst others, be used by customs or by third-party service providers that want to enable comparability between different products of a product group. An additional possible use case of the central registry would be to provide a long-term archive solution in case storage providers or data owners cease to exist.

Some stakeholders such as textile sorters have stated the requirement to process data in real time. A solution for this is yet to be developed as neither a centralised nor a decentralised system can enable real-time data collection with a growing amount of data and possibly unstable internet connections. A possible approach is to download certain subsets of data, e.g. by batch-scanning identifiers on entering a sorting facility and downloading the respective datasets to a temporary cache.

Takeaways for Data Storage

- The question of centralisation comes with the aspects of data control and data storage, where data control refers to the organisational aspects and data storage means the physical storage of data. The discussion in this chapter focuses on data control that also includes decisions about data storage.
- Aligned with the consistent opinion of the interviewed experts, the project team advises decentralised data control.
- No concrete implementation is recommended. DLT and Blockchain are one of many possible implementation for decentralised data storage.
- A central registry can complement the system to provide access to product data without the data carrier of the individual products at hand.

4.2.4 Data exchange

The data stored in the product information system needs to be exchanged between different parties. Besides exchangeable data formats, this requires technical infrastructure, providing human and machine interfaces for data input and output.

Data exchange can occur between the product information system and a user (through a human interface) or the system and another computer program (through a machine interface).

4.2.4.1 Human interface

For human parties in the product information system, user-friendly interfaces need to be provided, both for input and output. Standards and guidelines for human interfaces for increased productivity, decreased stress, reduced training expense and overall product quality and aesthetics have been developed. (P. Reed et al. 1999). These standards and guidelines are mainly based on providing consistency and familiarity for the user.

For existing product information systems on the market, input can be handled in familiar formats (e.g., excel upload in the circularity.ID system (circular.fashion 2023) or through familiar systems (e.g., integration with PLM, PIM and ERP systems in the Trustrace platform (https://trustrace.com/benefits-brands)). The IMDS in the automobile industry for example has the declared aim of being accessible to everyone with minimal computer capability and therefore allows data input through any browser. This provides a familiar environment and simplifies the application for the users.

For human-facing output, often websites (e.g., circularity.ID product site (circular.fashion 2023) or internet platforms (e.g., GTS Cat (GTS 2023c))are used.

The KEEP Electronics system on the other hand is planned to use a “routing layer” system for data exchange where information can be exchanged between all stakeholders in a format that is similar to emails. (Liljestrand et al. 2023)

Consumer incentives may be helpful to teach consumers about how to interact with their products and take responsibility in the circular economy (Avery Dennison, Workshop 2022)

4.2.4.2 Machine interface

Exchanges between different product information systems require both document-equivalent and business-process-driven exchange. (UNECE 2021). These can be covered, for example through traditional electronic data interchange (EDI), process-driven data exchange structures, electronic product code information systems (EPCIS - ISO/IEC 19987), or application programming interfaces (APIs). Traditional electronic data interchange is based on the exchange of strictly formatted messages between two parties.

A more modern approach is the use of APIs. An API is a set of functions and procedures that an operating system, application or service provides. The functions and procedures enable access to the system's data and features. For application programming interfaces, different protocols have been used in the past and today (e.g., RPC, SOAP or CORBA).(Gilling 2019) Nowadays, RESTful APIs have become the de facto standard. The advantage over former API solutions is that no libraries or initialisation are needed to communicate with a REST API. Instead, common software like web browsers can be used. REST APIs use the HTTP Verbs GET, POST, PUT and DELETE and leverage HTTP conventions and web resources.

Information is usually sent between systems in standardised information formats such as the Extensible Markup Language (XML) or JavaScript Object Notation (JSON).

- XML is a markup language and file format for storing and transmitting data that is both human and machine readable. It is interoperable with HTML. (W3 schools 2023b)
- JSON is a data format used for storing and transmitting data that is often described as "light-weight" and easy to understand. (W3 schools 2023a)

Since 2012, large companies such as Facebook, Git, or Pinterest, but also teams of all sizes are switching their APIs to use the query language GraphQL. GraphQL, like REST, is typically served over HTTP and simplifies requesting data. (GraphQL 2023)

4.2.4.3 Resolvers

On the internet, web pages, information sources and other digital objects such as images have specific, unique addresses which they can be retrieved from. Since these addresses usually include IP addresses that would be hard to memorise, resolvers have been built to make them more accessible. When typing a web address to a browser, a resolver is contacted. Here, the corresponding IP address to the web address is stored and the request is forwarded there. Similar architectures can also be built on a higher level to make web resources available from a single point of contact.

The GS1 Digital Link (DL) concept is designed around a resolver that stores a number of different web resources and forwards the user to the requested information. This is achieved through so-called link types that are added as a parameter to the URL either manually or by using an application. For example, scanning a QR code on a T-Shirt with an app to check for certifications will add the linkType gs1:certificationInfo to the URL and get this specific information. Scanning it as usual would not add a linkType and the user would be forwarded to a conventional product page. For this concept, the data received by the user is not yet standardised.

A central resolver, set up in a similar way to the GS1 Digital Link, where each identifier is registered with a short URL could help to keep URLs on the products short. If QR and NFC scanners on phones would additionally be extended so they would automatically resolve certain identifiers via this resolver, this could make identifiers resolvable over the web without the need to store a URL on each data carrier. This would require each smartphone and scanning app producer to consider the resolver. Furthermore, having a central resolver comes with risks (e.g., data breach, server availability).

4.2.4.4 Digital signatures and public key infrastructure

A digital signature represents a cryptographic analogue of handwritten signatures. It is for example used for certifying contracts or authorisation. The process involves a signer and a set of potential verifiers. The signer will start by generating a pair of keys, consisting of a private key and a public key, using a specific algorithm. The public key is publicised so that any verifier can obtain it. The underlying system needs to be designed in a way that makes it impossible for any third party to publicise a key in the name of another party. Once the public key is established, the signer can start to "sign" a message using a so-called signing algorithm with their private key. This results in a "signature" that can be verified using the corresponding verification algorithm and signer's public key. This procedure also takes into account a hashed value of the message to ensure that it reaches the verifier unaltered (Katz 2010). The underlying system that provides the algorithms and storage for the private and public keys as well as verification is referred to as Public Key Infrastructure (PKI). Another task that the PKI must provide is the possibility of revoking keys that have been unintentionally disclosed.

Several Organisations and governments have built PKIs for digital signatures. In the EU area, the eIDAS Regulation applies, which includes requirements for advanced electronic signatures and qualified certificates for electronic signatures (European Commission 2014). Digital signatures and PKIs are e.g., used in XML signatures (W3C 2003) or JSON Web Signatures (M. Jones et al. 2015)

4.2.4.5 Decentralised identifiers and verifiable credentials

W3C defines a digital ecosystem around verifiable credentials (VCs) and digital identifiers (DIDs) based on public key infrastructures (Brunner et al. 2020; W3C 2022). VCs are defined as digital, verifiable attestations which can be used to capture data. The VC can cryptographically prove who issued it. To do so, it includes an identifier related to the issuing authority and is digitally signed by this issuer. Verifiable Credentials can be interlinked, so that for example a credential that describes a product could link to all the credentials that describe the materials used in the product. The data stays with the data owners and can be accessed through the link.

The identifier for the issuing party is usually a decentralised identifier (DID). DIDs are unique, digital identifiers for humans, companies, machines, processes, or products. They can be created and managed in a decentral way by the data owner themselves. The format of a DID enables global uniqueness as well as scalability to a large scale. DIDs come with a key for the electronic signature validation. Technically, DIDs are often stored on DLTs. The DID leads to a URL and can therefore be easily encoded as a QR code.

DIDs and VCs are handled through so-called wallets. These are standardised open source or commercially available pieces of software to create and manage DIDs as well as create, sign and manage VCs.

Usually, VCs and DIDs are based on blockchain technology. (Guth-Orlowski 2021, 2022b; W3C 2022)

4.2.4.6 Standards, laws and guidelines

To provide for interoperability, exchange protocols need to be standardised. This may include the definition of data types, data structure (DIN, Workshop 2022) and exchange formats such as XML or JSON (Avery Dennison / European Commission, Workshop 2022). Alternatively, it may be possible to develop guidelines on how multiple different data formats or types can be exchanged (Wuppertal Institut, Workshop 2022).

For security, W3C suggests using the cryptographic protocol Transport Layer Security (TLS) for data exchange. Guidelines for configuring the TLS procedure have been published by the Federal Office for Information Security. (BSI 2019)

4.2.4.7 Expert opinions on data exchange

In the workshop, different solutions were proposed to create standardised interfaces both for human and machine interaction. To store data in the system, they can either be put in by a human via a form, e.g., an online form, or by using APIs to create automated connections between the usual, existing storage systems and the product information system described. For obtaining data, it can either be shown directly to a human viewer from the system or be presented by third party services, in which case it needs to be machine-readable.

The provision of human interfaces or media up-/downloads is required because many organisations especially in the textile industry are not yet technologically adapted to storing their data in systems ready for machine-to-machine communication. A lot of data is still stored in spreadsheets for example. The OS Hub made the experience that even providing Comma Separated Value (CSV) uploads is too restricted for some companies, so the additional option of uploading excel data was added. (Shaw K., Interview 2022)

There are several different state of the art data exchange mechanisms that need to be supported in order to achieve interoperability with existing systems: REST APIs, GraphQL, Software Development Kits (SDKs) and File Exchange (Avery Dennison, Workshop 2022). There is a need for open source SDKs or libraries to enable the data transfer (Avery Dennison, Workshop 2022). The efficiency of data exchange needs to be raised. The requirement of real-time data should be weighed against the high data traffic and the resulting limited data availability. In certain environments, the access speed is also of high relevance in order not to slow down processes. (Datamars, Workshop 2022) (Fashion Cloud GmbH 2022)

4.2.4.7.1 Human interaction

To view information from the product information system as a customer, Heemskerk sees two options: either the information could be provided in form of a website by the data owner, or there could be applications that pull the data from the product information system and present it in a clear, human-readable form.

One limitation that Shaw and Grillon emphasise is that some of the involved users have very little exposure and access to technology. This is especially true for people who work in organisations that are original data sources such as some resource suppliers. Some of the supply chain actors do not have the knowledge or resources to prepare their own product information systems for the data exchange needed (European Commission, Workshop 2022), the digital readiness of the textile sector is in general a concern (Avery Dennison, Workshop 2022; Fashion Coud, Workshop 2022; Wuppertal Institut, Workshop 2022). For this reason, Grillon and Shaw also assume that manual interfaces will always be needed. The adoption of new technologies takes time (Spherity, Workshop 2022). If some organisations cannot build an electronic way of exchanging data, the product information system should allow for a manual data upload (European Commission, Workshop 2022) and/or an excel upload (GTS, Workshop 2022).

Particular attention should be paid to ensuring that the technology used is comprehensible and usable for all stakeholders. This includes, amongst other challenges such as technical literacy, also the languages of access. Next to European Languages, also the languages spoken by the contributors should be considered[49]. Grillon stresses that it is essential to test user experience with actors from the global south.

4.2.4.7.2 Machine interaction

Currently, mostly JSON and XML are used as data exchange formats.

If an API is to be used as an interface for a central system, an enormous number of requests must be expected in a short time. The system must then be prepared to reliably process these requests. (Heemskerk G., Interview 2022) The provision of open source code could support companies in the process of adapting their systems to the API.

Guth-Orlowski is convinced that the use of wallets could make it possible to retrieve any data via a corresponding resolver and display it in the wallet via a suitable user interface. The wallet thereby manages the identity, the certificates, the product information and any additional exchange information. It also controls data access and authorisation.

4.2.4.7.3 Including information from existing data servers

When using data from existing sources, it may be a possibility to simply link the original data in order not to create redundancy (Wegener D., Interview 2022). The alternative would be to copy over the data from where they are stored originally. The viewer of the data does not need to be aware of how the data is handled to receive the information they need. With the asset administration shell for example, the link stored in the data carrier can be resolved by the information system to find the server that stores the information needed. The data is then directly loaded from this server, without the need to copy it to other places. Wegener states that with the historically grown ecosystem of data storage that Siemens uses, this is the preferable solution.

Regardless whether the data is loaded from the original source or copied over to a new system, using data from existing storages may require definitions on how to map the data that is already available to the newly defined data standard. Furthermore, definitions are needed on how to deal with data that are partly available and how to deal with data that are difficult to access (Wautelet T., Interview 2022). Wautelet considers involving the data custodians of currently available platforms into the definition of requirements, but it should not shape the general architecture of the product information system. According to him, further attention should be paid not to restrict the systems that can be used as data sources too much in order to enable an open market without monopoly position. As an example from another context, he describes that the GTIN could be considered for a standardised identifier, however, since it's created as a paid service by a private organisation, it would be better to use the ISO norm that the GTIN is based on as the standard instead. This would allow for GTIN as well as competitive identification services to use the same format. (Wautelet T., Interview 2022)

Translating data could be offered as a service by so-called "translators" that make the link between different data platforms (Heemskerk G., Interview 2022). They could take care of the authorisation and make sure that the data is delivered. Such services already exist now, because data often needs to be translated to serve different stakeholder requirements.

4.2.4.7.4 Decentralised identifiers and verifiable credentials

Guth-Orlowski believes feasibility by SMEs can be achieved through the use of DIDs and VCs. Companies only need a wallet to contribute to such a system, which is a technology that is already being developed within the framework of GAIA-X (ecsec GmbH 2022; gaia-x 2023). For

[49] More than 32% of the world's clothing exports is supplied from Asia, more than 60% are manufactured in developing countries.ILO (1996) In the electronic sector, more than 68% of global production exports of parts originate in the 11 states of eastern and south-eastern Asia. S&P Global (2021)

large businesses, open source solutions can be provided, while for small businesses without their own IT department, service providers can also offer hosted wallets to store VCs and DIDs. For the small businesses, this service would probably appear in the form of a website where they can authenticate and enter data without a deeper understanding of the technical complexity behind. This approach is aligned with Archer's and Wegener's opinion that large enterprises will host data themselves, while small companies may pay service providers for data hosting. According to Heemskerk, using DIDs and VCs allows for a better scalability of the system.

4.2.4.7.4.1 Example solutions

When asked for well-working solutions for data storage and exchange, experts put together the following a list in the workshop:

- **EDIFACT**
  As described in the subsection of Vocabulary, Ontology, Taxonomy and Standards the UN/EDIFACT is one of the Standards published by the UN/CEFACT. The standard regulates the Electronic Data Interchange (EDI) for administration, commerce and transport. It sets syntax rules to structure user- and service data in the interchange of messages in an open trade market. The syntax defines uniform segments and elements, giving information about the content of the electronic file, e.g., an invoice, purchase orders, delivery notes etc. In the beginning, EDIFACT was comprehensively used in every sector and every business transaction. This caused confusion about the interpretation of messages. To understand from the first moment which message has been received, as the categorization of the subject, subsets were developed. ENACOM for example is a subset for the retail sector containing only mandatory fields of the EDIFACT standard. The ISO 9735 standard has set a syntax for EDIFACT.

- In the business directory, data elements are defined as tradable elements such as date, time or street. A segment is a functional grouping of data elements with mandatory and optional elements applying the syntax rules. A message to be sent between business partners is a grouping of segments giving information about business processes.(SEEBURGER 2023; UNECE 2023b)

- **eBiz (UNECE)**
  The eBIZ initiative was founded in January 2008 by the European Comissions within the eBIZ-TCF project. A common digital language was invented for e-business processes in the Textile/Clothing and Footwear (TCF) industry. The first phase included a two-year cooperation developing the standardised language. In 2012 (phase 2) the CEN Workshop eBIZ was launched with the aim to consolidate, update and diffuse the adoption of eBIZ and its Reference Architecture. After the CEN WS eBIZ the eBIZ 4.0 was launched to spread the system widely among the European industries and to integrate RFID technology in phase 3. From that point on eBIZ 4.0 has been further developed until today's version 2018-1. It is now promoted by EURATEX, CEC and ENEA. A specific Reference Architecture has been built with:

  1. organisational and procedural aspects of business scenarios
  2. semantic and data models to exchange information
  3. product and party classification and identification
  4. middleware and communication protocols.

  It also integrates a list of codes to define certain characteristics of the material.(eBIZ 2023; MODA 2023)

- **XML/EDIFACT (UNECE)**
  The XML/EDIFACT, as well as the GS1 ENACOM, is a sub-application of the UN EDIFACT standard. It is mainly used in business-to-business transactions within XML-systems. XML is the most widely used file format so a combination of the two formats was indispensable. The rules for XML/EDIFACT are set in the ISO TS 20625. (ISO 2002; UNECE 2020; Wikipedia 2022)

- **GTS-Cat (GTS)**
  As described in chapter 4.1.2.2, data can be uploaded on the GTS-CAT platform in a standardised way (using GTS vocabulary) with a set syntax (GTS 2023a). The aim is to establish automated data exchange using a standardised language along the entire textile supply chain.
  Global Textile Scheme (GTS) is a standardising initiative establishing easy communication through a common language. The goal is to develop transparent data, exchanged between all parties along the supply chain. The data can be uploaded to the GTS-CAT platform as uniform master data in form of a catalogue with specifically set characteristics. There, the data can be exchanged with all stakeholders in the same consistent GTS language, which is machine-readable and multilingual. In total there are 29 members and partners working together in the standard consisting of associations, brands, retailers and suppliers, IT partners etc.

- **EPCIS repositories**
  The Electronic Product Code Information Service (EPCIS) is a GS1 standard for supply chain management. The service provides data exchange between organisations. The data contains information about objects along the supply chain. It communicates the information with standardised object events describing e.g., what item is the subject or when the event occurs. It uses an append-only database, documenting the status along the supply chain. Every stakeholder documents the current status, without modifying previous entries. For example, if a supplier sends (as an event) five pallets to a manufacturer and only one pallet arrives, the manufacturer will document the discrepancy as an event, no changes will be made at the supplier. The events are encoded as JSON-LD, a JSON-Schema is available. (EVRYTHNG Developer Hub 2023a 2023b)

- **International Data Spaces Association IDAS**
  The International Data Spaces (IDS) initiative was established in 2015 through a project of the Fraunhofer-Gesellschaft funded by the German Federal Ministry of Research and Education (BMBF) with the goal of promoting interoperability and data sovereignty in the sharing of data. The initiative aims to protect the trust of both data providers and data users by using a distributed software architecture. (Otto & Burmann 2021)
  This architecture, known as the IDS Reference Architecture Model (IDS-RAM), allows for the sharing and exchange of data between participants in a data space. The IDAS, a non-profit association bringing together data providers and data users, was founded in early 2016 to oversee the initiative. The IDS-RAM access management model differentiates between core participants, such as data owners and providers, and data recipients and users. Data is only exchanged between data providers and data recipients. There is no central data storage or central office with access to the exchanged data. (Otto & Burmann 2021)
  (International Data Spaces; International Data Spaces, 2022; International Data Spaces 2023)

- **GAIA-X**
  GAIA-X is a European initiative developing a digital governance for existing cloud systems and edge technology. The goal is to build a secure data infrastructure for data sharing in which users control data access and usage. Cloud services from different providers are

interlinked to obtain portable and interoperable data and services. Common European requirements and rules for a trustworthy and transparent data infrastructure are developed for European sovereignty. The requirements and rules enable the creation of Data Spaces which comply on a technological basis and enable safe data exchange for multiple stakeholders in product information systems. A common architecture is built by the association's members to achieve the objectives. A qualification authority for Gaia-X compliance is developed. It is not planned to create its own cloud platform, software or hardware. (gaia-x 2023)

- **circularity.ID platform**
  In the circularity.ID system, input can be handled by providing an excel sheet or directly between machines through an API (circular.fashion 2023). The output for consumers comes in the form of a product page which is a website reachable by scanning the product data carrier. The system also provides an API to get data for the augmented sorting stations in a machine-readable format.

- **PCDS**
  Wautelet explains the creation process of the PCDS as an example for a well-working solution for adding data to the system. There are two possible scenarios for a manufacturer to create a PCDS. Either the manufacturer can become part of the PCDS ecosystem by creating their own local node with a specific IP address. The PCDS is stored on this node, so it can be obtained from the internet via this IP address. The other option for them is to add the PCDS through a portal accessed through the global node and upload their information there. The data can then be retrieved via the IP address of the global node. In both cases, the source of the data and the owner of the data remain the same and they are responsible to keep their data correct and updated.

4.2.4.8 Discussion and conclusions

For data exchange, human interfaces and machine interfaces need to be considered. Both need to be standardised to improve accessibility and understanding for consumers as well as technical interoperability between different stakeholders. For human interfaces, the usability for all stakeholders is a requirement, involving different usage languages, comprehensible interfaces and in general a shallow learning curve.

Currently, there is no solution for interoperability between systems that use different data standards. There are three main approaches to achieve this interoperability:

1. Data can be stored in a central system. Following the argumentation in chapter 4.2.3, this is not recommended.
2. A single data standard can be mandated for each data source and storage platform. This would enable interoperable direct data exchange between all standardised sources without changes to the data before exchanging them. However, it would require the existing data storage systems to adapt to the new standard which comes with effort and time intensive transformation processes. Once the initial adaptation is finished, the systems need to go through changes every time the standard is updated to a new version and there are at least short interim phases to be expected where certain systems still use the former standard version while some have already adapted to the next. This requires a solution.
3. The third option is to map the data between different standards and/or standard versions. This allows many systems to remain unchanged as long as the required data is stored in the database. The storage providers can either build adaptors themselves or use third-party services to translate data between their language and

the common standard. Whenever a stakeholder accesses data, the data in the system goes through the translation service and can then be presented in the common, standardised format and language. This approach also requires a solution for the adaptation phase after a new standard version has been launched as the adaptors need to be adjusted.

Approaches 2 and 3 can also be combined; while some (especially newly created) systems can choose the option to implement the standard directly, others could use adaptors.

Resolvers can be a tool to navigate in the information system easily by being able to store a certain identifier or URL on the product and then resolving this URL to the original data source. With the historically grown data infrastructure that is already available, this approach is recommended. In case data storage systems cease to exist at a certain point, this architecture also allows changing the data source without changing the URL on the data carrier by simply redirecting the request to the new source. Resolvers however do not facilitate interoperability of language or format. Standardisation is needed in addition to the resolvers.

Public key infrastructure and digital signatures can be used as part of the technical infrastructure for data exchange to authorise the affected parties and ensure integrity of the data. Providing a PKI also enables the use of DIDs and VCs as one possible implementation for data storage and exchange.

Takeaways for Data Exchange

- For data exchange, human interfaces and machine interfaces need to be considered.
- Human interfaces need to be implemented for adding, updating and viewing data. The requirements and needs of all stakeholders, especially SMEs and stakeholders from the global south need to be considered. This involves considering a multi-language approach and comprehensible technology.
- Machine interfaces need to be provided to reach interoperability with existing solutions such as the companies' information systems.
- Currently, no working solution exists that provides interoperability between systems that use different data standards. Approaches for enabling interoperable data exchange are to store data in a central system, mandate a single data standard or to build a system that maps data between different standards.
- Resolvers provide a uniform way to access information in their original presentation. Additional standardisation could be added to the datasets to make them interoperable.
- For some data points, integrity of the data is of higher relevance (see also chapter 4.2.5). In these cases, digital signatures and public key infrastructure can be considered; an often-mentioned variation of this concept is Digital Identifiers and Verifiable Credentials.

4.2.5 Ownership and data verification

One challenge in implementing a product information system is to ensure the quality of the stored information. For this purpose, it must be clarified who owns the data and who is responsible for its quality.

4.2.5.1 Ownership standards, laws and guidelines

The term "data ownership" is still controversial. The European Union has not defined data ownership and is unlikely to do so in the near future. It instead focuses on access rights and data portability rights, e.g., in its proposal for the Data Act (Geiregat 2022). It is likely that the Ecodesign for Sustainable Products Regulation (ESPR) from the EU Commission will define where and which stakeholders are responsible for the data quality.

In this document, the term refers to the entity that is responsible for the quality of the data and for managing access. The legal situation and the need for definitions will be investigated in more detail in Part D of this project.

Some of the experts express an additional need for rules in terms of data ownership and liability. Apart from the overarching question, who is the owner and therefore responsible for the product information, standards should be defined for the data quality (DIN) and accuracy, especially how to prevent intentional false inputs (Datamars, Workshop 2022)

4.2.5.2 Approaches to ownership

There are **two overarching approaches** to the question of "ownership" in this context that can be associated with the paradigms of *creator-as-owner* (sometimes also referred to as data holder) (Geiregat 2022) and *user-as-owner*. These paradigms can help to understand the rationale behind the different approaches. Both paradigms involve two parties: The one that creates the data (e.g., because they create the product or add data through further processing steps) and the one that uses the data. The *creator-as-owner* paradigm builds on John Locke's labour theory and allocates ownership to the creator, according to the amount of value created through labour (Hart 2002). The using party can theoretically acquire the data through funding or payment and thus becomes the owner. The *user-as-owner* paradigm on the other hand reflects the view of Immanuel Kant's first ownership theory, which attributes ownership to the first person to possess a property or object (Hart 2002). There are also other paradigms (e.g., *everyone-as-owner* or *subject-as-owner*) that are not applicable to the case of product information systems. (Fadler & Legner 2022)

The approach of considering the party that originally generates the data as the owner (creator-as-owner) is used to some extent in currently existing systems (e.g., PCDS). Raw material producers are often excluded here, so the producers of the materials are considered to be the origin of the data. For example, the manufacturers of a material would be the responsible owners of the data for their value adding step (Spherity 2022a). If this material becomes part of another product, the material data does not need to be copied to the product data; instead, a link can be created from the product data to the material data (Wautelet T., Interview 2022, Guth-Orlowski S., Interview 2022). This way it is always clear where the data originates and who the owner is. Companies could be responsible for false information, such as not mentioning toxic substances (Guth-Orlowski S., Interview 2022). Moreover, responsibility includes ensuring the data to be accurate and maintaining the data also in case of updates. Technically, the responsibility can e.g., be traced with an authentication such as a signature or identity.

A difficulty of this approach is that the textile industry as well as the EEE industry have complicated global value chains (Guth-Orlowski S., Interview 2022). Producing or recycling the products outside of Europe could create difficulties in making suppliers responsible for incorrect data. Certifications could be used to enhance trustworthiness. A company that has been certified by a trustworthy government or organisation is more likely to be trusted than one without such a certificate. Though the effort of certification may be challenging for SMEs and small production lines, Guth-Orlowski considers it a feasible way to improve the reliability of data.

Several studies come to the conclusion that retaining data ownership with its origin (i.e., where the data is created) helps to ensure the success of the system (Wang et al. 1995). Guth-Orlowski also points out that the approach of considering the source of the data, its owner, may be well interoperable with existing systems. For example, for taxation every time value is added, information is added and tax can be claimed from the information owner. For CO_2-footprint-calculations, every time value is added, information is added to the system and the data owner is responsible for the CO_2-footprint that this data implies.

Following this concept consistently, consumers and service providers would be assigned ownership and responsibility for the data they may add during the life cycle of the product, such as the number of washing cycles or repair history. However, the practical implementation of this approach remains complex (Dinter 2013).

Alternatively, the distributor of the product can also be seen as the owner of the data (user-as-owner). Here, responsibility is passed on from one supplier to the next along the value chain until retail, where the original equipment manufacturer (OEM) is the final owner (Heemskerk G., Interview 2022; Wegener D., Interview 2022). This approach is currently more common amongst existing systems (e.g., circularity.ID, KEEP, IMDS). The OEM is responsible to deliver a product under the applicable market rules. This rule could be adapted to also include the responsibility of data ownership, so the OEM could be held responsible for their data and be obliged to check the data that comes from their suppliers (more on the topic of liability in Part D). The OEM has the means to engage its suppliers to provide accurate data through business-to-business relationships. After the retail, an option is that the consumer, repair service providers and then sorters could be considered the owners of the product data when they become the owners of the product (Wegener D., Interview 2022).

The approaches may depend on which scope the identifier should refer to in terms of the product, because often the "finished product" is mentioned as the product to which an information entry should be affixed (+ImpaKT, Workshop 2022; Wautelet T., Interview 2022). However, it is not yet defined what a finished product is. For example, if the fabric for a garment is sold on the European market, would it be considered as a product by itself? It may be necessary in this context to define when ownership needs to change, e.g., within the supply chain or when a device or product is refurbished and then resold. Some experts emphasise that no single entity should own the complete product data set; instead, it should be a modular system where different parts are owned by different stakeholders (DFKI, Workshop 2022, Wuppertal Institut, Workshop 2022). Another expected pitfall that +ImpaKT brings up in the workshop is that the designed system may not be flexible enough to adapt to changing property. Therefore, it might be difficult to define a limited ownership system that implements user-as-owner.

Independent of the approach, anyone who contributes data to the system either needs to be the source of the data, the owner of the data or have permission to share it (Grillon N., Interview 2022). This however excludes name and address data of manufacturing companies because they are in the public domain. In any case, applicable data protection laws must be complied with (e.g., for entering company data that includes personal data) (Avery Dennison, Workshop 2022). For each data owner, the information and level of detail to be provided should be defined and mandated.

The owners of the data can contractually delegate some of their accountabilities to third parties, such as data platform providers, which then take the role of a data platform owner and are responsible for ensuring that the data is accessible and available. (Fadler & Legner 2022)

Legal aspects of "data ownership" will be revisited in Part D (see chapter 5.2.4.

4.2.5.3 Validation, verification and certification

Though the terms validation and verification are at times used interchangeably, the definitions in terms of objective database assessment differentiate between validation as an automated process and verification as a manual process involving the inspection and analysis of data.

Data validation can be encoded into the product information system and becomes an automated routine to ensure that the data is reasonable and meets the requirements of the intended use. It is however not able to measure the accuracy of data. While it can check whether the data is available, has the correct format and falls into a certain range (e.g., percentages should be between 0 and 100), it is impossible to check whether the data represents the product in question and is therefore correct. Data validation should be a recommended standard operating procedure for the product information system. It is however not sufficient to ensure data quality.

Data verification on the other hand answers a set of predefined questions which could for example include checks on the accuracy of certain data points or the data acquisition methods. Verification can be performed on all data or data samples. The inspections can take the form of internal or external system audits. (EPA 2008)

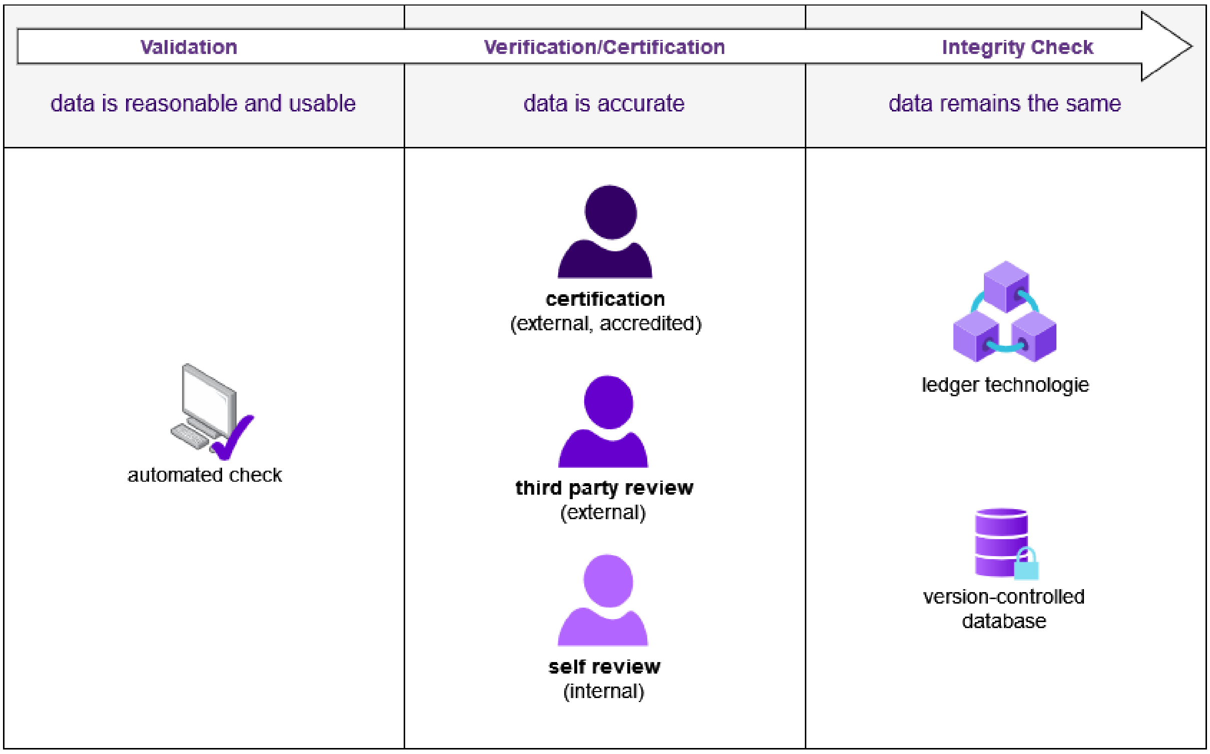
Certification is defined as the provision of written assurance (a certificate) by an independent body that the product, service or system in question meets specific requirements. (ISO 2023b) Certification can therefore be seen as data verification by an authorised entity.

Once the data is entered into the system, the integrity of the data needs to be ensured, which means that the data stays in its original state and is not tempered with. This can be achieved by using immutable data structures for data storage. Immutable data is data that cannot be deleted or modified by system users. If new data is added, it does not overwrite the original data. Data structures supporting this include blockchain technology (see chapter 4.2.3.4.1) and version-controlled databases. There are different ways of implementing version control features to databases. The main features needed to enable integrity control are timestamps and relations to users that create or update data. Also, data histories can be enabled by implementing data fields like "active-from" and "active-to" and instead of overwriting or deleting datasets, setting them to inactive. There are also tools for complete version control of data in a database such as Terminus (https://terminusdb.com/) or Dolt (https://github.com/dolthub/dolt). There are various other technical approaches to support data integrity[50].

An overview of the different methods used for data quality assessment can be seen in Figure 29. Further information can be found in the sources in the footnote, a detailed analysis would go beyond the scope of this work.

[50] e.g., mercurial mercurial (2023), Concurrent Versions System (CVS 2023)or Lightrun Lightrun (2023) for version controlled databases and Ethereum Ethereum (2023) or Kaleido for Blockchain kaleido (2023)

Figure 29: Overview of different approaches for validation, verification, certification and integrity checks



4.2.5.4 Approaches to verification

A range of literature has been published around quality assessment of data and information in different sectors.(Chai 2023) (Cai & Zhu 2015). The quality aspects to be assessed include, amongst others, accuracy (correctness), completeness and credibility, but also criteria like availability and accessibility of the data hosting system.

Different approaches for verification were mentioned by the experts for different levels of desired validity. One already mentioned approach to storing accurate data is to leave the responsibility to the data "owners" (UN CEFACT). The easiest solution is that the stakeholder uploading their data confirms (e.g., by actively ticking a box) that the data is accurate and can be held liable for any misstatement. To authenticate users before uploading data, an identity management system could be used. An option that is rooted in the OS Hub is that whenever a company is adding information along the value chain, their name is visibly linked to the data (Grillon N, Interview 2022, Shaw K., Interview 2022). Linking the data to the source in a traceable way has proven to provide an incentive to add accurate data for the OS Hub, since business partners may hold the data source accountable for incorrect information. This can be complemented with mechanisms to penalise inaccurate entries, e.g., with fines and through competition law.

An additional tool that can be considered is financial incentives (Grillon N, Interview 2022, Shaw K., Interview 2022). Compensating organisations, especially suppliers, for taking the time to verify the information they put into the system could lead to more validated and accurate data. Since one of the basic ideas of the circular economy, for which the data is needed, is to contribute to stopping the climate crisis, Grillon and Shaw see the responsibility for financial compensation with the civilisations and organisations (incl. companies) of the global north. From this perspective, they also advocate working with financial incentives rather than penalties, especially if the companies that provide the data are located in regions that suffer from the climate crisis. This is to prevent these companies from being further oppressed by exploitative structures. Instead, they should be given the resources to effectively manage the additional expenses such as grants and training. On the other hand, they also consider penalties a valid tool to sanction companies that deliberately add false data to the system.

An additional incentive for data quality is a third-party verification to check whether the data can be trusted by whom it has been verified (Heemskerk G., Interview 2022). Together with validation of the data and the use of blockchain technology to ensure the data has not been tampered with, this can help to incentivise data sources to provide correct and complete data. Alternatively to blockchain technology, also version-controlled databases can be used.

For verification by monitoring through business partners, third-party audits could be a suitable solution to verify entries and/or to identify false entries (+ImpaKT, Workshop 2022). PCDS, for example, uses this approach for data verification. The verification is done at two levels: at the process level (i.e. process to create and manage PCDS) and at the PCDS data level on the basis of randomly chosen samples (e.g., 5 per 100 product variations) (Wautelet T., Interview 2022). However, the monitoring approach should be handled with care. +ImpaKT states that many products on the European market are currently not compliant with REACH, although this monitoring mechanism is actually mandatory (+ImpaKT, Workshop 2022).

The lack of clarity for the assessment methods used for product data, such as the recycled content, can be considered an additional barrier (+ImpaKT, Workshop 2022). A political incentive for correct and complete data could be introduced through law by making the data owner responsible for the data they provide (Guth-Orlowski S., Interview 2022). This law could be supplemented with a CO_2 tax for each value adding step as it clears up responsibilities for the impact the data implies.

As an alternative to verifying the information itself, a third party verification process could integrate an audit of the processes used to create and maintain the data in the DPP (Wautelet T., Interview 2022) . The auditing should integrate a list of requirements for the creation and maintenance of accurate data e.g., which tools are used or how the data is stored. The format and storage should also be reviewed in this process. Third party services could support the data owners here by providing certified storage solutions that do not require further auditing. They could also inform the data owners about the verifications/certifications that are mandatory for the data they store in the system. The advantage of auditing the process of creating and maintaining the information in contrast to verifying each single data point is the scalability of the auditing for a large number of SKUs.

A system for validating random samples of product information could also be combined with a warning system (Guth-Orlowski S., Interview 2022). If a stakeholder is flagged giving out wrong information, a more frequent and greater scrutiny should take effect. If there is no change noticed or the stakeholder repeatedly attracts attention with false information, a ban from selling products on the European market can be set. The Ecodesign Directive, which sets requirements in particular for electronic devices, could be linked to the Digital Product Passport. Products would need to be registered electronically before entering the European market. Requirements from the Ecodesign Directive could be reviewed using the product data in the system and the compliance could be ensured. Once it actually enters the market, the products can be randomly controlled again. If there is no pre-registering with the right certifications and qualifications or a product repeatedly stands out for wrong information, it will not enter the market (anymore).

An additional tool can be the use of artificial intelligence (AI). TrusTrace, for example, is an AI-based document recognition system that uses certifications as a basis for validating data entries. (TrusTrace 2023). A similar tool could be used as a basis to identify data that might be inaccurate and should be checked.

KEEP allows for verification of data through different independent certifications (e.g., TCO Certified). The system is planned to show clearly how the data has been evaluated, e.g., by displaying the certifying organisation.

4.2.5.5 Barriers and pitfalls with ownership and data verification

Barriers and pitfalls to expect with ownership liability and data verification include implementation efforts of the requirements to be set and the IT infrastructure needed. There is not enough trust in and knowledge of modern technologies; it is a challenge for small undigitized companies to become part of the changing system. (Datamars, Workshop 2022)

A difficulty is also seen in the data ownership by stakeholders outside the EU, which might not be willing to invest the necessary effort and are not directly affected by EU directives.

The current data structures are considered too complex by some of the experts, e.g., the data structure in the PLM (Product Lifecycle management), the PIM (Product Information Management) and the ERP (Enterprise Resource Planning) systems. PLM and ERP systems are often not capable of reconstructing historic data on product order and batch level, which may lead to difficulties with integrating them in the future system. (Global Textile Scheme GmbH 2022) There could also be a reluctance to provide in-depth data by companies. (Datamars, Workshop 2022; Wuppertal Institut, Workshop 2022) Another barrier is the financial system behind ownership, liability and verification: There will be a cost to pay for certification and verification of the data, so the question arises who will be responsible for the costs? This might also have an influence on SME, who do not have the money to pay this extra cost. (W3C)

Another challenge is considered in finding the right timing to transfer the ownership and responsibility of the data. (Fashion Cloud, Workshop 2022) A clear set of chain of custody use cases is necessary to define ownership, liability and verification to reduce the confusion of responsibilities using a standardisation e.g., the ISO 22095:2020. (GTS, Workshop 2022)

4.2.5.6 Discussion and conclusions

The European Union has not defined the term "data ownership" and is unlikely to do so in the near future. The specific obligations arising from ownership have also not yet been legally regulated.

There are different concepts to define ownership that assign responsibilities either to the party that originally creates the data or the marketer/distributor of the product. The two main concepts to be further assessed are "creator-as-owner" and "user-as-owner". The first method is considered to be the most widely used so far.

The theoretical construct of the user-as-owner, which, taken further, leads to the consumer being responsible for the entire product data, including production data, for example, at a certain point in time, reaches its limits here. Consumers should never be responsible for data arising from the production of the product. If this theory is applied, the ultimate responsibility should lie with the distributor of the product. They would be responsible to use their business relationship with their suppliers to ensure that the data are available, correct and complete.

If the creator-owner approach is used, it must be defined who is the creator of which data fields and consequently has the ownership of this data. When it comes to data that can be added after the point of sale, such as usage times or washing cycles, rights and responsibilities of consumers must be carefully considered. They should be in control over how much data they want to disclose about their personal interactions with the product; however, being accountable for the correctness of the data could be a barrier that prevents them from adding data at all. Therefore, the authors of this report recommend that only legally mandatory data come with a responsibility of correctness. This topic will be further discussed in Part D (see chapter 5.2.4).

Several steps of reassuring data quality are recommended. The data should first be automatically validated for availability, reasonability and usability, then verified manually for accuracy. Data validation is an automatable process which checks the available data, format and range but does not check for accuracy of the data. Data verification is the manual process of assessing data quality according to a predefined set of rules. Data integrity and accuracy are important characteristics to include. Verification can be done internally by the data source or owner themselves, by a peer company or by a certifier. As a third step, integrity can be ensured by using unchangeable data such as versioned databases or blockchain/DLT technology.

Methods to motivate companies to improve data quality include financial incentives or penalties and legal sanctions. It is questionable how much effort can be expected to be put into providing correct and complete data, especially when it comes to data owners from SMEs and/or the global south. Data quality assessment comes with a cost that needs to be covered. It can be assumed that these costs are passed on the sales price of the product because every organization in the market must pay this extra costs. However, it is expected that the costs per item will be much higher for SMEs. This should be considered when designing measurements to avoid additional market hurdles for SMEs. Regulation to make data owners responsible, accompanied by audits and certification by an authorised entity can be a suitable tool.

Conclusions for ownership and data verification

- Data ownership is still to be legally defined by the EU. Depending on the approach, either the creator or the distributor of a product could be the owner of the product data.
- Particular attention should be paid to data added or owned by consumers. Consumers should never own product data that have been added by other stakeholders. The topic of ownership over data about the use phase of the product will be further discussed in Part D (see chapter 5.2.4).
- Several steps of reassuring data quality are recommended: The data should first be automatically validated for availability, reasonability and usability, then verified manually for accuracy. In a third step, integrity can be ensured through technology.
- Regulations to make data owners responsible for the correctness and completeness of the data can be accompanied by financial incentives, penalties, or legal sanctions to incentivise data quality.

4.2.6 Access management and protection of intellectual property (IP)

The task of information management is to provide information of the right quality at the right time for the right person/place (Krcmar 2015). To accomplish this while ensuring that intellectual property (IP) and personal information is protected within the system, an access management system needs to be established.

4.2.6.1 Concepts of data protection, data security and IP protection

In the field of information, data protection and data security, there are different concepts representing different interests.

- **Data security** is a collective term for various approaches that can be used to protect data from unauthorised access and alteration as well as hacking attacks. The methods can usually be applied to either the data storage or exchange channels. (Sen & Basahel 2019)

- **Intellectual Property (IP)** is defined as creations of the mind such as inventions, literary and artistic works, designs, symbols, names and images used in commerce. It is legally protected for example by patents, copyrights and trademarks (WIPO 2023). Technically, IP protection can be achieved through terms of data security as well as contractual obligations (e.g., terms and conditions).
- **Data protection** is a concept to protect the processing of personal data and sensitive personal data. Therefore, data protection legislation is not relevant in the context of (non-personal) product data. It may become relevant in the context of consumer tracking through RFID tags attached to body-worn products (e.g. smart watches or T-Shirts). Several workshop participants bring up the importance of data protection issues in regard to the product information system (European Commission, Workshop 2022; Wuppertal Institute, Workshop 2022) Potential challenges of data protection as described above will be addressed in Part D (see chapters 5.2.2.2 and 5.2.6.2). Other challenges may arise for example due to individuals signing up as users of a platform (where personal data may be collected, including IP address or contact information) (Sen & Basahel 2019).
- **Need-to-know principle**: The "need-to-know principle" is a principle of access control in which an individual or system is only granted access to information or resources that they need to perform their specific job or task. The goal is to limit access only to information that is strictly necessary to ensure sensitive or confidential information is protected from unauthorised access or misuse. (Bell 2006; ISO 2023d; Sandhu & Samarati 1996)

The necessary basis for all approaches related to access management and IP protection is a data security concept for the data storage and exchange channels. (Sen & Basahel 2019)

- **Confidentiality** for example can be achieved by encrypting the data that is stored or transmitted between two users.
- **Integrity of data** can be ensured by using hashing algorithms, back-ups, validating mechanisms and control of write access.
- Different hardware and software solutions are available to assure the **availability of data** for example by preventing denial of service attacks.

There are state-of-the-art approaches available for each aspect of data security that are widely implemented by database providers. These include for example encryption, hashing or digital signatures (Sen & Basahel 2019). A detailed description of the security measures to be taken can be found in (BSI). With these security measures as a basis, a solid identity and access management system can be set up.

An obstacle discussed in the workshop is to make sure that the product information system always stays up to date with technology progress, especially when it comes to security measures. (Avery Dennison, Workshop 2022, Datamars, Workshop 2022)

4.2.6.2 Principles of identity and access management (IAM)

The purpose of access control is to constrain actions or operations that a legitimate user of a computer system can perform in order to prevent activities that lead to a breach of security. (Sandhu & Samarati 1996). For this purpose, IAM seeks to manage digital and electronic identities and regulate user privileges and access to on-premises and in-cloud assets.

The functionality of an IAM system includes managing digital identities of devices and applications and restricting access to subsets of data based on specific roles. A central directory is to be provided to capture and record user login information, manage databases of user identities and arrange assignment and removal of access privileges.

IAM consists of regulating provisioning, requests, authentication and authorization. In this context, **provisioning** means the regulation of access levels and permissions for all users. (Beal 2015) **Requests** are defined as users seeking access to the system. **Authentication** is the provision of credentials to prove a user's identity. **Authorisation** handles the user's right to perform certain actions such as viewing or verifying data.

Authentication can be handled automatically with existing solutions. There are five main categories for different approaches to validate a user login (Ledbetter 2021):

- **Knowledge factor**: information only known by user (password, PIN, secret)
- **Possession factor** possession only user has (ID card, security token (see for example FIDO2 (FIDO Alliance 2022), one-time code (see for example TOTP as defined in RFC 6238 (M'Raihi et al. 2011)
- **Inherence factor** (biometric -): physical characteristic inherent for user (fingerprint, retina/iris scan, facial recognition, speech pattern)
- **Location factor**: through location of access attempt (Internet protocol (IP), GPS, access device)
- **Time factor**: noting time of access (during predictable time periods)

Methods of authentication can be combined for **two-factor authentication (2FA)** and **multi-factor authentication (MFA)**. The underlying concept is that the user needs to verify their identity through two/multiple different channels of authentication factors. (Ledbetter 2021) Therefore, 2FA and MFA are login protocols with a high security standard (zero trust security model) (Ledbetter 2021). Two-factor or multi-factor authentication is supported by most major platforms that have a user login (e.g., Github or Lastpass (GitHub Docs, 2023; LastPass 2023)).

Single-Sign-On (SSO) is a user authentication option for getting access to multiple systems eliminating the need to repeatedly log in with credentials. SSO credentials can be used in any web browser without security vulnerabilities (Roy 2021). Different Software as a service (SaaS) providers provide SSO solutions. (IBM 2023; JumpCloud 2023; OneLogin 2023)(Roy 2021; (Beal 2006)

Access management needs to be complemented with retrospective auditing of the requests and activities that users perform in the system to create a complete solution for securing a system. (Sandhu & Samarati 1996). Such reporting and monitoring applications as well as behavioural analytics can be implemented as part of the IAM system to increase the reliability of the software security. (Beal 2022) Developments in the field of IAM go towards cloud computing and more flexible account access. Moreover, artificial intelligence is explored to monitor network traffic and audit user behaviour and send alerts if an anomaly is detected. (Beal 2015)

PCDS is in the process of developing a solution for identity management in their system. The system they are designing consists of different nodes. Nodes can be local for example a person's computer or global for example a server infrastructure maintained by a dedicated team. A global node is set up as the unique ID issuer and for authorising actors in the product information system. It also verifies their access requests. Local nodes can belong to a single operator or be shared between a set of operators and handle registration. (Wautelet T., Interview 2022, +IMPAKT 2021)

4.2.6.3 Electronic/Digital identities

Different processes in online trade involve secure and trusted service infrastructure including authentication mechanisms and electronic signatures. Because a variety of concepts and approaches have been developed, the EU has published a regulation for consistent standards for electronic identities, authentication and signatures to establish a single, secure digital market: The eIDAS[51] regulation (eIDAS 2014) was suggested by W3C in the expert workshop to provide a baseline for the concept for the product information system. The aims of this regulation include to enable citizens of the EU to use online trust services such as electronic signatures and to establish legal acceptance of electronically signed documents across EU member states. The two key aspects that the regulation solves are electronic identities and trust services. Government-issued electronic identities that use national ID schemes to prove the identity of a person or business (e-Identity or eID) need to be internationally recognised. The e-Identity can come with different levels of assurance that the identity is valid. Trust services for authentication and signatures include electronic signatures as the equivalent for handwritten signatures, time stamping, website authentication and registered electronic delivery. Both aspects (e-Identity and trust services) rely on the same public key infrastructure (see chapter 4.2.4.4). eIDs can be used in trust service processes to sign documents.

While public key infrastructures are centralised systems, DIDs and VCs can be considered as a decentralised alternative. (W3C 2021b)(W3C 2022) For a definition and introduction of DIDs and VCs see chapter 4.2.4.5. and the W3C Verifiable Credentials Data Model 1.0. By using full-featured wallets that communicate with secure service endpoints, access can be granted to individuals who are equipped with the necessary access rights without the need to provide a central access management. To use DIDs and VCs for access management, an individual or organisation would first create a DID and associate it with a VC that includes a set of attributes (e.g., email address, company type, access rights). They would then use their DID and VC to authenticate themselves to a service endpoint, which would check the VC to verify the individual's identity and access rights. If the individual is authorised, they would be granted access to the service.

In the context of DIDs and VCs it is not necessary that a single trusted institution takes the responsibility to define roles and verify stakeholder access. Instead, a licence to assign usage rights and verify access requests can be given out by an institution to several entities that are trustworthy for this task. Once they own the suitable licence, they are allowed to take these tasks. This is also called a trust chain. (Guth-Orlowski S., Interview 2022)

The strength of the DID/VC system is that access management can be achieved through the same system, making all resources available to the respective stakeholders with a single account. (Guth-Orlowski S., Interview 2022). However, the practical adoption of such an access management system in the industry faces the obstacle that many organisations have access management systems in use that they want to keep or reuse. Now, these systems can be kept, or they can be translated into the VC system. This can be done using tools that are readily available, such as Open ID Connect. (OpenID - The Internet Identity Layer 2011)

In the ID union project, of which Spherity is a partner, the OpenID Connect is tested. Different applications and combinations are analysed and tested to be used for authorization and authentication. Different available systems need to be tested to connect them to the product passport approach. (Guth-Orlowski S., Interview 2022)

[51] eDIAS is an EU regulation and the short form for electronic Identification, Authentication and trust Services and in long form for REGULATION (EU) No 910/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on electronic identification and trust services for electronic transactions in the internal market and repealing Directive)

4.2.6.4 Decision-taking in access management

The most open approach of access management is to make all data in the system publicly accessible. However, since many manufacturers classify various data as sensitive, this would mean that the data set would have to be either greatly reduced to data that is not problematic or that data that are currently considered trade secrets would need to go into the public domain. This includes for example certain data that generate market advantages over competitors (Wegener D., Interview 2022) or audit scores for supply chain partners (Grillon N., Interview 2022). However, the results from Part A show that it could be potentially possible to reduce the data set for certain product groups (e.g., apparel) to data that are not considered sensitive. In that case, data could be limited to the necessary data to foster a circular economy without making sensitive data freely available. If this would be possible, the access management could be much simpler and entry barriers reduced.

If data needs to be stored and shared with certain stakeholders and this data cannot be made public, there are options to restrict and manage data access. Archer points out that it may be necessary to review the calls for information to be kept secret and distinguish those who classify a great deal of information as secret without further background from those who can give true and very genuine commercial reasons.

One option to solve access management is to share data on request (Wautelet T., Interview 2022). This is however considered to be too time and effort intensive for time sensitive processes such as repair or sorting after the use phase.

Each stakeholder can be presented a selected subset of the information which is relevant to them (Avery Dennison, Workshop 2022). Access management concepts differentiate between data that is publicly available and data for which the access should be restricted to authorised stakeholders (see Table 30 - below). Authorised stakeholders can get access through their business relations or based on their assigned role in the circular economy. Role based access management is suggested as a simple solution for clear access rights and IP protection. More specifically, role-based access management could be solved through credential-based access management or attribute-based credentials (Spherity, Workshop 2022). In any case, the role of the stakeholder needs to be verified.

Table 30: Overview of mandatory and optional data sharing with the public or specific stakeholders

	Publicly accessible	Shared with specific stakeholders
Mandatory data set	• Shared openly • *E.g., product type, recommended retail price*	• Shared through a technical access management solution with stakeholder groups or on bilateral basis on request • *E.g., detailed material composition shared with sorters or recyclers*
Addtional optional data	• Shared openly if desired by data providers • *E.g., product description*	• Shared through a technical access management solution with stakeholder groups or on bilateral basis on request if desired by data providers • *E.g., supplier information shared with certifiers*

For both, the publicly available and the restricted dataset for certain stakeholders, a mandatory subset can be set in policies (Wautelet T., Interview 2022). A definition of relevant information per user group is needed to cluster the access. The definition should integrate who can access which data (+ImpaKT, Workshop 2022). Profiles should be created for different value chain stakeholders based on a common structure (UNECE, Workshop 2022). The need-to-know principle is considered as a suitable approach. Surveys, interviews and discussions could be a solution to define the roles and profiles (Wegener D., Interview 2022). circular.fashion has used a similar approach to gather and evaluate the information needs of different stakeholder groups in the development of the circularity.ID Open Data Standard (circularity.ID 2023). In order to document the profiles, roles and access rights, the Open Digital Rights Language (ODRL) can be used (Spherity, Workshop 2022; W3C, Workshop 2002; World Wide Web Consortium, Workshop 2022)

Chapter 4.5 introduces a proposal for user profiles for specific stakeholder groups in the textile and electronic sectors based on the need-to-know principle. In order to investigate the user groups' information requirements, the results of Part A were consulted. A similar approach could be part of the standardisation work to define the data sets.

Some see the decision-making power and responsibility with the data owner, who should have control over the use and processing of their data. (Heemskerk, Wegener, DFKI). Losing control could make the data owners hesitant to make their data available at all (Wegener D., Interview 2022).

Other experts prefer legislation to set the standards resulting in the owner of the data not having the authorization to manage the access rights for the stakeholders (Guth-Orlowski, Wautelet). Instead, the access is determined by the stakeholder's role. Another approach is to bring industry and community together to answer the question of what data should be available and to whom (Heemskerk, Hohenecker S., Wegener D., Interviews 2022).

Using these policies as a basis, a uniform access management system can be developed that facilitates access to information without the need to request specific information from the respective company at the moment you need it (Wautelet T., Interview 2022).

Legislation on due diligence would be suitable to make provisions on disclosure and access and is potentially being released in the next years. (European Council 2022) (Heemskerk G., Interview 2022) In February 2022, the European Commission published its Proposal for a Directive on Corporate Sustainability Due Diligence (COM/2022/71 final). The proposal includes obligations for large companies active in the EU to conduct human rights and environmental due diligence by integrating due diligence into companies' policies. This includes identifying actual and potential adverse impacts arising from their own operations and those of their subsidiaries. The objectives are to take actions to prevent and end potential adverse impacts.

The Wuppertal Institute raises the concern that organisations and companies fear losing the competitive advantages in IP when information that grants these advantages need to be disclosed (Wuppertal Institut 2022b). Another concern of the companies may be that the information sharing rules conflict with data privacy regulations (e.g., GDPR), which can be especially a barrier for SMEs which have not hired data security lawyers. (Wuppertal Institute)

Certain data that are not necessarily required by stakeholders for their role in the circular economy can also be added on an optional basis, so the data owner can decide whom to share this information with (Wegener D., Interview 2022; Datamars, Workshop 2022). In this case, information can be shared on a bilateral basis with selected business partners. A demand is expressed to manage access rights in a fine-granular way (DFKI, Workshop 2022, Wuppertal Institut. Workshop 2022). A similar approach is chosen in the IMDS system where additional data to the Material Data Sheets can be shared either voluntarily by the suppliers or on request from the manufacturer (IMDS 2023b).

The OECD furthermore refers to the concept of enhancing access to and sharing of data (EASD) (OECDiLibrary 2023). The concept describes more specifically who the data can be accessed by, shared with and used for while taking into account individual/group interests and security.

The representatives of the EC propose a two-step process: In general, the data should always be accessible to the data owner, until they decide the data (to different extents) to be publicly available, then the relevant stakeholders can access that data (European Commission, Workshop 2022). Parts of the data originally generated may be kept undisclosed so that no other users are able to gain access.

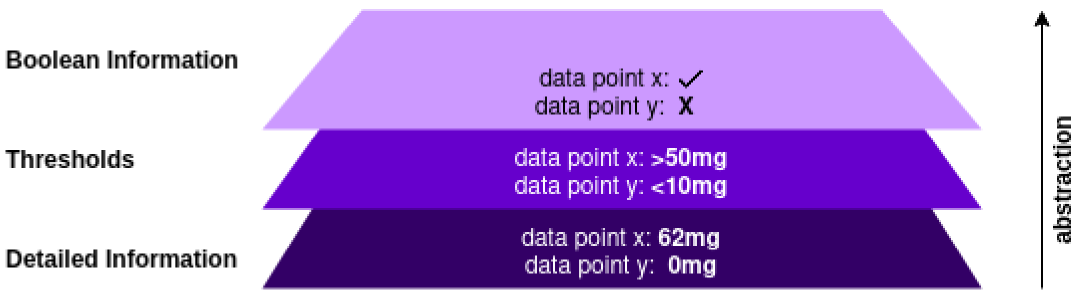
GTS proposes to develop an innovative and easy access management model that would motivate the user to pay for data. (Global Textile Scheme GmbH 2022) However, a fee for the data users would conflict with the goals of a product information system such as to foster sustainable purchasing, prolong use and repurpose products after use. A financial system supporting the product information system is still to be conceptualised and exceeds the scope of this project.

4.2.6.5 Further approaches to access management

Data can be aggregated to provide stakeholders with the information that they need without unnecessarily revealing background information. Aggregation of data is any process that includes the gathering and processing of data and expressing them in a summarised form. (Krunal 2020). As an example, for product related data, it would be possible to store any data related to where and under which conditions a product has been produced. This information could be used to calculate a score or label that refers to the production conditions. This score or label can then be shared with partners and consumers without having to disclose the underlying data. However, a unified method to aggregate critical data would need to be agreed on (GTS).

Data can also be shared on a different level of information depth (e.g., PCDS is using this approach). Levels of information depth considered here include boolean information (answers to yes/no questions), thresholds that create different categories of data, or detailed information (exact numbers). For an overview of levels of information depth, please refer to Figure 30: Levels of information depth(below). If detailed information is stored in the system, the interfaces can still be programmed to use e.g., thresholds against which the data is evaluated. This means that through the interfaces different stakeholders have access to different levels of information depth.

Figure 30: Levels of information depth



4.2.6.6 Example solutions

The DPP 4.0 concept: The ZVEI show case "PCF@Control Cabinet" is a concept for the technical implementation of a Digital Product Passport for Industry 4.0 (DPP 4.0) (ZVEI 2023). With DPP4.0, the industry is able to document and provide required product information. The concept was developed as part of the Industry 4.0 initiative. It is based on two integrated pillars: the Digital Nameplate (DNP4.0) via IEC 61406 (Identification Link) and the Asset Administration Shell (AAS) according to IEC 63278 (in progress). The Digital Nameplate 4.0 follows a hybrid approach, comprising a physical nameplate with most relevant information, combined with digital information which are accessible via a QR-code. The AAS acts as the digital twin of the asset. It describes an asset in a standardised and semantically unique form.

The linking of the OT and IT levels (operational technology and information technology) is the goal. By linking with the Asset Administration Shell (AAS), each asset of the OT level (hardware and software) becomes an I4.0 (Industry 4.0) component. This creates interoperability between all I4.0 components and connects the I4.0 component to the IOT world in a plug-and-play manner.

In the DPP 4.0 concept any stakeholder should be enabled to get data the owner is willing to share either on a “need-to-know-principle” or a “voluntary-basis”. (Wegener D., Interview 2022). Digital services could be provided to organise shared data between owner and any other stakeholder in a technical manner. Two technologies are proposed for access management:

1. the Digital Nameplate which gives access to the publicly available product information and
2. the Asset Administration Concept which organises data corresponding to the product. With the Asset Administration Concept, there is also the opportunity to share only parts of the data to relevant stakeholders.

Siemens for example already shares a lot of information about their products on their website. (Wegener D., Interview 2022) The information can be read and downloaded, some of it is mandatory, other is voluntarily shared. Additional digital services related to the products are offered. Access is only allowed to those who have paid for the product or are in another way involved. Third party providers can do the maintenance of the products, but owners of the data and the product get to decide which information to share. Access management of the DPP 4.0 concept needs to be managed so that it is compliant with access rights of current databases such as SCIP. Therefore, a top-down approach could be useful to define the DPP 4.0 access rules. The level of complexity can be reduced by using a product information system as the DPP 4.0. However, it should not be mandatory but used on a voluntary basis.

4.2.6.7 Discussion and conclusions

The simplest solution to access management is to define a dataset that includes only data that can be made publicly available. If it is possible to enable the necessary circular economy use cases without disclosing any sensitive information, this method is recommended, as it makes a complex role-based access management system obsolete. Aligned with the request by Archer, the project team recommends reviewing claims to keep certain information secret and check whether they are based on genuine reasons.

However, stakeholders may require certain information that for genuine reasons cannot be made publicly available. Assuming this is the case, the project team recommends a role-based access management based on the need-to-know principle. Decision making on which data needs to be shared with which stakeholder groups needs be the responsibility of legislation. They should consider the perspectives of industry and community representatives as well as the data owners themselves. Allowing a more bottom-up approach on defining the role-based access management would result in great complexity and inconsistencies. In addition to considering which information is relevant to which stakeholders, the level of information depth at which the information is needed should also be considered. For example, some stakeholders may require access to the exact amount of a particular ingredient, while for others it may be sufficient to know whether that amount exceeds a certain threshold. This calculation can then be performed by the system for the appropriate role profile. This allows each stakeholder to be provided with a subset of the information that is relevant to them while protecting intellectual property and trade secrets as well as possible. Other solutions, such as sharing data on request are considered not to be feasible due to time delays which are not acceptable for several use cases.

Within this project, a first role definition has been developed by the product team for the DPP front-end demonstrator. Those roles are material producer, product designer/developer, certifier, customer, and sorter/recycler. More on the roles and access management in chapter 4.5. Furthermore, if access rights can be set at a fine granularity, additional data could be shared in the same system on an optional basis. This would leave it up to the data owners to decide under which conditions (e.g., role-based, contracts or payment) this additional data should be shared with certain roles or specific business partners.

There are technical solutions readily available for data security, authentication and authorisation of users. An SSO solution is strongly recommended to prevent stakeholders from having to have an account with login credentials ready for every data store they need to access.

Takeaways for access management and IP protection

- Data can be shared publicly or with specific stakeholder groups on a mandatory or optional basis.
- Making all product data publicly accessible might conflict with the requirement of stakeholders to protect their intellectual property and with that keeping their competitive advantages. However, a certain subset of data could be defined to be publicly accessible.
- Decision making on which data needs to be shared with which stakeholder groups should be the responsibility of legislation, considering requirements by industry and community representatives as well as the data owners themselves. Data could be classified based on the need-to-know principle to develop an appropriate access management.
- There are technical solutions available for data security, authentication and authorisation of users.

4.2.7 Data carriers

To link the digital information stored in the product information system to a physical product, the physical product can be equipped with a data carrier such as a Quick Response (QR)-code or a Radio Frequency Identification (RFID) tag. This data carrier can either directly store product information, or a unique identifier such as a URL or GTIN that can be used to identify the correct data associated with the product. Identifiers are digital strings or numbers that uniquely identify a product.

A central listing of all products in the system for manual identification can be an alternative or addition to the data carrier/identifier combination.

4.2.7.1 Data carrier requirements

There are several aspects that need to be considered when choosing a data carrier in a product information system:

- **Durability**
- Needed **equipment to read**
- Process **time to read and access product information**
- **Storage capacity** for identifiers or product data
- **Implementation** to product without disturbing use phase

- Ensure **protection of personal data**
- Suitability for **recycling** processes
- **Costs**
- **Environmental impact** (for production and end of use, potential of recycling)

For each of these aspects the requirements for data carriers depend on the use cases which shall be covered with the product information system. Five potential use cases are:

1. Support **sustainable production** (material composition and origin, social and environmental impact),
2. enable **transition to circular economy** (e.g., better sorting and recycling**),**
3. provide **new business opportunities** to economic actors and **user empowerment** (accessibility on use, maintenance and repair),
4. support consumers in making **sustainable choices** and
5. allow authorities to verify compliance with legal obligations (European Commission, Workshop 2022) (see chapter 1.1 in part A).

Durability: As use cases 2 and 3 relate to in-use and end-of-life phases, they result in the requirement for the durability of the data carrier to resist the full use phase. In this case, the required durability is also dependent on the average use of the product type (e.g., a T-Shirt is usually washed more often than a down jacket or refrigerator is used differently than smart wearables).

Needed equipment to read: Another important aspect is the readability for different stakeholder groups. Use case 1, 2, 3 and 5 are business-to-business or business to government use cases. It can be assumed that rental services, repairers, waste collectors, sorters, recyclers and authorities such as customs can use special equipment to read data carriers (e.g., RFID readers). However, it cannot be expected that they buy a large variety of specialized equipment. For use cases 3 and 4 private users are addressed and readability via smartphone or sight (e.g., text with information or a URL) needs to be provided.

Process time to read: For business-to-business and business to government use cases, the process time to read the data carriers is crucial. Ideally, the reading process should not slow down processes. Otherwise, there is the risk that the gained value due to an improved process output is lost by additional process costs and addressed data users do not use them due to a potential competitive disadvantage. However, legal minimum sustainability requirements for product quality which could only be met by using the product data could force these stakeholders to use them anyway and create a level playing field for competitors (e.g., in the sorting/recycling industry for post-consumer goods).

Storage capacity: Furthermore, the storage capacity of the data carrier is essential. There are two options of storing data: Either the product data can be stored directly on the data carrier, or it can be linked to through an identifier. The amount of storage needed for storing the complete dataset depends on the dataset but is expected to be larger than standard storage of most data carriers (e.g., QR codes, RFID and NFC tags). Models that provide more storage are either large (QR code) or more expensive (RFID, NFC). Data carriers need to provide at least enough storage to store a unique identifier which excludes data carriers with a limited address room (e.g., micro particles used for traceability in supply chains).

Implementation: For the implementation of data carriers several aspects need to be considered. On the one hand, they should be easily accessible for their users (use cases 3 and 4), business entities (use cases 1,2 and 3) and authorities (use case 5). On the other hand, they should not disturb the intended use. Data carriers should be implemented in a way that they do not get removed from users before the product is prepared for recycling. Furthermore, for many products, design is an important selling point (e.g., apparel or watches), as well as unrestricted functionality (e.g., wearing comfort). Additionally, the implementation process during manufacturing should be possible in a lean process which is not prone to errors. These aspects need to be considered when implementing data carriers.

Privacy of personal data: There are concerns that some potential data carriers could be tracked without user consent. (Auerbach M. 2018) For this reason, today many data carriers get removed or deactivated at the point of sale. This is no option when the function of data carriers is needed in the use phase and in the reverse supply chain. The selection of a data carrier should take this into consideration.

Interfering recycling and potential removal: Some data carriers could disturb recycling because they contain materials which the core product does not contain (e.g., RFIDs include small amounts of metals). In such cases, the removal of data carriers before the recycling process starts should be easy. Ideally, data carriers are made of materials that fit into the recycling process of the product.

Costs: Today, the use of data carriers needs to be justified with a return on investment for the organisation that purchases them (e.g., by lower process costs in logistics, improved retail management etc.). Therefore, costs are crucial for the decision of data carriers. This might change when the use of data carriers is mandated to achieve certain sustainability goals. In such an initial situation, organisations would not compete with organisations that do not use data carriers and a level playing field would be given. The cost of the data carrier would presumably be passed on to consumers. At the same time, the data carrier would create savings of the true costs of the product.

Environmental impact: As the overall goal of the product information is to pave the way for a circular economy and eventually reduce the environmental impact of the economy, the environmental impact of the technologies used in the system should be kept minimal. The impact analysis should not only include the production of the data carrier itself but also the full process which they enable for the product where they are attached to. A brief analysis of the environmental impact of the technologies used will be addressed in chapter 4.2.9.

4.2.7.2 Data carrier options

There is a variety of data carrier technologies including the following:

- **Optical codes** such as QR, datamatrix, barcodes, digital watermarks etc.,
- **Electronic tags** like RFID/NFC or Bluetooth tags and
- Other methods, for example **DNA or microparticle tracking** or **chemical tracking**.

Combinations of different data carriers also exist such as RFID Ultra-High Frequency (UHF) or High Frequency (HF) tags with QR code prints on it. In the context of the previously described requirements of a digital product information system, only some of the above-listed data carriers come into consideration.

4.2.7.2.1 Optical codes

There are various types of optical codes that could be used as data carriers. Barcodes are the most common ones in retail today. However, the storage capacity of barcodes is limited. There are several types of barcodes. One of the most common ones in Europe is the European Article Number (EAN) which can include 13 characters. In a decentralised system a bigger data space can be beneficial. This way, URLs could be included. DataMatrix and QR codes do have this capacity. DataMatrix codes are smaller and have a higher content capability compared to QR codes. However, QR codes have a high acceptance within the population as most people know how to scan them with their smartphone. Digital watermarks are another option which are mainly used for plastic packaging today (HolyGrail 2023). However, accessibility for consumers is not given today.

Next to 1D and 2D codes, plain text with either a URL, an identifier or information in text could be a possible solution. Using text creates some extra effort to read and type the URL/identifier in but it has the lowest technical barrier. The durability of optical codes is mainly dependent on the physical properties of the tag and where on the product they are placed.

A potential limitation of optical codes is that they need a direct line of sight. That can create extra process costs in business-to-business use cases (to find and scan the optical codes). Mandated guidelines on how to affix them to the product could help to reduce these extra costs. Because optical codes can for example be printed, engraved or woven, they offer a higher flexibility in the selection of materials. This allows the producers to use the same type of material which the product consists of or integrate on the product itself. Hence, the data carriers do not need to be separated from the product before recycling. Additionally, the variety of materials and the resulting flexibility in placement in the product offer a larger versatility in design decisions without restricting functionality. The codes should be implemented in a way that users do not feel the urge to remove them during the use phase. Also costs and the environmental footprint are usually rather low for optical codes.

4.2.7.2.2 Electronic tags

For electronic data carriers, active and passive tags can be distinguished. Passive tags are powered by energy from the reader's interrogating radio waves. Active tags are powered by a battery and can be read at greater range. Active tags include Bluetooth tags and active RFID tags, while other RFID tags, including NFC tags, are passive. RFID uses electromagnetic fields to automatically identify and track tags attached to objects. (BSI 2021). There are many different types of RFID tags with different frequency bands. Two common ones are ultra-high frequency (UHF) tags (865-868 MHz in Europe) and high frequency (HF) tags (13,56 MHz) which include Near Field Communication (NFC) tags. Since no optical scanning is used for RFIDs, they do not directly need to be in the line of sight of the scanner to be recognized as described by Lotlikar et al. (Trupti Lotlikar et al. 2018). That makes them better suitable for (automated) industry processes. There is a wide range of durability between different products, and it influences costs. High frequency (such as NFC) and Bluetooth tags can be read with modern smartphones, while UHF tags can only be read with UHF scanners and antennas. That makes HF and Bluetooth tags more suitable for user interactions while UHF tags are better suitable for business-to-business use cases. RFID tags are available with many different memory sizes. Ideally, the electronic tags used can save a URL or an Electronic Product Code (EPC) (see chapter 4.2.8.3).

When working with electronic tags, the issue of personal data protection needs to be addressed. (Schwarz Bour & Jönsson 2020) Especially for products worn on the body, there is some criticism that the person could be tracked via electronic tags. However, this would be a costly endeavour as the reading range for most tags is limited and there are easier ways to track people. To reduce the concerns around tracking, countermeasures (e.g. a reduced reading range) can be implemented (see chapter 4.2.6.1).

State of the art electronic tags contain small amounts of metals. This makes them harder to integrate especially for products such as apparel and wearables. However, the industry has developed products in many different shapes (e.g., in the shape of buttons, threads, labels etc.) to overcome this hurdle. Metals also have an influence on the recyclability of a product when the rest of the product does not contain metals. In this case, they need to be removed before the recycling process.

Costs of electronic tags are usually higher than those of optical codes. However, electronic tags hold the potential to improve all kinds of processes (e.g., avoid counterfeit, improve logistics, retail management, loss prevention[52] etc.) beyond the use cases in a product information system. The Tex.IT project analyses in three case studies the use of RFIDs in the textile industry. They conclude a positive return on investment for the use of RFIDs in logistics and retail management. (Schwarz Bour & Jönsson 2020) This indicates that the costs could be compensated by other benefits (examples described above).

Electronic tags belong to the product group of electronic equipment. The directive on waste electrical and electronic equipment (WEEE) from the EU lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste from electrical and electronic equipment. The WEEE Directive had to be transposed into national law by all EU Member States. In Germany, the WEEE is transposed into the Act Governing the Sale, Return and Environmentally Sound Disposal of Electrical and Electronic Equipment (ElektroG). As a consequence of this law, electronic equipment needs to be registered from producers when they place them on the market. In Germany the Stiftung Elektro-Altgeräte Register (EAR Foundation) is responsible for executing these tasks. The registration of electronic devices is associated with costs and the obligation to dispose of waste ekectrucack abd ekectrinal equipment. These are already standard procedures for producers of electronic equipment. However, if textile producers voluntarily or if required by law introduce electronic tags to their garments, and such garments containing electronic tags are deemed to be "electronic equipment", obligations such as registering and disposing of the garments will come with additional efforts and costs. The definition and list of examples in both the WEEE Directive and the German ElektroG leave room for interpretation whether garments containing electronic tags fall into the scope of the respective legislation or not. This leaves producers with an unclear legal situation and may lead to many producers registering their garments, just to be safe to avoid administrative fines. The legal framework is discussed in more detail in Part D of this report (see chapter 5.2.6.1).

4.2.7.2.3 Other methods

There are a couple of other methods to identify products such as DNA tracer, microparticles or chemical tracking. To the authors' knowledge, the information stored cannot be converted into a string or identifier. That makes it impossible to save product information on a database and therefore, they are not suitable data carriers to identify a finished product. Hence, they cannot be used to show for example the exact material composition of a product. However, they can be very beneficial to verify data points such as the origin of a material. It can be concluded that their use case is mainly for supply chain tracking.

4.2.7.3 Standardisation of data carriers versus allowing different formats

Wegener considers a definition for preferable and non-preferable data carriers. There are restricting characteristics which complicate the selection of data carriers, e.g., the price and interactions of the stakeholders. Therefore, Guth-Orlowski and Hohenecker suggest harmonized data carriers per industry or product category, e.g., one for textiles, one for electronics etc., as different characteristics may be preferable. However, even within the product category, different technology options may be suitable. The usage of which particular data carrier depends on the

[52] Loss prevention is a term which is used from the retail sector to describe the function of RFID tags that addresses shoplifting and employee theft.

industry of the data carrier. In the textile value chain other data carriers may be preferable than in the electrical industry (Guth-Orlowski S., Interview 2022; Hohenecker, S., Interview 2022).

Another problem is the scanning environment around the data carriers (Hohenecker S., Archer P., Interview 2022) The technology e.g., for scanning and processing the information and available trained staff can be an obstacle to fully implement the concept of a working product information system (Wautelet T., Hohenecker S, Archer P., Interview 2022). Especially when adding new technology to a working environment or a consumer interface, the learning curve needs to be considered (Avery Dennison, Workshop 2022). Single scanning systems could be developed that are able to read the information from different data carrier technologies. For example, textile sorting stations from circular.fashion are equipped with RFID UHF and RFID HF scanners and could also be enabled for optical codes. In the end, the identification needs to work for all stakeholders that use the product data and not only the ones implementing it (Archer P., Interview 2022; Hohenecker S., Interview 2022).

In Guth-Orlowski's opinion there is currently a conflict between the goals of the people implementing the technology and the people using it in the end (Guth-Orlowski S., Interview 2022). While the parties inserting the data carriers would like to choose a data carrier that is as inexpensive as possible, for the parties reading out the data the process costs depend on the optimisation of the scanning. As this conflict may not be resolved due to conflicting interests of the stakeholders but it is necessary to be solved for the circular economy, legislation might be necessary. In the circularity.ID system, a pre-selection of data carriers is made depending on which use cases are to be served. If end-of-life-services are to be included in the lifecycle of the product, the selection depends on the sorting and recycling requirements gathered from partner organisations.

4.2.7.4 Central listing of products in the system

Access to data is usually handled via identifiers stored on some kind of data carrier in the product. As a supplement to this, lists of all products in a category could also be made available. These could include a category name (e.g., screens) and a list of products within this category (e.g., all the screens that are sold on the European market) along with a link to the product information for each one of them. Providing such lists can be particularly advantageous in the application case at customs as well as for the comparability of products for consumers, market surveillance and legislators. For customs, the lists are important because the product identifiers may not be accessible if the products are e.g., packaged in large batches. Such public information can furthermore enable third-party providers to offer applications for comparisons and scoring of similar products to consumers, thus simplifying the conscious consumers' decision-making process. These applications could work by using the identifier of a single product (e.g., because a customer scans it in a store), finding comparable products within a category and comparing sustainability records between these products. This gives the consumer the opportunity to compare products and find the "best" (consumer's choice) sustainable product. It can also help consumers, sorters and other stakeholders to filter products which have certain attributes (e.g., sorters could check for screens that have a plexiglass screen). Such a central list could be approached as part of the development of the central registry (described in chapter 4.2.3.6.1). If the central list was used as a substitute for data carriers (rather than as a supplement), the time needed for looking up products can be a barrier for time critical business processes, as looking up the respective product requires manual input. It could also negatively impact the user experience.

4.2.7.5 Physical and digital data carriers

The requirements should be different between offline and online sales. Most products will need physical data carriers attached to the product. However, it can be discussed if some products do not need one. This can include products that do not have reuse and repair markets and the material composition can be detected with other methods (such as optical spectroscopy) for recycling decisions (e.g., socks). For all products that do have relevant reuse market the data carrier should be attached to the product itself. For very small products the data carrier could also be attached to packaging, user manuals or hang tags (e.g., microchips). Data carriers for online sales will only be necessary when products are sold online. For ecommerce optical codes or URL links can be suitable.

4.2.7.6 Example solutions for data carriers

In the expert workshop and interviews, lists of examples for technologies and approaches that are used for data carriers have been put together.

- **Barcode in retail**
  Barcodes are commonly used in retail. A barcode is an image of bars and spaces that represent an identifier. In product identification, it usually corresponds to a Uniform Product Code (UPC) or European Article Number (EAN). Barcode scanners decode the image to the identifier. They are usually attached to a computer that stores information corresponding to the respective identifiers. The concept originated in grocery retail and has spread across sectors. Barcodes are also used nowadays e.g., in hospitals to identify patients (ERP 2023)

- **QR-codes for retail and consumer interaction**
  Since GS1 is advocating for moving from 1D barcodes to 2D QR or data matrix codes as they are usually used to represent a Digital Link, major scanning manufacturers are starting to produce QR code scanners that can process GS1 Digital Link QR codes. In the transition phase from 1D to 2D barcodes both codes are available to be scanned, after some time only 2D barcodes will be available. The technology for several data carriers is in place. (Hohenecker S., Interview 2022)

- **RFID, NFC and QR data carriers for sorting**
  As discussed above, RFID, NFC and QR data carriers are to be considered for the sectors of textiles and electronics. Hecht and Malzacher showed in a field study that QR- or data matrix codes as well as RFID transponders are suitable for assigning products to the correct recycling process at textile sorting. (Malzacher & Hecht 2022)

- **RFID in retail**
  RFID tags used in nongrocery retailers can be used for multiple functions. A study from McKinsey shows that the implementation of RFID solutions can create benefits of 25% improvements in inventory accuracy, 10-15% reduction in inventory-related labour hours, and reductions in shrinkage and theft that can raise revenues by up to 1.5%. Due to the fact that the average costs of RFID tags has fallen by 80% in the last decade and the functionality improved it is more widely used in retail today. (Adhi et al. 2021)

- **Digital nameplate**
  As a digital equivalent for a physical nameplate, the digital nameplate has been developed within the concept of "Industry 4.0". The key aim of the development is to provide product information in a paper-free digital format. RFID chips and QR codes are suggested as data carriers, but not mandated. The storage can either be directly on the data carrier ("digital nameplate as unique product identifier") or stored in an online resource and available

through a web-resolvable URI that is stored on the data carrier ("digital nameplate as DPP"). (DKE 2022). The approach is demonstrated in the ZVEI show case "PCF@Control Cabinet".

- **DIN SPEC 91406:2019-12 Automatische Identifikation von physischen Objekten und Informationen**
  The DIN specification 91406 revolves around the automated identification of physical objects and information in IT and especially IoT-systems. For this purpose, metal tags with a data matrix code and optional additional NFC tags are to be used. As an identifier, unique URLs are used. (Endress+Hauser Temperature+System Products 2021) The specification is also the basis for the development of the digital nameplate. (DIN 2019). The standard was developed in cooperation with large companies from different sectors (e.g. ABB, Siemens, GS1, Festo, Covestro, Bayer).

4.2.7.7 Discussion and conclusions

The requirements for data carriers are dependent on the product group and characteristics. Therefore, the discussion will be divided into a discussion for textiles and one for electronic products.

4.2.7.7.1 Data carrier for textiles

Textile products have specific characteristics which need to be addressed when defining suitable data carriers.

1. For most apparel products reuse markets and recycling streams exist. As product information is needed for these processes, it is necessary to have functional data carriers after the use phase.
2. Many textiles (especially apparel) are washed with water, and some are also ironed or mangled, which places high demands on water, heat and pressure resistance for data carriers.
3. Textiles (especially apparel and to some extent also home textiles) have high design requirements. Also, wearing comfort is an important function of garments.
4. Sorting processes of collected used garments have efficiency requirements.
5. Most textile recycling processes are not made for metals. (Leal Filho et al. 2019).

These characteristics disqualify a couple of data carriers for this system.

Washing requirements of some products exclude active RFID and Bluetooth tags. There are so called "laundry RFID tags" on the market. These are passive tags which are designed to resist many washing cycles. The durability requirements are heavily dependent on the product type they are attached to (e.g., T-shirts are usually more often washed than jackets).

The requirement to minimise the influence on design decisions precludes digital watermarks for textiles. Furthermore, digital watermarks consist of a small code printed or embossed repeatedly over the entire material. This requires a uniform and smooth material, so it could e.g., not be used on a knitted fabric.

For apparel, the integration is of high importance as, on the one hand, care labels are often cut out but should stay until the end of use and, on the other hand, the placement can have influence on the wearing comfort. The various forms of optical codes and RFID tags help to overcome this challenge. Placement and fixation can also reduce the chance of tags being removed.

The sorting process is an important decision point for post-consumer textiles. Decisions are made manually on whether products can be reused, and through which reuse channels, whether they need to be repaired or prepared for recycling, and the type of recycling. These processes are time sensitive. Tests from circular.fashion with textile sorters have shown that optical codes slow down these processes significantly because sorters have to search the data carriers in all products and scan them afterwards. With this initial situation, sorters that would work with optical codes would have a competitive disadvantage compared to other sorters. Therefore, the use of optical codes in textile sorting would only work when it is legally mandated or incentivized. Standards that define the location of data carriers could be supportive for the use of optical codes because the search time can be reduced. This would be especially helpful when they define that the optical code must be visible from the outside so that an optical reader can detect the data carriers when the garment is put on a conveyor belt or sorting table for used textiles (e.g., when placed at the inner neck of an upper body garment).

Compared to optical codes, the use of RFIDs allows the data carriers to be recognised automatically, and thus the process time of the sorting decision is comparable to previous manual processes. Even automatic sorting processes could be supported with RFID tags. However, this time saving could be lost again compared to optical codes if the RFIDs have to be removed before recycling. As described above, durable optical data carriers visibly implemented (visible when laid down on a conveyor belt or sorting table) could be an alternative to RFID technology. Their advantage would be that they do not need to be cut out before recycling (when placed on a textile label). In any case, the use of product data holds the promise that the sorting quality could be increased. For example, more products could be reused instead of recycled or high-quality recycling can be served. Tests in small scales from circular.fashion with TEXAID and within the Tex.IT project support this hypothesis (Schwarz Bour & Jönsson 2020) (circular.fashion & TEXAID 2022). More tests on a large scale will be needed to be conclusive.

It can be concluded that RFID UHF and HF/NFC tags and optical codes such as QR and DataMatrix codes are the most suitable data carriers for textiles. Textile sorters appreciate the benefits of efficiency of RFID UHF and HF tags in the sorting process but they also need to be removed before recycling (circular.fashion & TEXAID 2022). However, RFID UHF tags are not suitable for consumer interaction. RFID HF (NFC) tags can be used for sorting and user interactions (NFC scanner in smartphones). Additionally, the challenges which the WEEE Directive creates by defining textiles as electronics when an electronic tag is included in textiles needs to be solved. The cheapest options for consumer interaction include QR codes and written text, where QR codes provide a more direct access to a web source. For this reason, some textile producers prefer QR codes. This could lead to a situation where fashion brands integrate QR codes while used textile sorters integrate sorting stations for RFID tags. Therefore, it is important to have an alignment along the whole integrated value chain of a product information system. A potential solution to address different target groups could be dual tags which combine for example QR codes and RFID technology in one tag.

4.2.7.7.2 Data carriers for electronics

The characteristics of electronics have a bigger variety through different types of products compared to apparel.

1. For many electronic products reuse markets and recycling streams exist. As product information is needed at this stage, it is necessary to have functional data carriers after the use phase for these products.
2. Durability requirements for this sector depend primarily on how long the products are in use rather than on additional strains to which the data carriers are subjected (e.g., machine washing for textiles).
3. Some electronic products have strong design requirements which need to be considered as part of their functionality.
4. Every electronic product includes metals which changes the recycling requirements for data carriers compared to textiles.

5. The WEEE Directive already provides a framework that regulates the disposal of electronic equipment.
6. Current sorting processes of used electronic equipment include mainly manual steps and it is questionable how helpful product information can be in such a process as electronic products are often very complex compared to textiles.

The argument named against active RFID und Bluetooth tags due to limited robustness for frequent laundry cycles for textile products is not valid for most electronic products. However, the additional reading range which active RFIDs provide is probably not needed which generates unnecessary additional costs. Additionally, they bear the risk that the battery is not working anymore after use. Therefore, the authors come to the conclusion that they are also not suitable for most electronic products.

Durability requirements vary depending on the application, where the service life and area of use have a major influence. For most electronics, the chosen material allows for the use of watermarks. However, the sorting processes of used electronics is less automated than for packaging which reduces the need for a data carrier such as watermarks. Additionally, design requirements for electronic (lifestyle) products are another argument against watermarks.

For the digital nameplate QR codes/DataMatrix codes or RFID tags are used for product labelling (ZVEI 2020). Siemens decided within the DPP 4.0 project to use QR codes as data carriers for electronics due to the high acceptance and good user experience at user level (Wegener D., Interview 2022). Optical tags such as QR codes can be a good solution because the main benefit for electronics is created in sustainable purchasing decisions, reuse and repair. For these processes the efficiency requirements are not as high as for textile sorting. Sorters of old electronics do not see such a big benefit; the use of electronic tags does not add much value to the sorting process. However, durability requirements for optical codes printed on a paper-based sticker can be hurdle. Additionally, design requirements of some product groups can be another argument against optical codes. In this case passive RFID HF/ NFC tags placed in the inside of the product can be a good alternative to avoid design restrictions and enable long durability. Passive RFID UHF tags increase the readability range compared to RFID HF/ NFC tags but lack the readability for private users.

Overall, it can be said that suitable data carriers for electronics are: Non-active RFID HF / NFC tags and optical codes (e.g., QR and DataMatrix). Which ones are more suitable is mainly dependent on the product group. Even if the technologies overlap with textiles, the specific data carrier models will be different due to different durability and integration requirements.

4.2.7.7.3 General conclusions

In the previous chapter pros and cons of different data carrier technologies for textiles and electronics have been discussed. It can be concluded that no data carrier fits all needs of the different subgroups of products. It can also be concluded that innovations can help to serve the cause better in the future. For this reason, the authors of this report recommend that the legislator defines requirements per product group that data carriers must fulfil. These requirements can include aspects of

- minimum durability (e.g., washability of x washing cycles under specified conditions),
- maximal process time to read (for time sensitive processes such as textile sorting),
- minimum storage capacity for unique serialized identifiers,
- implementation guidelines (to avoid removal from user and findability/readability),

- readability for users (e.g., readable with smart phones for private users and affordable reading equipment for B2B and B2G users),
- minimum privacy protection,
- and maximum environmental impact.

The advantage of defining these requirements instead of specifying specific lists of data carrier technologies is, on the one hand, that it is innovation-friendly. On the other hand, the users of data carriers in the supply chain downstream would like to have investment security when they invest into new technologies such as sorting equipment. Therefore, the readability aspect should also define that specified reading equipment (based on standards such as ISO/IEC 18000-6:2013 for RFID) must be able to read the data carriers. If innovative data carrier solutions can proof their suitability, the reading equipment could be updated later.

Physical data carriers are needed for most products especially when they have reuse and repair markets or complex material compositions. Exceptions can be products without such properties and very small products. In this case data carriers could be attached to packaging, user manuals or hangtags. Electronic data carriers will be needed for e-commerce.

A central list of products can be a complementary tool to data carriers, but it cannot replace them. The efficiency requirements in the textile and electronic industry for sorting exclude this possibility.

Takeaways for data carriers

- Data carriers must fulfil several requirements to be suitable for a product information system supporting a circular economy. Durability, storage capacity, not disturbing function during use phase, process time and needed equipment to read, protection of personal data and recyclability are some of them.
- The suitability of different data carrier technologies is dependent on the subgroup of products. They have different requirements in terms of durability, readability, design requirements and other aspects. There is no solution which fits all cases.
- RFID UHF and HF/NFC tags and optical codes such as QR and DataMatrix codes are the most suitable data carriers for textiles today. However, the current version of the WEEE Diretive causes some hurdles for electronic tags.
- For electronics non active RFID HF / NFC tags and optical codes (e.g., QR and DataMatrix) can be suitable solutions.
- Minimum and maximum requirements for data carriers defined per product group can be a good approach to foster innovation. At the same time requirements for accepted reading equipment can guarantee investment security for circular service providers such as sorters.
- For most products physical data carriers will be needed. Exceptions are very small products and products with no reuse and repair markets and simple material compositions.

4.2.8 Identifier

Identifiers are needed to identify products and connect data points and information with the physical product. The following chapter will elaborate different approaches how identifiers work and how they can and should be used in a product information 4.0 system.

4.2.8.1 Need for product identification

As discussed in chapter 4.2.7.2, there are two approaches for using data carriers. Either the complete product information set can be stored on the data carrier directly, or it can be stored in a database or similar system. In the first case, an identifier is needed to link the physical product to the database entry. Since the amount of data points needed by data users exceeds the storage of common and price competitive data carriers, the use of identifiers is recommended. A further option is to save a subset of the product information additionally to the identifier on the data carrier. This would allow to access the subset of product attributes without internet connection and independently of whether product data is still hosted. However, it would complicate the process of encoding the data carriers and increase the necessary data storage and therefore the costs. Furthermore, it would only be feasible with electronic data carriers not with optical codes such as QR.

4.2.8.2 Aspects and requirements for product identifiers

Identifiers to be used in the context of a product information system to support a circular economy need to meet several requirements. These requirements are described in the following paragraphs.

4.2.8.2.1 Uniqueness of identifiers

Product identifiers need to be globally unique in their functional environment (Wautelet T., Interview 2022). This ensures that the information can be clearly assigned to the product, even within different data systems of multiple stakeholders (Hohenecker S., Interview 2022). In order to achieve feasibility of uniqueness, one approach is to split the identifier into two parts. The first identifies the manufacturer and is globally unique. This allows the manufacturer to generate the second part, which only has to be unique within their product range, independently. The syntax of the ID could have a hierarchical logic; a fine ID resolution could be beneficial (Wautelet T., Interview 2022). The length of the number should be defined as a certain serialisation standard e.g., a model identifier could always have a certain number of digits and for the batch and serialised ID, more digits are added.

To avoid confusion, identifiers should also not be reused, even after a period of time. It is possible that certain items will be in use for a long time after production. Therefore, they arrive at the end-of-life services - where the information is needed - only after a long delay.

4.2.8.2.2 Granularity of identification

Identification of products could be solved on different levels of granularity: product model, variation, batch or item level. Ideally the level of granularity of the identifier is clear based on the identification string (Archer P, Interview 2022). Every approach has advantages and disadvantages that need to be considered depending on the use case (Archer P., Interview 2022; Hohenecker S., Interview 2022; Wautelet T., Interview 2022). For example, identification on product model level narrows down the selection of product attributes. Only those could be stored that remain the same throughout the lifecycle for any product of the model in question. While identification on item level allows to also track the use or repair history of an item, it comes with slightly higher costs and space requirements for the data carrier because they must include serialised identifiers. For some use cases, batch identification may be suitable. It allows for a more differentiated notation of production information (e.g., when a new batch of a product is produced with the same design data but in another factory), but no storing of data on item level. For products with mass production which usually go directly from the use phase into recycling or incineration, batch numbers are suitable while serial numbers are not necessary (Archer P., Hohenecker S., Interview 2022). For products where repair and reuse markets exist, item-level serialisation is needed to foster these circular business models. It allows for example that the current condition and actual photos of the used product can be connected to the DPP in recommerce activities. A serialisation in a later stage of the supply chain where serialisation is needed would not be practical and economically not feasible. A repair or sorting company for reuse needs already attached serialized identifiers to use them in a lean way in their processes.

PCDS would prefer serialised IDs as those would help to capture potential variabilities of the product composition that are relevant for circular economy (e.g., recycled content, recyclability). The ID could help identify the detailed material inputs and the manufacturing processes (Wautelet T., Interview 2022). Since companies typically supply materials from different suppliers for the same product model, which can be manufactured in several production sites, the details of the material composition and chemical content might differ between items. Therefore, identification on item level would be especially useful for recycling facilities to use the ID in the product information system and get reliable information for a product.

Since serialised identification, especially with RFID technology, has been associated with concerns around personal data protection (Schuh & Stich 2006), this topic will be taken up in Part D of this project (see chapter 5.2.6.2).

Experts raise the concern that so far there is a lack of clarity when it comes to the identification system of single components in the pre-production and end of use phase of a product (Grillon, EC). It is unclear at which point of the production a product gets an ID and at which point it will lose that ID again after use. Taking the example of a smartphone, it consists of various components such as the screen. The screen consists again of two screen glasses (and more negligible materials in this context) (Ueberschaar et al. 2017). It needs to be defined at which point the data carrier is implemented (Grillon, EC) and if components need a data carrier at all. Most components have a low value, and it does economically not make sense to attach a data carrier to it. The question raised is whether and how the (urban) mined resources used in the components of the product are managed within the identification system. Also, at the end of life, certain parts of the smartphone are more likely to be reused than others and contain more valuable materials for recycling. It should be defined whether some parts should be assigned a separate identifier for the purpose of more detailed sorting.

A concern which is sometimes brought up as an argument against serialisation is that storing product information that is identical for all items on a serialised level creates a massive amount of redundant data. This would come with a high need for storage capacity. However, this can be avoided if serialised datasets, instead of storing a duplicate of all product information, link to a shared source for the identical information on model or batch level.

4.2.8.2.3 Other requirements for identifiers

There are further requirements that need to be considered for product identifiers which are described in the following list:

- When minor changes are made to a product, identifiers may need to change on model, variation or batch level. This requires rules to ensure that two products with the same identifier are produced identically. (Archer P., Interview 2022)
- Identifiers must be a valid reference to the product data until the end of use of a product. Therefore, the identifier must keep working when the data owner discontinues their business activities. (Archer P., Interview 2022) Therefore, using the internet domain name of this company in the identifier can be problematic.
- All RFID tags have limited memory capacity and an increase is expensive. Also, optical codes such as QR and DataMatrix codes grow in size when more data are added. That can lead to

the situation that they do not fit onto the product anymore. Therefore, the smaller an identifier is the better. (Archer P., Interview 2022)

- Every actor in the supply chain must be allowed to use identifiers which have been added to the product from stakeholders earlier in the supply chain. Interoperability between different systems would be prevented if each actor added its own identifiers to the product. (Archer P., Interview 2022)
- Hohenecker and Guth-Orlowski stress that the identification needs to work for each stakeholder involved. Since different companies and service providers already work with different identifier standards, it may be necessary to adapt and establish target group specific options.
- Other desired requirements include the possibility to **resolve the identifier directly over the internet**, by formatting it as a URL. As an alternative a centralized resolver could solve this challenge and thereby shorten the identifier length (see chapter 4.2.4.3).

4.2.8.2.4 Costs of identifiers

Wegener and Grillon suggest that the system needs to allow identifiers that are available free of charge. However, ensuring globally unique identifiers usually creates work and needs some infrastructure. The costs can be created in direct or indirect forms as direct fees from the global issuing agency (GS1), indirect costs of the distributed ledger or trusted data system where DIDs are mostly registered (DIDs), indirect costs for web domain and web hosting when the company URL is used. An exception are UUIDs which are free of charge. Therefore, to keep the costs for product identifiers as low as possible different approaches and solution providers should be accepted as long as they fulfil the requirements for identifiers. (Archer P., Interview 2022)

4.2.8.3 Product identification schemes

There are existing approaches and standards for unique identification:

- **Universally Unique Identifier (UUID)**
  The UUID, also referred to as globally unique identifier (GUID), is a 128 bits long identifier that can guarantee uniqueness across space and time and does not require a central registration or administration process. It can instead be generated by an openly available generation algorithm (IETF Datatracker 2005). UUIDs are originally standardised by the Open Software Foundation and documented as part of ISO/IEC 11578:1996 *"Information technology – Open Systems Interconnection – Remote Procedure Call (RPC)"* and more recently in ITU-T Rec. X.667. (ISO, 1996; ITU 2012)
- **(Serialized) Global Trade Item Number (GTIN, SGTIN)**
  The GTIN is a unique identifier designed for priced products or services. The GTIN is fully compatible with ISO/IEC 15459-4. GTINs are a paid service provided and administered by GS1. They can be extended to become serialised identifiers (SGTINs). For a URI-based format, the GS1 Digital Link (DL) can be used which extends GS1 identifiers such as GTINs or SGTINs to become part of the web. (GS1US 2023)
- **Electronic Product Code (EPC) and serialised transponder ID (TID)**
  RFID tags of Generation 2 can store EPC and TID numbers in the memory to identify the model and manufacturer of the chip. TIDs are based on ISO/IEC 15963. They can include a serialised part to also identify the tag instance. While TIDs are globally unique, the additional tag serial number is defined by the company and could in theory be reused by them. (GS1 2015) If a unique serialised TID and an EPC code are stored on each data carrier in the

product information system, they could be used to identify the product to which they are attached.

- **DID URLs**
  DIDs as introduced in chapter 4.2.4.7.4 can be used as a URL based identifier format for products. The W3C defines a syntax for the DID and the DID URL that all DIDs must conform to. It consists of the string "did", a method name and a method-specific id, separated by colons, that form the domain of the URL. Like generic URIs, the DID URL can be supplemented with paths, queries or fragments. An example of a DID URL could be "did:example:123456/path" (Iannella 2022)

- **Global Textile Scheme**
  As a basis for identification GTS uses GTINs or SGTINs from GS1. On top of that, GTS offers the possibility to augment these identifiers with purchase order and batch numbers and if needed EPC codes for item related data.

- **IEC 61406-1 Identification Link**
  The IEC 61406-1:2022 standard defines minimum requirements for a globally unique identification of physical objects. It provides a link to its related digital information. The identification is called 'Identification Link' (IL) and the encoded data is called IL string. The IL can be attached to a physical product in a 2D symbol or NFC tag. The standard does not define requirements for the identifier itself. The uniqueness is derived from the internet domain name. A disadvantage of this concept is that if the internet domain changes that the URL might not work anymore.

4.2.8.4 Single standard for identifiers versus different formats

Some experts advocate for certain standardised identifiers or data carriers to become mandatory. Identifiers based on the ISO/IEC 15459 (UNECE, Workshop 2022) such as GTIN (Fashion Cloud, Workshop 2022) are named here along with UUID (GTS, Workshop 2022) and DIDs (Spherity, Workshop 2022). W3C suggests using a URI-based format. A newly developed standalone identifier system is not expected to be universally accepted and implemented as it will cost a lot of resources, especially time. (Guth-Orlowski S., Interview 2022)

There are however already different parties providing unique identifiers within the system (e.g., GTIN by GS1). Many companies are already using these different identifiers and do not necessarily show interest in changing. The different IDs are a difficulty for the data exchange and data access (Hohenecker S., Interview 2022, Wautelet T., Interview 2022). Therefore, it could be a simplification of the system if there was only one identifier to use. This identifier could still be linked to the companies' internal reference numbers (Hohenecker S., Interview 2022). Several identifier providers would probably like their solution to be a standardised solution for all (Guth-Orlowski S., Interview 2022).

At the same time, many different IDs raise the competitiveness and ambition to find more innovative solutions and applications of ID management (Wautelet T., Interview 2022). Some experts think that the product identifiers should be handled flexible and interoperable to minimise the barrier of adoption. In the end, different identifier schemes should be allowed to be used if the fulfil certain requirements. A global, decentralised identifier concept could be set up to deal with a wide heterogeneity of identifiers (Avery Dennison, Workshop 2022, Guth-Orlowski S., Interview 2022, Hohenecker S., Interview 2022; Wegener D, Interview 2022). The focus of standardisation should be set on the format of the identifier rather than a service provider, so that the identifiers can be read and dissolved in the same way (Wautelet T., Interview 2022). For example, a URI or URL can be used as the smallest denominator for identification that is resolvable on the internet (Guth-Orlowski S., Interview 2022).

An approach for allowing different identifier solutions is used in the UN/CEFACT system, which does not use a specific standard for identifiers. It does this by combining the data element “global identifier” (available for many entities such as a product, party, location) with another data element that identifies the issuing agency identifier or name. (Heemskerk G., Interview 2022) An option that could be added here is to allow self-created identifiers such as UUIDs (Heemskerk G., Interview 2022). Also, Art. 65 of the Proposal for a Regulation concerning batteries and waste batteries (COM/2020/798 final) refers to such a "unique identifier" without specifying a certain type of identifier or standard (Guth-Orlowski S., Interview 2022).

4.2.8.5 Discussion and conclusions

Identifiers are a crucial element of a product information system 4.0. They are the link to access product data which are saved in the cloud. The authors of this report recommend not to save product information directly on the data carrier but instead link them through an identifier. To be suitable for such a system, identifiers should fulfil several requirements such as:

- be globally unique in their functional environment
- they should not be reused before all products of its kind do not exist anymore
- there should be rules that define when a identifier needs to be renewed after minor changes to the product
- identifiers must be persistent until the end of use of a product
- the size of an identifier needs to be as small as possible
- attached identifiers must be usable for any stakeholder in the supply chain downstream to enable interoperability
- it should be possible to resolve identifiers directly over the internet, by formatting it as a URL.

Due to the fact that multiple stakeholders and industries are already used to work with certain identification schemes, a mandated scheme would cause high costs in the beginning. Approaches such as the UN/CEFACT system show that a system can work with different identification schemes by defining the type of identification scheme. However, not every identification scheme is equally suitable for the cause of a product information system 4.0. Therefore, it can be helpful if the legislator defines certain requirements that identification schemes must fulfil.

Maximum costs should not be a part of these requirements. The issuing and hosting of identifiers is inherently attached to costs that need to be covered. Every stakeholder can choose their identification scheme which creates the biggest value or lowest costs for their business case.

The granularity level is dependent on the use case of a product. The purpose of a product information 4.0 system as discussed in this report is to support circular business models. Under this assumption, serialized identifiers on item level are needed for product groups which have relevant repair, rental and reuse/recommerce services. It can also be enable incentivised tack-back channels after the use phase (to incentivise the former owner for the return). The extra costs for serialized identifiers are very small compared to adding serialized identifiers at a later stage. However, for products that do not have such markets and are usually wasted after the first use identification on variation or batch level is sufficient.

It can be useful to have identifiers on component level as well. However, most components would not need a data carrier as they are not valuable enough for this. The component identifier can be digitally linked to the finished product. In case of a reuse of single components these allocations can also be reassigned to the new product where they are newly integrated.

Next to identification for products, also the stakeholders within the product information system need to be identified. For this, DID and VC (see chapter 4.2.4.5) can be considered.

Takeaways for identifiers

- Identifiers need to be unique in their functional environment. Furthermore, they should be persistent, as small as possible, resolvable through the internet and usable for every stakeholder in the supply chain downstream.
- The granularity of identifiers should be dependent if product groups have relevant markets for repair, rental and reuse/recommence. If they have such, they should be on item level, otherwise batch or variation level is sufficient.
- Several identification schemes should be allowed to use as long as they fulfil certain minimum requirements. The diversity of solutions could be resolved by also storing the type of identifier.
- Identifiers are also needed for the stakeholders within the product information system.

4.2.9 Potential environmental impact

Two of the main goals of integrating a product information system are to pave the way to a circular economy and to minimise the environmental impacts to the lowest. However, the integration of a product information system might cause more environmental problems than it solves (Wuppertal Institut, Workshop 2022 Wautelet T., Interview 2022). A challenge when using technical data carriers is the sustainability, recyclability and waste management of the technology itself (Wautelet T., Interview 2022). The integration might not only improve the value chain and lead to less environmental impacts and a circular economy - instead, it is a concern that the use of the additional resources for the data carriers and the additional energy and resources needed to provide the servers and data exchange will result in even greater environmental pollution and release of greenhouse gases.
Digital technologies and services like a product information system require material and energy themselves before they can unlock positive environmental effects. The fundamental question is whether the benefits of a product information system can exceed the environmental impact of the necessary resources. A comprehensive environmental assessment of both, the benefits and the resources would be necessary to provide an answer to this question. However, the technical characteristics of the product information and also scenarios of the benefits are yet to be defined. To screen literature and available data towards, following elements are seen relevant in a product information system:

- Amount and format of data
  - Storing of pictures and other files
  - Storing of component and material data
- Number of product groups covered
- Frequent data transactions

- Data storage (centralised or decentralised, use of technologies like DLT)
- Data carriers and respective scanning technology
- Additional infrastructure needed for access management solutions (e.g., use of DIDs)

So far, there is no environmental assessment scoping such a product information system entirely. Some scattered studies exist, that analyse the environmental impact of data storage centres (servers) (Gröger et al. 2023) and ICT equipment. (Li et al. 2020) As these aspects are not defined yet and available data is limited, a hot-spot analysis for relevant impacts of a potential product information system is conducted in this study.

System elements with major energy and/or material intensive are assumed as hot spots. The following section presents a hot-spot analysis of the environmental impacts. The description follows the ISO 14040:2006 standard (ISO 2006) standard on the categories for goal, scope, used data, assessment method and a combined interpretation section at the end.

The goal of this analysis is the estimation of the environmental impact for the following aspects:

a) **RFID UHF or NFC tag** (material-based analysis)
For the data carrier, it is assumed that RFID technology is more material and energy intensive compared to QR codes. For this analysis, NFC is chosen for the comparison due to its consumer-friendly properties.

b) **One data transaction**
reading an NFC chip with a smartphone and receiving information, data processing via IT infrastructure.

c) **A comparative electronic product**
The environmental impact of the electronic product is used to estimate the proportion of the impact of the system compared to the potential environmental benefit.

It should be noted that RFID chips of different characteristics exist. Based on the evaluation of different data carrier technologies in chapter 4.2.7.2, passive RFID tags are considered as one of the most relevant. NFC is chosen for the analysis as they can be scanned with smartphones.

The scope for **aspect a)** comprises a material-based approach to calculate the environmental impact of the production of materials for one RFID tag. Thus, the use phase and recycling as well as the production and distribution are not considered.

Table 31 summarises the data for the calculation, which is based on two studies and a standard: First, the environmental impact per weight of the RFID tag materials is taken from the ProBas database (Umweltbundesamt 2023) , which includes all pre-production chains. Second, the standard ISO/IEC TR 24729-2:2008 Recycling and RFID tags (ISO 2008) as well as the study on the impact of RFID on recycling (Erdmann et al. 2009) provided data on the carrier dimensions (15mm x 97mm) and material based approach (heavy and light metals: copper, silver, aluminium, without the cover).

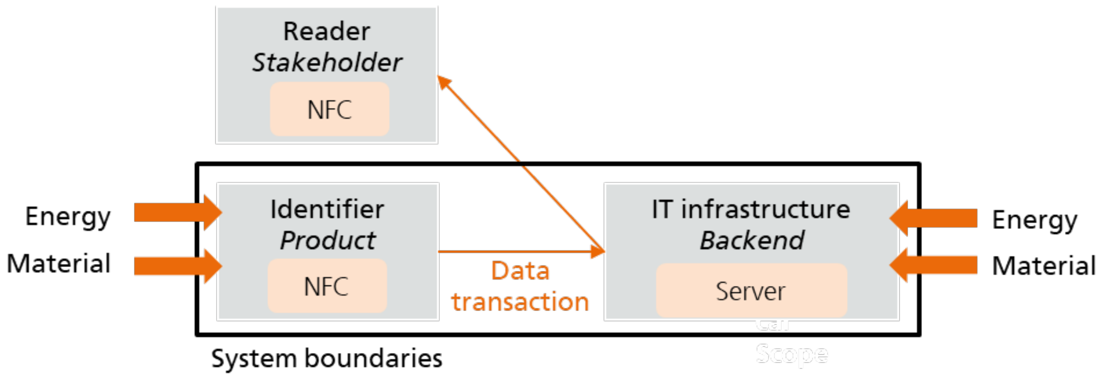
Table 31: Carbon footprint and mass per materials used for a passive RFID tag to calculate the overall CO_2 equivalent of 27.52 gram recycling (Erdmann et al. 2009)

Materials	g CO_2-eq./g (ProBas)	g mass per tag (ISO & UBA)	CO_2-eq. in g
Copper	2.87	0.29	0.82
Aluminium	11.90	0.20	2.34
Silver	123.70	0.20	24.36
Total sum			27.52 g CO_2 eq. per tag

Aspect b) of the analysis comprises four parts: the data sender and receiver, data storage and data transmission. The examined technology for reader and receiver is NFC to represent RFID technology. The environmental impact of NFC readers built into the smartphone is not considered, as these are included in modern smartphones anyway and have no additional impact. Also, smartphones are not usually purchased for the sole purpose of reading product information via NFC tags. The data storage (server) and data transmission are allocated to the IT infrastructure.

Figure 31: System boundaries for the estimation of the environmental impacts of a product information system (grey boxes)

Main elements for one transaction of product information include the identifier on the product, a server handling the information access request and reader for the stakeholder.



(source: TU Berlin 2022)

Although extensive data on the environmental impacts and energy use of servers exists, the allocation of those to a single transaction of data from reading an NFC chip is not available.

A study by Lindgreen et al. from 2018 (Lindgreen et al. 2018) on the environmental impact of debit card transactions shows similar system boundaries as the ones assumed for a product information system in this study: the scoped system considers the resources for one data transaction, NFC chip, server and reader (see Figure 31). The study balances a debit card transaction including a plastic debit card (NFC tag), server and reading terminal (NFC receiver chip). Detailed information on the data inventory for the CO_2 calculation are provided in the study by (Lindgreen et al. 2018):

- Debit card material composition: nickel, copper, gold, epoxy and silicon
- Reader (terminal):

- Energy consumption per reader and day incl. standby-mode, NFC transaction peak current, etc.
- Components: power supply, case, PCB, ethernet controller, USB ports, keyboard, display, etc.

► IT infrastructure (server):

- IT-equipment (high-end server, storage, switches), power equipment (switchgear, generators, batteries), cooling equipment and building structure
- Electricity use: energy mix Netherlands

The system boundaries comprise production, distribution, use and end-of-life. Assumptions for the use phase are made by an estimated lifetime of a debit card of 3,5 years, server of five years and terminal of five years. The impact is aggregated to one year. Data on transactions were taken for the Netherlands in the reference year 2015 with 3,23 billion debit cards transactions (on point of sale, at terminal). The functional unit is one transaction (reading the debit card/NFC chip with a terminal, requesting data from the server). The impact category is climate change total, the associated impact indicator is the Global Warming Potential (GWP100), which is derived from the International Panel on Climate Change (IPCC) model. The IPCC global warming potential method was used to calculate the climate change impact per debit card transaction. Data is used from Ecoinvent 3.0. Database, CE Delft's database (average Dutch energy mix) and primary data was generated (debit card payment system).

Table 32: Environmental impact of debit card, server and terminal per transaction and for Netherlands in 2015

		Impact of all debit card transactions, Netherlands, 2015 (CO2 eq.)	Impact per transaction, Netherlands, 2015 (CO2 eq.)
Debit	14%	1708 t	0,53 g
Data Centre	11%	1342 t	0,41 g
Terminal	75%	9150 t	2,84 g
Total	100%	12.200 t	**3,78 g**

Major environmental impact results from the reading terminal with 75%. This study neglects the terminal, as consumer smartphones are assumed to be used as NFC readers and specifications of NFC reading terminals at other stakeholders (e.g., sorting facilities) are unknown. The debit card is already considered in aspect a) based on an NFC tag. Therefore, only the impact of the data centre is taken as basis for the transaction, which is estimated in this study to 0,41g CO2 eq. for the authorisation and payment process in total. The study does not break down how many data centres are assumed or how many transactions or storage capacity is assumed per data centre. Also, the idle state of the data centre is not considered; but as most of the information already exists in some kind of data storage now, it is also neglectable for the product information use case. It is furthermore unclear how large the volumes of data transferred are and how complex the associated processes are, such as authorization. A transaction of a debit card however only consists of text data while a transaction within the PI 4.0 system can also include pictures. For this reason, this calculation assumes that the transaction impact based on the server is ten times the one from a debit card which results in a global warming potential of 4,1 g CO2 eq. per transaction.

The comparison of a debit card to a product information system (**Aspect b)**) is based on assumptions. For an in-depth analysis further data is necessary to differentiate between different scenarios based on the aspects discussed in this report (e.g., technical specifications of data storage and exchange, security mechanisms, additional infrastructure for identification and access management). Furthermore, the size of the transmitted data can vary immensely, for example based on picture sizes, so a more fitted estimate can be made once data and exchange formats are clarified. Another variable to be considered is whether data centres are powered by renewable energy, which would lower the estimated greenhouse gas emissions for the energy consumption. Altogether, this calculation provides an orientation on the potential environmental impact.

Aspect c): To assess the possible environmental impact of the product information system compared to possible environmental benefits, a proportionality to a common everyday product from the field of electronics is established. For this, the Fairphone is chosen as an example. It emits 43,000 g CO_2 eq. in a full life cycle of three years. This equals 14,333 g CO_2 eq. per year. Production, distribution, use and recycling are considered. Details on the scope, assumptions etc. are described in the Fairphone 4 LCA study. (Sánchez et al. 2022)

For the product information system, it can be assumed that the CO_2 equivalent value for the tag (27.52 g) and (as a high estimate) ten transactions throughout the life cycle of the product (42g) are added to the total of 69.52 g CO_2 equivalent. This equals 0.16% of the full life cycle emissions of 43,000 g CO_2 equivalent. The LCA study of the Fairphone also considers repair scenarios where the use time of the smartphone can be prolonged to five years instead of three (because of the repair). This leads to a reduction of the CO_2 eq. of 4,150 g per year and over the full use phase of five years 20,750 g CO_2 equivalent. It is assumed that environmental impacts of the product information system within this prolonged use phase are already covered in the former assumption which results in 69.52 g CO_2 equivalent. This means that savings of 20,750 g CO_2-equivalent over a period of five years are offset by additional emissions of 69 g CO2-equivalent for the information system. Based on this calculation, if one of 300 Fairphones gets repaired and this leads to a prolongation of the use phase by two years, then the global warming potential of the product information system equals the situation where all Fairphones are used for three years without repair. If more than one of 300 Fairphones gets repaired due to the product information system, then the impact on the global warming potential is positive. These comparisons and calculations are based on assumptions and should be seen as a broad indicator on the potential scale of the environmental impact.

One of the hypotheses of this calculation is that the introduction of a product information system will lead to a change towards a more sustainable behaviour. In this case, the information system is expected to lead to a prolonging of the use phase through repair. Other possible behavioural changes include more sustainable purchasing decisions, reselling products or recycling them instead of disposal and are disregarded for this example. The viability of this hypothesis exceeds the scope of this project. However, the example calculation for a smartphone in this chapter shows that even relatively small behaviour changes (if one of 300 Fairphones gets repaired and the use is prolonged by two years) can compensate for the extra environmental impacts which a product information system creates.

The relation for other product types such as textiles will be different and will need further studies. To get a rough idea of the scale, the ecological footprint of a T-shirt can be used for a rudimentary comparison. (Lehmann et al. 2019) Assuming that a white cotton shirt weighing 150 grams is washed 44 times in a non-fully loaded machine, dried every 10th time and finally disposed of, a study by the Technical University of Berlin comes to the conclusion that the T-shirt consumes about 3,700 g of CO_2 equivalents in the course of its life cycle. Around 50% of these greenhouse gases are emitted during production and distribution. The use of the same NFC tag would therefore have a significantly higher percentual impact for this use case. However, due to the reuse potential that the tag unlocks, an overall positive impact can still be expected.

The heterogeneity between the different studies from aspect a, b and c in terms of system boundaries, assumptions, scope and functional units affects the comparability of the results and shows that more research is required for a detailed analysis.

It is shown that reading terminals have a major impact for the given example. However, in the use case of a circular economy the impact would be lower because of the smaller number of dedicated reading terminals (e.g., in waste management). Other impacts might be neglected, like the information storage on servers. Similar information is largely available on company websites and accessed by consumers already today.

4.3 Overview and evaluation of existing product information systems

In the field of digital product information, there are a variety of systems already on the market to store and share information about the supply chain, the material composition, and the product itself in different sectors and with different objectives and requirements. After intensive desk research and analysis of the experts' assessments, five systems could be identified which appear to be particularly interesting for the electronics and textile sectors, but also across the spectrum. The KEEP system is representative of a well-developed system for the electronics sector. For the textile sector, the circularity.ID is selected. Both systems will be analysed in more detail because the focus of this project was on electronics and textiles. PCDS and RAMI are cross-sectoral systems that are often mentioned as examples of product information systems in use. Since both systems are already integrated in many research initiatives they have been included in the evaluation. IMDS is the preferred system of the automotive industry, which is a sector that already sets high quality standards for its suppliers. This system has already been developed over a longer period of time (IMDS 2023a, 2023c; Vibracoustic 2022). Hence, experience gained can be considered of high value.

The five systems should continually be analysed and included in the conceptualisation of a standard product information system. However, it should also be noted that systems were selected in this project of which the authors already have a broad knowledge. Therefore, future research also needs to consider other systems such as the GS1 Digital Link, GAIA-X etc. which have been named by experts and stakeholders (described in chapter 4.2). The five systems below should therefore not be seen as the final 'best' systems, but rather as examples of good use cases and recommendations for further research.

This chapter gives an overview on the five selected systems based on their goal and scope, including target group, sector, market uptake and regionality (Table 33: Overview of product information systems). Chapter 4.2 evaluates the technological characteristics of such systems in the context of generally available technology.

Table 33: Overview of product information systems

Short name	KEEP	PCDS	circularity.ID	RAMI 4.0	IMDS
Initiative name	Keep Electronics	Product Circularity Data Sheet	circularity.ID	“Reference Architectural Model” for the Industry 4.0	International Material Data System

Short name	**KEEP**	**PCDS**	**circularity.ID**	**RAMI 4.0**	**IMDS**
Sector	Electronics	Cross-sectoral	Fashion and textiles	Cross-sectoral, industrial products	Automotive
Market scope	EU	International	EU	International	International
Technology readiness	Demonstrator	Data model in use	In use	Data model in use	In use
Business model	Non-profit	Non-profit	For profit	Non-profit	Free for suppliers, paid by manufacturers
Target group	Producers, certifiers, consumers, support, remanufacturer, recycler	Producers, manufacturers, consumers, reuse, repair	Product designers, consumers, textile sorters	Suppliers, manufacturers, other customers	Suppliers, manufacturers
Vocabulary, ontology, taxonomy	Planned: Joint information-sharing standard with pre-defined options for data entry	PCDS dataset	circularity.ID Open Data Standard - an ontology to describe apparel attributes and exchange data	Reference Architecture Model Industry 4.0	Material Data Sheet (IMDS 2023b)
Data storage & exchange	Planned: Decentralised storage that allows either the producer of the data or a traceability system provider to store the data Planned: System similar to emails where information is sent to all stakeholders	Distributed data storage on site of the stakeholders	Central data storage; prepared to become service provider in a decentralised system Input: via API/JSON or Excel Output: Consumer product site or augmented sorting decisions	Not applicable (RAMI 4.0 is a description standard, it does not include technical infrastructure)	Central

Short name	KEEP	PCDS	circularity.ID	RAMI 4.0	IMDS
Ownership, liability and data verification	Planned: Different ways to validate data, storing and showing information on the validation process Planned: use of blockchain for integrity	Each supplier owns their product data 3rd party verification process (audit system)	The brand of the product is the owner of the data and is responsible for data verification	Not included in RAMI (RAMI 4.0 is a description standard, it does not include technical infrastructure)	Ownership stays with the data provider (modular system) Basic plausibility checks are performed automatically
Access management and IP protection	Planned: Data stays with the producers of the data and is shared on request Planned: System for a role-based “trusted data access” model	Supply chain partners and brands have full insight into PCDS	Different roles (consumer, sorter) have different access profiles Data can be shared on an optional basis	Data owner defines the access for each asset	Access can be assigned on a project basis or MDS can be made available: Internal Published Sent/proposed
Identifier & data carrier	Unique identifiers assigned to each product by the system For data carriers: Barcode and/or QR code	CAS-No, Product ID code or GTIN, No data carriers specified	Different possible Identifiers: serialised, unique shortcode-URL; tag-IDs or GS1 (S)GTIN/ EPC codes. For data carriers: hybrid RFID + QR codes, NFC (ISO/IEC 15693) or QR codes for consumers	Unique identifiers assigned to each product by the system Description of different interfaces possible (e.g., data carriers or digital interfaces)	Part/item/material number assigned to each product by the system Information can potentially be traced back via identification number

As described for these five systems, the conception for a product information standard can be implemented in different ways. All the named aspects need to be defined in detail to create a clear and easy to understand system which includes a high level of data security and are an efficient tool to optimise the supply chain management and at the same time reduce the environmental impact.

4.3.1 In-depth analysis of selected systems

The analysis of the findings led to selecting three possible solutions which have been already known to the researchers. The systems are considered as relevant examples for different aspects of product information systems:

- The **circularity.ID** is designed for the textile industry. It contains circularity product information for stakeholders along the entire value chain.
- The Reference Architectural Model Industry 4.0 (**RAMI 4.0)** as a reference model for the Industry 4.0 to establish interoperability.
- The International Material Data System (**IMDS)** is a well-established, modular system in the automotive sector for gathering material and other information from suppliers.

In the following chapter, the systems are analysed in more detail towards their suitability as a product information system. Important aspects which were analysed are *data security, modularity, interoperability (open data format, documentation), applicability to other product groups and data quality*. Also, granularity and accessibility are assessed. However, not all aspects are equally relevant in the three systems. For example, the RAMI 4.0 is a data model to increase interoperability which does not set requirements on data security. Therefore, each system is qualitatively described in consideration of their goals.

4.3.1.1 circularity.ID

The circularity.ID, developed by circular.fashion UG (haftungsbeschränkt) (circular.fashion), is a system to facilitate product circularity tailored for the textile industry. The circularity.ID combines several modules:

1. Open Data Standard
2. Requirements for data carriers and identifiers
3. Product platform to save and provide product data
4. Digital product sites for consumers
5. Interface for sorters

The circularity.ID Open Data Standard (circularity.ID 2023) defines product and material data required to enable the prolonged use of products through repair, upcycling, recycling, reuse and care instructions. These were defined through interviews with recyclers, sorters, second hand buyers, repair companies, brands, retailers, consumers, and textile producers. As there are different perspectives from data users (e.g., recyclers or sorters) and data providers (e.g., brands) the standard differentiates between mandatory data (necessary for reuse and recycling decisions and possible to provide by most data providers) and optional data (not absolutely necessary or hard to access). It covers commercial product information, details about production and life cycle stages and material composition. Unlike other initiatives like PCDS, the circularity.ID Open Data Standard aims to store exact values such as percentages of material compositions (as opposed to thresholds or similar). However, to protect data and intellectual property, the circularity.ID platform allows sharing partial data, aggregated data or thresholds with different target user groups based on the need-to-know principle. Access management is built in, showing consumers commercial data (e.g., price, brand or product description) and environmental information, while sorters get specific information relevant to their workflows such as the material composition. Parts of this information are abstracted to meet information needs but do not reveal company secrets. The standard has been released 2019 under an open-source licence and is under continual development (Current version: 4.0, 02/2023). With the goal of maximising interoperability, circular.fashion has several active projects to align the circularity.ID Open Data Standard with initiatives such as PCDS and GTS. circular.fashion is also active in ISO and DIN working groups to standardise vocabulary and align terms with GS1 vocabulary where overlaps exist.

To link the relevant product information to the physical garment, the circularity.ID system uses product identifiers and data carriers. Product data is stored in a central database. The data carrier (e.g., RFID tag) holds a product identifier (e.g., unique number) which links the physical product to the database entry. Product data can be linked on product model, variation (e.g., a shirt exists in two variations: blue and white) or item level. Any commonly used identification standard can be applied for identifying the product (e.g., GTIN or SGTIN/EPC). To develop requirements for the data carriers (e.g., durability, washability, reading range), circular.fashion considered the needs of various stakeholders conducted e.g., from pilot trials with the data carrier at sorting facilities or expert interviews. circular.fashion constantly researches suitable data carriers on the market and provides a portfolio of circularity approved tags to their customers.

The product platform is a centralised data storage tool that provides **access for different target users**. However, it is designed to be part of a decentralised system once such a system is defined. Product data is saved in a centralised way due to the requirement of real-time access in the sorting process where decentralised systems can be too slow. Product data can be created, updated, and deleted via an API for which documentation is available. For smaller brands, a web interface to manage product data is in development. Meanwhile, the brands can submit their data via email using a standardised excel sheet. To explore the possibilities of developing the platform as a trusted service within a decentralised system, circular.fashion participates in the EU funded project System Circularity and Innovative Recycling of Textiles (SCIRT, Horizon 2020 Programme).

To make data accessible to customers, a Digital Product Site can be accessed by scanning the data carrier which opens a URL and informs consumers about the following aspects:

- Production of the garment (origin, materials, product steps)
- Strategies and services to prolong use
- Prepared take back channels
- Collect data and feedback through surveys (e.g., reason for sorting out, resale etc.)

To support all stages of a circular value chain and enable sorting and recycling, the circularity.ID also powers Intelligent Sorting Stations for textile sorters; designed to be implementable to current sorting processes and support sorting decisions with real-time augmented information. It consists of scanners for the different data carriers connected with a computer which runs a sorting software. This sorting software has access to the product platform. It processes the product data into customised suitable sorting decisions for reuse and recycling.

What can be derived from the circularity.ID in reference to the development of a Product Information System?

1. **Standardisation**: The circularity.ID Open Data Standard went through several iterations and is aligned with semantics and taxonomy of other standards. Therefore, it could be a good basis as an ontology for garments (standard for other segments such as footwear, home textiles etc. will follow). While a cross-sectoral universal data set could be defined for the applicability of the system to other product groups, the circularity.ID Open Data Standard could assure that the sector specific crucial information requirements for textiles are included.
2. **Data Carriers:** The requirements for data carriers are tested with sorters and could be a basis for setting standards for the industry. Policy makers should enforce requirements for data carriers and make them standard for the entire industry.
3. **Identifiers**: The circularity.ID identification system supports different identifier protocols and identification on product model, variation or item level which is beneficial

to enable different use cases for different product types. Therefore, it could be used as the basis to develop an identification system that is applicable across sectors.

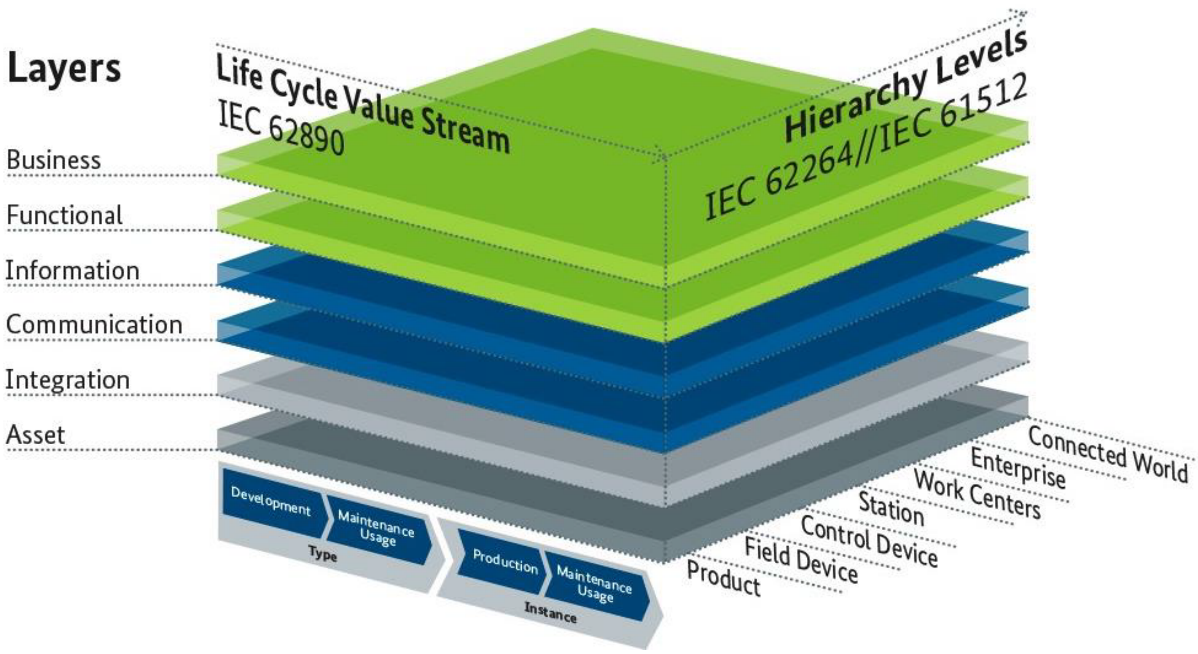
4. The services "Digital Product Sites" as well as "Intelligent Sorting Stations" are good examples of new business models which connect to the product information system and create an added value for participating stakeholders including the achievement of sustainability goals. There are several other initiatives generating product sites, however mostly those are not based on data standards. Furthermore, there are no alternative solutions providing product ID powered sorting solutions.

4.3.1.2 Reference Architectural Model Industry 4.0 (RAMI 4.0)

The "Reference Architectural Model Industry 4.0" (RAMI 4.0) provides a common language within the Industry 4.0 context to improve interoperability and enable communication among all stakeholders (BMWi 2017). It is not a database or visualisation tool with specific information requirements, but a model that enables the structured description of Industry 4.0 assets over their lifecycle. Assets are any kind of physical products or components as well as intangible assets like documents, plans and other objects that can be represented as data. RAMI 4.0 is developed for manufacturers to gain a detailed insight into the interconnection of the production of the products.

As shown in Figure 32, the data model has three dimensions: the y-axis comprises six layers that describe the physical and digital aspects of the asset. The layers must be respected when describing a product; for example, the concept comprises an identification layer, so products must have an identifier. Also, potential product information is allocated here. Specific standards are generally not defined, the choice of stored data points as well as suitable languages, formats and software is left to the respective data owner. The data owner is also responsible for ensuring that the data is correct and usable for the user. The second dimension describes the life cycle stages until the manufacturing stage. Downstream value chain stages like the use or end-of-life stages are not considered but could potentially be included. The third dimension defines hierarchy levels relevant to Industry 4.0 interconnectivity, which is not applicable to consumer products as such but can potentially be extended to other product groups.

Figure 32: Reference layer model "RAMI 4.0" with product relation



(source: DIN SPEC 91345)

The model therefore initially appears somewhat abstract and generic but reflects the necessity and complexity of standardised product descriptions to enable **interoperability**. **Data quality mechanisms** are not considered as a descriptive layer or dimension of the asset.

Based on RAMI 4.0, the ESPR-compliant concept DPP 4.0 is developed, which significantly reduces complexity with a focus on feasibility. It is to be understood as a meta-model to drive an implementation of the digital data of real products and includes the digital nameplate and the so-called management shell.

What can be derived from the RAMI 4.0 approach in reference to the development of a Product Information System?

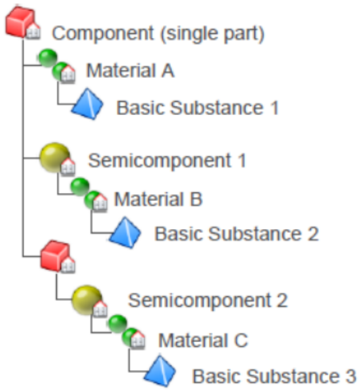
- **Standardisation**: The RAMI 4.0 concept provides a standardised structure, which is necessary for automated processes within an organisation and along the value chain. However, it does not provide an ontology for the information itself.
- **Information Requirements**: The differentiated breakdown of the product into several dimensions and layers allows for a structured description of any asset in a level of detail that is valuable for example for logistics and enables the industry 4.0 concept.
- RAMI 4.0 and the subsequent development of the DPP 4.0 demonstrate the different complexity requirements of the various stakeholders: While manufacturers require a detailed breakdown of the production chains, the complexity can be reduced for most other use cases.
- **Ownership**: In RAMI 4.0 the source of the data is also considered its owner and is responsible for the correctness and usability of the data

4.3.1.3 International Material Data System (IMDS)

The "International Material Data System" (IMDS) was established in 2001 as a joint development of several automotive sector stakeholder (Audi, BMW, etc.) with the goal to meet obligations on automobile manufacturers (and suppliers) of national and international standards and laws. In particular, the collection of material information from suppliers outside of the EU is facilitated by the IMDS, due to the free of costs and multilanguage system. Additionally, the system design and access management follow a modular approach, meaning that information can be added, owned and stored by different stakeholders in a modular way. Data interoperability is given by using an XML format (Extensible Markup Language) and DTD (Document Type Definition) for defining the form and structure of the data necessary for upload into IMDS.

The system consists of a front-end (platform) interface for data provision and access as well as a central database for storage (cloud based). It allows for the registration of new users (companies) and modules including components, materials and substances (see hierarchy in Figure 33 below). Finished products are identified on batch level.

Figure 33: IMDS components



(source: IMDS 2021)

All materials present in finished automobile manufacturing are collected, maintained and archived based on the modular principle. The documentation allows to store all information which might become regulated in the future. Modules follow specific information requirements to meet compliance in the automotive industry (e.g., identification of at least 90% of the substances in the material). Generally, the modular principle enables suppliers to make their information available cross-sectionally to all their customers. The material information is not limited to one specific sector. Other legal information requirements could be implemented and therefore the IMDS system is potentially applicable to other product groups. Data quality control is performed automatically and manually: The system itself automatically checks if mandatory fields are filled in, to some extent it performs checks regarding the contents of fields (e.g., double entries) and on material composition. However, the obligations and responsibility are with the creator and receiver of the data sheet. The IMDS system supports the data quality control by pointing out where human investigation is necessary. Data security is covered with a multiple-layer model of security aspects: physical and network environment protection (by firewalls and server encapsulation), hardware and operating system, database and application security by redundancy as well as all access and authorization processes.

What can be derived from the IMDS system in reference to the development of a product information system?

- **Standardisation:** Data sheets follow a predefined structure but allow for customisation.
- **Data exchange**: Bidirectional communication between manufacturers and suppliers is supported:
  - The information management is based on a modular system where suppliers can add their modules with data that they would like to share.
  - Top-down requirements for information can be added by manufacturers.
  - The multi-language feature facilitates communication additionally. A completely interoperable Chinese equivalent to IMDS is also available. (Neumann 2021)
- **Data storage:** IMDS is a centralised cloud solution. So, it is an excellent blueprint for a centralised solution approach.

- The IMDS system is built on standards that ensure a high quality of information, data governance and convenient usage. Thus, it is widely trusted and used by suppliers and manufacturers.
- There is a useful capacity building infrastructure in place to support the different stakeholders.
- The system is usable free of charge for the suppliers and financed by the OEMs of the automotive industry.

4.3.2 Integration of selected systems

Relevant product information data is currently stored within different available systems. It would be beneficial to integrate them to minimise hurdles in implementing the product information system.

The selected systems however are structurally rather different. While some rely on decentralised data storage, others are centrally organised. So far, there are no standardised interoperable interfaces for exchanging information between the different systems. The circularity.ID has a central data storage that can be accessed through an API, allowing different stakeholder groups to provide and use data. The PCDS relies on distributed data storage on site of the data owners. KEEP has a decentralised storage plan that allows either the producer of the data or the traceability system provider to store the data. IMDS has a complete centralised data storage system. This comparison is also shown in Table 33 . Additionally, access management is handled in different ways: While for example on the circularity.ID platform, different predefined roles with different access profiles exist, RAMI 4.0 allows to define the access on a project basis.

These different approaches for data storage and access management result in the challenge to combine the systems. To overcome this challenge and reach interoperability between the systems, at a minimum, standardised interfaces have to be built to enable data use. Furthermore, access management needs to be unified across systems.

The data sets used by the system providers are partially similar in the selection of the information attributes. However, the data sets are not readily transferable. For example, PCDS uses true/false questions as its basis, thus this information is not transferable to any systems that require exact data. An example for the true/false questions is: “A product composition disclosed at the defined threshold is publicly available. - Choose True/False”. The vocabulary, syntax and semantics need to be standardised or sufficiently unified that a translation between the different systems is possible at least for the mandatory product attributes. Existing standards should be used and aligned. Where they overlap, it should be defined which ones have priority. Integration opportunities of the systems highly depend on the technical infrastructure of the product information system that is to be developed. For example, if a central data storage solution is desired, the information would need to be copied from all the different systems to the central storage, possibly via standardised interfaces. However, this creates data redundancy which is a hurdle for updatability of the data. If, on the other hand, the system is decentralised, there could be options to link to data from different sources without the need to copy them. Data stored on specific platforms such as circularity.ID or IMDS could be connected without having to change the storage location or the established processes.

Where applicable, the different systems could have different roles in a new product information system. The KEEP system and the circularity.ID platform, which are designed to store and provide data relevant to the circular economy, could be expanded to become a storage provider of the information system: They could offer standardised data storage and a harmonised access management system as service providers in a decentralised structure. The data in the system could additionally include links to PCDS data (stored in the PCDS system) to give high level information about circularity and sustainability (as yes/no or threshold values). These could include data about recycled content.

The product information system could also enable additional services: The circularity services that circular.fashion provides (product sites for consumers, intelligent sorting stations) could be integrated to a decentralised system and make use of data from different data sources. +ImpaKT could provide a service to exact data into usable abstract PCDS information using their established processes and offer auditing.

A more comprehensive examination of the possibilities of using different currently existing product information systems is described in chapter 4.4.

4.3.3 Discussion and conclusions

As the different systems are historically grown, have different business models and target different sectors and user groups, they use various approaches for the aspects defined in chapter 4.2. As of now, each system uses a different data standard (or, with RAMI 4.0, no data standard at all) and different identifying technology. While some have a rather centralised data storage, others use decentralised or even distributed storage. The data carriers, access management and ownership approaches also differ. While in some aspects, such as identification, multiple approaches can certainly be allowed and combined, in other aspects, such as exchange formats and access management, stricter standards need to be applied to enable interoperability. The standards to build a product information system can combine approaches from different systems and organizations. Each analysed systems implements different aspects of the product information system but as of now no blue print solution for all aspects is developed.

The systems examined provide learnings for the different aspects:

- **Standardisation**: Standardisation for several aspects of a product information system are needed. The circularity.ID Open Data Standard, provides one piece for the most relevant product information for apparel. The PCDS is a standard to provide circular product data on a high level for multiple industries. Like IMDS, the system should also be designed to allow modular customisation and addition of further data points. RAMI 4.0 delivers a framework that allows using different standards in one system.
- **Data exchange**: Bidirectional communication between manufacturers and suppliers can be beneficial to support top-down requirements for information that can be added by manufacturers as in the IMDS system.
- **Data carriers:** The requirements for data carriers should be tested with the stakeholders that will need to use the data for their role in the circular economy. For the circularity.ID platform for example, data carriers were tested with sorters and consumers.
- **Identifiers**: The circularity.ID identification system supports different identifier schemes and identification on product model, variation or item level which is beneficial to enable different use cases for different product types. Therefore, it could be used as the basis to develop an identification system that is applicable across sectors.

IMDS shows that a central data storage is feasible and trusted for a whole industry. To reach this trust level, they rely on standards that ensure a high quality of information, data governance and convenient usage. However, the automotive industry is an industry with a small number of OEMs which dominate the global market. For that reason, it is easier to force all suppliers to participate in such a central system. Most other industries have a different structure with more

OEMs. The circularity.ID also currently relies on a centralised data storage. One might conclude that a central repository would be preferable. However, the fact that these systems are already used and trusted, actually strengthens the case for a decentralised system; each stakeholder could stay with the data platform they already know and trust. There are several measures that each system must take to achieve the interoperability required to become part of this decentralised system, yet by doing so they can remain relevant as service providers in the product information system and retain their customers. RAMI 4.0 in reduced scope such as DPP 4.0 could be reference architecture for such a product information system. Further aspects including data standards need to be defined to complement the RAMI 4.0 reference architecture.

Takeaways for analysis of selected systems

- Different approaches are used by the different systems on the market for each of the aspects of a product information system due to their different business models and target sectors and users.
- Each system provides aspects which can be used for e product information system.
- While for some aspects, the different approaches can coexist and be used interchangeably, others, such as exchange formats and access management require a harmonised solution that platforms need to adapt to become service providers in the product information system.
- Though several systems rely on centralised data storage, this should not be taken to mean that centralised storage is favourable for a product information system. Instead, the fact that these systems are already used and trusted advocates for a decentralised system, where stakeholders can keep using the data platform they already know and trust.

4.4 Matching identified information barriers with available data sets

The following section evaluates available information sources that are potentially suitable to meet the stakeholder information demand.

Part A of this study focuses on describing and evaluating the information requirements outlined in legal acts. It analyses gaps and barriers using objective criteria. These criteria assess three key aspects: the presence of the information requirement in legislation, its availability from the obligated stakeholder, and its usability for the target stakeholder. Building upon this analysis, the study identifies five specific categories of information gaps and barriers as follows:

- **Legal information gap**: The information requirement does not exist, e.g., due to exemptions.
- **Availability gap**: The information requirement does exist in legislation but is practically not provided or available.
- **Accessibility barrier:** The information requirement exists and is available but cannot be accessed.
- **Format barrier** (interoperability): The information requirement exists and is available but not in a useful format.
- **Granularity barrier:** The information exists, is available and can be accessed but is not specific in its level of detail or can be too detailed or too aggregated.

These gaps and barriers were identified primarily regarding information requirements related to material, product design and service and circularity. To create a product information system with fully available and usable data sets and full interoperability, these barriers must be overcome.

The legal information gap can only be solved with stricter and more comprehensive regulations. Voluntary approaches may help to bridge the gap until these regulations will come into force, but they cannot replace them.

Availability gaps should be closed by improving enforcement and education on the necessity of the information. Voluntary approaches like the circulartiy.ID, IMDS, or ToxFox[53] can assist specific in the process of making more data available by demonstrating the need for the information, providing a platform to store them and offering support in the gathering of information.

The barriers identified in Part A concerning accessibility, format and granularity can be overcome by storing information in voluntary data platforms on condition that they are accessible and interoperable and store the information at the right level of granularity.

4.4.1 Possibilities of using data from existing systems

Since product information is already available in various databases at the companies or on online platforms, these databases could be considered as sources. The information in the databases could be transferred or linked to fill information gaps. The following requirements were identified for a system to be usable as a data source to fill information gaps:

1. **Granularity**
   Information needs to be product model, batch or item specific. Statistical information e.g., on material streams of the industry is not sufficient to fulfil the information requirements that arise e.g., from repairers or recyclers. They need information at least on product level.
2. **Accessibility**
   A minimum subset of the information access needs to be free of charge. If automatable use cases such as textile sorting should be enabled, there needs to be a download function or API to access the database as a machine user. Information that is only accessible through a human interface such as a website cannot be automatically processed to become part of the product information system.
3. **Interoperability**
   In order to provide interoperability, documentation of the dataset and access possibilities needs to be openly available. Additionally, a non-proprietary data format is necessary.

The search on potential data sources is based on generic web search, websites, software and communities. A detailed breakdown of the findings including links to the data sources can be found in the table in Annex 6 (Database - Information Sources). Summarizing the analysis, for almost all data points identified as having limited availability in Part A, at least one voluntary data platform exists that provides for the storage of that data point. Exceptions to this are durability test results, usage history and repair history.

However, the possibility to store datapoints in specific databases inherently does not overcome the barriers described. Table 34 reflects the limitations of the data sources in terms of

[53] ToxFox (https://www.bund.net/themen/chemie/toxfox/) is a Smarthone app by the BUND that is designed to enable consumers to gather information about hazardous substances in products. It utilises the legal obligation of manufacturers to share data on hazardous substances on consumer request, stores the information and makes it freely available to its users. in the context of the project, a Europe-wide database under the name AskREACH is also being established.

granularity, accessibility and interoperability. Material information coming from e.g., raw material information systems, Minerals4EU, etc. (primary materials) or urban mine platforms (secondary materials) are publicly available and well documented but not linked to product models or variations. To enable the goals of the different stakeholders in the circular economy, averages per product group are however not sufficient. The demanded information, e.g., on recycled content, material properties and full material declarations needs to be linked to a specific product so that the information can be used e.g., to prepare suitable feedstock for recyclers.

The SCIP database potentially provides the functionality to link substances of very high concern to articles and complex objects (products). Although this is mandatory, it is not always applied in practice, resulting in data gaps. (Oertel et al. 2018) Furthermore, the information demand is not only on the SVHC content but the full material declaration. Another limitation of SCIP is the interface (API) which allows the user to write data automatically but does not provide a download or reading endpoint to access information.

The EPREL database has similar functional and technical characteristics as SCIP and both were established due to legislative initiatives on the European level. While SCIP contains cross-sector material information, EPREL contains technical, design and service information as well as a comparison function for electronic products as mandated by the 2017 Energy Labelling Framework Regulation. General company and product information as well as functional and technical specifications are useful to determine the field of usage as well as supplier details (if provided).

Table 34: Overview of suitability of different possible data sources

Data source	Granularity	Accessibility	Interoperability
Public websites/database Material data (primary raw materials): Raw Material Information System (RMIS), Minerals4EU, Exiobase/Panorama Material data (secondary raw materials): Urban mine platform (UMP) Circularity data: European Platform on Life Cycle Assessment (EPLCA), ProBas	No relation to product models. Average material composition per category	Public, can be downloaded or accessed via API	Documentation and meta-data available, non-proprietary format
Public websites/database Material data: SCIP General and technical data: EPREL	Product or component variant	Public, write-only API	Documentation and meta-data available, non-proprietary format

Commercial software/database Enterprise or life-cycle data: ERP, PLM, PIM systems Environmental assessment (data): Ecoinvent, GaBi, Simapro	Potentially product model, batch, variant, item	Non-public or commercial, can potentially be made available	Potentially yes (manufacturer own interest for reliable data, documentation and interoperable data-format)
Websites Sector specific data: GSMarena, areamobile, Open Repair Alliance General, technical, material and circularity data: Price comparison websites (idealo.de, geizhals.de), Websites of labels, retail platforms	Product model or variant	Public, cannot be downloaded automatically	No documentation, reliability or data-format unknown

Large enterprises often use information systems for enterprise resource planning (ERP) and product lifecycle management (PLM) or product information management (PIM). Such systems do not constitute databases with publicly available data, but rather a software to manage company individual data on product and enterprise level. PLM and PIM systems focus on the management of assets (products) by gathering accurate and complete product information e.g., technical specification, lifecycle information and metadata. The software does not limit the type or amount of information but will rather be adapted to the information demand of the individual company. The underlying software assembles the data from various internal and external sources and manages data transactions by access management. However, the information included in such systems is non-public, but can be made accessible individually to specific roles or stakeholder groups. Thus, it holds great potential to collect and distribute the relevant data if demanded by the company. Such systems could potentially become part of a decentralised product information system by standardising interfaces and access management systems. In this way, data can be stored in the form that companies are used to, processes would barely have to be changed and the data could still be made available in the desired form. However, the precondition is that various PLM and PIM systems are adapted to the standardised formats and access management. With current systems, interoperability is not available.

Other sources of information include publicly accessible websites like retail and product comparison platforms or domain and community driven websites. These allow to look up single products or search for them. Depending on the website, retailer and product some information are available like the product category, type, description, attributes, sustainability certificates and warranty information. Other information e.g., on recycled material, staple fibre length or disposal instructions are rare. This reflects the disadvantage of information from public websites: their quality is heterogeneous concerning availability, granularity and interoperability but also language, semantic and accessibility (e.g., information in pictures). Furthermore, data can usually not be downloaded as datasets or accessed via an API.

4.4.2 Strategy for closing information gaps

In Part A of this project, information gaps are defined as information that is needed by the stakeholders in the context of the circular economy for which no legal requirement for disclosure exists. A list of information gaps has been gathered from currently applicable legislation. In chapter 4.4.1, an analysis has been conducted on currently used product information sources. It was analysed how they could be used to fill the information gaps. The analysis shows that for most data points required, there are storage systems that already allow users to store the information. However, since there is no legal obligation for data providers to store this data, there is no guarantee that the data of a certain product is available or accessible. Additionally, a large percentage of the available information is either not accessible or requires substantial effort for gathering and data quality control. Barriers of inaccessibility and unusable formats can theoretically be overcome by adapting the systems. If available datasets are to be used as part of a product information system, a revision of the data platforms is needed to harmonise access possibilities and data standards. Unavailable data, however, cannot be overcome.

4.4.3 Discussion and Conclusions

In conclusion, some of the information could be gathered from voluntary data management systems, but as long as the data is not legally mandated, the information gaps cannot reliably be filled with any of the systems examined. There are two strategies to deal with currently unavailable data:

Legislation can be amended to require provision of a minimum data set that needs to be available and accessible for specific stakeholders and includes all the required information. Strategies and possibilities will be examined in Part D of this project.

An alternative approach, that could potentially also be used to bridge the time until the legislation comes into effect, is to use average or estimated data. For this approach, generic data from lifecycle assessment databases, secondary sources, standards or simple estimations could be used as a basis (e.g., ProBas). If this kind of average and estimated values are used, they should be clearly marked as they have a lower information content. In cases where the correct value is crucial (e.g., because a certain material could damage recycling technology), the products should be excluded. Also, no certification should be made based on such numbers. However, it is questionable if it is worth investing time in such a bridging solution as the other approach can build up on pre-work and therefore could be achieved in a reasonable time.

While the requirements for the DPP are still being developed, the existing systems can of course continue to be used to the usual extent. The authors consider the effort to add any missing information fields to be justified. They would however advise against investing in the harmonisation of e.g., access management as long as no clear requirements are given.

Takeaways for closing information gaps

- To qualify as a source to close information gaps, product information systems need to fulfil the requirements of granularity, accessibility and interoperability.
- Additionally, the information needed to close the gap needs to be mandatory in the system and all products need to be registered.
- Since these requirements are not met by any of the systems, closing information gaps should not rely on existing voluntary product databases.

- Strategies for closing information gaps are to either mandate the data by legislation or use average or estimated values instead. The latter approach results in less information content, so that certain conclusions cannot be made from the data.

4.5 User profiles and access right management

In this section, role profiles for access management are proposed for five specific stakeholder groups in the textile and in the electronics sector. The proposal for specific roles and their access rights based on the theoretical and technical discussion of access management in chapter 4.2.6. Implementation should be based on the results presented there.

To structure the data usage rights, the four roles data source, data owner, data custodian and data user have been defined as described in Table 35. For each particular attribute, data source and owner have full access for reading and adding data. In case a product dataset has multiple data sources for different attributes, the sources only have read and add access to the attributes that they contribute. The option to update existing data can be given to data source and owner if needed; however, some approaches that prioritise integrity do not allow updating of data in general. Data custodians are usually the platform providers that ensure accessibility of the data. They can be given limited read access by the data owner. As providing a data platform is a facilitating role, it is disregarded in the further analysis. The data user also has limited read access to the subset of data needed for their role in the circular supply chain. The report concentrates on the role of the data user for the different attributes because this role is particularly relevant when it comes to developing user profiles based on the need-to-know-principle. Moreover, the question of ownership has yet to be clarified as described in chapter 4.2.5.

Table 35: Usage rights of different roles in the product information system

ROLE	READ DATA	ADD DATA	UPDATE DATA
Data source	Full access	Full access	Depends on approach
Data owner	Full access	Full access	Depends on approach
Data custodian	Limited access	-	-
Data user	Limited access	-	-

The allocation of these roles is based on the results of Part A and Part B, where information demands of different stakeholder groups were identified. A table was created to map the data requirements to the different stakeholder groups (see Annex 10).

Some of the data requirements defined in the previous analysis leave room for interpretation. For further research, a survey was sent out to the advisory board of the project. Results of the survey can be found in Annex 7. The results of these analyses are used as an overview and basis for further investigation; however, it should be noted that the scope of the workshop and surveys does not allow for representative statements about the individual user groups.

A heuristic approach was chosen to bridge the missing information. Based on the information received and the researchers' experience in building product information systems, the researchers developed a proposal for the specific roles that stakeholder groups have for the different attributes in the system. For this proposal, five different actor groups are taken as a basis for the analysis (see Table 36): Producer and distributer in the design phase, producer and distributors in the supply chain, consumers and consumer-related stakeholders, repair and waste treatment as well as public and civil stakeholders.

Table 36: Actor groups and corresponding stakeholders

Actor Group	Phase of Lifecycle	Corresponding Stakeholders
Producer and distributor	Design phase	Product developers, designers, manufacturers
Producer and distributor	Supply chain	Raw material producers, importers, product manufacturers, suppliers, distributors, retailers
Consumers and consumer-related stakeholders	Use phase	Consumers, consumer organizations, consumer protection
Repair and waste treatment	Use phase; End-of-life	Repair companies, upcyclers, used goods dealers, waste disposal companies, waste treatment technology, producers of secondary raw materials
Public and civil stakeholders	Across the whole lifecycle	Procurement bodies, certification bodies, market surveillance authorities, scientific and political authorities, civil society actors

Since the concrete information requirements of the individual roles may differ (for example, market surveillance authorities may have different information requirements than certifiers though both are public and civil stakeholders), the approach chosen was to use specific representative roles per actor group, rather than the group itself, as the basis for developing the role profiles. In this work, the corresponding five role profiles are exemplarily developed, validated, and presented. A similar approach can be taken for other role profiles. Should very similar or identical information requirements indeed arise for larger groups of actors, the role profiles could then be subsequently combined, or continue to co-exist, in order to simplify future changes per role profile. Stakeholder groups were chosen that represent the different phases of a supply chain with different information requirements, as listed below. In the proposed user profile model, the role of the data user was specifically analysed.

Textile:

- Producer and distributor / Design phase: Product design/Development
- Producer and distributor / Supply chain: Material producer
- Consumers and consumer-related stakeholders: Consumer
- Repair and waste treatment: Textile sorter
- Public and civil stakeholders: Certifier

Electronics:

- Producer and distributor / Design phase: Manufacturer/Designer
- Producer and distributor / Supply chain: Material Producer
- Consumers and consumer-related stakeholders: Consumer
- Repair and waste treatment: Recycler

- Public and civil stakeholders: Certifier

The proposal for role based access management was subsequently put to the test and refined in the course of the project within the framework of the demonstrator front-end. To create a comprehensive access management system based on the need-to-know principle, in which all stakeholder groups only have access to the information they need to realise their role in the circular economy, a large-scale stakeholder survey is necessary that exceeds the scope of this report. This comprehensive survey should also include the levels of detail and protection that the data points should have in the system.

4.5.1 Demonstrator front-end

The demonstrator front-end has been built to show stakeholder groups a potential front-end of the product information system and receive concrete feedback for it. The demonstrator builds on the previously presented access management. It comes with separate views for the five different user groups based on the need-to-know principle. For a clear overview, the information requirements have been divided into categories which are displayed as individual pages of the front-end. The mock-ups for textiles and electronics were created using the tool Figma. They were shown to representatives of the different user groups in the format of workshops where they could click through the demonstrator and leave feedback on questions.

The final stage of research involved semi-structured user research interviews with five expert stakeholders working in consumer organisations, a certifier material production, sorting and a large textile brand. Users were asked to explain their thinking out loud while using the FE Demonstrator prototype. The semi-structured format included both prepared and unprepared questions and provided a way to ensure comparable results while still allowing for probing of user feedback to allow discovery of insights.

This section describes the final design of the demonstrator after the workshops and interviews as well as further results and findings of the workshops and interviews.

4.5.1.1 Design

After collecting feedback on the data fields required by different stakeholder groups, these fields were then organised into categories by clustering and theming. An iterative process was followed with different data fields being adjusted and moved to other categories following feedback throughout the workshop and interview phase, also integrating feedback within the project team. The categories themselves were also renamed and edited throughout the process based on participant and expert feedback. A comparative overview of the initial suggestion versus the final results can be found in Annex 11.

Initially, the categories were developed separately for each product to weigh during research whether there were similarities or necessary differences between the two different product types. A good example of this is the Usage and History page which appears in the fridge but not the T-shirt prototype due to the expectation that a repair history is more useful for a fridge than a T-shirt. Differences between the two prototypes are rooted in the different information requirements that stakeholders stated throughout the project.

This list gives an overview of the data allocated in the different sections of the demonstrator. Screenshots of the different pages can be found in Annex 12.

- **Product overview**
  The Product Overview provides the basic details of each product, including product images, identifiers, brand information and product categories. Some of the information is repeated from other categories to display the most important information at a glance. For the

demonstrator prototype of the refrigerator, the data used came from the information provided for a similar product in the European Product Registry for Energy Labelling (EPREL) database.

- **Product specifications**
  The specifications pages show more detailed information for each product. For the demonstrator prototype of the refrigerator, the data used came from the information provided for a similar product in the EPREL database. In this case the textile and electronic mock-ups feature different layouts to consider the different types and details of information available for each. The EU energy label and WEEE Directive disposal notices were also included here.

- **Materials and composition**
  The Materials and Composition section features information related to the materials. For textiles, this includes the fabric type, recycled content information, material durability test results and safety information. Material durability test results could also fit into the Sustainability and Circularity section, but the authors of this report decided to put it here because it is an information on material level and not product level. For the electronic item, there is a list of components, information on recycled content, hazardous materials, and a full material declaration.

- **Usage and history**
  Usage and History was only included in the electronic prototype and features information about the lifecycle of the product. For product groups with serialised identifiers, information like sales history and repairs could be added to this history.

- **Service**
  The Service pages were mainly intended to give consumers information about how they could care for, repair and dispose of their product in the best way. It includes details from brands about potential takeback systems, WEEE information and a Service Finder where users can search for repair and recycling operators. The hierarchy of the page prioritises product reuse and repair over recycling and disposal.

- **Sustainability and circularity**
  The Sustainability and Circularity page features information related to environmental impact and sustainability certificates. Detailed data from an LCA/PEF was included to evaluate whether this was understandable and/or valuable to users.

The subset of sections that is shown to users is based on the role-based information requirements; an overview of which information is suggested to be shown to which user groups is presented in chapter 4.5.4 (Table 37 and Table 38).

The demonstrator features global navigation in a left sidebar menu (see Figure 34: Screenshot - product overview page of the t-shirt demonstrator a. Global navigation b. Top bar with main product information c. Product identifiera., Figure 35: Screenshot - product overview page of the refrigerator demonstrator a. Global navigation b. Top bar with main product information c. Product identifiera.) that remains consistent across all pages of the interface. A top bar also provides the main product information - image thumbnail, brand, product name, ID and a direct link (URL). In the bottom left is an option for changing the user profile role – this would not appear in a live version of the DPP but was included to allow feedback from users on different profile views during testing. Figure 34 and Figure 35 show an overview of the demonstrator for electronics and textiles, respectively. More screenshots can be found in Annex 12.

Figure 34: Screenshot - product overview page of the t-shirt demonstrator a. Global navigation b. Top bar with main product information c. Product identifier

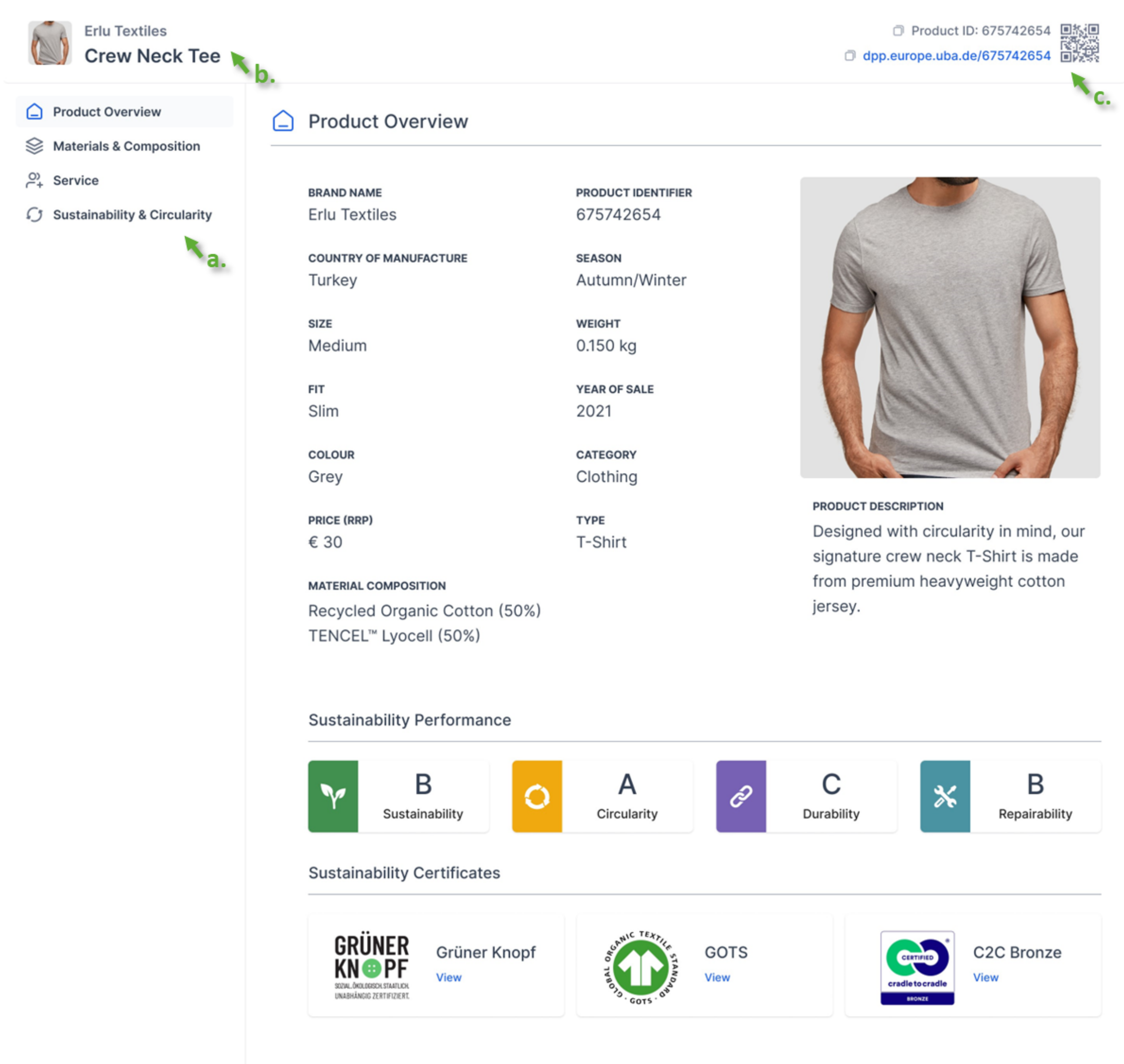
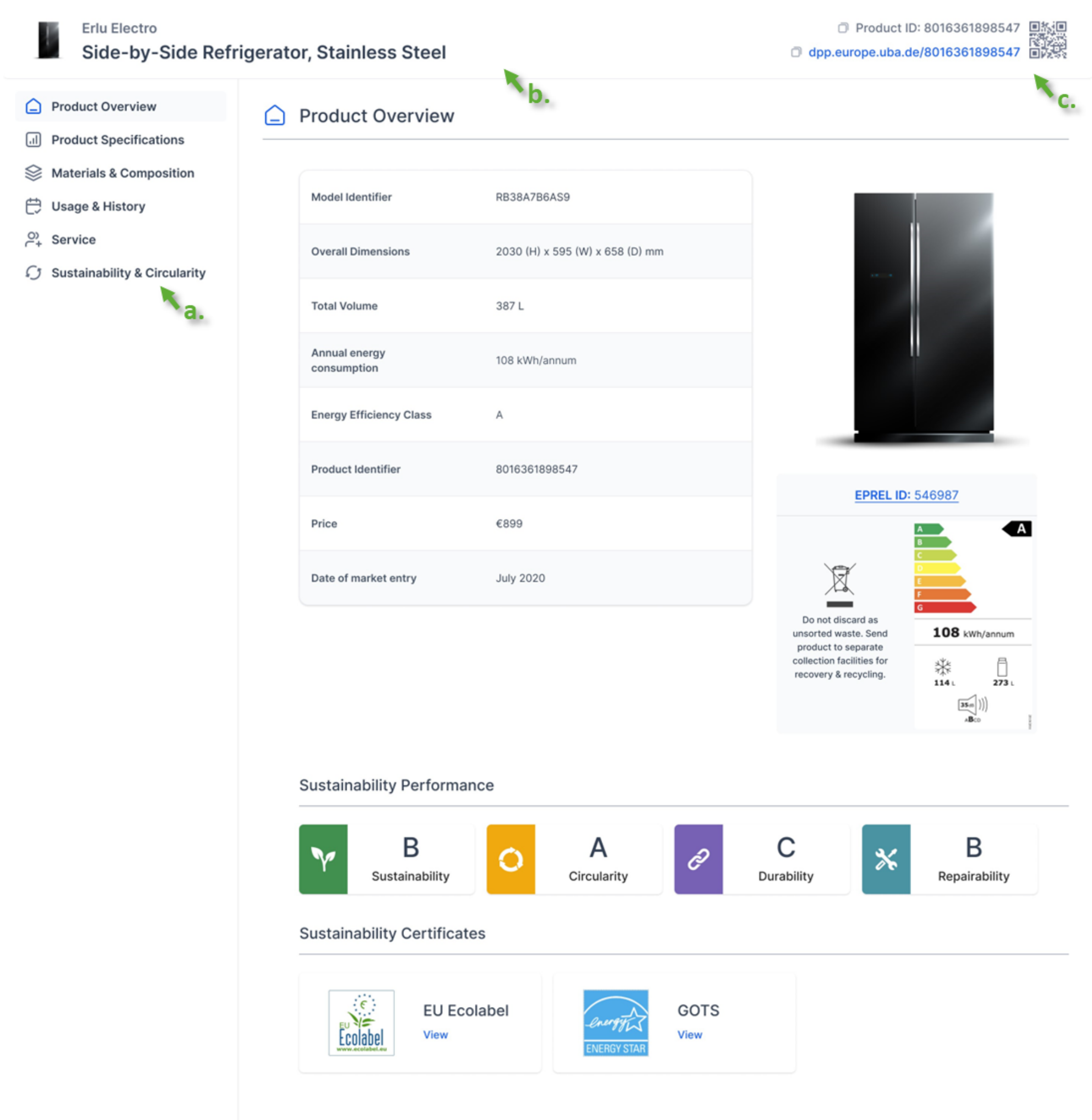


Figure 35: Screenshot - product overview page of the refrigerator demonstrator a. Global navigation b. Top bar with main product information c. Product identifier



4.5.1.2 Results

In the stakeholder workshop, more than 90% of users stated that they could successfully use the interface and that it was easy or very easy to navigate. There were delays for some users in loading the Figma prototype/Useberry survey and these negatively affected the record metrics.

In general, users were able to navigate around the interface and find information easily. Some information was too detailed or technical to be well understood for consumers. More context or data for comparison was requested to help with understanding. Consumers expected a quick understanding of how sustainable a product was without having to sacrifice access to detailed information. They wanted to know how they could trust the information. The details provided a certain level of trust. More general information raised suspicion of greenwashing. Users (particularly consumers) wanted traceability through the supply chain and sought more specificity on environmental impacts at each process step. Users wanted knowledge about social and working conditions in addition to sustainability and circularity concerns.

The feedback provided in the semi-structured stakeholder interviews ranged from questions and confusion about specific product attributes to more general insights about the purpose and value of a product information system.

Heatmap analysis

Heatmaps are a user research technique used to visually represent data collected from user interactions with a user interface (UI). They help to evaluate the effectiveness of a UI by tracking how users interact with it, such as which buttons or links they click on and how long they spend on certain pages. Heatmaps help to identify areas of the UI that are confusing or difficult for users to navigate, as well as areas that are particularly effective.

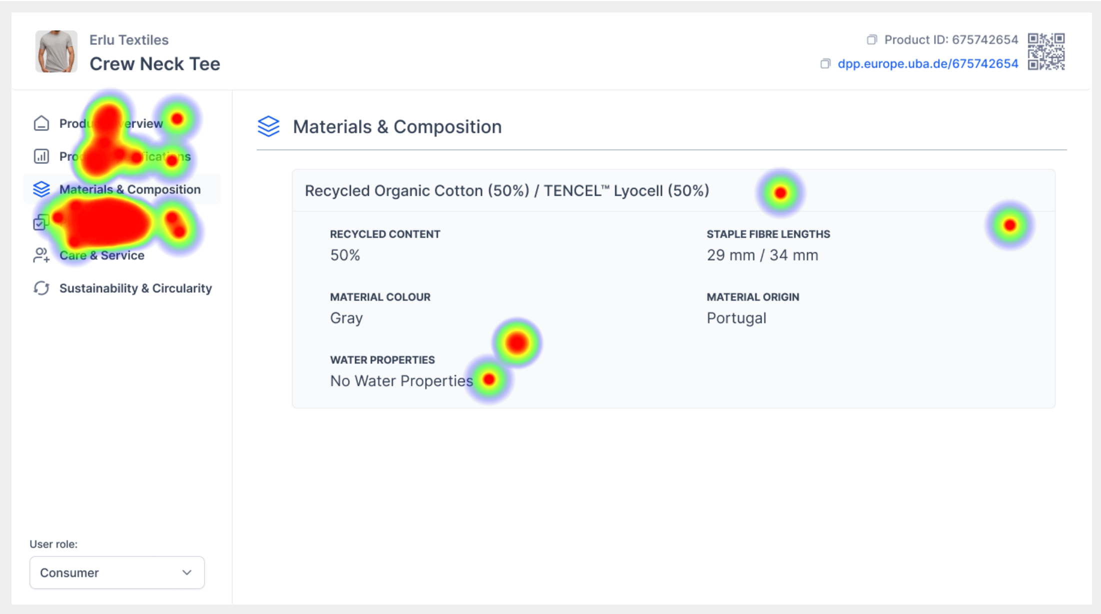
Heatmaps were created for each workshop and for each page of both products. There were no noticeable differences in click patterns between each workshop or between product types. This is expected given the navigation pattern was the same for both products and that the navigational structure is fairly common in other software interfaces.

The heatmap included in this report (Figure 36) is an example heatmap from one workshop for one product on one page. All heatmaps were reviewed and similar patterns appeared in each. The example given is representative of the overall pattern i.e., main clicks appeared on the left navigation menu with a few outlier clicks on the right content side. Outliers mostly appeared on interactive components like links and occasionally for other non-interactive values like “Water properties”.

Overall, there were 200 participant interactions recorded in heatmaps (127 for the T-shirt and 73 for the fridge). The example given represents 20 participants and the pattern of interaction with one page of the T-shirt prototype.

The heatmap analysis shows that the global navigation menu in the left sidebar was effective in allowing users to find the relevant page or screen of the demonstrator. Overall, there were few clicks outside of the main navigation or interactive elements, suggesting that users were not surprised or confused as to which elements were interactive or how to navigate the interface. In some cases, specific data elements were clicked on. In general, this occurred on data points of a highly technical nature or on sustainability certificates. This suggests more information or context was sought by users on these subjects.

Figure 36: Heatmap analysis – Mouse user interaction is colour coded (red = most clicked areas)



4.5.2 Insights to user group results

Within the stakeholder workshops, the participants were asked questions on how usable they found the prototype, what additional data they would request and further ideas they might have. This chapter summarises the results by user group.

4.5.2.1 Certifiers/Market surveillance

The sustainability and circularity section was the most relevant for the Certifier and Market Surveillance user group. Participants generally had a positive assessment of the amount and detail of the information provided but there were some concerns regarding the clarity and presentation of the information provided. For certifiers, it was important that sources of data were also displayed and there should be a clear distinction between primary and secondary information. Participating certifiers sought more information on the traceability of the supply chain with specific information about resources and materials used at each stage. Information on durability and chemical use were also important to market surveillance representatives.

Additional data requests: Participants suggested the following additional data: purchase date; allergenic material details; where to find spare parts (like zippers and buttons); transportation methods; a list of Substances of Very High Concern (SVHC); data source information; traceability information.

Takeaways: To ensure users understand the relevance of technical information, data should be presented with reference to the overall scale used for assessment and could be compared to other products or industry averages.

4.5.2.2 Supply chain/Manufacturers/Brands

Participants in the Supply Chain and Brands user group would benefit from the ability to compare product scores with others in the same category. The use of average comparison scores could help provide context to the data provided. Overall, the sustainability scores were viewed as lacking context. Participants appreciated the Life Cycle Assessment (LCA) values but sought more details about the method used and an indication of the significance of each value. The inclusion of repair information and manuals was highly rated.

Additional data requests: Information relating to laundry and wash cycles was seen as important for participants operating in the workwear and commercial laundry industry and a unique identifier for textiles was suggested to track wash cycles. However, these data should only be created on an optional basis in laundry specific data systems.

Takeaways: Similarly to the Certifier user group, Brands and Manufacturers sought further context to the data values given. Similar fields such as product and material durability should be presented in a similar way.

4.5.2.3 Reverse supply chain/Sorters/Recyclers

Participants highly rated the relevance of the Sustainability and Circularity and Materials and Composition sections. Sorters and Recyclers expected more information about recycled content and stated that a percentage was not sufficient or helpful. Highlighting components, materials and substances which need to be separated according to waste legislation would help reverse supply chain operators make faster and more accurate decisions during sorting and disposal.

The placement of restricted substances information would be more useful for this user group if it were placed in the Material and Composition section.

Additional data requests: Participants suggested the following additional data:

- Dyes
- Additives on the fibre
- The type of recycling fibre used
- More detail on the composition and materials of trims, yarn, buttons, labels and zippers.
- Material details on multi-layered textiles (e.g., Jackets) should be divided and presented by layer.

Takeaways: Like other user groups, Sorters and Recyclers saw the value in using aggregated data from the overall product information system. However, the need was not only to better contextualise data but to identify specific parts in a product that were the most valuable or the most concerning during disassembly and disposal.

4.5.2.4 Consumers

Consumers found several sections highly relevant with information about how the product was made and the Care and Service sections rated the highest. Usage History was also rated highly (for electronics). While Sustainability and Circularity were not as frequently rated as relevant, the items on that page were the subject of most of the subsequent feedback from consumers, suggesting that the level of interest in this area was very high. Several users found the data on sustainability and circularity overwhelming and sought more context to understand the sustainability of a product. Most users wanted to quickly identify how sustainable a product was and several suggestions on how to achieve this were proposed:

- Including a summary of the data and an explanation of what it means
- Giving the data a score with a comparison to a benchmark or average
- Using a traffic light system to easily identify good and bad indicators

Sustainability certificates were considered important but were not prominent enough in the demonstrator. Warranty information was not clear to all users and they wanted to know if it was still valid and specific to their location.

Additional data requests: Participants did not feel they had enough information to make decisions about recycling options and sought knowledge about work standards and social conditions of employees through the supply chain.

Takeaways: While Consumers wanted to understand the overall sustainability score of a product quickly and easily, they also wanted to maintain access to more detailed information. Access to this data helped users to trust the information provided and more general information was treated with some suspicion. Sustainability Certificates should be featured more prominently than in the current iteration of the demonstrator.

4.5.2.5 Product design screen - qualitative statements

The latest version of the product design screen was not well understood and there was some confusion as to the metrics there (Seam Slippage and Dimensional Stability) being shown under the term “design”. The brand representative felt there was a need to explain circularity strategies that influenced the product design but that the metrics presented did not fit this purpose. An earlier version of the prototype had shown similar statements but feedback by stakeholders showed a valid concern with greenwashing. Some circular design strategies are difficult or impossible to communicate through quantitative data. Qualitative statements summarising completed circular strategies do have value, but these statements need to be verified by trusted third parties or government bodies.

4.5.2.6 Specific ideas and requests

Within the workshops and interviews, some of the participants brought up ideas for the product information system. A detailed description can be found in (Annex 9).

- **Traceability, supply chain transparency and social conditions**
  Participants highlighted the importance of traceability and supply chain transparency. They expressed a desire for the inclusion of detailed information about production at each stage in the supply chain. A common concern across all user profiles was the absence of information on the social and working conditions of employees involved in the production of the product. To ensure the ethical and sustainable production of products, some users emphasised the need for visibility into supplier sourcing and suggested that this should include, at the very least, the basic data of suppliers, including addresses of factories. However, stakeholder workshops in Part A showed that this information about suppliers is considered most sensitive.

- **Verification of data and certifications**
  For the most part, participants contended that the addition of certificates would be more credible and trustworthy if certificates were added to the DPP system by certifying organisations rather than by brands. Supporting this argument were the sentiments that the certifying bodies were less likely to take part in “greenwashing”, that there was more of a guarantee of accuracy and that it prevented brands from tampering with or falsifying data and that it was the only way to maintain the confidence of consumers in the product information presented. One problem raised with this approach was that leaving responsibility solely to the certifying body could leave certification information incomplete at the time the product becomes purchasable. As a solution, a hybrid approach was suggested where the brand provides the information related to certification and once the

product becomes purchasable, the certifier is notified and prompted to quickly check the information provided.

- **Entering data in the system**
  There was a high preference for automation across participants and user profiles. Many participants were concerned about the potential of overly manual processes of entering data. On the other hand, the possibility of web portals and online standardised forms were presented as options and there was some concession that there may need to be some manual data entry in the early stages of a product information system before automation solutions become available later.
  Overall, participants saw the value of different stakeholders being responsible for inputting the data that they had access to and was closest to them. E.g., Manufacturers inputting data on parts at the point and time of manufacture; Certifiers verifying certificates just prior to the product being put on the market. One suggested solution was a "hub and spoke" design, with the brand being ultimately responsible for the majority of product information and data input but allowing suppliers and certifiers to add data or certify data through verified links. This could exist in both an automated or manual format, depending on the particular stakeholders and providers.

- **Data being interesting but problematic for another**
  One of the core challenges in a product information system with multiple stakeholders is the competing need of each stakeholder. Some brand representatives were surprised at the amount of information available to sorters and recyclers and they also raised concerns about the display of supplier and shipping information being shown to consumers. Balancing the overall objective of providing transparency of the system with the competitive advantage afforded currently to brands through their relationships with suppliers is a core challenge in the creation of a product information system.

- **Sustainability indicators and industry ranges**
  In some cases, further information was sought about information provided in the Demonstrator. The sustainability performance indicators were applauded for their direct approach and ease of understanding but stakeholders wanted to get more information about what these indicators really meant and how they were calculated. One participant also suggested to include industry ranges, meaning the spectrum of values or levels where comparable products lie, e.g. regarding their carbon footprint.

- **Material durability metrics**
  Durability metrics found on the materials and composition page were also considered to be overly complex and not well-understood. There is a need to balance standardisation with making the data understandable - terms like "Water properties", "Pilling resistance", "Dimensional stability" and "Seam slippage" align with terminology in ISO standards but were not easily understood by any stakeholder.
  One potential option would be to add these metrics to an on-demand informational pop-up or modal that helps to explain the metrics that support the durability performance indicator rating while also giving more space to explain what the metric means.

- **Rights of repair have expiration dates**
  Rights of repair are linked to the date the item was introduced to the market. Therefore, the date a product entered the market would be a valuable data point. This was considered a valid and significant input.

- **Maintenance and care information**
  Particularly in regard to the fridge version of the prototype, the addition of information that would help a consumer to correctly maintain and care for their appliances and ensure longevity would help consumers, especially since user manuals are often long, lost or ignored.

- **Levels of application**
  Stakeholders also sought further clarity and distinction between the attributes that applied at the component or material level and those that applied to the product as a whole.

4.5.3 Aggregation and comparison of data

Several participants mentioned the need to access data based on aggregated values across industry and product categories. The use cases for this information differed by user profile. For market surveillance representatives and consumer associations, viewing averages, min-max ranges and trends across data would be useful. Waste operators and recyclers need to have the ability to calculate information across multiple items within a category, such as all t-shirts or items under a specific WEEE collection category. This information would allow for more informed decisions in regard to recycling and waste management. Consumers sought context to understand the significance of individual product data.

The ability to, both, evaluate individual products in terms of sustainability and environmental impact and compare products and gather large-scale data was recognised as one of the key advantages of the product information system. And the requirement itself of requiring extensive information was seen as a way to encourage manufacturers to improve practices.

4.5.4 User roles and access rights proposal

Based on the results of this project, a proposal for user profiles was developed as shown in Table 37 (T-Shirt) and Table 38 (refrigerator).

Table 37: Categories and Attributes shown per user group for textile products

Category / Attributes shown	Consumer	Certifier	Sorter / Recycler	Brand	Supplier
Product Overview - Brand Name - Product Identifier - Country of Manufacture - Size - Weight - Fit - Year of Sale - Colour - Category - Price - Type - Material Composition - Product Image - Product Description	x	x	x	x	x
Materials and Composition - Category - Composition - Country of Production	x	x + Safety Data Sheets	x + Safety Data Sheets	x + Safety Data Sheets	x + Safety Data Sheets

Category / Attributes shown	Consumer	Certifier	Sorter / Recycler	Brand	Supplier
- Recycled Content - Colour - Water Properties - Material Durability					
Service - Care Instructions - Take-back and Return - Repair and Disposal - Service Finder - Contact	x		x	x	
Sustainability and Circularity - Sustainability Performance - Sustainability Certificates - Compliance with Restricted Substances List - Product Durability Results - Life Cycle Assessment (LCA) / Product Environmental Footprint (PEF)	x	x	x	x	x

Table 38: Categories and Attributes shown per user group for electronic products

Category / Attributes shown	Consumer	Certifier	Sorter / Recycler	Brand	Supplier
Product Overview - Model Identifier - Overall Dimensions - Total Volume - Annual Energy Consumption - Energy Efficiency Class - Product Identifier - Price - Sustainability Performance - Sustainability Certificates - Product Image	x	x	x	x	x
Product Specifications - General Product Parameters (EPREL) - Type (EPREL) - Compartment Parameters (EPREL) - Light Source Parameters (EPREL) - Additional Information (EPREL) - Suppliers (Name and Address) - Product Image - EPREL Information	x	x	x	x	x

Category / Attributes shown	Consumer	Certifier	Sorter / Recycler	Brand	Supplier
Materials and Composition - Hazardous Substances - Recycled Content	x	x + Material Declaration	x + Material Declaration	x + Material Declaration	x + Material Declaration
Usage & History	x	x	x	x	
Service - Updates - Warranty - Repair and Disposal - Take-back and Disposal - Manuals - Parts and Components - Contact	x		x	x	
Sustainability and Circularity - Sustainability Performance - Sustainability Certificates - Life Cycle Assessment (LCA) / Product Environmental Footprint (PEF)	x	x	x	x	x

4.5.5 Discussion and conclusions

Despite initially quite different role profiles, in the end the information to be presented per category is the very similar. Finally, the role profiles only differ in that some categories are not available for some profiles and that certain details of material composition are hidden from consumers. Interviewes had access to the role profiles of all roles during the interview process. This might have influenced what people envisioned for their own access to information, so the profiles aligned during the process. While this is an advantage for standardisation and technical feasibility, it might unintentionally break with a strictly applied need-to-know principle. If the information envisaged turns out to be worth protecting for information owners, the information requirements could be re-evaluated in a different process.

In the stakeholder interviews, it was clear that access to different points of information differs between different companies and not only between industry roles. Different brands, for example, will have access to different information and large companies may have scaling issues in implementing new information requirements that smaller companies do not.

It is important to note that the FE Demonstrator was designed in a modular way to allow for the absence of some data. This ensures a flexible interface that can communicate available data while being able to scale in time as available data increases.

Stakeholders agreed that while the information presented in the FE Demonstrator represented an ideal state and not a current application, the information required of such a system should start small and be incremented over time. This would not only allow stakeholders to adjust to these information requirements but also provide the ongoing testing and evaluation of any future version of a Digital Product Passport (DPP).

To meet the requirement of the different user groups to have comparative values on a certain product group available, the registry described in chapter 4.2.3.6.1 can be considered. By entering the product data (or corresponding links to standardized data sources) in a central registry, such comparative values can be derived.

Stakeholders were asked for their views on whether the Demonstrator met the expectations of what a DPP might look like. While most said it did, one stakeholder from the textile industry pointed out that the Demonstrator was much more than the expected "basic product sheet" and instead showed how a DPP could provide comprehensive information about a product.

While consumers requested a quick understanding of how sustainable a product was, they were also suspicious of greenwashing and did not want to sacrifice access to more detailed information. This could potentially be complied by hiding the more detailed information in a "details" page that can be accessed by the consumers, without overwhelming the with the details on the front page. It could also be considered to break up the uniform product overview and customise it more to the different user groups, so that customers are presented more abstracted information compared with other user groups.

Takeaways for user profiles and access right management

- Information requirements should be examined for each different stakeholder group. However, in the process of defining the user profiles, it became apparent that any user profiles will include quite similar information. It can still be beneficial to define the requirements per user group as this allows for later adjustments.
- User roles for five user groups from the textile and electronic sector are proposed in this report based on non-representative stakeholder research including workshops and a survey as well as on experience and knowledge of the researchers.
- For consumers, there is a tension between the desire to get an overview of the information and sustainability of a product immediately and the need to be able to access detailed information to verify the sustainability promises.
- Comparative values and industry ranges were requested by several user groups. In this respect, the idea of a registry should be considered again and directed accordingly.

4.6 Summary and conclusions

This chapter summarises the investigations of Part C of the project, indicates limitations and draws conclusions.

4.6.1 Summary: Product Information 4.0 concept

In the following, the different aspects identified as relevant for building the technical infrastructure for a product information system are revisited. The key points of the analysis are summarised and, where appropriate, recommendations are concluded.

4.6.1.1 Vocabulary, ontology, taxonomy

Standardization of data serves two main objectives: achieving technical interoperability and enhancing understandability for users. Ideally, a fully standardized vocabulary spanning all industries and sectors would be desirable. Next to the vocabulary, ontology and taxonomy, exchange formats and circularity/environmental/sustainability claims need to be standardised. However, practical challenges make this scenario unlikely.

A standardised vocabulary, ontology, or taxonomy should ideally be based on existing standards to ease interoperability. There is a wide range of existing standards available for different sectors and cross-sectorial applications. They should be extendable, flexible, scalable, consistent, and machine-readable. However, the availability of a wide range of standards also causes a challenge: existing data platforms are built on different data standards, and transitioning to new standards can be prohibitively expensive.

Cross-sectoral interoperability is another critical consideration, particularly for low-tier suppliers whose products are used in various industries. Achieving such interoperability is a challenge. To cater to the unique demands of different industries, each sector must define its specific information requirements. Subsequently, collaborative efforts involving data expert committees should be undertaken to develop standardized datasets that meet information requirements across multiple industries. This approach would alleviate the burden on suppliers who would otherwise need to provide data in different formats multiple times.

Moreover, harmonized wording would enhance the user experience for consumers when using information of products from different product categories to make informed purchase decisions. More standardisation also eases providing a multi-language approach, possibly accompanied with infrastructure to translate between the languages, which can be beneficial for user interaction.

To address the previously listed challenges, the project team recommends a pragmatic approach:

1. Start with a minimal, strictly standardized dataset per product group as foundation. These datasets include the essential information needed to facilitate a circular economy. They should be based on comprehensive stakeholder surveys to define a minimal set of information requirements. Use the previously described process to align the vocabulary across sectors.
2. Integrate standardised modular additional datasets to meet specific needs of different stakeholders in a specific sector. These should also be based on stakeholder surveys. As they affect less stakeholders, they may be more flexible to adapt to changing requirements.
3. Enable customizable (non-standardised) data in business-to-business (B2B) relations, similar to the flexibility provided by systems like IMDS.
4. Whenever possible, provide data mapping tools to facilitate the transition between existing vocabularies and the suggested standards. The precondition for this is that the data platforms and databases provide at least the required information of the minimal datasets in some kind of standardized vocabulary.

As hosts for the data standard, different kinds of organisations could be considered, such as standardisation organisations, governmental organisations, non-profit organisations, certification bodies, or industry platforms. This approach strikes a balance between standardization and flexibility, ensuring data serves both technical interoperability and user understandability effectively.

4.6.1.2 Data storage

Aligned with most interviewed experts, the project team recommends a system with decentralized data control, allowing stakeholders to choose between storing information on their own premises or with a third-party platform provider. Decentralized data storage means data is stored in different physical locations. This can involve local central storages or distributed systems with datasets stored in various locations. This way, different requirements of companies of different size and technical capacities can be met: Some companies prefer to store data themselves to have more control, while others would rather outsource data storage to a third party and thereby minimise the effort. Also, familiar systems would not have to be exchanged; instead, they can be adapted to meet the standards. This could help to avoid the copying of data and the resulting redundancy. A centralized system on the other hand could lead to industry reluctance, slower development, and higher risks due to a single point of failure.

To ensure interoperability in this decentralized system, standardization is crucial for data, interfaces, and access management. Adapting existing data storage systems, including PLM systems, platforms like circularity.ID, and many others, to these standards requires a considerable effort. Enforcing centralized storage however could result in even more complex transformation processes.

There is no specific implementation recommendation. Different players can implement the system differently as long as they meet interoperability and security requirements. Environmental impacts should be considered when comparing different technological solutions.

A central registry can complement the system, providing a single place to access certain information. This can include product identifiers, product categories, or minimal datasets. It has various potential uses, including customs checks and long-term archiving. It can also be used to accommodate the frequently requested feature of incorporating industry ranges and comparison values to better classify the displayed information.

Some stakeholders require real-time data processing. However, neither centralized nor decentralized systems can guarantee real-time data provision with growing data volumes and potentially unstable internet connections. A possible approach that remains to be examined is to download subsets of data based on specific events or triggers.

4.6.1.3 Data exchange

For effective data exchange, both human interfaces and machine interfaces need standardization to enhance accessibility and understanding for consumers and ensure technical interoperability among stakeholders and existing information systems. Human interfaces should prioritize usability for all stakeholders, especially SMEs and stakeholders from the global south, including multiple usage languages, comprehensible interfaces, and a shallow learning curve.

Currently, no working technical solution exists that provides interoperability between systems that use different data standards. Approaches for enabling interoperable data exchange are to store data in a central system, mandate a single data standard or to build a system that maps data between different standards. The central system is not recommended as discussed in the previous section. The other two approaches both require a certain effort, but can be combined, with some systems implementing the standard directly and others using adaptors.

Resolvers are tools for easy navigation within the information system. With identifiers or URLs stored on data carriers in products, resolvers resolve these to the original data source. The project team recommends the use of resolvers for the historically grown data infrastructure. They facilitate data source changes without altering data carriers but do not address interoperability of language or format.

PKI and digital signatures can be used in data exchange infrastructure to authorize parties and ensure data integrity for data points where it is of relevance. PKI enables the use of Decentralized Identifiers (DIDs) and Verifiable Credentials (VCs) as potential implementations for data storage and exchange.

4.6.1.4 Ownership, liability and data verification

Various concepts define data ownership, attributing responsibilities either to the data creator or the product marketer/distributor. Data ownership is still to be legally defined by the EU. The main concepts to consider are "creator-as-owner" and "user-as-owner," with the former being more widely used. The "user-as-owner" concept however reaches its limits when implemented to its full consistency as it would imply consumers are responsible for all product data, including production data. Instead, distributors of the product should bear ultimate responsibility for ensuring data availability, correctness, and completeness.

In the "creator-owner" approach, it's crucial to define who the creator is for each data field and their ownership rights. When users can add data post-sale, such as usage details, consumers' rights, and responsibilities, particularly regarding data accuracy, need careful consideration. Consumers should never own product data that have been added by other stakeholders. The topic of ownership over data about the use phase of the product will be further discussed in Part D (see chapter 5.2.4.2.2).

Both approaches have advantages and disadvantages, and depending on legal feasibility, either can be used to address the question of ownership.

Several steps are recommended to assure data quality:

1. Automatic validation checks for data availability, reasonability, and usability.
2. Manual verification for data accuracy, ensuring data quality. Verification can be performed internally by the data owner or externally through a third-party auditing process or a certification. Some stakeholders stated in the workshops that they prefer third-party verification. Either the data can be audited directly, or the processes used to gather the data.
3. Ensuring data integrity using unchangeable data methods like versioned databases or blockchain/DLT technology.

Encouraging companies to enhance data quality can involve financial incentives, penalties, and legal sanctions to supplement regulations. SMEs and data owners from the global south may require additional support due to potential resource limitations. Regulation, audits, and certification by authorized entities can be effective tools to hold data owners responsible for data quality. In general, a data quality and assessment system come with costs that need to be covered. Therefore, this will be a factor which increases the costs of the final product for consumers, or the legislator could create incentives that reward those who take these extra steps for better data quality for example integrated in an EPR scheme.

4.6.1.5 Access management and IP protection

The simplest approach is to define a dataset that includes only publicly available data. This approach is recommended if it enables circular economy use cases without disclosing sensitive information, eliminating the need for complex role-based access management. Claims to keep certain information secret as well as claims to require certain details should be reviewed to ensure they are based on genuine reasons.

If certain information that is needed by stakeholders in the circular economy cannot be made publicly available for genuine reasons, role-based access management based on the need-to-know principle is recommended for a minimal required dataset. Other data sharing solutions, such as sharing data on request, may not be feasible due to unacceptable time delays for certain use cases. Defining role-based access management in a bottom-up manner would lead to complexity and inconsistencies. Therefore, legislation should decide which data should be shared with which stakeholder groups, considering industry, community, and data owner perspectives. Roles, such as material producer, product designer/developer, certifier, consumer, and sorter/recycler, have been developed for the DPP front-end demonstrator.

Based on defined user profiles, the product information system can include logic to provide each stakeholder with relevant information while protecting intellectual property and trade secrets.

Additional to the minimally required dataset, data owners can have the opportunity to share further information with specific roles or business partners on a voluntary basis. Data owners can decide under which conditions (e.g., role-based, contracts, or payment) this additional data should be shared. Fine-grained access rights could allow these optional exchanges within the same system.

There are readily available technical solutions for data security, authentication, and authorization. A Single-Sign-On (SSO) solution is strongly recommended to avoid the need for stakeholders to maintain multiple sets of login credentials.

4.6.1.6 Data carrier

To support circular economy through a product information system, data carriers must fulfil several requirements: Durability, storage capacity for a unique identifier, not disturbing function during use phase, process time and needed equipment to read, protection of personal data and recyclability are some of them. Depending on the subgroup of products, different data carrier technologies can be suitable. Data carrier preferences also depend on the stakeholder interacting; e.g., for private users readability with a smart device is priority while textile sorters depend on the use of a data carrier that allows for a fast and ideally automated reading process. The scanning environment needs to be set up and the multitude of technologies used for data carriers complicate the process. Often, the requirements of the parties implementing the data carrier do not align with the requirements of the reading parties. No single data carrier fits all product needs; innovation and product-specific requirements are crucial.

The various product groups have different requirements in terms of durability, readability, design requirements and other aspects. Data carriers for textiles for example need to meet washing and design requirements. They also need to support the textile-specific sorting processes with efficiency. For textiles, optical codes and RFID (UHF, HF/NFC) tags are suitable; the project team advises for hybrid tags to support both consumer information and enabling sorting in the best way possible. However, the current version of the WEEE Directive causes some hurdles for electronic tags.

Electronics, on the other hand, vary widely; functional data carriers are needed for reuse and recycling. Durability, design and the metal content influence data carrier choice. Active RFID and Bluetooth tags are generally unsuitable – optical data carriers such as QR codes and passive RFID HF/NFC tags are preferable.

Defining requirements that data carriers need to meet instead of mandating specific data carriers can foster innovation. Recommendations for legislator-defined requirements include durability, process time, storage capacity, implementation guidelines, readability, privacy protection, and environmental impact. However, allowing a wider choice of different technologies also has implications, as the reading of the data carriers often requires different technologies, which would have to be available to all reading users. Hence, to ensure investment security for data users specified reading equipment requirements should also be defined. A central product list should complement but not replace data carriers due to industry efficiency requirements.

4.6.1.7 Identifier

Identifiers are vital for product information systems because they identify the cloud-stored product data entry and make it directly accessible without a search function. Identifiers must be globally unique in their functional space. They should be persistent until the product's end of use, small in size and usable by all stakeholders either, the identifiers should be resolvable directly over the internet via URL formatting. Alternatively, a central resolver could exist that is built into every QR code or NFC scanner and thereby can be referred to by all data users.

Serialized identifiers at the item level are necessary for products with relevant repair, rental, and reuse/recommerce channels to support circular business models. For products without such markets, identification at the variation or batch level is sufficient to support sustainable purchasing decisions and recycling stream decisions.

Identifiers at the component level can be useful if components are expected to have a dedicated repair or recommerce channel; but certainly not all components need data carriers. Digital linkage to the finished products is viable. Reassigned allocations to new products are possible during component reuse.

A mandated identification scheme could incur high initial costs, so similar to data carriers, defining certain requirements by the legislator is considered beneficial. Although suggested by some experts, the project team advises against including being cost-free as one of the requirements, as there can certainly be costs incurred by operating the system that must be covered. The resulting diversity of solutions could be resolved by also storing the type of identifier.

4.6.1.8 Closing information gaps

Information gaps and barriers identified in Part A of this project primarily relate to material composition, product design, service, and circularity information requirements. Overcoming these barriers is essential for creating a product information system with fully available and usable datasets and complete interoperability.

Especially legal information gaps can only be resolved through stricter and more comprehensive regulations. Information that is not mandatory to be stored is not necessarily available from any system. The systems EPREL and SCIP for example conceptually come close to fulfilling the technical requirements. However, the available information is currently limited to the legislative scope.

Storing information in voluntary information systems and data platforms can overcome barriers related to accessibility, format, and granularity. These systems play a key role in achieving a comprehensive product information system. Voluntary approaches can be used as an information source but cannot replace mandated regulations. To qualify as a source to close information gaps, data platforms and information systems need to fulfil the requirements of granularity, accessibility, and interoperability. For most of the systems assessed, meeting these requirements would demand certain adjustments. Additional quality control could also improve the approach of using data from existing systems.

In general, it is questionable whether the approach of using different existing data points from various systems is feasible for future products - or whether fundamentally a more structured approach to providing the data is required so that no additional data needs to be collected from diverse systems. Therefore, the researchers suggest that the minimum information needed to close the gap should be mandatory in all systems that qualify as an information source in the product information system. Also, all products should be required to be registered in a single one of the systems that offers storage of product data in a standardised format.

While DPP requirements are under development, existing systems can continue to be used. Efforts to add missing information are considered to be justified by the project team, but investments in harmonization (e.g., access management) should wait for clear requirements.

Using average or estimated data from sources like lifecycle assessment databases can also aid as a temporary solution. However, this data should be clearly marked due to its lower reliability. Critical applications (e.g., potentially damaging recycling processes) should not use such data.

Moreover, enhancing enforcement and education is crucial to bridge availability gaps. Voluntary platforms can assist by demonstrating the need for information, providing storage platforms, and offering support in data gathering.

4.6.1.9 User groups and information requirements

The project team advises to assess the information requirements on a stakeholder-group level. Despite different initial role profiles based on the findings of Part A, a stakeholder survey and the experience of the project team, it became apparent throughout the interview process that any user profiles will include quite similar information. Role profiles differed mainly in the availability of certain categories and in hiding specific material composition details from consumers. It can still be beneficial to define the requirements per user group as this allows for later adjustments. Customizing information presentation for different user groups, providing abstracted information for consumers compared to other user groups, was considered.

The FE Demonstrator was designed modularly, allowing for the absence of some data and ensuring a flexible interface. Stakeholders agreed that the information requirements should start small and be incrementally increased over time.

Evaluation with the front-end demonstrator showed that the chosen format of providing information in different categories was useful for the users. They were able to navigate through the mock-up and find the information that they needed. In the stakeholder interviews, a central registry was suggested for entering product data, allowing the derivation of comparative values for specific product groups. Consumers wanted a quick understanding of a product's sustainability but at the same time were concerned of greenwashing; detailed information could be kept in an accessible "details" page to balance simplicity and depth.

4.6.2 Limitations and need for further research

Some aspects that have been analysed in this project are being studied in parallel at EU level, in various projects to work towards the concept of the Digital Product Passport. The developments at EU level should be taken into account when national efforts are made to develop a product information system. A cross-check with comparable projects could also ensure that all relevant sub-aspects of a product information system are sufficiently examined.

A central question that was repeatedly raised during the expert interviews is that of costs. Setting up and maintaining the necessary infrastructure, as well as converting current processes, is associated with considerable costs. The inherent costs of the system are unevenly split across the value chain. Providing data potentially comes with costs for the technical infrastructure, data carriers and trained staff, etc. Data usage on the other hand holds the potential to gain financial value. A statement on the expected financial, economic and social justice effects of the system, is beyond the scope of this study, but an investigation is recommended by the authors. It should be considered that each competitor is subject to the same additional costs and that the imbalance in cost sharing is between parties that are not in direct competition with each other. Another interesting question in this regard is whether the disclosure of the data has a pro-competitive or anti-competitive effect and which additional business fields may open up.

When discussing the timing of the introduction of a mandatory product information system, the transition time that companies need to change their current systems and processes and train their staff (and suppliers) accordingly should be carefully estimated.

Different technical solutions can be used for many of the aspects examined. Often, the experts also came to different proposals and conclusions. In doing so, the experts naturally drew on their own experience and, in some cases, represented the interests of their organisations. At this point, a need for further research could be identified: In-depth stakeholder interviews with the parties involved should be conducted for the respective technical aspects to ensure that the chosen technologies are accessible and feasible. This should also specifically consider power relations between different stakeholders within the system. For example, a system that benefits larger companies from the global north could put smaller companies from the global south at a disadvantage.

Especially in the case of environmentally intensive technologies, further environmental analyses must be carried out. In this work a short environmental analysis on data carriers (chapter 4.2.9) and blockchain (chapter 4.2.3.4.2) was conducted. A more detailed analysis that is beyond the scope of this research is seen as highly important by the researchers. On the recommendations of this work different scenarios for a product information system could be set up and should be tested in a laboratory frame or simulation, examining energy consumptions an d material compositions. The specific aim of this analysis should be to investigate how a product information system could be implemented so that the environmental impact resulting from the use of the technologies can be minimised. Furthermore, it should be investigated whether with this minimal impact the benefits resulting from the availability of the information indeed outweigh the environmental impact from a sustainability perspective. The example calculated in this project, can be interpreted as an indication that the benefits can outweigh the environmental impact, at least for the chosen product group of smartphones.

The question of who should be responsible for defining and further developing standards could not be conclusively clarified in the project. One problem that the researchers see is the great variety of standards that exist in the field of product information and information systems and overlap to a greater or lesser extent. Instead of bringing more standards onto the market, which cost users money, the standards should be organised, catalogued and, if necessary, summarised in a meaningful way. There are already first approaches that go in this direction: The standardisation research within the Standardization Roadmap Circular Economy can be seen as a basis for sifting and analysing the existing standards.

Three systems for in-depth research were highlighted as part of this report. These systems should be considered as solid examples of solving specific use cases. Since no comprehensive market analysis was conducted, no statement can be made as to whether these systems are in general favourable compared with other solution approaches.

Information access requirements and user rights are a complex topic. Even experts may miss out on information that may prove to be important but have not been thought of. Therefore, the information requirements examined through stakeholder workshops and validated by using the demonstrator front-end should not be regarded as final but rather as a proposal to be further evaluated and validated with a representative number of stakeholders from each relevant user group, as well as in further expert interviews.

The investigation of information requirements in this project comprises textiles and electronics, but excludes all other sectors and product types, for which similar surveys also must be made. In this process, claims to require certain details as well as claims to keep certain information secret should be reviewed to ensure they are based on genuine reasons. A framework for this evaluation in particular, as well as for the process in general is still to be developed. Subsequently, a data standard that is as harmonised as possible between the different sectors and product groups needs to be abstracted from the investigations.

An often-named request in the workshops, especially by consumers and producers, was to be provided with scores, ranges or comparability data within a product group. This requirement could be met in many different ways which have not been assessed. It should be further investigated which approaches serve the cause best.

Another idea from the demonstrator frontend development is the introduction of a so-called service-finder. This is a tool that could be added to the consumer interface of the product information system and inform them about e.g., the nearest repair shop. The proposal has found favour in the interviews, but such a tool would require another registry where service providers can register. The development of this registry is not part of this project, so the tool is to be considered more of an ideation.

A possible framework for further investigations could be to set up use case scenarios in which technical and informational requirements can be assessed in detail for different perspectives. For example, a small design company could be considered, that would like to make sustainable fashion and is therefore interested in detailed supply chain data but does not have a lot of capital to invest in information infrastructure. Another scenario could be a large enterprise that is able and willing to invest in technology and could also support their suppliers in doing so, to provide their customers with the product information they would wish for. A third suggested scenario would include a supplier from the global south that just wants to be compliant with the legislations and requirements that their EU customers have but has had little exposure to digital technology so far.

4.6.3 Conclusions

The research in this part of the project aims to identify available technologies and approaches for the technical infrastructure of a product information system. Seven aspects of product information systems have been identified. To enable interoperability, standards and legal requirements need to be defined for all aspects. Parallel developments on EU level should also be considered. Approaches and solutions have been presented for each of the aspects.

- **Vocabulary, ontology and taxonomy**
  The product information system needs a minimum information set that meets the information requirements for a circular economy. This information needs to be saved in the system following a standard. Different standards can be allowed if it is possible to translate between them - for example through mapping tools. Interoperability of data standards across the value chain as well as cross-sectoral interoperability needs to be considered. The current number of different standards in the field should be reduced or prioritised.

- **Data storage**
  Aligned with most expert opinions, the project team advises for a decentralised system, keeping existing information systems and data spaces in place and harmonising different aspects between them, like access management or data exchange. Data sources are likely to prefer keeping the control over their data and - to a certain extent - decide about access. Additionally, allowing different service providers in the system should facilitate more flexibility for innovation. The service providers can build customized solutions for their target groups while fulfilling minimum requirements and standards for interoperability. A central registry can enable additional use cases like customs or providing comparability data for consumers.

- **Data exchange**
  Human and machine interfaces both need to be standardised. At present, there's no functional solution for interoperability between systems with different data standards.

Possible solutions include centralizing data, enforcing a single standard, or building a system to translate data. Central storage is discouraged. The other methods require effort but can be combined: some systems adopt the standard directly, and others use adaptors. Resolvers should be used to keep the connection to database entries flexible.

- **Ownership and data verification**
  Organisations that bring products to market should be responsible for the corresponding mandatory data. Regulation can enforce responsibilities with incentives or penalties to ensure data accuracy and completeness. Data added to the system should be checked in a three-step process: First it should be validated automatically, then at least random samples should be verified manually and lastly, it should be stored in a system that secures integrity of the data. Optional data can be added and provided within the same system but the data quality control for this data should be up to the participating partners who exchange data with each other.

- **Access management**
  Access management will only be necessary when information shall be shared that is not open for the public. If so a need-to-know approach should be applied. Information can then be shared based on role-based access rights. This process should not need individual approval which is essential for time-sensitive processes. The decision-making on the information profiles should be performed by legislation, based on the requirements gathered from the affected stakeholders.

- **Data carriers**
  The data carriers must fulfil the requirements of the product group and stakeholders, including, amongst others, durability, storage capacity, process time and protection of personal data. For the two product groups investigated, textiles and electronics, optical codes (e.g., QR codes) and passive electronic tags (e.g., RFID tags) are advisable. There may be exceptions for products that do not need a data carrier implemented on the product if they are very small or have no reuse and repair markets and a simple material composition.

- **Identifiers**
  One of several requirements for identifiers is that they need to be unique in their functional environment. They also need to be on serialized level when repair and reuse should be supported. Different standards are possible to coexist, as long as it is made clear which standard is used. A central resolver with a short URL could help saving on storage capacity.

The examined systems RAMI 4.0, IMDS and circularity.ID showcase solutions for different aspects working in real life. RAMI 4.0 outlines aspects of a potential product information system reference architecture but lacks industry-specific elements. It also includes some non-essential aspects for a circular economy-supportive system.

The project shows that a product information system can create value for circular business models. All parties involved in a product information system need to be considered, so each can profit from using the system, especially SMEs and organisations from the global south which may face some additional obstacles in implementing the product information system. Many do not have the technical infrastructure, trained staff or the budget to invest in it. They also lack budget to invest in certifications. For some, little to no exposure to digital technologies has taken place so far. In general, complexity of the product information system is to be reduced as much as possible to create an accessible and feasible solution.

Also, the effort of building a completely new infrastructure (e.g., centralised or using blockchain technology) is expected to be immense. However, it needs to be weighed against the effort of transforming existing systems to a standardised format.

An environmental footprint analysis at the example of a smartphone indicates that such a system using electronic data carriers could have positive environmental impacts. Further analysis of the ecological impacts of the system is advised.

All in all, it can be stated that approaches and solutions exist and are already used and validated for all the different aspects of capturing, linking, saving, verifying, and exchanging product data. There are good arguments for and against most approaches; however, for a well-working overall system, suggestions have been made for each of the aspects. Ultimately, choices must be made that are feasible for the stakeholders and combined into a product information system.

5 Part D – Legal recommendations for the further development of information requirements

5.1 Information requirements for different stakeholder groups and potential to close gaps through law

This chapter reviews the information gaps that were identified in Part A of the research project for each relevant legal act and provides a proposal for each gap to be closed or reduced appropriately. The review is oriented towards the different stakeholders identified in Parts A and B that should be covered by / have access to information from an information system for their respective use-cases.

The review shows that not all identified information gaps in relevant legal acts impact all stakeholders. In fact, many information gaps only affect one or two stakeholder groups. The legal acts are grouped into the following sections: (1) Textiles, (2) Cross-Sector and (3) Electronics. Within the sections, the stakeholders are named and the impact on their use-case is shortly evaluated. Lastly, it is evaluated whether a legal act should be amended and what consequences this may have.

It was found that to close existing information gaps, introducing entirely new legal acts on a European level is currently (mostly) not necessary. It may be sufficient to amend existing legal acts (European directives and regulations) and to rely on upcoming legislative acts. In this regard, the European Union (EU) can rely on already existing competences (e.g., Art. 114 or Art. 192 Treaty on the Functioning of the European Union (TFEU)) to propose amendments to the respective legal acts.

Table 39 provides a short overview over the proposals for identified information gaps in relevant legal acts, which are described in more details below.

Table 39: Proposals to reduce legal information gaps, sorted by sector and information user. Recommendations shown in right column.

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Recommendation to reduce the identified information gap
Textile	Textile Regulation	Textile fibre name and composition of each component (above 5-15%)	Consumer	Labels	Legal information gap	**Recommendation:** Amend the wording of Art. 9 (2) and (4) of the Textile Regulation, delete Art. 9(5), as follows: (1) *(Wording unchanged)* A textile product shall be labelled or marked with the name and percentage by weight of all constituent fibres in descending order. *(New sentence)* If the product is regulated by (name of Ecodesign Regulation), the information must be included in a digital data carrier, e.g., a digital product passport of the product. (2) *(New wording)* By way of derogation from paragraph 1 of this Article, manufacturers who employ fewer than 250 persons may, where it cannot be easily stated at the time of the manufacture, state a fibre which accounts for up to 3 % of the total weight of the textile product, be designated by the term “other fibers”, immediately preceded or followed by their total percentage per weight. The manufacturer shall be able to demonstrate that the complete product labelling cannot be easily stated. (3) *(Wording unchanged)* Products having a pure cotton warp and a pure flax weft, in which the percentage of flax accounts for at least 40 % of the total weight of the unsized fabric may be given the name ‘cotton linen union’ which must be accompanied by the composition specification ‘pure cotton warp — pure flax (or linen) weft’ (4) *(New wording)* By way of derogation from paragraph 1 of this Article fibres not yet listed in Annex I may be designated by the term “other fibres”, immediately preceded or followed by their total percentage by weight. The composition of the fibre and chemicals used on the fibre must be specified immediately followed by the information of sentence 1. (5) *(Delete paragraph)* • In addition to information about fibres used, it should be obligatory for manufacturers to declare chemicals and dyes used on fabrics.

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Recommendation to reduce the identified information gap
Cross-sector	REACH-Regulation (Article 31 and Art. 33)	For Art. 31: Identification of hazardous substances and mixtures; For Art. 33: Identification of articles containing SVHC above 0.1% to all actors	For Art. 31: Recipient of the substance/ mixture; For Art. 33: Recipient of the article (user, consumer, repair, reuse, waste treatment)	For Art. 31: Safety data sheet (SDS) For Art. 33: SCIP database	For Art. 31: Availability gap For Art. 33: Legal information gap, Availability gap	**Recommendation**: • Amend the REACH-Regulation so that (1) suppliers (both in the European Union and in Third Countries) **must provide any further suppliers** along the supply chain with information about chemicals used in the substance or mixture using the SDS, **without exceptions**, (2) **including**, whether a **cumulation** of chemicals reaches a (do be determined) threshold which is considered to be “risky” (e.g., hazardous). This information should additionally be included in a digital data carrier. In the beginning, correctly filling-in the digital data carrier information requirements could lead to being able to print a correct SDS. Over time, using the SDS could be phased out until only a digital data carrier is used. • Shorten the current legal timeline of 45 days to provide consumers with information to “without undue delay, but at least within 72 hours”. Evaluate whether alternatively, the relevant information must be made **publicly available** in the SCIP database for a consumer to easily find (e.g., by GTIN or another identifier readily available to the end-user and/or consumer) and access **at any given time**; • Additionally, the SCIP database should be **extended to finished products** (with serial number, e.g., GTIN or another number known to the end-user and/or consumer) and entries in the database should be **machine-readable** in a way that the necessary provision of information is given to all relevant stakeholders in a timely manner, e.g., via an **Application Programming Interface (API)**; • Evaluate whether it is feasible to require suppliers to provide information, certificates or audit reports that help **validate** whether a substance or mixture contains hazardous substances or even to prove that no such chemicals are included;

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Recommendation to reduce the identified information gap
Cross-sector	CLP Regulation	Hazard pictograms, signal words, hazard statements, precautionary statements	Recipient of the substance, mixture or article (incl. consumer)	Labels	Usage barrier (format)	**Recommendation**: • Add **digital labels** with additional information on physical products; • Add information for consumers on how to **sort, recycle or dispose of** the mixtures and substances; • Include information for sorters, recyclers and waste treatment.
Cross-sector	Packaging Directive	Information on return, collection and recovery systems	Consumer	Labels	Usage barrier (format)	**Recommendation**: • Switch from a European directive to a **regulation** (as proposed by the EU Commission); • Follow the **proposal of the EU Commission** as set out in Art. 11 (2) and (4) of the Proposal for a Regulation on packaging and packaging waste (COM(2022) 677 final).
Electronics	Ecodesign Regulation Computer/ Displays	Identification of mercury (computer); marking of cadmium and plastic components (displays)	Waste treatment	Marking	Usage barrier (accessibility)	**Recommendation:** • Introduce (as a minimum) an obligation to provide for the information and/or marking not only to be "clearly visible" (anywhere, e.g., even after dismantling some parts); but for example, "clearly visible without the product having to be dismantled"; • Introduce an obligation to provide the necessary information on a **digital** data carrier that is **easily accessible**, **machine-readable** and can provide the relevant information digitally to all relevant stakeholders, especially to sorters and recyclers.
Electronics	WEEE Directive	Information on different materials and location of dangerous substances and mixtures in EEE	**Waste treatment**	Manuals, electronic media	Usage barrier (accessibility, granularity)	**Recommendation:** • Switch from a European directive to a regulation; • Introduce an obligation for manufacturers to provide information about specific materials contained in parts of EEE and information on how to disassemble EEE on a **product model level**; • Amend the wording of Art. 15(1) WEEE Directive as follows: 1. ***(Wording unchanged)*** In order to facilitate the preparation for re-use and the correct and environmentally sound treatment of WEEE, including maintenance, upgrade, refurbishment and recycling,

Sector	Legal act	Information requirement and granularity	Target information user	Access/ format	Identified gap or barrier	Recommendation to reduce the identified information gap
						Member States shall take the necessary measures to ensure that producers provide information free of charge about preparation for re-use and treatment in respect of each type of new EEE placed for the first time on the Union market within one year after the equipment is placed on the market. This information shall identify to ***(Delete*** "as far as it is needed by") centres which prepare for re-use and treatment and recycling facilities in order to comply with the provisions of this Directive, the different EEE components and materials ***(New wording)*** on a product model level, as well as the location of dangerous substances and mixtures in EEE. ***(New sentence)*** The information shall further provide instructions for the disassembly of the product on a product model level. ***(New wording)*** It shall be made available in digital, machine-readable form and easily accessible to centres which prepare for re-use and treatment and recycling facilities by producers of EEE. ***(New sentence)*** If the product is regulated by (name of Ecodesign Regulation), the information must be included in a digital data carrier, e.g., a digital product passport of the product. ***(Delete*** "in the form of manuals or by means of electronic media (e.g. CD-ROM, online services).”).
Electronics	RoHS Directive	Confirmation of absence of certain hazardous substances by CE marking	**Market surveillance**	Datasheet CE-Label	Usage barrier (granularity)	**Recommendation:** • CE markings should be removed from parts of the product that are visible to consumers and other end-customers of products; • CE markings should be made a mandatory part of the digital product passport and as such made easily and readily available to relevant stakeholders, such as Market Surveillance Authorities.

5.1.1 General remarks regarding product information for a product information system 4.0 in a circular economy

A product information system and (digital) data carriers can improve circularity within the EU, provide useful information to users (incl. end-users, consumers, supply chain actors) as well as recycling and sorting of products in general. The relevant information should be machine-readable and digitally accessible, but in order to protect, for example, the elderly, visually impaired, and/or otherwise impaired users of products, articles, substances, mixtures, textiles etc., digital information should not (entirely) replace physical information. Instead, a hybrid system is recommended.

Some **critical information** must (always) be placed directly onto the product.

- For **consumers**, the current mandatory information should not be extended much further than it already is. The canon of mandatory information is already large, stemming from, for example, the Directive 2011/83/EU on consumer rights (Consumer Rights Directive), the Directive (EU) 2019/2161 as regards the better enforcement and modernisation of Union consumer protection rules (Enforcement and Modernisation Directive) etc. This can already be overwhelming both to consumers and to actors who must provide such information. Additional mandatory information must (in some cases in the future) be provided under legislation passed as part of the European Commission Priority "A Europe fit for the digital age" (e.g., under the Data Act, Digital Services Act, Artificial Intelligence Act etc.) and the European Commission Strategy "The European New Deal" (e.g., the Energy Labelling Regulation, Packaging and Packaging Waste Regulation, etc.).Therefore, if more obligatory information towards consumers is introduced, it should be considered whether other currently obligatory information can be reduced or, for example, moved (solely) to a digital data carrier.
- **Recyclers** could profit from more mandatory information to be provided to them on a product. Depending on what kind of product (e.g., electronics, subsets of electronics or textiles), information on hazardous materials such as those which fall under REACH or RoHS as well as detailed information on the material composition of textiles may be helpful. It is to be noted though, that whatever is additionally provided in writing onto a product will also be visible to consumers and may potentially lead to confusion.

For clarity, all critical information should be included in the (digital) data carrier for a product information system as well.

Additionally, non-critical information can should be included in a (digital) product passport, for example as follows:

For **consumers**/all stakeholders, information included on the data carrier could be the following (see 2.2-2.4):

- Instructions
  - about the use of a product;
  - on how to repair or care for a product;
  - on how to dispose of the product;

- Information about
  - the environmental / ecological footprint of the product;
  - biodegradability;
  - the manufacturer brand incl. contact options;
  - supplier sustainability
  - the origin of the product (e.g., “made in”);
  - the durability, recyclability and longevity;
  - included (complete list of) materials;
  - the price;
  - allergenic substances in a product or textile;
  - production of a product or textile (e.g., if it was fabricated socially and environmentally responsibly);
  - claims, certificates and labels, as well as links to the substantiation of such statements;
  - prior repairs (e.g., parts that were replaced) or usage history of a product (e.g., washing cycles);
  - warranty of a product;
  - etc.

Such information of the (digital) data carrier shall be made available to the consumer before making a purchasing decision.

For **repairers and recyclers**, digital availability of the following (additional) information can be useful (see 2.2-2.4):

► Information about
- Full material declaration of chemicals (per component and product);
- staple fibre length for textiles;
- disassembly, spare parts, optionally information about spare parts prices, delivery time;
- recyclables and pollutants per removable main components (priority parts);
- recycled component per material and/or product;
- recycling performance;
- material origin;
- component map (name/ID);
- etc.

Introducing new information requirements poses the question of where to locate such requirements into legislation. One option would be to add information requirements (only) into each applicable legislation where the requirement fits well, e.g., requirements for textiles could be added to the Textile Labelling Regulation. This would lead to the requirements being scattered in different legislation applicable to a product, which may lead to confusion and poses the risk that relevant information may be (unintentionally) omitted from the (digital) data carrier and product information system.

A better option could be the solution as set out by the Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC (Ecodesign Regulation Proposal / ESPR Proposal) which leaves detailed information requirements for specific product groups up to **Commission delegated regulations**. In that case, manufacturers and other actors can rely on those delegated regulations to fulfill information requirements of the (digital) data carrier. The delegated regulations should repeat / include (or at least reference) information requirements that are currently only to be found in the applicable regulations.

5.1.2 Textiles

Currently, the EU does not have an extensive legal framework regulating textiles. One relevant European regulation is the **Regulation (EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products (Textile Regulation)** which addresses labels in / of textiles and fibre composition of textiles. Further relevant regulations are the cross-sectorial **Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency (REACH-Regulation)** addressing chemical substances, mixtures and articles (including textiles) Under the **Directive 2001/95/EC on general product safety**[54], there is one harmonised standard for clothing which concerns the safety of children's clothing (EN 14682). In practice, there are European standards (EN standards) relevant for some clothing and textiles. Unlike legislative acts, however, EN standards are not legally binding and therefore not further analysed here.

Soon, the legal framework for textiles is likely going to change. On March 30th, 2022, the EU Commission published its Communication on the EU Strategy for Sustainable and Circular Textiles (European Commission 2022a). In the Strategy's Annex, the EU has identified key actions, inter alia:

- Mandatory performance requirements for the environmental sustainability of textile products;
- Digital Product Passport for textiles with information requirements on environmental sustainability;
- Review of the Textile Labelling Regulation and considering the introduction of a digital label; and
- Extended Producer Responsibility requirements for textiles with eco-modulation of fees and measures to promote the waste hierarchy for textile waste.

[54] This Directive is not further analysed in this project.

Until today, no legal acts have been formally adopted under the Strategy, but the EU Commission has published several relevant proposals for regulations or directives. The following legal acts have been proposed by the EU Commission under the new strategy:

- Proposal for a Regulation establishing a framework for setting ecodesign requirements for sustainable products (COM/2022/142 final);
- Proposal for a Directive as regards empowering consumers for the green transition through better protection against unfair practices and better information (COM/2022/143 final);
- Proposal for a Directive on substantiation and communication of explicit environmental claims (Green Claims Directive) (COM/2023/166 final);
- Proposal for a Directive amending Directive 2008/98/EC on waste (COM/2023/420 final)[55].

Due to the relevance to this project, the **Ecodesign Regulation Proposal** will be taken into account for the recommendations on how to fill identified legal gaps in the Textile Regulation.

5.1.2.1 Legal information gap in the Textile Regulation

A legal information gap was identified in the **Regulation (EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products (Textile Regulation).** The Textile Regulation seeks to harmonise the names of textile fibres and the indications appearing on labels, markings and documents which accompany textile products at the various stages of their production, processing and distribution (Recital 3). The main goals of the Textile Regulation are improving the functioning of the internal market and to providing accurate information to consumers (Art. 1). The Textile Regulation wants to empower consumers to make informed purchasing decisions by, for example, setting out requirements to indicate the presence of non-textile parts of animal origin on the labelling or marking of textile products containing such parts, in order to enable consumers to make informed choices (Recital 8).

The Textile Regulation, however, falls short of the requirement for an exact indication of fibre composition of materials. It stipulates that where it is technically difficult to specify the fibre composition of a textile product at the time of its manufacture, it should be possible to state, on the label or marking, only those fibres which are known at the time of manufacture provided that they account for a certain percentage of the finished product (Recital 10, Art. 9). This leads to a legal information gap affecting stakeholders such as consumers, sorters / recyclers and certifiers.

The Textile Regulation differentiates between

- pure textile products (Art. 7),
- fleece wool or virgin wool products (Art. 8),
- multi-fibre textile products (Art. 9),
- decorative fibres and fibres with antistatic effect (Art. 10),
- multi-component textile products (Art. 11) and
- textile products containing non-textile parts of animal origin (Art. 12).

[55] To note: This Directive includes an "Extended producer responsibility scheme for textiles" (Art. 22a et seq.).

The articles set out requirements for how detailed the information about fibres contained in the textiles must be given. One requirement that creates difficulties in practice because of its exceptions is set out in Art. 9 of the Textile Regulation. Art. 9 reads as follows with regard to multi-fibre textile products (emphasis added):

> "1. A textile product shall be labelled or marked with the name and percentage by weight of all constituent fibres in descending order.
>
> 2. By way of derogation from paragraph 1, and without prejudice to Article 7(2), <u>a fibre which accounts for up to 5% of the total weight of the textile product, or fibres which collectively account for up to 15 % of the total weight of the textile product, may,</u> where they cannot easily be stated at the time of the manufacture, <u>be designated by the term 'other fibres'</u>, immediately preceded or followed by their total percentage by weight.
>
> 3. Products having a pure cotton warp and a pure flax weft, in which the percentage of flax accounts for at least 40 % of the total weight of the unsized fabric may be given the name 'cotton linen union' which must be accompanied by the composition specification 'pure cotton warp — pure flax (or linen) weft'.
>
> 4. Without prejudice to Article 5(1), for <u>textile products the composition of which is hard to state at the time of their manufacture</u>, the term '<u>mixed fibres'</u> or the term '<u>unspecified textile composition' may be used</u> on the label or marking.
>
> 5. By way of derogation from paragraph 1 of this Article, <u>fibres not yet listed in Annex I may be designated by the term 'other fibres',</u> immediately preceded or followed by their total percentage by weight."

Similar derogations and exceptions from the requirement for complete or 100% accurate information about fibres contained in textiles are included in the other Articles mentioned above. Additionally, there is no requirement to declare chemicals and dyes used in the production of textiles.[56]

5.1.2.1.1 Consumers

Consumers may be affected by the legal information gap when they do not receive sufficient information about the textiles in the purchased product.

While consumers generally rate the information about materials included in textiles as very important, they also stated that they do (already) have enough information to make a purchasing decision. Some consumers (especially those with sensitivities or allergies to certain chemicals or dyes) may be able to make better informed choices about a purchase when they are transparently informed about materials, chemicals and dyes used in the making of the product. However, this consumer group is likely to be rather small.

5.1.2.1.2 Sorters / recyclers and waste treatment

Mostly, stakeholders of waste treatment and sorters / recyclers are affected by the legal information gap. The fact that materials do not have to be declared below a certain threshold means that important material information is missing for waste treatment. Consequently, materials cannot be recycled to their best value if, for example, fibre length and composition, including dyes and chemicals, are unknown.

[56] Cf. for further information about the potential effects of chemicals and dyes on humans, *Alden Wicker*, To Dye For – How Toxic Fashion Is Making Us Sick – And How We Can Fight Back, G.P. Putnam's Sons New York, 2023.

5.1.2.1.3 Supply chain / manufacturers

Additionally, manufacturers along the supply chain may be affected by the legal information gap regarding chemicals that fall below the threshold of mandatory information provision. Chemicals used in upstream processes of the supply chain can lead to higher emissions into air and water in downstream processes. If all information is provided without any gaps, downstream processes along the supply chain and end-of-pipe techniques could be adapted accordingly. Depending on the information provided to manufacturers, they may also make different purchasing decisions depending on which chemicals were used on fabrics of interest.

5.1.2.1.4 Recommendation to close the legal information gap

The general requirement to disclose 100% of the fibres used in textiles should be strengthened in the Textile Regulation.

- It is also recommended that the chemicals and dyes used for pretreating, dyeing, finishing and printing textiles are (at the least) made available along the production and supply chain and to sorters, recyclers and waste treatment. It should be considered if it is useful to provide such information to consumers on labels. How much information should be provided to consumers may depend on how much information they need or wish for. As shown in 3.3.2 even though 47 % of consumers stated to already have enough information overall, most consumers value information on hazardous substances and included materials (as well as recycled content). Especially consumers with sensitivities and allergies can profit from information on used chemicals and dyes. The need for information may have to be weighed against the data gathering effort needed to make to provide such information. If providing such information is not required by law, it is to be expected that only under certain circumstances, e.g. in the scope of environmental labels or certificates, such information is provided. On the other hand, any manufacturer making the effort of gathering such information may be in better shape to match future legal requirements of full material declarations.

- Regarding the (pre-)treatment and dying of products, there already are information requirements on so-called Substances of Very High Concern (SVHCs) under the REACH Regulation. Textiles manufacturers also fall into the scope of the REACH Regulation, currently making it mandatory to limit SVHC content to 0,1% of the total product weight or having to notify the European Chemicals Agency (ECHA). However, as described below, this threshold should also be lowered to a requirement of providing information on any SVHCs used in a manufacturing process, not only if it is above 0.1% of the total product weight.

- It is therefore recommended that Art. 9 of the Textile Regulation is amended as follows (proposed deletions are marked with "strikethrough", additions are in bold and underlined letters):

  - "1. A textile product shall be labelled or marked with the name and percentage by weight of all constituent fibres in descending order. **If the product is regulated by the Textile Regulation, the information must be included in a digital data carrier, e.g., a digital product passport of the product.**

  - 2. **By way of derogation from paragraph 1 of this Article, manufacturers who employ fewer than 250 persons may, where it cannot be easily stated at the time of the manufacture, state a fibre which accounts for up to 3 % of the total weight of the textile product, be designated by the term "other fibers", immediately preceded or followed by their total percentage per weight**.

- 3. Products having a pure cotton warp and a pure flax weft, in which the percentage of flax accounts for at least 40 % of the total weight of the unsized fabric may be given the name 'cotton linen union' which must be accompanied by the composition specification 'pure cotton warp — pure flax (or linen) weft'.
- 4. **By way of derogation from paragraph 1 of this Article fibres not yet listed in Annex I may be designated by the term "other fibres", immediately preceded or followed by their total percentage by weight. The composition of the fibre and chemicals used on the fibre must be specified immediately followed the information of sentence 1.**

► Furthermore, any exceptions or derogations from the above proposed general requirement should be differentiated only by the size of the company (e.g., numbers of employees) and/or net worldwide turnover. For coherence, the thresholds could be mirrored as set out in Article 2 of the **Proposal for a Directive on Corporate Sustainability Due Diligence** (European Commission 2022b). According to the latest EU Council version of the Proposal of March 15th, 2024 (6145/24), the Directive covers, for example, "more than 1000 employees on average and had a net worldwide turnover of more than EUR 450 million in the last financial year for which annual financial statements have been or should have been adopted" as well as companies formed in accordance with the legislation of a third country, which "generated a net turnover of more than EUR 450 million in the Union in the financial year preceding the last financial year".

► Additionally, it is recommended to add a new article into the Textile Regulation that manufacturers are obliged to declare chemicals and dyes used while processing fibres and textiles.

► Another positive impact on the environment could be reached by introducing a harmonised sizing system that companies are required to use for textiles and shoes. Currently, the sizing of clothes is often different between different brands, and even within brands (e.g., size "36" or "S" of two pairs of jeans can differ by more than one size), which leads to frequent returns of online shoppers buying clothes or shoes.

5.1.2.1.5 Improvements to be expected from the Proposal of the Ecodesign Regulation

While the term "textile" is not used in the main legislative body of the Ecodesign Regulation Proposal, the defines "products" in its Art. 2 (1) as "any physical good that is placed on the market or put into service" and "intermediate product" in its Art. 2(3) as "a product that requires further manufacturing or transformation such as mixing, coating or assembling to make it suitable for customers". Both textile fabrics and wearable clothing are therefore covered by the Ecodesign Regulation Proposal.

There are some rules that may positively impact consumers for making purchase decisions and that may help sorters, recyclers and waste treatment treat textiles throughout their life cycle:

► Art. 7(1) determines that products shall comply with information requirements to the product aspect listed in Art. 5(1), which are, inter alia, durability, reusability, presence of substances of concern, resource use or resource efficiency, recycled content, possibility of recycling, expected generation of waste materials. However, the information requirements will be laid down in delegated acts by the EU Commission adopted pursuant to Article 4 of the Proposal.

► Article 7(2) and (5) of the Ecodesign Regulation Proposal contain the requirement to include information about substances of concern in products. Under Art. 7(5) of the Ecodesign

Regulation Proposal, the name of the substances of concern present in the product, the location within the product, as well as the concentration of the substances of concern must be provided. While it is understandable that the EU Commission may adopt exemptions from the information requirement about substances of concern due to the need to protect confidential business information, the option to create exemptions based on "the technical feasibility or relevance of tracking" should be used with great caution to protect consumer health.

5.1.2.1.6 Potential to close the information gap through Extended Producer Responsibility (EPR) Schemes?

There may be a potential to (indirectly) close the legal information gap through the scheme of Extended Producer Responsibility (EPR) for textiles. In its current proposal to update the WFD, the EU Commission proposes to introduce mandatory and harmonised EPR schemes for textiles in all Member States (Art. 22a of the Proposal). When manufacturers are responsible for their products at the end of the product's life, in order to fulfill obligation of re-using, repairing and recycling textiles, a full material declaration is helpful (and potentially necessary). However, the WFD is a directive and therefore gives all Member States leeway to define the roles and responsibilities of relevant actors involved in the implementation, monitoring and verification of the extended producer responsibility scheme. If the information requirement of a full material declaration is instead implemented in a regulation, actors from all Member States have the same obligations regarding the information requirement. This is preferable. Additionally, the Proposal excludes from EPR schemes so-called microenterprises (up to 10 employees), which represent 88% of all companies in the textile sector. This means that microenterprises can expect less financial and administrative impacts, especially regarding EPR. However, all SMEs can participate in EPR organisations on a voluntary basis.

In any case, closing the information gap through the Textile Labelling Regulation will be highly beneficial for EPR schemes. Having the exact information on materials used in textiles, requirements under EPR schemes such as providing information on waste prevention, re-use, preparing for re-use, recycling of textiles etc. may be easier and more exact.

5.1.2.1.7 Potential impact

It is to be expected that some stakeholders of the value chain will argue that it is or may not be possible to receive more detailed information (full material declaration without exceptions) as currently mandatory under applicable law from material producers. In a globalised supply chain, textile manufacturers who are not established within the EU are not covered by the EU legal requirements for textiles and the direct enforcement of rules is not possible. They may not provide complete information on what kind of fibres were used in textiles. In some cases, especially when recycled materials are used, it is argued that it may not even be possible to state exactly what kind of fibres are included or the exact amount of mixed fibres in fabrics.

In this regard, it is questionable whether such strict rules as proposed would be proportionate, especially for startups and Small and Medium Enterprises (SMEs). Strict requirements that lead to a risk of startups or SMEs to go out of business may impact Art. 16 of the EU Charter of Fundamental Rights of the European Union (Charter) or the fundamental freedoms guaranteed by the TFEU. However, the fundamental rights and freedoms of businesses must be balanced with the fundamental right to environmental protection (Art. 37 of the Charter) as well as with consumer protection (Art. 38 of the Charter). Exceptions to strict information requirement provisions could therefore be made for legal entities which cannot be expected to have the required resources and / or are not able to exert the same pressure on supply chain actors outside of the EU as big textile corporations may have. However, as small enterprises grow, they may at some point no longer be in the scope of an exception of giving a full material declaration. In this regard, it may be useful to encourage and incentivize (e.g., through tax breaks or funding opportunities) SMEs to provide full material declarations. Additionally, SMEs could be required by law to at least adhere to some transparency requirements, such as country of manufacture, and the origin of raw materials. Another option which could help SMEs would be longer periods until strict information requirements come into force. This way, SMEs are likely to benefit from the fact that, until the respective requirements become applicable for them, other relevant actors along the supply chain (both upstream and downstream) are already familiar with the requirements.

Overtime, it can be expected that even if lawmakers outside of the EU do not amend their legislation regarding textiles, the fact that a product entering the European internal market will have to adhere to strict requirements under the Ecodesign Regulation, when formally adopted, businesses outside of the EU will adjust to EU legislation. Otherwise, suppliers outside of the EU will no longer be able to distribute their products to the European internal market. It is rather unlikely that suppliers would forego access to the EU's internal market instead of adjusting their processes and providing the necessary information.

Much of the EU's legislation has, already strongly influenced and will in the future influence legislation and businesses outside of the EU.[57] One strong example for this is the **Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation) (GDPR)**, which is applicable in the EU since May 2018. Since then, many countries around the world have followed suit or are in the process of establishing and adapting their data protection legislation similar to the one of the EU.[58] A strict regulatory framework for textiles and fibres may therefore lead to greater transparency and compliance within the limits of and even beyond the borders of the EU.

5.1.3 Cross-sector

5.1.3.1 Availability gap and legal Information gap in the REACH-Regulation

Both (legal) information gaps and availability gaps were identified for **Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency (REACH-Regulation**). The Regulation seeks to ensure a high level of protection of human health and the environment as well as the free movement of substances, mixtures and articles as specified in the Regulation (Art. 1).[59]

[57] Cf. for example *Anu Bradford*, The Brussels Effect: How the European Union Rules the World, Oxford University Press, 2019.
[58] Cf. *Sarah O'Brian, Asélle Ibraimova*, The fourth anniversary of the GDPR: How the GDPR has had a domino effect, under The fourth anniversary of the GDPR: How the GDPR has had a domino effect | Technology Law Dispatch (link last accessed on Oct. 10th 2023); *Anu Bradford*, The Brussels Effect: How the European Union Rules the World, Chapter 5 (Digital Economy), p. 131 sqq.
[59] Cf. also *Katja Biedenkopf*, EU Chemicals Regulation, in: EU Environmental Governance, Routledge, 2021, Part IV.7., p. 149 sqq.

5.1.3.1.1 Availability gap regarding the identification of hazardous substances and mixtures

An availability gap was identified between the article manufacturer and the producer/supplier of a substance or mixture. One reason for this is that in practice, the Safety Data Sheet (SDS) is not consistently handed over from company to company along the supply chain.[60]

Article 31(1) of the REACH-Regulation provides (inter alia) that the supplier of a substance or a mixture shall provide the recipient of the substance or mixture with an SDS compiled in accordance with Annex II of the Regulation. The Article further contains more details on the content of the SDS and few exceptions. For example, under Art. 31(4) the SDS "need not be supplied where hazardous substances or mixtures offered or sold to the general public are provided with sufficient information to enable users to take the necessary measures as regards the protection of human health, safety and the environment, unless requested by a downstream user or distributor". Furthermore, SDSs have to be updated under Art. 31(9), when, for example, new information on hazards becomes available or once a restriction has been imposed. Furthermore, in practice, the process of handing over SDSs is not always working as set out in the REACH-Regulation, which also effects the legal information gap as described in the following.

The issue of the availability gap is not of a legal nature but one of enforcement of the Regulation. Under Art. 125, Member States shall maintain a system of official controls and other activities as appropriate to the circumstances. Member States shall, under Art. 126, lay down provisions on penalties which must be effective, proportionate, and dissuasive.

If the information that is currently included in an SDS is digitised in a digital data carrier, such as a DPP, the information flow and comprehensiveness of required of information could be improved.

5.1.3.1.2 Legal information gap and availability gap regarding the identification of articles containing SVHC above 0,1 %

There is a legal information gap as well as an availability (delay) gap for the provision of the identification of articles containing SVHCs above 0.1%. Under Art. 33 (1) of the REACH-Regulation,

"any supplier of an article containing a substance meeting the criteria in Article 57 and identified in accordance with Article 59(1) in a concentration above 0,1 % weight by weight (w/w) shall provide the recipient of the article with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance." Furthermore, under Art. 33 (2) of the REACH-Regulation,

> "On request by a consumer any supplier of an article containing a substance meeting the criteria in Article 57 and identified in accordance with Article 59(1) in a concentration above 0,1 % weight by weight (w/w) shall provide the consumer with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance.
>
> The relevant information shall be provided, free of charge, within 45 days of receipt of the request."

The provision has different effects on the stakeholders as described below.

[60] This is also reflected by the fact that data submission to competent authorities under the REACH-Regulation is a challenge and not all submissions are complete or include all necessary data to evaluate potential hazards and risks, cf. *Katja Biedenkopf*, EU Chemicals Regulation, in: EU Environmental Governance, Routledge, 2021, Part IV.7., p. 159.

5.1.3.1.3 Material producer

To material producers, the information of what substances they are using in their products is readily available. It can be assumed (as argued in more detail above under 5.1.2.1.7), also with regards to EU legislation's information requirements, that material producers either have the information on file or are able to receive/request the information on materials they are using in their products.

5.1.3.1.4 Manufacturer / designer

Manufacturers and designers rely on information provided by the material producers for their material information. If the SDS is not handed over, or not handed over with correct information about the materials used, this creates an availability gap.

5.1.3.1.5 Consumer

Consumers may also rely on information by the manufacturers or designers of a product for their purchasing decision. Under Art. 33 REACH Regulation, a consumer may request such information to be provided. However, a manufacturer has up to 45 days to provide the requested information. This timeline is unnecessarily long for consumers who should be able to expect that the required information can easily be provided (or even publicly available), especially with ongoing digitisation of information and processes. If it were obligatory that manufacturers add an identifier to a product with which consumers and other interested parties can easily find information on the product and publish this identifier, for example, within the database SCIP[61], consumers could more easily and readily access necessary information. Another option would be using a data carrier such as a digital product passport to provide the relevant information to consumers. The latter option would be better even, since it covers more (potentially all) products. Products in the SCIP database either do not contain SVHCs above the legal threshold as set out in the Candidate List (Art. 59(10) REACH-Regulation), or the manufacturer failed to input the legally required information.

5.1.3.1.6 Sorter / recycler and waste treatment

The material information as required by Art. 33 REACH-Regulation is provided via the SCIP database. The database can only be accessed leading to single articles, which is not effective during a sorting process, where during a short period of time all necessary information should be available without manually accessing a database. Additionally, articles included in the SCIP database are not necessarily related to the finished product. Therefore, while the information as required by Art. 33 REACH-Regulation could be useful for sorters, recyclers, and waste treatment, whenever the information is not readily available and easily accessible, it cannot be used effectively. Furthermore, while a threshold of 0,1% weight/weight may be acceptable to users and consumers of a product because of limited exposure or risks, it may impact recycling and sorting processes, where complete information on SVHCs would be preferred. Where material information, including on SVHCs, is not available in detail, recycler, for example, may have to measure how much recycled material is included in a product and how much of the recycled material is contaminated by chemical substances. Recycling processes could be improved if recyclers had access to complete information about SVHCs in substances or mixtures, not just above 0,1% weight by weight. This information could be included in a digital data carrier and accessible to recyclers on a need-to-know basis.

[61] The SCIP database was introduced under the Directive (EU) 2018/851 amending Directive 2008/98/EC on waste (Waste Framework Directive).

5.1.3.1.7 Recommendation to close the legal information and availability gap

Based on the above, the following recommendations can be made to reduce or close legal information gaps or availability gaps:

- Enforcement of the REACH-Regulation should be strengthened. The fact that implementation and enforcement of the REACH-Regulation must be improved has also been recognised by the EU Commission. According to its Communication on the Chemicals Strategy for Sustainability, the EU Commission states that the **Regulation (EU) 2019/1020 on market surveillance and compliance of products and amending (Market Surveillance Regulation)** will strengthen enforcement both within the EU and at the EU's external borders (European Commission 2020). Enforcement also needs to be increased across the Member States, which depends on capacities and resources at national level. According to the Commission, "Member States must increase their enforcement capacity to levels where they can be effective, allowing to reap the benefits from the EU's rapid information and alert tools, better exploit digital tools for faster action and optimise resources, including of market surveillance authorities" (European Commission 2020).

- Additionally, relevant stakeholders have argued that it would be beneficial to have a process for the validation of material information. Validation could be improved where, along with the SDS, suppliers were obliged to hand over audit reports, certifications or other validation information that shows whether a substance or mixture may pose the respective hazards or risks. However, since already only one third of the registration dossiers under the REACH-Regulation are fully compliant with the information requirements, it is questionable whether additional information requirements for validation processes would be, in practice, adhered to by the relevant stakeholders (European Commission 2020).

- Amend the REACH-Regulation so that (1) suppliers who's substances, or mixtures are to be offered on the Union market must provide any further suppliers along the supply chain with information about chemicals used in the substance or mixture using the SDS, without exceptions, (2) including, whether a cumulation of chemicals reaches a threshold which is considered to be "risky" (e.g., hazardous) (Biedenkopf 2021). Currently, the REACH-Regulation addresses chemicals in isolation from one another. Yet, humans as well as the environment are usually exposed to several chemicals that may interact with each other and may have a negative effect by cumulation (as opposed to in isolation). While each chemical taken individually below a certain threshold may not (yet) pose risks to humans and/or the environment, in cumulation, such risks could occur (Biedenkopf 2021). This topic has been, for example, addressed by the Swedish Government and could also be analysed further by the EU (Swedish Government 2019). To determine whether a substance or mixture is to be offered on the Union market, contracts, questionnaires or information in digital data carriers along the supply chain can be useful.

- Shorten the current legal timeline of 45 days to provide consumers with information to "without undue delay, but at least within 72 hours." Evaluate whether alternatively, the obligated stakeholder should be required to send a link to consumers / end-users with the required information. relevant information must be made publicly available in the SCIP database for a consumer to access at any given time. It should be obligatory to include an identifier easily and readily available to any end-user / consumer to find products within the SCIP database (e.g., GTIN). Making the information accessible via a digital data carrier will also help stakeholders to access necessary information.

- Additionally, it should be mandatory to include in the SCIP database a serial number, e.g., GTIN, so that consumers or other stakeholders may easily find and access information about a product and entries in the database should be machine-readable in a way that the necessary provision of information is given to all relevant stakeholders in a timely manner, e.g. via an Application Programming Interface (API). Furthermore, this information should be included in a digital data carrier attached to the product (or, if the product is too small, on the packaging).
- Evaluate whether it is feasible to require suppliers to provide information, certificates or audit reports that help validate whether a substance or mixture contains hazardous chemicals or even to prove that no such chemicals are included.

5.1.3.1.8 Potential impact

The recommendations may influence timelines and financial as well as administrative resources of the relevant stakeholders addressed by the REACH-Regulation.

- Requiring every supplier to provide the SDS without exceptions (as described in section 5.1.3.1.1) means that more stakeholders may have to prepare the information as required by the SDS, which may increase time and resources spent on adhering to the REACH-Regulation. Currently, the SDS may be provided on paper or electronically (Art. 31(8) REACH-Regulation). Providing the SDS digitally together with the mixture, substance and even a product which includes such mixture or substance, e.g., including such information in a digital product passport, may on the other hand save time and resources in situations where, because of exceptions, until today, downstream stakeholders must ask upstream stakeholders to receive the necessary information, losing time and resources in the waiting period.
- Adding the requirement to additionally provide information on whether a cumulation of chemical used in a substance or mixture reaches relevant thresholds of the REACH-Regulation will lead to additional time and effort spent on testing the substance or mixture and providing the relevant information. However, the benefits (e.g., enhanced transparency and health benefits) of increasing relevant information to users of the substance ormixture, including consumers, may outweigh the drawbacks.
- Shortening the timeline to provide consumers with information from 45 days to "without undue delay, but at least within 72 hours" or making it mandatory to provide the relevant information to consumers publicly in the SCIP database for a consumer to easily find (e.g., by GTIN or another identifier readily available to the end-user and/or consumer) and access at any given time should not pose any challenge for the stakeholders, especially if they are already providing SDSs downstream. If the information is not provided on time (or not made public) as required by the Regulation, to improve enforcement, consumers should be able to claim damages or have a right to a complaint with a competent supervisory authority.

5.1.3.2 Usage barrier for consumers in the CLP Regulation

A usage barrier (granularity) in the context of labels was identified for the Regulation **(EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP Regulation**). The Regulation seeks to ensure a high level of protection of human health and the environment as well as the free movement of chemical substances, mixtures and certain specific articles (Recital 1). One objective of the Regulation is to determine which properties of substances and mixtures should lead to a classification as hazardous (e.g., regarding physical hazards as well as hazards to human health and to the environment), for the hazards of substances and mixtures to be properly identified and communicated (Recital 10). To achieve this, the Regulation requires, inter alia, manufacturers, importers and downstream users to classify substances and mixtures placed on the market (Art. 1(b)(i)) and requires suppliers to label and package substances and mixtures placed on the market (Art. 1(b)(ii)).

Under the CLP Regulation, the EU Commission can adopt delegated acts, such as the new **Delegated Regulation 2023/707** amending the CLP Regulation, which sets out new hazard classes and criteria for the classification, labelling and packaging of substances and mixtures.[62] The recipient of the substance or mixture shall be given information about potential hazards, for example by hazard pictograms, signal words, hazard statements and precautionary statements (cf. the Annexes of the CLP Regulation).

5.1.3.2.1 Usage barrier for consumers

Currently, there is a risk that consumers misinterpret the markings of substances and mixtures placed on the market. An evaluation by the EU of the most relevant chemicals legislation (excluding REACH) showed that label comprehension and consumer protection could be further improved.[63] In general, however, enough (if not too much) information is made available to consumers of many daily used products, such as glues, laundry or dishwashing detergent and fertilising products. With the current markings, one additional issue is the fact that consumers often do not know how to recycle or discharge of products containing mixtures and substances governed by the CLP Regulation. The CLP Regulation currently does not specifically address an obligation to include labels with regards to recycling, sorting, and waste treatment.

5.1.3.2.2 Recommendation to reduce the usage barrier

The CLP Regulation must find a compromise between highly aggregated and simplified information, pictograms and logos as well as providing sufficient and transparent information along the supply chain and to consumers.

- Providing the relevant information could be improved by simplifying and, in addition to keeping the physical information, digitalising parts of the (physical) labels. The simplification could, depending on the specific label, be achieved by adding or removing information. The CLP Regulation currently does not incentivise adding information to a digital label (European Commission 2021). However, the Proposal for a Regulation amending Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures (COM/2022/748 final) addresses the need for digital labels in addition to physical labelling. The latest European Council version of the Proposal (Interinstitutional File 2022/0432(COD) of Jan. 10th 2024) states, for example, that the CLP Regulation must be adjusted to technological and societal changes in the field of digitalization (recital 12). Furthermore, digital data carriers to digital labels should be "firmly affixed or printed on the physical label or on the packaging

[62] For an overview over the new Delegated Regulation 2023/707, see under New hazard classes 2023 - ECHA (europa.eu) (last accessed on July 16th 2023).
[63] Cf. the reasoning for a public consultation "Chemicals – simplification and digitalisation of labelling requirements" in 24 November 2021 - 17 February 2022, see under Chemicals – simplification and digitalisation of labelling requirements (europa.eu) (last accessed on September 30th 2023); Report from the EU Commission, "Findings of the Fitness Check of the most relevant chemicals legislation (excluding REACH) and identified challenges, gaps and weaknesses", COM(2019) 264 final.

next to the label in such a way that it can be processed automatically by digital devices that are widely used" (Art. 31 of the Proposal in its most recent version).

- It is therefore recommended to add digital labels with additional information on physical products that fall into the scope of the CLP Regulation. It is furthermore recommended to add information for consumers on how to sort, recycle or dispose of the mixtures and substances as well as to include information for sorters, recyclers, and waste treatment. The information for consumers on how to sort, recycle or dispose of a product should be governed more generally by a Regulation such as the proposed ESPR, not necessarily only for products falling under the CLP Regulation. Either each Regulation or Directive that addresses any "items" (mixtures, substances, products, …) should include requirements on how to dispose of the item falling into the scope of the respective legislative act, or (possibly more efficient), a general legislative act should regulate such information requirements.

5.1.3.2.3 Potential impact

Introducing a requirement to add a data carrier to the physical product of mixtures and substances may initially pose an administrative and financial burden for businesses, especially while adjusting existing processes.

At the same time other administrative costs may be reduced since the digital information would enhance the effectiveness of downstream communication (European Commission 2021). It will enable compliance and bring legal clarity for businesses when the required information must be provided in a harmonised format, all throughout the EU. The EU Commission further notes that "actions should be taken to avoid that a range of voluntary schemes lead to potential market fragmentation or systems that are incompatible with developments such as those under the Globally Harmonised System for the classification and labelling of Chemicals (GHS)" (European Commission 2021).

It is to be expected that digital labelling by using data carriers will, over time, lead to a (communication) benefit for all economic operators involved, especially consumers making more informed purchasing decisions and the use of chemicals. This will lead to improved health of consumers and add to the protection of the environment.

Lastly, market and surveillance authorities will also benefit from a simplified access to relevant information to perform product checks.

In order to reduce financial or administrative burdens for startups and SMEs, for these businesses a longer adjustment period could be implemented, or they could be granted financial support to adjust to new requirements.

5.1.3.3 Usage barrier in the Packaging Directive

Another usage barrier (format) was identified in the **European Parliament and Council Directive 94/62/EC on packaging and packaging waste (Packaging Directive**). The directive aims to harmonise national measures concerning the management of packaging and packaging waste to prevent any impact thereof on the environment of all Member States as well as of third countries or to reduce such impact (Art. 1 (1)).

The usage barrier stems partly from the fact that the **Packaging Directive** is a directive which under Art. 288 TFEU "shall be binding, as to the result to be achieved, upon each Member State to which it is addressed, but shall leave to the national authorities the choice of form and methods." Consequently, a (more detailed) national transposition act is necessary in a Member

State to transpose the directive into national law.[64] Therefore, a directive itself may not be as specific as, for example, regulations, which have general application and are binding in its entirety and directly applicable in all Member States.

5.1.3.3.1 Usage barrier for consumers

Member States have some leeway due to the legal form of the Packaging Directive regarding Information for users of packaging, which can be seen in Art. 13 of the Directive.

Art. 13 of the Packaging Directive states:

> "Member States shall take measures, within two years of the date referred to in Article 22 (1), to ensure that users of packaging, including in particular consumers, obtain the necessary information about:
>
> — the return, collection and recovery systems available to them,
>
> — their role in contributing to reuse, recovery and recycling of packaging and packaging waste,
>
> — the meaning of markings on packaging existing on the market,
>
> — the appropriate elements of the management plans for packaging and packaging waste as referred to in Article 14.
>
> Member States shall also promote consumer information and awareness campaigns."

Since the Directive does not mandate a particular format for providing the information, in particular the information concerning the return, collection and recovery systems available to them, Member States may choose different ways to provide the information.

In Germany, the Packaging Directive was transposed into national law through the "Gesetz über das Inverkehrbringen, die Rücknahme und die hochwertige Verwertung von Verpackungen (Verpackungsgesetz – VerpackG) (Act on the Placing on the Market, the Taking Back and the High- Quality Recycling of Packaging)" (Kahl et al. 2021). In § 14 of the German VerpackG, some of the information obligations of Art. 13 Packaging Directive can be found. There are no specific details, however, as to how the necessary information must be presented to consumers.

Consumers (at least in Germany, but also in other Member States – see net point) could therefore profit from a more harmonised format of information about consumer sorting and recycling.

5.1.3.3.2 Recommendation/Plans to close the usage barrier gap for consumers

A need for adjustment has already been recognised by the EU Commission (Gierke 2022). The EU Commission has therefore published a **Proposal for a Regulation on packaging and packaging waste** on Nov. 30th, 2022 (European Commission 2022c). The EU Commission stated in its Executive Summary that the Packaging Directive showed a mixture of poor implementation and enforcement by not providing enough clarity to national authorities about a compliant implementation of the Directive. One key problem identified is "an increased use of packaging design features that inhibit recycling and confusing labelling of packaging for consumer sorting" (European Commission 2022d, Grisse 2022). An example for this is the "Green Dot Symbol" which is used in some Member States to signify that a producer has made a

[64] For an overview over German and selected other Member State's transposition, cf. *André Gierke*, Verpackungsgesetz und nationale Besonderheiten in der EU, InTer Beilage 1/22, p. 31 sqq.

financial contribution to a national packaging recovery system; however, this symbol can mislead consumers to believe that packaging bearing such a symbol is always recyclable.[65]

Therefore, the EU Commission proposes the switch from the Directive to a Regulation (European Commission 2022d).

► The project team supports this change.

The proposal suggests the following approaches to labelling of packaging. Under Art. 11(2) of the Proposal, packaging

> “shall bear a label on packaging reusability and a QR code or other type of digital data carrier that provides further information on packaging reusability including the availability of a system for re-use and of collection points, and that facilitates the tracking of the packaging and the calculation of trips and rotations. In addition, reusable sales packaging shall be clearly identified and distinguished from single use packaging at the point of sale.”

And furthermore, under Art. 11(4),

> “the QR code or other digital data carrier shall be placed, printed or engraved visibly, clearly legibly and indelibly on the packaging. (…)
>
> Where Union legislation requires information on the packaged product to be provided via a data carrier, a single data carrier shall be used for providing the information required for both the packaged product and the packaging.”

Those new requirements could facilitate and enable consumers’ responsibilities when sorting or disposing of their product and packaging waste. The relevant information about deposit and return systems can be found in one place (instead of via multiple different data carriers).[66]

5.1.3.3.3 Potential impact

A positive impact can be expected from digital labels especially for consumers regarding relevant information on how to recycle or dispose of packaging. Since all Member States have different waste systems and waste management systems, the relevant labels and information for each Member State can and should be added to the digital data carrier in a format that is easily accessible for consumers, such as a QR code. This will enable consumers both within the Member State of habitual residence as well as travelling consumers to identify how and where to dispose or recycle packaging.

Introducing a mandatory digital label to packaging on the internal market will also avoid differences within Member States that may undermine the European principle of free movement of goods (Art. 26 et seq. TFEU). National-specific labelling, such as the labelling requirements

[65] Cf. Recital 49 in the EU Commission Proposal for a Regulation on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, COM(2022) 677 final.

[66] Cf. also Recital 48 of the Proposal: “There should be no multiplication of labels on packaging. In order to avoid this, where other Union legislation requires information on the packaged product to be available digitally through a data carrier, the information required for the packaging under this Regulation and the information required for the packaged product should be accessible via the same data carrier. That data carrier should comply with the requirements under this Regulation or other applicable Union legislation. In particular, where the packaged product is covered by the Regulation [Ecodesign for Sustainable Products] or other Union legislation requiring a digital product passport, that digital product passport should also be used for providing the relevant information under this Regulation.”

under French Circular Economy Law to introduce a Triman Symbol to packaging, came under scrutiny from the EU Commission in February 2023.[67]

For companies, implementing a digital label or data carrier (e.g., a QR code or RFID) to packaging is likely to come with an initial additional administrative and financial burden. However, a more harmonised approach within the EU may also save some costs and effort, since some current requirements of individual Member State legislation may fall away.

To avoid confusion and information overload, there should not be more than one digital label on packaging (or products) providing the relevant information as required by law (e.g., the Packaging Regulation or other (upcoming) applicable European legal acts, such as the Ecodesign Regulation Proposal).

5.1.4 Electronics

5.1.4.1 Usage barrier in the Ecodesign Directive

A usage barrier (accessibility) regarding information on computers and displays was identified in the **Commission Regulation (EU) 2019/2021 of 1 October 2019 laying down ecodesign requirements for electronic displays pursuant to Directive 2009/125/EC ("Ecodesign Regulation Displays").** The Ecodesign Commission Regulation for displays stipulates ecodesign requirements for electronic displays pursuant to the **Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products** (**Ecodesign Directive**).

Under the Ecodesign Commission Regulation for displays, for example, manufacturers must provide a specific marking for displays that contain cadmium content to facilitate the correct and environmentally sound treatment at end of life, as well as markings of plastic components heavier than 50g, and components containing flame retardants (Annex II (Ecodesign Requirements), D.). The Annex specifies that:

- for plastic components heavier than 50 g, the marking shall be "legible"; furthermore, some exemptions from the marking obligation are made, e.g., where the marking is not possible because of the shape or size or it would impact performance or functionality of the component;
- for cadmium, the logo "shall be clearly visible durable, legible and indelible";
- for flame retardants, that "components containing flame retardants shall additionally be marked with the abbreviated term of the polymer followed by hyphen, then the symbol 'FR' followed by the code number of the flame retardant in parentheses. The marking on the enclosure and stand components shall be clearly visible and readable".

In practice, there is currently no effective way to easily identify such markings on devices. In some cases, devices must be dismantled to optically find an applicable marking for the identification of the above-named materials. The markings are further not always machine-readable. In many cases, the additional time needed to find such markings is disproportionate to a slightly higher purity in the waste treatment stream.

[67] Cf. Press release of the EU Commission to open an infringement procedure by sending a letter of formal notice to France for failure to address its labelling requirements concerning waste sorting instructions, see under February infringements package: key decisions (europa.eu) (link last accessed on Oct. 10th, 2023.)

5.1.4.1.1 Sorter / Recycler

As part of waste treatment (e.g., sorting), physical markings on electronics cannot easily be identified and may not be visible from the outside. Therefore, products may have to be disassembled first to retrieve the markings optically, which is time-consuming and consequently ineffective in sorting processes. Providing easily accessible digital information gives sorters and recyclers the possibility to increase sorting and recycling processes.

5.1.4.1.2 Recommendation/Plans to close the usage barrier gap for sorters / recyclers

The Ecodesign Commission Regulation for displays should be amended regarding the rules for affixing the markings. There should be an easy and effective way for sorters and recyclers to retrieve the necessary information of what materials are contained in the devices or parts of devices.

- Marking on the product without necessity of dismantling it: One option to improve the status quo would be to introduce an obligation to provide for the marking not only to be "clearly visible" (anywhere, e.g., even after dismantling some parts); but for example, "clearly visible without the product having to be dismantled".
- Marking on the product must be digitally accessible: Another option would be to make it mandatory to provide the necessary information on a data carrier that is easily accessible, machine-readable and can provide the relevant information digitally to all relevant stakeholders, especially to sorters and recyclers. The type of "machine-readable" access to information, e.g. optical code, or RFID tag etc., could be specified for products, product groups, or in technical standards.

Providing information digitally, through a "digital product passport" is also one "major" part of the **Ecodesign Regulation Proposal** (European Commission 2022e).

Art. 7(6) of the Ecodesign Regulation Proposal as published by the Council of the European Union in its General approach, states (Council of the European Union 2023):

> "Information requirements shall indicate the manner in which the required information shall be made available. When a product passport is available, the required information shall be provided therein and shall, when necessary as a complement, be provided in one or more of the following manners:
>
> (a) on the product itself;
>
> (b) on the product's packaging;
>
> (c) -
>
> (d) on a label referred to in Article 14;
>
> (e) in a user manual or other documentation accompanying the product;
>
> (f) on a free access website or application.
>
> (…)"

It is therefore recommended that a digital product passport is made mandatory (also) for products currently in the scope of the Ecodesign Regulation for displays and that the product passport must be (at least) on the product itself, easily accessible and machine-readable. To clarify, the recommendation for this example of the Ecodesign Commission Regulation for displays does not mean that a digital product passport shall be exclusively made available for displays. A digital product passport can be introduced for all products falling onto the scope of ecodesign legislation.

5.1.4.1.3 Potential impact

A digital solution for the relevant markings under the Ecodesign Commission Regulation for displays would come with an administrative and financial impact for all companies required to mark their product with such a solution. It is to be expected that companies must amend their processes to (1) include the digital product information (e.g., through a digital product passport) on the product and to (2) input the relevant information into a digital system. Implementing a digital product passport onto or into products and adding relevant information into a digital product system, especially if it is information newly required under new legislation may lead to higher prices of products having to be paid by consumers. However, the Ecodesign requirements for products (not necessarily information requirements) should lead to better repairability and durability of products, which may mean that even if prices are slightly increased, the products should last longer.

For sorters and recyclers, a digital solution through which the relevant information about the materials used in a product can easily be retrieved, will increase recycling and sorting of cadmium, plastics heavier than 50g and flame retardants, contributing to the circular economy and the protection of the environment.

5.1.4.2 Usage barrier in the WEEE Directive

A usage barrier (accessibility, granularity) was identified in the **Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (WEEE Directive)**. The WEEE Directive aims to regulate waste electrical and electronic equipment (WEEE) in view of the application of the principles of prevention, recovery and safe disposal of waste (Recital 3). It therefore lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of WEEE and by reducing overall impacts of resource use and improving the efficiency of such use, thereby contributing to sustainable development (Art. 1).

Same as the Packaging Directive, the WEEE Directive had to be transposed into national law by all EU Member States. It therefore only sets out the goals of the Directive but is not as detailed as an EU regulation would be.

Art. 15(1) of the WEEE Directive states:

> "1. In order to facilitate the preparation for re-use and the correct and environmentally sound treatment of WEEE, including maintenance, upgrade, refurbishment and recycling, Member States shall take the necessary measures to ensure that producers provide information free of charge about preparation for re-use and treatment in respect of each type of new EEE placed for the first time on the Union market within one year after the equipment is placed on the market. This information shall identify, as far as it is needed by centres which prepare for re-use and treatment and recycling facilities in order to comply with the provisions of this Directive, the different EEE components and materials, as well as the location of dangerous substances and mixtures in EEE. It shall be made available to centres which prepare for re-use and treatment and recycling facilities by producers of EEE in the form of manuals or by means of electronic media (e.g. CD-ROM, online services)."

The granularity for information on “components and materials”, in particular, for example, the concentration of dangerous substances to be provided by manufacturers, are not regulated in detail by the WEEE Directive. Furthermore, the information shall be made available in the form of “manuals or by means of electronic media”. This allows a bilateral exchange of information (only), instead of a practical distribution of information via, for example, databases or online portals, accessible for many.

In Germany, the WEEE is transposed into the “Gesetz über das Inverkehrbringen, die Rücknahme und die umweltverträgliche Entsorgung von Elektro- und Elektronikgeräten (ElektroG)” (Act Governing the Sale, Return and Environmentally Sound Disposal of Electrical and Electronic Equipment). Art. 28 ElektroG does not specify further how or in which granularity the manufacturers must provide their information. Instead, it mostly repeats the wording used in Art. 15 WEEE. Art. 28 ElektroG states as follows in German (English Version in brackets):

> „(1) Jeder Hersteller hat den Wiederverwendungseinrichtungen und den Behandlungsanlagen Informationen über die Wiederverwendung, die Vorbereitung zur Wiederverwendung und die Behandlung für jeden in Verkehr gebrachten Typ neuer Elektro- und Elektronikgeräte kostenlos zur Verfügung zu stellen.“ (*Each producer shall make available to reuse facilities and treatment facilities, free of charge, information on reuse, preparation for reuse and treatment for each type of new EEE placed on the market.*)
>
> „(2) Die Informationen sind innerhalb eines Jahres nach dem Inverkehrbringen des jeweiligen Gerätes in Form von Handbüchern oder elektronisch zur Verfügung zu stellen. Die Informationen sind in deutscher oder englischer Sprache zu verfassen.“ (*The information must be made available in the form of manuals or electronically within one year of the respective device being placed on the market. The information is to be written in German or English language.*)
>
> „(3) Aus den Informationen muss sich ergeben, welche verschiedenen Bauteile und Werkstoffe die Elektro- und Elektronikgeräte enthalten und an welcher Stelle sich in den Elektro- und Elektronikgeräten gefährliche Stoffe und Gemische befinden. Die Pflicht nach Satz 1 besteht nur, soweit dies für die Wiederverwendungseinrichtungen und die Behandlungsanlagen erforderlich ist, um den Bestimmungen dieses Gesetzes nachkommen zu können.“ (*The information shall indicate the various components and materials contained in the EEE and the location of hazardous substances and mixtures in the EEE. The obligation under sentence 1 shall apply only to the extent necessary for the reuse facilities and the treatment facilities to comply with the provisions of this Act.*)

Therefore, the German transposition also lacks specification on how to provide the information and shows the same accessibility and granularity gap that was identified for the WEEE Directive.

5.1.4.2.1 Recommendation to close the usage barrier gap for sorters / recyclers

The legislative framework for providing and the form of providing necessary information should be improved.

- One improvement could be to introduce a European regulation instead keeping the WEEE Directive, and to include more specific requirements on how, as well as the level of detail, information must be provided to relevant stakeholders, such as sorters and recyclers. This would further harmonise rules within the EU and bring clarity for sorters and recyclers. Sorters and Recyclers would likely no longer have to adhere to different levels of requirements in each member states (e.g., stricter requirements than foreseen by the WEEE). Such regulation should aim to include currently existing strict requirements of the Member States, avoiding minimum harmonisation and instead aiming for full harmonization with a high level of environmental protection.

- It is further recommended that the specific materials contained in parts of EEE and information on how to disassemble EEE is given on a product model level to increase selective treatment and potentially increase economic viability.
- An indication of materials contained in each part of a product and instructions for the disassembly on product model level would allow for a selective treatment and could potentially increase economic viability of depollution and recovery.

Art. 15(1) of the WEEE Directive should be amended as follows (red and crossed out: recommendation to delete; bold and underlined: recommendation to add):

> "1. In order to facilitate the preparation for re-use and the correct and environmentally sound treatment of WEEE, including maintenance, upgrade, refurbishment and recycling, Member States shall take the necessary measures to ensure that producers provide information free of charge about preparation for re-use and treatment in respect of each type of new EEE placed for the first time on the Union market within one year after the equipment is placed on the market. This information shall identify to~~, as far as it is needed by~~ centres which prepare for re-use and treatment and recycling facilities in order to comply with the provisions of this Directive, the different EEE components and materials **<u>on a product model level</u>**, as well as the location of dangerous substances and mixtures in EEE. **<u>The information shall further provide instructions for the disassembly of the product on a product model level.</u>** It shall be made available **<u>in digital, machine-readable form and easily accessible</u>** to centres which prepare for re-use and treatment and recycling facilities by producers of EEE. **<u>If the product is regulated by (name of Ecodesign Regulation), the information must be included in a digital data carrier, e.g., a digital product passport of the product</u>**<u>.</u> ~~in the form of manuals or by means of electronic media (e.g. CD-ROM, online services)~~"

5.1.4.2.2 Potential impact

It is to be expected that all producers who must provide the information under Art. 15 WEEE will have an initial additional administrative and financial burden to change their processes and the provision of information to the relevant stakeholders.

For sorters and recyclers, receiving more detailed information on the product model level, including disassembly instructions, will contribute to the goal of using the best available treatment, recovery and recycling techniques (Recital 17 and 26 of the WEEE Directive).

5.1.4.3 Usage barrier in the RoHS Directive

A **usage barrier (granularity)** was identified in the **Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment** (**RoHS Directive**). The Directive lays down rules on the restriction of the use of hazardous substances in electrical and electronic equipment (EEE) with a view to contributing to the protection of human health and the environment, including the environmentally sound recovery and disposal of waste EEE (Art. 1 RoHS Directive).

Under Art. 7 RoHS Directive, manufacturers must affix a CE marking[68] on their finished product where compliance of EEE with the applicable requirements has been demonstrated by the procedure in line with module A of Annex II to **Decision No 768/2008/EC (Uniform conditions for the marketing of safe products in the EU (conformity marking)**).[69]

5.1.4.3.1 Market surveillance and consumers

The target information group for the CE marking is European Market Surveillance. The CE marking is not directly addressed to consumers and does not demonstrate product safety. It only means that the product conforms to applicable European product legislation. However, German consumers often misinterpret the label in general and/or confuse it with the marking "GS" (Geprüfte Sicherheit" (Certified Safety")). Since the CE marking does not specify with which applicable product legislation a product complies, the CE marking does not provide useful information to consumers (and potentially business end-customers as well).

5.1.4.3.2 Recommendation to close the usage barrier gap

To avoid confusion or misinterpretation of the CE marking, it is recommended to change the RoHS Directive and other product legislation where CE marking is mandatory.

- The usage barrier should be closed by removing the CE marking from parts of the product that are visible to consumers. Ideally, a CE marking is only part of the (digital) product information and as such made easily and readily available to relevant addressees, such as market surveillance authorities.

5.1.4.3.3 Potential impact

Manufacturers can benefit from no longer affixing the CE marking directly on their products. However, including the relevant information in a digital product information and removing the CE marking from products may mean an initial additional financial and administrative burden.

Consumers and other end-customers of products may benefit from not being able to see CE markings on their products as the CE is oftentimes interpreted to relate to some sort of tested or verified safety of the product, which in reality it does not.

5.2 Legal framework for the concept of a system of product information 4.0

The research of the project team has shown the technical and practical complexity around introducing a product information system for electronics and textiles. The legal framework around the concept is equally complex. A product information system may not only be governed by product legislation as well as environmental legislation, but it also falls into the scope of European and national rules governing the European data economy.[70]

[68] A CE marking (only) indicates that a product complies with specific EU health, safety, and environmental protection standards. It is required by applicable law for a wide range of products, such as electronics, toys, machinery, medical devices, and personal protective equipment.
[69] Annex II to the Decision No 768/2008/EC relates to conformity assessment procedures. Cf. Art. 4(1) of the decision, which states: "Where Community harmonisation legislation requires conformity assessment to be performed in respect of a particular product, the procedures which are to be used shall be chosen from among the modules set out and specified in Annex II, (…)".
[70] See EU Commission Communication, "Building a European Data Economy", COM(2017) 9 final; for an overview over one of the EU Commissions priorities, A Europe fit for the digital age, see A Europe fit for the digital age (europa.eu) (link last accessed Oct. 18th 2023).

Part C of the Project "product information 4.0" focused on the approaches and solutions for the capturing, linking, saving and exchanging the necessary product data. Seven different aspects of the technical infrastructure needed for a product information system were assessed:

- Vocabulary, ontology and taxonomies;
- data storage;
- data exchange;
- ownership, liability and data verification;
- access management and IP protection;
- data carriers and
- identifiers.

This chapter will analyse the legal framework for those seven aspects of the technical infrastructure.

5.2.1 Vocabulary, ontology and taxonomy

Part C concluded that the circular economy will benefit from technical interoperability of data. This can best be achieved with a fully standardised vocabulary, ontology, taxonomy, exchange formats and circularity/environmental/sustainability claims spanning all relevant industries.

One way to achieve this would be to

(1) Harmonise or align currently used definitions within the respective European legislative acts relevant for the circular economy, e.g., "sustainability"[71], "value chain"[72], "environmental impact"[73] etc. (Wende 2022);

(2) regulate by law the technical exchange formats to achieve interoperability;

(3) regulate by law which claims are allowed to be made by actors regarding circularity, the environment and sustainability, e.g., as set out in the **Regulation (EC) No 1924/2006 on nutrition and health claims made on foods to the Health Claims (Health Claims Regulation)** or the **Proposal on substantiation and communication of explicit environmental claims (Green Claims Directive)** (European Commission 2023e).

5.2.1.1 Harmonising and aligning definitions

The research team strongly recommends reviewing and aligning definitions used in directives and regulations in the context of the **Circular Economy Action Plan (CEAP)**. The CEAP wants to

[71] *Anne-Christin Mittwoch*, Nachhaltigkeit und Unternehmensrecht, 2022, p. 59 sqq., describes different approaches and definitions used for the concept of sustainability, even though it should be precise to be included in written rules of law.
[72] As an example, the Corporate Due Diligence Directive Proposal includes in Art. 3(g) two definitions of the term "value chain", both longer and more detailed than the definition of "value chain" in Art. 2(11) of the Art. 2(14) of the Ecodesign Regulation Proposal.
[73] Art. 3(b) of the Corporate Due Diligence Directive Proposal (only) defines the term "adverse environmental impact", as an "adverse impact on the environment resulting from the violation of one of the prohibitions and obligations pursuant to the international environmental conventions listed in the Annex, Part II" while the Ecodesign Regulation Proposal defines "environmental impact" as "any change to the environment, whether adverse or beneficial, wholly or partially resulting from a product during its life cycle".

"establish a strong and coherent product policy framework that will make sustainable products, services and business models the norm (…)"(European Commission 2020a).

One negative example for the current use of definitions is the use of terms such as "user" and "end-user", which are not only frequently spelled differently (e.g., "end-user" in the Battery Regulation and "end user" in the Market Surveillance Regulation[74]) but may mean different persons depending on the definition. Additionally, the terms "user" and "end-user" are not always defined in the regulation or directive where the terms are used. For example, the Market Surveillance Regulation defines the term "end user" as "any natural or legal person residing or established in the Union, to whom a product has been made available either as a consumer outside of any trade, business, craft or profession or as a professional end user in the course of its industrial or professional activities", but in Art. 8, Art. 16 it introduces the term "user", which is not explicitly defined in the Regulation. It is not clear whether the changed term was intentional or not.

The Ecodesign Regulation Proposal refers for its definition of the term "end-user" (also sometimes spelled as "end user") to the Market Surveillance Regulation, but also uses the term "user" (e.g., in art. 33 Ecodesign Regulation Proposal) without defining the term.

The WEEE Directive uses the terms "user" (Art. 14), "users other than private households" (Art. 13) and "end-users" (Art. 5(1)(c) without defining or clearly differentiating between them.

A positive example is the definition of "unique (product) identifier" of the Battery Regulation (Art. 3(66)) and the Ecodesign Regulation Proposal (Art. 2 (31)). Even though the former leaves the definition at "unique identifier" and the latter uses the term "unique product identifier", the meaning is the same: a "unique string of characters for the identification of products that also enables a web link to the product passport".

In conclusion, not defining crucial terms in regulations or directives leads to legal uncertainty and confusion. In order to establish a coherent framework for the Circular Economy, definitions should be harmonised wherever possible. In the context of an interoperable, machine-readable (digital) product information system, especially terms referring to specific groups of persons or entities must be clearly defined.

5.2.1.2 Technical specifications by law

One way to harmonise and manage interoperability of data and exchange formats would be to set out, for example in a European regulation, what formats data may and may not have if included in a mandatory (digital) product system information. It is questionable, however, whether detailed technical specifications or standards set out in and required by law would be a proportionate approach to enable a circular economy. Agreeing upon detailed product specifications and technical exchange formats for data may lead to a lengthy, if not impossible, negotiation process between Member States. This would be contradictory to the aim of enabling the circular economy which requires flexibility and innovations.

Additionally, such an approach to product safety was abandoned by the European Council over thirty years ago because of slow procedures and the risk of hindering innovation (Council of the European Union 1985, Schucht 2017). The role of technical standards has greatly increased since the "New Approach" in 1985 to resolve fragmentation of technical specifications within Members of the EU (Council of the European Union 1985, Rossana 2023, Giesberts et al. 2019). The first and second principles of the New Approach state that the European law only sets out

[74] Regulation 2019/1020 on market surveillance and compliance of products. Art. 34 unfortunately of the Regulation uses the term "end-user" instead of "end user".

essential product requirements while details of essential requirements are outsourced to European Standardisation Organisations (ESOs) (Schucht 2017).[75] Following the harmonised standards is not required of producers/manufacturers by law (third principle), but if a producer follows such a standard, it is (refutably) presumed that the respective product is in line with the essential product requirements (fourth principle) (Schucht 2017, Rossana 2023).

While the New Approach started out with the focus of product safety, it currently also plays an important role for environmental product law, in particular regarding the Ecodesign Directive, RohS Directive, Battery Regulation[76] and other directives and regulations addressed in this research project (European Union 2022f, Schucht 2017).[77] However, it can be observed that the first principle – only laying out the basic or essential requirements by law – is not always strictly observed in environmental product law (Schucht 2017). Some strict requirements, such as the prohibition of substances under the RoHS Directive, are set out directly by law and not by harmonised norms. Currently, the Ecodesign Regulation Proposal is also making use of the New Approach and refers to harmonised standards, inter alia, in Art. 34 addressing the presumption of conformity for products.[78]

The goal for a product information system should therefore be that the essential requirements (e.g., interoperability, machine-readability, accessibility etc.) are set out in the respective legislative act (e.g., regulations and directives) or delegated Commission regulations and that they refer to European harmonised standards (to be developed) which detail the requirements of the product information system.

Lastly, in order to ease the financial burden for small and medium sized enterprises, all harmonised standards that are referenced by European legislation should be open access/free of charge. In its communication "An EU Strategy on Standardisation Setting global standards in support of a resilient, green and digital EU single market" the EU Commission calls upon European standardisation organisations to consider free access to standards and other deliverables (European Commission 2022g). Additionally, the Advocate General *Medina* argues in a procedure at the European Court of Justice (CJEU) that harmonised standards should even be classified as EU legal acts (CJEU 2023). The fact that harmonised standards form part of the EU law is supported by the CJEU (CJEU 2024).

European harmonised standards are commissioned by the EU Commission and are in practice, because of the presumption of conformity, de facto mandatory (CJEU 2024, Rossana 2023). Such standards should therefore be seen as official EU acts and published in the Official Journal, resulting in open access of the documents (Rossana 2023).

However, two arguments are frequently brought against giving free access to harmonised standards, commercial interests, and intellectual property rights (Rossana 2023). Regarding the commercial arguments of ESOs, they are not fully convincing. For example, the revenue of selling

[75] The European Standardisation Bodies are: European Committee for Standardisation (CEN); European Committee for Electrotechnical Standardisation (CENELEC); European Telecommunications Standards Institute (ETSI), see under Key players in European Standardisation (europa.eu) (last accessed on Oct. 21st 2023).
[76] Cf. Art. 77 et seq. of the Regulation (EU) 2023/1542 concerning batteries and waste batteries (Battery Regulation).
[77] However, not all environmental legislation is part of the New Approach; e.g., the WEEE Directive is considered to be out of scope of the New Approach; *Schucht, Carsten*, EuZW 2017, p. 47.
[78] An ISO standard is even directly referenced in Art. 9 of the Ecodesign Regulation Proposal. Even though ISO standards are not harmonised standards developed by the European Standardisation Organisations, they use International Standards (e.g., IEC, ISO) wherever they exist and are suitable, CEN and ISO Cooperation - CEN-CENELEC (cencenelec.eu) (last accessed Oct. 22nd 2023).

of harmonised standards only corresponds to 4.6% of the European Committee for Standardisation's (CEN) budget (CJEU 2024, Rossana 2023). Furthermore, all ESOs are nonprofit organisations. Regarding the copyright protection of European harmonised standards, it is questionable whether they have sufficient originality in order to be protected. Even with a low threshold of originality, it can be doubted that the authors of such standards have indeed effective creative freedom, given the control exercised by the EU Commission and the fact that the documents are of immense technical nature (CJEU 2024, Rossana 2023).

5.2.1.3 Regulating claims

Another way to harmonise and standardise the use of vocabulary is to regulate circularity/environmental/sustainability claims that are allowed or prohibited to be made about products. The EU is already active in this field and has published two proposals to address regulating green claims and greenwashing.

(1) In March 2023, the EU Commission announced in 2019 as part of the European Green Deal to reduce the risk of false green claims (greenwashing) and published a proposal for a Directive on substantiation and communication of explicit environmental claims (Green Claims Directive Proposal) (European Commission 2023e).

(2) In March 2022, the EU Commission published a proposal for a Directive amending Directives 2005/29/EC and 2011/83/EU as regards empowering consumers for the green transition through better protection against unfair practices and better information (European Commission 2022).

Both proposals have the goal to reduce "greenwashing", where a product is made out to be "greener" or more environmentally friendly than it actually is (Meierernst 2023). With regards to how consumers should be informed about environmental claims and environmental labels, the Green Claims Directive Proposal addresses these topics in Recital 36 and Art. 5(6).

Recital 36 of the Green Claims Directive Proposal stresses that consumers "should have easy access to the information on the product or the trader that is the subject of the explicit environmental claim and regarding information substantiating that claim". Furthermore, (…) "traders should either provide this information in a physical form or provide a weblink, QR code or equivalent leading to a website where more detailed information on the substantiation of the explicit environmental claim is made available in at least one of the official languages of the Member State where the claim is made. In order to facilitate the enforcement of this Directive, the weblink, QR code or equivalent should also ensure easy access to the certificate of conformity regarding the substantiation of the explicit environmental claim and the contact information of the verifier who drew up that certificate."

Art. 5 of the Green Claims Directive Proposal sets out the requirements for the communication of explicit environmental claims towards consumers. In Art. 5(6), it states:

> "Information on the product or the trader that is the subject of the explicit environmental claim and on the substantiation shall be made available together with the claim in a physical form or in the form of a weblink, QR code or equivalent. That information shall include at least the following (…)"

Unfortunately, the Proposal gives the option of providing information on the physical product <u>or</u> alternatively in digital form. However, where a product information system such as a digital product passport is present, the information should not be missing in the digital system. The wording that this information should be made available in physical form or in the form of a weblink etc. should therefore be changed. For any product that falls into the scope of having to include a data carrier of a product information system, it should be mandatory to provide any substantiation of claims as well as certifications etc. available through a product information system.

5.2.1.4 Summary

The following (legal) recommendations can be made for the product information system regarding vocabulary, ontology and taxonomy:

- Review and alignment of definitions used in Directives and Regulations in the context of the Circular Economy Action Plan (CEAP). This will lessen legal uncertainty for all involved stakeholders and help to establish a coherent framework for the circular economy.
- Regulate essential requirements for the product information system (e.g., interoperability, machine-readability, accessibility etc.) coherently in each relevant legislative act and make reference to harmonised standards (to be developed) which detail the requirements of the information system. The harmonised standards should be open access/free of charge.
- Regulate circularity/environmental/sustainability claims as already proposed by the EU Commission; ensure that for any product that falls into the scope of having to include a data carrier for a product information system, it is mandatory to provide relevant information not only on the physical product but through the product information system.

5.2.2 Data storage

The project team came to the conclusion that a system with decentralised data control which lets stakeholders to choose between storing information on their own premises or with a third-party platform provider is the best approach for data storage in a product information system.

From a legal perspective, giving stakeholders the above-named options instead of prescribing a certain system or location for the data storage seems proportionate. One benefit is that stakeholders who have their data digitised would not necessarily need to make changes to their existing systems.

Some stakeholders will benefit from an (additional) central registry with data points relevant to their tasks. The central registry should receive a copy of data stored in the decentralized system. It should be set out by law which stakeholders will receive access to such centralised registry.

5.2.2.1 Additional central registry for data storage

It may be useful or even necessary to establish a central registry that receives a copy of the dataset included in a data carrier and the product information system. A central registry could be managed by the European Commission and/or national authorities (e.g., market surveillance, customs authorities) on a need-to-know basis. With such a registry, it is likely to be easier for the authorities to review and access certificates, declarations of conformity, labels etc. upon market entry or upon other requests defined by law.

Art. 12 of the Ecodesign Regulation Proposal already plans for such a registry, set up by the EU Commission. The minimum information stored in the central registry, apart from a list of data carriers and unique product identifiers is information that allows (1) for the verification of the authenticity of the product passport, (2) for the improvement of the efficiency and effectiveness of market surveillance checks and customs controls and (3) is not a disproportionate administrative burden for economic operators. The EU Commission delegated acts adopted under the Ecodesign Regulation Proposal for specific product groups will specify which respective information must be provided to the EU Commission registry.

The Battery Regulation does not set up a similar central registry that includes battery passports. Under Art. 42(2)(a), producers (as defined in Art. 3(49)) must be registered in the register of producers; Art. 55 requires Member States to establish a register of producers to monitor compliance with Chapter VIII of the Battery Regulation (Management of waste batteries). It does not directly require producers to provide the battery passport information to the register. However, under Art. 55(5) Battery Regulation, "Member States may request additional information or documents, as necessary, to use the register of producers in an efficient manner". Therefore, Member States may potentially request and store battery passport information as additional information to fulfill their tasks efficiently.

Even though the Battery Regulation does not set up a central registry, some persons with "legitimate interest" (to be specified by implementing acts) shall have access to specific information in the battery passport that other stakeholders/the public are not able to access (Art. 79(9)). The timeline for such implementing acts is August 18th, 2026. How this access is to be granted or how the data shall be provided is not yet specified.

Following the example of the Battery Regulation below, the information provided to market authorities, custom authorities and other persons with legitimate interest can be more detailed or include information that would otherwise be not shared with the public or competitors in order for the relevant stakeholders/authorities to fulfill their duties under national or Union law.

Furthermore, the systems must be secure and, if applicable, be in line with data protection law. From a legal perspective, a requirement for data security should be regulated by law as intended by the New Approach, meaning only to the extent that the essential requirements are set out, and details are left to harmonised standards.

A differentiation can be made between the security for the storage / processing of personal and non-personal data.

5.2.2.2 Secure storage of personal data

Personal data is already covered by the GDPR and Art. 32 GDPR sets out specific requirements on the security of data processing.[79] Personal data may be processed whenever a natural person (e.g., a person working for the manufacturer, a repairer, recycler or even a consumer, etc.) accesses/uses the information system and

(1) either uses a login function with personal data (e.g., email address, name, IP address, etc.); or / and

[79] Art. 32 GDPR (1) states: "Taking into account the state of the art, the costs of implementation and the nature, scope, context and purposes of processing as well as the risk of varying likelihood and severity for the rights and freedoms of natural persons, the controller and the processor shall implement appropriate technical and organisational measures to ensure a level of security appropriate to the risk, including inter alia as appropriate (a) the pseudonymisation and encryption of personal data; (b)the ability to ensure the ongoing confidentiality, (c) integrity, availability and resilience of processing systems and services; (d) the ability to restore the availability and access to personal data in a timely manner in the event of a physical or technical incident; a process for regularly testing, assessing and evaluating the effectiveness of technical and organisational measures for ensuring the security of the processing."

(2) when a natural person accesses a digital data carrier, and the IP address of that person is transmitted.

In a decentralised system, each recipient of personal data is either a controller (Art. 4(7) or processor (Art. 4(8)) under the GDPR. The respective data processing must be in line with the GDPR. In a centralised system, the host of the system could be a controller or a processor, depending on the respective set-up of the system and the freedom of determination of means and purposes of the processing of the personal data. The same applies to other natural or legal persons having access to the system, e.g., in order to add information to a (digital) data carrier, or to amend such data (e.g., repairers). Depending on the role, the controller must be able to demonstrate compliance with the GDPR (Art. 5(2)) and between controllers and processors the relevant agreements must be in place, such as data processing agreements as set out in Art. 28 GDPR.

The current Ecodesign Regulation Proposal states that data should be processed "securely and in compliance with Union law, including applicable rules on the protection of personal data." (Art. 12 (1)). The Battery Regulation requires the technical design an operation of the battery passport to have "a high level of security and privacy".

5.2.2.3 Storage of non-personal data

For non-personal data, the essential requirements for security could be worded similarly to the Art. 32 GDPR security requirements in the respective legislative act(s) referring to a product information system. Security requirements for non-personal data could be set out, for example, as follows:

> "Taking into account the state of the art, the costs of implementation and the nature, scope, context and purposes of processing as well as the risk of varying likelihood and severity for the accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to data, the natural or legal person storing the data shall implement appropriate technical and organisational measures to ensure a level of security appropriate to the risk, including inter alia as appropriate (a) the encryption of data; (b)the ability to ensure the ongoing confidentiality, (c) integrity, availability and resilience of processing systems and services; (d) the ability to restore the availability and access to data in a timely manner in the event of a physical or technical incident; a process for regularly testing, assessing and evaluating the effectiveness of technical and organisational measures for ensuring the security of the processing."

To maintain cohesion, alternatively to following the GDPR wording, it is also an option to simply require, as set out in the Battery Regulation, a high level of security. It is not recommendable to include a reference to "privacy", it would be preferable to reference "applicable rules on the protection of personal data", since it is not clear and not defined what a "high level of privacy" actually means in the context of the battery passport.

5.2.2.4 Summary

The following (legal) recommendations can be made for the product information system regarding data storage:

- In addition to the option of decentralised data storage, a central registry should be set up with access by persons with "legitimate interest", e.g., market surveillance authorities or customs authorities. The respective persons with legitimate interest on a a need-to-know basis to fulfill their duties under national or Union law should be specified for each product group in delegated acts or implementing measures by the EU Commission. The information accessible to such stakeholders could be more detailed than publicly accessible information, in order to protect trade secrets or other similar interests of the provider of the information.

- It would be proportionate to create a legal framework for a product information system which lets stakeholders to choose between storing information on their own premises or with a third-party platform provider. For data security, the legal framework should include or make reference to **essential requirements** / existing European harmonised standards for the interoperability of data, security of data and, where applicable, protection of personal data.
- The essential requirements for the secure storage/processing of personal data are already covered by Art. 32 GDPR. It is not necessary or feasible to change the scope of applicability of the GDPR for a product information system. The legal framework of a product information system should therefore make reference to the applicability of the GDPR whenever personal data is stored or otherwise processed.
- For non-personal data, the essential requirements for security could be worded similarly to the Art. 32 GDPR security requirements in the respective legislative act(s) referring to a product information system. Alternatively, reference could be made to a high level of security.

5.2.3 Data exchange

The basis for an efficient exchange or transfer of data stored in a product information system is interoperability. Both humans and machines must be able to access and retrieve, see or even interact with the information.

5.2.3.1 Legal Framework for the interoperability of data

For interoperability of a product information system, the EU Commission could request that one or more European Standardisation Organisations (ESOs) draft a European standard under Art. 10 of the Regulation (EU) No 1025/2012 on European standardisation. In fact, regarding a digital product passport as set out in the Ecodesign Regulation Proposal and the Battery Regulation the EU Commission has already notified the ESOs of an initiative for a draft standardisation request (European Commission, European Commission 2023f). Existing standards should be used or amended, if they are considered sufficient to achieve the goals of a product information system.

The goal of the standard(s) should address interoperability, machine-readability and accessibility via human interfaces.

5.2.3.2 Summary

The following (legal) recommendations can be made for the product information system regarding data exchange:

- For the interoperability of data, the EU Commission should request that one or more European standardisation organisations (ESOs) draft a European standard under Art. 10 of the Regulation (EU) No 1025/2012 on European standardisation. Existing standards should be used or amended, if they are considered sufficient to achieve the goals of a product information system.

- The standard(s) should address interoperability, machine-readability and accessibility via human interfaces.

5.2.4 Ownership, liability and data verification

From the legal perspective, several questions must be addressed by the framework establishing a product information system. Firstly, the question of who "owns" the data and is ultimately liable for the accuracy of the data. Secondly, what kind of liability or sanction scheme should be implemented for providing false or inaccurate data.

5.2.4.1 (No) "ownership" of data

While there used to be some discussion around "data ownership" as exclusive rights to (non-personal) data, even within the EU Commission, this kind of concept was abandoned (European Commission 2017, Hennemann et al. 2022). Therefore, the legal framework for a product information system should cover (within EU Commission implementing measures or delegated regulations covering product groups) access (and other) rights based on the need-to-know principle. The types of rights (e.g., writing, adding, or amending (e.g., repairers, maybe consumers), retrieving data (e.g., competent market authorities) etc.) should be specified in applicable European harmonised norms created by ESOs. Deletion of data should only be allowed in cases of correcting false data entries, otherwise there is a risk that important historical data may be deleted. It should be traceable and therefore tracked within the product information system, who had access to the respective dataset and what kind of change was made (e.g., with timestamps, IP-addresses or / and User-IDs).

Once it can be established, who input what data and when, the question is what kind of consequence an actor must face in case they provide inaccurate or falsified data into the product system.

5.2.4.2 Liability for the accuracy of (mandatory) data

Neither the Battery Regulation nor the Ecodesign Regulation Proposal clearly address the issue of liability for inaccurate data or for not providing any data at all. The Battery Regulation addresses penalties for infringements in recital 138 and in Art. 93 and leaves it to the Member States to lay down applicable rules.

Recital 138 of the Battery Regulation states:

> "Member States should lay down rules on penalties applicable to infringements of this Regulation and ensure that those rules are implemented. The penalties provided for should be effective, proportionate and dissuasive. When imposing penalties, it is important that due regard be given to the nature, gravity, scope, intentional nature and repetition of the infringement and the level of cooperation of the natural or legal person held responsible with the competent authority. The imposition of penalties is to comply with Union and national law, including with applicable procedural safeguards and with the principles of the Charter of Fundamental Rights of the European Union."

Article 93 of the Battery Regulation states:

> "By 18 August 2025 Member States shall lay down the rules on penalties applicable to infringements of this Regulation and shall take all measures necessary to ensure that they are implemented. The penalties provided for shall be effective, proportionate and dissuasive. Member States shall, without delay, notify the Commission of those rules and

of those measures and shall notify it, without delay, of any subsequent amendment affecting them."

It can already be expected that this framework will lead to very different penalty systems in all Member States. For some coherence within the Member States, it would have been preferrable if the Battery Regulation set up a frame of minimum and maximum fines or a catalogue of measures to be taken by national competent authorities in case of infringements. An example for this kind of framework can be seen in Art. 83 (General conditions for imposing administrative fines) and Art. 84 (Penalties) of the General Data Protection Regulation (GDPR).

The Ecodesign Regulation Proposal takes a similar approach and broadened the details regarding penalties and fines. Its Art. 68 states, in the **most current EU Council Version of December 19th, 2023 (16723/23)**:

"Member States shall lay down the rules on penalties applicable to infringements of this Regulation and shall take all measures necessary to ensure that they are implemented. The penalties provided for shall be effective, proportionate and dissuasive., ~~taking into account the extent of non-compliance and the number of units of non-complying products placed on the Union market~~.

"Member States shall ensure that the penalties established pursuant to this Article give due regard to the following, as applicable:

(b) the nature, gravity and duration of the infringement;

(c) where appropriate, the intentional or negligent character of the infringement;

(d) the financial situation of the natural or legal person held responsible, as indicated for example by the total turnover of the legal person held responsible or the annual income of the natural person held responsible;

(e) the economic benefits derived from the infringement by the natural or legal person held responsible, insofar as they can be determined;

(f) the environmental damage caused by the infringement;

(g) any action taken by the natural or legal person held responsible to mitigate or remedy the damage caused;

(h) the repetitive or singular character of the infringement;

(i) any other aggravating or mitigating factor applicable to the circumstances of the case.

Member States shall at least be able to impose the following penalties in case of infringements to this Regulation:

(a) fines;

(b) -

(c) time-limited exclusion from public procurement procedures.

Member States shall, without delay notify the Commission of the rules and measures referred to in paragraph 1 and of any subsequent amendments affecting them."

Under the ESPR Proposal, providing inaccurate information or omitting required information can lead to damages. Stakeholders can be held accountable for their actions when they are non-compliant with the Regulation as required by Chapter III of the Regulation (Digital product passport).

5.2.4.2.1 Options to introduce liability for the accuracy of data

The data in a product information system must be reliable and the goals of the European circular economy will in the future rely heavily on the data provided in such a system. If the need for accuracy of such data is not taken sufficiently seriously, or if no comprehensive enforcement measures are taken as a consequence of providing insufficient or inaccurate data, the system is likely to set up to fail. If the data inside the system is not reliable, any information taken from such system is not reliable and consequently not of use to the stakeholders, including consumers.

The damages that are to be expected from missing or inaccurate data / information are also different to those stemming from human rights violations, which usually occur outside of the EU. Inaccurate or missing data may influence consumers' decision-making when buying products and therefore affect competition in the EU internal market. Furthermore, inaccurate or missing data may mean that incompliant products enter the EU internal market, for example textiles treated with toxic substances, mixtures or substances that are banned or restricted in the EU (e.g., CMR substances restricted under the REACH Regulation (Annex XVII)). Recycling facilities may recycle products based on the information provided in the information system. If this data is incorrect, not only could this negatively affect, even break recycling equipment, the environment may even be harmed.

Since the value chain often will start outside of the EU and actors outside of the EU where it is unlikely for European enforcement authorities to enforce European legislation, the enforcement of responsibility must start with the first actor within the EU. They should be held liable for data provided by their suppliers outside of the EU. Since there is a contractual chain along the supply chain, actors are likely to introduce strict clauses (regress, liability, penalty payments, cancellation policies) into their contracts (upstream and downstream) with each prior or subsequent actor to incentivise always providing accurate data. Such measures are likely to increase the validation of data by all relevant actors both inside and outside of the EU to limit liability risks. Suppliers who repeatedly provide false or no data are over time likely to be replaced by more reliable suppliers. Within the EU, each actor who actively inputs, amends, adds their data, shall be responsible and liable for the data they control. Consumers (see below) should not be liable for adding any data.

Drawing a comparison to the system of liability and sanctions of the GDPR, the burden and liability is mainly on the so-called "controller" (Art. 4(7)) of the personal data, meaning the person who decides the means and purposes of the data processing. The controller has to be able to demonstrate compliance with the GDPR and may have to pay damages, administrative fines or face other sanctions specified in applicable Member State law. The controller is also responsible and liable for choosing or involving other entities in the data processing, so-called "processors" (Art. 4(8)) of personal data. When it comes to liability towards a data subject who has suffered damages because of a GDPR infringement, it is mainly the controller who is liable for the damage caused by the infringement (Art. 82(2)). Only if the controller can prove that it is not in any way responsible for the event giving rise to the damage, the controller may be exempt from liability. However, choosing an unreliable data processor who, for example, did not implement appropriate measures to protect data subjects during the data processing, is also an infringement of the GDPR.

Comparisons are intentionally not drawn to national laws like the French "loi de vigilance" (*Law No. 2017-399 of 27.3.2017 on the duty of vigilance of parent companies and its affiliated entities /*

Loi n° 2017-399 du 27.3.2017 relative au devoir de vigilance des sociétés mère et des entreprises donneuses d´ordre) or the German "Lieferkettensorgfaltspflichtengesetz" (*Act on Corporate Due Diligence to Prevent Human Rights Violations in Supply Chains / Gesetz über die unternehmerischen Sorgfaltspflichten zur Vermeidung von Menschenrechtsverletzungen in Lieferketten*), neither to the EU Proposal for a Directive on Corporate Sustainability Due Diligence. These acts / the proposal do not address the provision of accurate or inaccurate data but lay down rules for violations of human rights, fundamental freedoms, health and safety of persons and the environment etc. The direction of impact under those laws is mostly outside of the EU and not inside of the internal market.

5.2.4.2.2 Consumers as data providers

Consumers should in general not be liable for manually adding data into a product information system. Their access and/or writing rights should, in any case, be very limited. The main goal for consumers is to access information to make educated decisions on the purchasing and subsequent use of a product. There should not be any legal obligation to add information, however, there may be incentives for consumers to add information on a voluntary basis. One example for textiles could be information on washing cycles. While it is unlikely that a consumer is able to count how many times he or she washed a textile, if the data carrier is able to automatically count the washing cycles, a consumer could opt-in to have such a number tracked and stored in the data carrier. It is in such a case noteworthy that if a (digital) data carrier turns into a connected IOT product collecting data during its use, the legislative framework of Regulation (EU) 2023/2854 on harmonised rules on fair access to and use of data (Data Act) may apply.

Another example of allowing a consumer to add information into a product information system would be that the consumer repairs their own products instead of bringing them to a professional repairer. While the professional repairer is granted with access and writing rights to the relevant data entry points to add the respective information into the product information system, the consumer should not have this option. The consumer may be provided with a separate / dedicated field to make an entry, preferably from a drop-down menu instead of a text field.

It is furthermore recommended that the start of a product information system should focus on legal entities as data providers for mandatory data; voluntary data fields for consumers (even in general) could be introduced at a later stage.

5.2.4.2.3 Providing data on a voluntary basis

A different system of liability could apply for data that is provided on a voluntary basis. In this case, the strict liability rules (e.g., administrative fines, other sanctions) should not apply at all or not from the start of a product information system. Any stakeholder using the voluntarily provided data will do so in their own responsibility. Competent authorities should furthermore not pursue infringements voluntarily provided data, unless, for example, there are indications that the data was provided with malicious intent.

Still, data provided on a voluntary basis must be accurate in order to be useful, so it is recommended that the EU Commission asks Member States to collect data / feedback on the accuracy of voluntarily provided data. Where there is no legal obligation to provide data, it can be expected that stakeholders will only provide data that they already collect and that they know is accurate or validated. Voluntary data could also be provided under a certification scheme; in that case both the voluntary data as well as the certificate could be part of the product information system.

5.2.4.3 Incentives for providing accurate data

Further measures to incentivise EU actors to provide complete and accurate data could be:

- Financial incentives for providing accurate data over a long period of time;
- Establishing a framework for third-party validation of datasets;
- Establishing a framework to audit the processes of how the data to input into the product information system is chosen and validated;

Providing accurate data can also be part the enforcement under competition law. In this case, providing inaccurate or not providing any data could (and should) be seen as an unfair commercial practice, since they are likely to materially distort the internal market. Member States have different approaches to enforcement against unfair commercial practices, since the **Directive 2005/29/EC concerning unfair business-to-consumer commercial practices in the internal market ('Unfair Commercial Practices Directive')** is transposed differently in each Member State. It is recommended that data relevant to the product information system falls into the scope of that Directive. Especially Germany can benefit from this model, since competitors can monitor each other, which can be more effective than monitoring only by competent authorities.

5.2.4.4 Proportionality

Sanctions and administrative fines would have to be effective, proportionate and dissuasive. This system will create different results for each stakeholder. Similar to the GDPR, fines could be measured in proportion to the worldwide annual turnover of the preceding financial year. When administering fines, the prior behaviour and other factors of the actor should be taken into account, e.g.,

- nature, gravity and duration of the infringement;
- intent or negligence;
- relevant previous infringements;
- other aggravating or mitigating factors depending on the specific circumstances of the case.

5.2.4.5 Summary

The following (legal) recommendations can be made for the product information system 4.0 regarding "ownership", liability and data verification:

For personal data, the following is recommended:

- Personal data is already governed by the GDPR, which gives control and extensive rights to the data subjects itself, while regulating when and how natural or legal persons are allowed to process personal data. Therefore, any personal data stored in a product information system will have to adhere to the principles and framework of the GDPR.

For non-personal data, the following framework is recommended:

- There is no need to introduce "ownership" of data. The legal framework around the product information system shall specify (e.g., in the implementing acts or Commission delegated acts) access rights and other rights (read, write, delete, retrieve, add etc.). The types of rights should be specified in applicable European harmonised norms. It is important to track who had access to the system and what changes or additions etc. were made by any actor.

- There should be a framework for the liability of providing accurate data. If no pressure is put on stakeholders to provide accurate and reliable data, the whole system and expected benefits of a product information system for the circular economy may fail. If there are no consequences for providing inaccurate or not sufficient data, it is to be expected that stakeholders, especially consumers, do not / cannot trust the data from the system.
- The first actor/stakeholder inside the EU shall be responsible for data provided by its suppliers outside of the EU. If each actor along the supply chain is contractually bound to provide accurate, validated data in order to reduce (contractual) liability risks, the data is likely to be more reliable. Suppliers who repeatedly provide false or no data are over time likely to be replaced by more reliable suppliers. Within the EU, each actor who actively inputs, amends, adds their data, shall be responsible and liable for the data they add into the product information system.
- Consumers should not be liable for adding any data and have either no or very restricted options to add information into the system.
- A system of liability and sanctions for providing inaccurate or omitting data could be established similar to the system of the GDPR. When data is provided on a voluntary basis, strict liability clauses should not apply at all or only within a limited scope.

5.2.5 Access management and IP protection

As stated above and to avoid repetitions, the details of access and rights management should in general be specified by the ESOs through European harmonised standards.

Some legal aspects of IP protection and trade secrets should be taken into consideration when setting up the framework for a product information system.

5.2.5.1 Publicly accessible data

The dataset that is mandatory to be publicly accessible (e.g., access by consumers) should not lead to an obligation of involved stakeholders to disclose any data relating to their trade secrets or intellectual property rights.

The start of a product information system should be with a relatively small/minimum dataset that should not overwhelm stakeholders to provide the relevant data entries. The information could mainly consist of data that is already obligatory to provide (e.g., in printed form on the product), so it should be proportionate to have this data provided in digital form. Additionally, new data fields, each depending on the specific product category, should be defined in the respective EU Commission implementing acts or delegated acts.

5.2.5.2 Data with restricted access

If trade secrets or intellectual property must be protected, data in the information system should be restricted to access on a need-to-know basis and potentially be protected by license agreements, which could be introduced via EU model clauses. The prerequisite would be, however, that the data inside the product information system actually is protected as under applicable IP law or as a trade secret.

5.2.5.2.1 Data as trade secrets

Under Art. 2(1) of the **Directive (EU) 2016/943 on the protection of undisclosed know-how and business information (trade secrets) against their unlawful acquisition, use and disclosure** a trade secret means information that is (1) secret in the sense that it is not, as a body or in the precise configuration and assembly of its components, generally known among or readily accessible to persons within the circles that normally deal with the kind of information in question, (2) has commercial value because it is secret and (3) has been subject to reasonable steps under the circumstances, by the person lawfully in control of the information, to keep it secret. Since the definition is part of a Directive and defines the minimum criteria, the Member States transposing the Directive into national law may have introduced slightly different and/or broader definitions.

Only data that amounts to "information" can be protected under trade secret legislation.[80] Examples for trade secrets can be customer lists, supplier lists, business plans, formulas, methods, or design/manufacturing/engineering processes etc. It may be a case-by-case decision whether data stored in the product information system can amount to information protected as a trade secret or not.

It s therefore questionable, whether the protection of trade secrets will pose a big barrier to sharing data in a product information system. It is not to be expected that complete formulas, methods, processes etc. will have to be provided. For textiles, as an example, even if all fibres used in a fabric must be provided, this does not mean that the processes used to treat the garments have to be provided. Furthermore, even if data of chemicals used on textiles have to be provided, this could be – if necessary – limited to specific chemicals or specific combinations of chemicals.

It is likely that during the feedback process for the proposal of an EU Commission implementing measure or delegated regulation for specific product groups, feedback about the potential risk of having to disclose too much or too detailed information and therefore trade secrets, will be voiced. The feedback should be evaluated and taken into consideration.

5.2.5.2.2 Trade secrets under the Ecodesign Regulation Proposal

The issue of trade secrets is also addressed in recital 62 of the Ecodesign Regulation Proposal, where it says (emphasis added):

> "To speed up and facilitate the verification of compliance of products placed on the market, the power to adopt acts in accordance with Article 290 TFEU should be delegated to the Commission to supplement this Regulation by requiring responsible economic operators, where necessary, to make specific parts of the technical documentation digitally available both to competent national authorities and to the Commission. This should allow competent national authorities to access this information without request, **while continuing to guarantee the protection of trade secrets and intellectual property rights**. Possible means of making this information digitally available should in principle include a product passport, or via inclusion in the compliance part of the product database referred to in Regulation (EU) 2017/1369, or on a website of the economic operator. Such an obligation should not take away from the competent national authorities' right to access other parts of the technical documentation on request."

[80] Cf. *Andreas Wiebe*, The Data Act Proposal, Access rights at the Intersection with Database Rights and Trade Secret Protection, GRUR 2023, 227 et seq. on the complexities of protecting data as a trade secret

5.2.5.2.3 Trade secrets under the Data Act

The need for the protection of trade secrets is being addressed in more depth in the **Regulation (EU) 2023/2854 on harmonised rules on fair access to and use of data (Data Act)**.

The Data Act

states in its Art. 1(a) that the Regulation lays down harmonised rules on “the making available of product data and related service data to the user of the connected product or related service”; in Art. 1(b) “the making available of data by data holders to data recipients”; and Art. 1(c) “the making available of data by data holders to public sector bodies, the Commission, the European Central Bank and Union bodies, where there is an exceptional need for those data for the performance of a specific task carried out in the public interest”. ”.

In short, the Data Act regulates the data of IOT products. Because of the amount of data that a connected product may collect during its use, trade secrets stemming from such data collection must be taken into consideration.

Art. 4(3) of the Data Act states that (emphasis added):

> “Trade secrets shall only be disclosed provided that all specific necessary measures are taken to preserve the confidentiality of trade secrets in particular with respect to third parties. The data holder and the user can agree measures to preserve the confidentiality of the shared data, in particular in relation to third parties. “

Art. 5(8) regarding the right to share data with third parties states that:

> “Trade secrets shall only be disclosed to third parties to the extent that they are strictly necessary to fulfil the purpose agreed between the user and the third party and all specific necessary measures agreed between the data holder and the third party are taken by the third party to preserve the confidentiality of the trade secret. In such a case, the nature of the data as trade secrets and the measures for preserving the confidentiality shall be specified in the agreement between the data holder and the third party.”

The extracts show that the protection of trade secrets is being taken seriously and therefore addressed in greater detail when it comes to data collected by IOT products and subsequent access (requests) to such data. Even though the data stored in the product information system are unlikely to fall (fully) under the Data Act , the expertise around the protection of trade secrets collected during the discussion around the Data Act could be helpful here as well. It is therefore recommended to include experts from the Data Act into the discussion of the product information system.

5.2.5.2.4 Data as intellectual property

Trade secrets and intellectual property rights (IPR) are often discussed or addressed together, without finding a clear distinction between the terms (as can be seen by the above examples of the Data Act). While personal data is protected by, for example, the GDPR and other non-personal data may be protected under traditional IPR (e.g., copyright law in case of the work being (1) original in the sense that it is the author’s own intellectual creation and (2) something which is the expression of the author’s own intellectual creation (CJEU, Judgment of 13 November 2018, *Levola Hengelo BV v Smilde Foods BV*, Case C-310/17; ECLI identifier: ECLI:EU:C:2018:899), other data (e.g., machine-generated data) falls outside the scope of protection by applicable traditional IPR or data protection laws. In some cases, the investment into setting up a database may be protected under the **Directive 96/9/EC on the legal protection of databases (Database Directive)**. Under Art. 7(1) of the Directive provides:

“Member States shall provide for a right for the maker of a database which shows that there has been qualitatively and/or quantitatively a substantial investment in either the obtaining, verification or presentation of the contents to prevent extraction and/or re-utilisation of the whole or of a substantial part, evaluated qualitatively and/or quantitatively, of the contents of that database.” The European Court of Justice sees the purpose of this right is to “ensure that the person who has taken the initiative and assumed the risk of making a substantial investment in terms of human, technical and/or financial resources in the setting up and operation of a database receives a return on his or her investment by protecting him or her against the340nauthorizedd appropriation of the results of that investment” (CJEU, Judgment of 19 December 2013, *Innoweb*, Case C-762/19, ECLI:EU:C:2021:434). Investments (solely) into the generation of data and the collection of data are therefore not protected by the right in Art. 7(1). Access to the data and usage of data included in the database is protected.

When the product information system is, as recommended, set up in a decentralised way, stakeholders who host their own product information system may be protected not only under Member State copyright law (if and insofar as applicable), but also under Member State law transposing the Database Directive into national legislation. The same applies to service providers who offer to host such product information system for their customers in their databases. <u>In such cases, license agreements for the use of such database may have to be concluded between the rights holder of the database and the user/customer who wants access to the data included in the database (independent of costs associated with using the database).</u> License agreements may also affect third parties who, for example, want to access such data to provide information to consumers via mobile or web applications (Apps). License agreement terms would have to be assessed to analyse whether such publication is allowed or not. Another option could be that the EU introduces standard model clauses on the use of information requirements under the ESPR Proposal.

5.2.5.2.5 Access on a need-to-know basis, EU Model Clauses

Access to information that may be considered a trade secret (e.g., a supplier network) or protected under intellectual property law should, if it cannot be protected otherwise, only be granted to competent Union or Member State authorities fulfilling their duties under Union or applicable national law.

Similar to the Data Act, for the framework of the product information system, whenever trade secrets or intellectual property rights are affected, it may be useful that stakeholders accessing such sensitive information (e.g., repairers or recyclers in order to fulfill their tasks) conclude agreements laying down the conditions of access (license), confidentiality and measures to implement to protect trade secrets and IPR. <u>The EU Commission could draft **model clauses** for such situations that can easily be incorporated between (B2B-) stakeholders. Private use is by law privileged under copyright law and database law.</u>

5.2.5.3 Summary

The following (legal) recommendations can be made for the product information system regarding access and IP protection:

- Datasets that must be published to the public should not lead to an obligation to disclose trade secrets or information protected under IP rights.

- If datasets are made available only under restricted access, the prerequisite should be that the data is actually protected as a trade secret or by other applicable IP rights. The burden to prove this should be with the stakeholder claiming such rights.
- For more details on the protection of trade secrets and other IP rights, the Data Act or experts from drafting the proposal should be consulted.
- Access to information that is a trade secret or protected under IP law should, if it cannot be protected otherwise, only be granted to competent Union or Member State authorities fulfilling their duties under Union or applicable national law.
- The EU Commission could draft model clauses that can easily be incorporated between (B2B-) stakeholders for situations where, for example, a repairer, sorter or recycler needs access to information that is considered a trade secret or otherwise protected under IP law.

5.2.6 Data carriers

The project team concluded that there is no one data carrier that can be used for all product groups since the needs of interaction with a data carrier are different from stakeholder to stakeholder (e.g., a consumer may want to use a smart device to access a website; textile sorters need an automatic reading process). Data carriers in textiles will need to survive many washing cycles and should not be in places that are often manually cut off by consumers (e.g., labels sewn into a garment).

Suitable data carriers could be QR codes, passive RFID HF/NFC tags, and optical codes. From a legal perspective, two main issues were identified: Textiles that may be registered as electronic equipment and falling under Member State law transposing the WEEE Directive and potential tracking of natural persons to data carriers.

5.2.6.1 Data carriers and textiles as electrical and electronic equipment

For textiles, which usually do not contain any electronic equipment, introducing data carriers could be somewhat problematic.

5.2.6.1.1 Textiles with electronic tags under the WEEE Directive

The WEEE Directive defines electrical and electronic equipment (EEE) as “equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current” (Art. 3(a)). Passive RFID tags and NFC tags are dependent on electronic currents to work properly and therefore are EEE. This is further clarified explicitly for RFID tags by the EU Commission in its Document “Frequently Asked Questions on Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE)”, where it states under 3.7: “RFID tags (active and passive) meet the definition of EEE as set out in Article 3(1)(a) and thus fall within the scope of the Directive, unless they benefit from an exclusion on the basis of Article 2.”

A regular t-shirt or pants, at least if they do not include electronic tags, do not fall under this definition. Alone from its wording, t-shirts or pants are usually not referred to as “equipment”. However, this may change if they include an electronic data carrier. It can be argued that any item of clothing which includes an RFID tag must be seen as “electronic equipment”, even though its main function is that a person wears the item on their body. The law does not differentiate between different types of uses of the RFID tag.

It may also be possible to argue that items of clothing which include RFID tags fall under an exclusion of the WEEE Directive. A potential exclusion that could fit this case is Art. 2(3) of the WEEE Directive, which provides (emphasis added):

> "This Directive shall **not** apply to any of the following EEE (b) equipment which is specifically designed and installed as part of another type of equipment that is excluded from or **does not fall within the scope of this Directive**, which can fulfil its function **only if it is part** of that equipment."

As stated, it would not be typical to describe textiles as "equipment", but textiles would generally not fall within the scope of the WEEE Directive. Electronic tags may be specifically designed to serve as a data carrier for textiles. Only in connection to the textile, the electronic tag is able to fulfill its function, namely, to provide the necessary information for stakeholders. If the tag were removed from the textile, the information stored on the tag in connection with the textile is lost, or at least worthless. Therefore, it could be argued that it was not the intention of the European legislator to turn textiles with electronic tags into "equipment" and view textiles with such tags as EEE.

This shows that is currently not clear whether the WEEE Directive includes textiles with an RFID tag or not. Until a clarification is added by the European lawmakers or a relevant decision published by the European Court of Justice regarding this issue, it should be assumed that textiles with an RFID tag fall into the scope of the WEEE.

5.2.6.1.2 Textiles with electronic tags under the German ElektroG

Since the WEEE Directive must be transposed into national law, a different conclusion may be reached for each Member State. As an example, the German Act Governing the Sale, Return and Environmentally Sound Disposal of Electrical and Electronic Equipment (ElektroG) is analysed.

As with the WEEE Directive, regular textiles are not covered by the ElektroG. Electronic tags fall under the definition of § 3 No. 1 ElektroG. The ElektroG also includes the same exception to the scope as defined in the WEEE Directive. It provides in § 2 (2):

> „Dieses Gesetz gilt nicht für folgende Elektro- und Elektronikgeräte: Geräte, die
>
> a) als Teil eines anderen Gerätes, das vom Geltungsbereich dieses Gesetzes ausgenommen ist oder nicht in den Geltungsbereich dieses Gesetzes fällt, in dieses eingebaut sind und
>
> b) ihre Funktion nur speziell als Teil dieses anderen Gerätes erfüllen können"

Here as well, the fact that the electronic tag may be part of a textile does not fit the wording of a textile being another "equipment" which does not fall into the scope of the ElektroG. Textiles are not "equipment". Despite the wording, or even more so, a textile with an electronic tag should not fall into the scope of the WEEE. Insofar, the same logic/argument applies as above regarding the WEEE Directive.

However, Annex 1 to the ElektroG has a non-exhaustive list of examples of EEE, including Annex 1 No. 5, "Clothing with electrical functions (e.g. heating, massage or lighting functions)" (in German: "Bekleidung mit elektrischen Funktionen (z.B. Heiz-, Massage- oder Leuchtfunktionen)". Another example of the list are "Shoes with light functions" (in German: "Schuhe mit Leuchtfunktionen"). This may mean that in Germany, if textiles include an electronic tag as described, it could fall into the scope of the ElektroG. It is noteworthy that the "shoes with light functions" were added to the list after a court ruling concluded that the legislator intentionally did not mean to include "clothes" into the scope of application of the ElektroG (Judgment of 21.02.2008 - BVerwG 7 C 43.07). Although this could have been helpful, the case was not referred to the European Court of Justice for clarification if the European legislator meant to include textiles in the scope of the WEEE directive.

In the aftermath of the court ruling, the German legislator updated Annex 1 to the ElektroG and specifically decided to include "shoes with light functions" (Drucksache 19/26971 of February 21st 2021). The reasoning behind this was stated as follows: „Clarification that clothing can also fall under the Electrical and Electronic Equipment Act, as well as other "new" electrical appliances". Reference is made to an opinion of the "Stiftung Elektro-Altgeräte Register" (Stiftung EAR) (stiftung-ear.de/de/themen/elektrog/hersteller-bv/anwendungsbereich, link last accessed on Oct. 31st 2023), stating that Products such as furniture, clothing or lifestyle products may also fall into the scope of the German ElektroG.

To further complicate things, Stiftung EAR explains:

> "Electrical appliances according to the ElektroG are always only end devices, i.e. "finished" products; these

- fulfil an independent function,
- are intended for use or installation by end-users, and
- In principle, their installation can also be carried out without great technical effort, albeit by technically qualified persons."

Stiftung EAR does not explain what is meant with the term "end-user". However, category 5 of Annex 1 ElektroG (which includes clothing and shoes) refers to "Small appliances that can be used in private households". Therefore, the "end-users" are consumers, as they reside in private households.

With regard to electronic tags in textiles, this could mean the following: if an electronic tag is only accessible to recyclers/sorters, not private households, a textile with such a tag would not fall into the scope of the ElektroG, since there is no intention for use by the end-user. However, if a consumer – as would be preferable for the circular economy – is given a way to use the electronic tag, e.g., to receive information from the product information system, then the textile would fall into the scope of the ElektroG. Furthermore, a consumer could then be required to remove the electronic tag before disposing of the textile. This would entirely defeat one of the main purposes of the electronic tag, namely, to enable the circular economy by facilitating sorting and recycling processes.

In view of the rather limited scope of the WEEE Directive as well as the above-mentioned court ruling, this opinion of the German Stiftung EAR is rather unfortunate. It is even more unfortunate that the German legislator took the opinion as a reason to specifically amend Annex 1 of the ElektroG to include clothing as an EEE.

Overall, the German Annex 1 of the ElektroG and the opinion of the Stiftung EAR seem to overcomplicate things. It may be similar in other Member States, but it is to be expected that textiles including electronic tags will be handled differently in different Member States, complicating their use for stakeholders within the internal market. Since the WEEE Directive does not state that it intends full harmonization and the recitals indicate that minimum standards for the treatment of WEEE should be developed (recital 6), Member States are free to use some leeway on the national level.

It is therefore recommended that, under the current legislative framework, electronic tags are not used in textiles as data carriers used for the product information system.

5.2.6.1.3 Alternative options

Alternatively, only optical data carriers, such as a QR-code, could be used. However, there is a risk that the QR-code is cut out of clothes (especially if it is part of a sewn-in tag that is often cut-out by consumers as it may lead to irritation on the skin) or, if it is part of the fabric itself, lost / faded due to many washing cycles.

The preferrable solution would be that a clear legal exception is created to the WEEE Directive that clarifies that passive electronic tags which are part of a product group under the product information system do not fall under the scope of the WEEE Directive. Member States should not be allowed to introduce stricter rules nationally when transposing this exception of the Directive (full harmonisation). In this case, however, the burden would fall onto sorters and recyclers to read and remove the passive electronic tag before starting the recycling process.

5.2.6.2 Tracking of natural persons through RFID data carriers

The introduction of RFID tags to a product or textile may lead to concerns over data protection law. This would require that the data stored in an RFID tag can be considered personal data. In general, the information stored on the data carrier as well as in the product information system is mainly product-related data. Therefore, a clear distinction can be made between an RFID tag as a data carrier for the product information system and, for example, RFID tags in passports or medical records which purposefully store personal information.

However, in some cases even product-related data may be considered personal data. Personal data is defined in Art. 4(1) GDPR as “any information relating to an identified or identifiable natural person”. This is clarified through examples: “an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person”. In short, whenever a natural person can be identified, even if the person is not identified directly by their name or contact details, the GDPR applies.

The question is whether an RFID tag carrying only product-related data can be used to identify a person directly or indirectly. If an RFID tag contains a unique identifier, this could potentially be the case. Simply reading the RFID tag once will not produce any personal information, but only product related data.

Example: A unique identifier could be used in the context of tracking an individual, for example, as the individual is walking through a store. In practice, tracking through passive RFID tags depends on the distance from which the RFID tag can be read. It is often argued that this is only possible if the tag and the reader are in very close range to each other (only a few centimeters to one meter apart). If a store installs many RFID tag readers and reads all RFID tags that come into their distance, a tracking/walking profile could be created based on the movements of the person inside the store in connection to the unique identifier. It could monitor what aisles or parts of the store a customer is mostly interested in, etc.

In such a case, it is the legal entity owning the store that must adhere to applicable data protection laws, in particular the GDPR. It is the store that acts as the controller, collecting personal data (the unique identifiers) and therefore must meet all the principles of data processing under the GDPR, in this case in particular finding an applicable legal basis for the data processing (Art. 6 GDPR) and meeting transparency obligations (Art. 12 et. seq. GDPR).

5.2.6.3 Legal framework around RFIDs

While it is unclear whether passive RFIDs (RFIDs without batteries) are governed by the **Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment (RED Directive)**, both active and passive RFIDs fall into the scope of **Commission Implementing Decision (EU) 2022/172 on the harmonisation of radio spectrum for use by short-range devices within the 874-876 and 915-921 MHz frequency bands**. The latter Decision refers to the RED Directive for the compliance with essential requirements and applicable harmonised standards which have been published in the Official Journal of the European Union under Directive 2014/53/EU. Part of these essential requirements under Art. 3(3)(e) of the RED Directive provides (emphasis added): "Radio equipment within certain categories or classes shall be so constructed that it complies with the following essential requirements: radio equipment incorporates safeguards to **ensure that the personal data and privacy of the user** and of the subscriber **are protected**".

A list of harmonised standards for Radio Equipment can be found under Radio equipment (europa.eu) (link last accessed on Nov. 1st 2023).

5.2.6.4 Summary

The following (legal) recommendations can be made for the product information system regarding data carriers:

- It is recommended to introduce a clear legal exception into the WEEE Directive that clarifies that passive electronic tags which are part of a product group such as textiles under the product information system do not fall into the scope of the WEEE Directive. Member States should not be allowed to introduce stricter rules nationally when transposing this exception of the Directive (full harmonisation).
- Under the current legal framework of the WEEE directive and transpositions into Member States law, it cannot be recommended to use electronic tags (RFID, NFC) in textiles as data carriers for the product information system.
- An electronic tag with a unique identifier can potentially be used as a tracking device. In that case, the entity or person who is responsible for the tracking has to adhere to the GDPR, including basing the personal data processing on an applicable legal basis (Art. 6 GDPR) and meeting transparency obligations (Art. 12 et seq.).

5.2.7 Identifiers

Identifiers are vital for the product information system , but they could lead to data protection risks. Depending on the level of granularity, the risk stemming from identifiers can increase or decrease. If the identifier is matched to an item, the data protection risks are higher than if the identifier is used on a batch, variation or product model level. Therefore, the general approach when designing the product information system must be that identifiers on the item level are generally avoided and are only used where a higher level of granularity would defeat the purpose of the system and fail to serve the goals of the circular economy.

Regarding personal data protection concerns during the use of RFID, refer to 5.2.6.2.

5.3 Summary

Part D of this study aims to develop legal recommendations and conclusions for a product information system 4.0 enabling the circular economy within the EU.

5.3.1 Summary part A and B

Part 1 analysed information gaps found in current European and partially in Member State's legislation that could and should be closed by amending the respective legislative acts or by including information requirements in upcoming legislative acts, such as the ESPR Proposal.

5.3.1.1 Textiles

For textiles, stakeholders such as consumers, sorters, recyclers, waste treatment, supply chain actors and manufacturers can profit from more information by introducing an obligation for a full material declaration of fabrics used. Current exceptions or derogations from the obligation to provide a full material declaration should be entirely removed or amended. One example to change exceptions and derogations in the Textile Regulation would be to differentiate the obligation by the size of a company, e.g., whether they are SMEs, start-ups, or large companies.

This obligation to provide a full material declaration could even be extended to dyes and chemicals used on a garment. It should also be considered to introduce a standard sizing system that could lead to fewer returns of online purchases by consumers / customers.

The requirements could be part of an amendment of the Textile Regulation or / and part of Commission delegated acts under the ESPR.

5.3.1.2 Cross-sector

A cross-sector analysis addressed the needs for information requirements in the area of the REACH Regulation, the CLP Regulation and the Packaging Directive,

Under the REACH-Regulation,

- improvements could be made to the use and availability of so-called Safety Data Sheets (SDSs) and regarding the declarations of articles containing Substances of Very High Concern (SVHCs). To close or reduce the availability and information gaps, enforcement of the REACH-Regulation should be strengthened;
- it should be further analysed whether it can be useful to introduce a requirement for the validation of material information provided under the REACH-Regulation (e.g., audit reports, certifications);
- it should furthermore be analysed in more detail whether it can be helpful to introduce requirements about information on potentially negative effects or risks to humans or nature when several chemicals accumulate or interact in a substance, mixture or finally in an article/finished product;
- the legal timeline to provide information to consumers should be shortened to a maximum of 72 hours (instead of 45 days). It would be even better if consumers were provided with an easily accessible and readily available identifier (e.g., GTIN or a digital data carrier) to find information on products in the SCIP database.

Under the CLP Regulation,

- relevant information could be improved by simplifying and, in addition to keeping the physical information, digitalising parts of the (physical) labels;
- It is furthermore recommended to add information for consumers on how to sort, recycle or dispose of the mixtures and substances as well as to include information for sorters, recyclers, and waste treatment. Ideally, such information for consumers is not limited to products falling into the scope of the CLP-Regulation and therefore could be addressed in upcoming legislative acts, such as the ESPR Proposal.

Under the Packaging Directive,

- The proposal to switch from a directive to a regulation is supported by the project team.
- Digitising information about packaging reusability and introducing QR codes or other digital data carriers to provide information on the availability of a system for re-use and of collection points etc. can help to close the current usage barrier for consumers.

5.3.1.3 Electronics

An analysis in the field of electronics addressed the needs for information requirements under the Ecodesign Directive, the WEEE directive and the RoHS Directive

Under the Ecodesign Directive and in particular the Ecodesign Commission Regulation for displays,

- There should be an easy and effective way for sorters and recyclers to retrieve the necessary information of what materials are contained in the devices or parts of devices. One option to improve the status quo would be to introduce an obligation to provide for the marking not only to be “clearly visible” (anywhere, e.g., even after dismantling some parts); but for example, “clearly visible without the product having to be dismantled”;
- Marking on the product must be digitally accessible: Another option would be to make it mandatory to provide the necessary information on a data carrier that is easily accessible, machine-readable and can provide the relevant information digitally to all relevant stakeholders, especially to sorters and recyclers;
- Under the upcoming ESPR (currently a Proposal), digital product passport is made mandatory (also) for products currently in the scope of the Ecodesign Commission Regulation for displays and that the product passport must be (at least) on the product itself, easily accessible and machine-readable.

Under the WEEE Directive,

- a European regulation could help to introduce more specific requirements on how, as well as the level of detail, information has to be provided to relevant stakeholders, such as sorters and recyclers.
- a requirement should be introduced that on a product model level the specific materials contained in parts of EEE and information on how to disassemble EEE must be provided to increase selective treatment and potentially increase economic viability;
- a requirement should be introduced to indicate materials contained in each part of a product and instructions for the disassembly on product model level to allow for a selective treatment.

Under the RoHS Directive,

- to avoid confusion and misinterpretation by consumers, the CE mark should be removed from parts of the product that are visible to consumers.

5.3.2 Summary part C

Part 2 analysed the legal framework around the proposed concept of a product information system for electronics and textiles. A product information system is not only governed by product legislation as well as environmental legislation, but it also falls into the scope of European and national rules governing the European data economy. Therefore, numerous European legislative acts and Member States legislation apply to such systems.

5.3.2.1 Vocabulary, ontology and taxonomy

Regarding the legal challenges around vocabulary, ontology and taxonomy,

- Definitions used in Directives and Regulations in the context of the Circular Economy Action Plan (CEAP) should be reviewed and aligned to improve coherence and lessen legal uncertainty.
- Essential requirements for the product information system should be regulated coherently in each relevant legislative act and aligned with harmonised standards (to be developed).
- For any product that must have a data carrier for a product information system. Relevant information regarding circularity / environmental / sustainability claims should be included in the product information system.

5.3.2.2 Data storage

Regarding Data storage,

- In addition to the option of decentralised data storage, a central registry should be set up with access by persons with "legitimate interest", e.g., market surveillance authorities or customs authorities. To protect trade secrets or other similar interests of the provider of the information, the information accessible to such stakeholders could be more detailed than publicly accessible information,
- Stakeholders should be able to choose between storing information on their own premises or with a third-party platform provider.
- The legal framework of a product information system should refer to the applicability of the GDPR whenever personal data is stored or otherwise processed.

5.3.2.3 Data exchange

Regarding the interoperability of data,

- the EU Commission should request that one or more European standardisation organisations (ESOs) draft a European standard under Art. 10 of the Regulation (EU) No 1025/2012 on Eu-ropean standardisation.
- The standard(s) should address interoperability, machine-readability and accessibility via human interfaces.

5.3.2.4 Ownership, liability and data verification

Regarding the ownership, liability, and data verification,

- The storing of any personal data in a product information system should be governed by the GDPR.
- Access rights and other rights (read, write, delete, retrieve, add etc.) should be specified in applicable European harmonised norms. It is important to track who had access to the system and what changes or additions etc. were made by any actor.
- There should be a framework for the liability of providing accurate data. If there are no consequences for providing inaccurate or insufficient data, it is to be expected that stakeholders, especially consumers, do not / cannot trust the data from the system.
- Consumers should not be liable for adding any data and have either no or very restricted options to add information into the system.

5.3.2.5 Access management and IP protection

Regarding the access management and IP protection,

- Datasets that must be published to the public should not lead to an obligation to disclose trade secrets or information protected under IP rights.

5.3.2.6 Access to information that is a trade secret or protected under IP law should, if it cannot be protected otherwise, only be granted to competent Union or Member State authorities fulfilling their duties under Union or applicable national law.

- The EU Commission could draft model clauses that can easily be incorporated between (B2B-) stakeholders for situations where, for example, a repairer, sorter or recycler needs access to information that is considered a trade secret or otherwise protected under IP law.

5.3.2.7 Data carriers

Regarding data carriers,

- The WEEE Directive should be amended to introduce a clear legal exception that clarifies that passive electronic tags which are part of a product group such as textiles under the product information system do not fall into the scope of the WEEE Directive. Member States should not be allowed to introduce stricter rules nationally when transposing this exception of the Directive (full harmonisation).
- Under the current legal framework of the WEEE directive and transpositions into Member States law, it cannot be recommended to use electronic tags (RFID, NFC) in textiles as data carriers for the product information system.
- An electronic tag with a unique identifier can potentially be used as a tracking device. In that case, the entity or person who is responsible for the tracking has to adhere to the GDPR, including basing the personal data processing on an applicable legal basis (Art. 6 GDPR) and meeting transparency obligations (Art. 12 et seq.).

5.3.3 Conclusions

The project team found a complex legal framework around the introduction of a product information system for electronics and textiles. The success of a product information system relies on the mandatory information stored in such system as well as the accessibility and interoperability of datasets. The circular economy can profit from closing some existing information gaps and introducing new information requirements for electronics and textiles. The upcoming ESPR can lead to the closing of such existing information gaps if the EU Commission makes use of promising Commission Delegated Acts regarding different product groups. In some cases, to close information gaps it may be useful not only to rely on Commission Delegated Acts but to also amend existing Directives and Regulations (e.g., the Textile Regulation). It does not seem necessary to introduce more legislative acts regarding the legal framework of a system of product information system. However, European harmonised norms should be introduced for a successful introduction of product information system and digital data carriers to textiles and electronics. All affected stakeholders should be made aware of the complex legal framework that encompasses environmental legislation as well as rules governing the European data economy.

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7 Glossary

Table 40: Overview of relevant terms and definitions

Term (English)	Term (German)	Definition
2-factor-authentication (2FA)	2-Faktor-Authentisierung	Two-factor authentication is a method where the user needs to verify their identity through two different channels of authentication factors. (Ledbetter 2021)
Access Management	Zugriffsmanagement	Refers to all the tools, policies, and procedures used to control and manage user access within an IT ecosystem. (Techopedia 2013)
Asset Administration Shell (AAS)	Industrie 4.0 Verwaltungsschale (VWS)	The Asset Administration Shell (AAS) is the digital representation of an asset. The AAS consists of a number of submodels in which all the information and functionalities of a given asset – including its features, characteristics, properties, statuses, parameters, measurement data and capabilities – can be described. (Plattform Industrie 4.0)
Audit Trail	Prüfpfad	Audit trails are secure electronic records that allow the reconstruction of events related to the creation, modification or deletion of electronic records. (Oqotech 2019)
Authentification	Authentisierung	The provision of credentials to prove a user's identity. (Beal 2022)
Authorisation	Authorisierung	Authorisation handles the user's right to perform certain actions such as viewing data or creating or deleting other users. (Beal 2022)
Barcode	Strichcode	A machine-readable and scannable code printed on a product.
Blockchain	Blockchain	Blockchain technology is a decentralised, distributed ledger that stores the record of ownership of digital assets. Any data stored on blockchain is unable to be modified which makes the history of any digital asset unalterable and transparent (Daley 2019)
Bluetooth	Bluetooth	Bluetooth is a wireless technology that can be used for exchanging data over short distances. (Bluetooth 2023)
CAS number	CAS-Nummer	A unique identification number for chemical substances.
Certifiers	Zertifizierer	A person or company who inspects something, such as a product, process, or organisation, to ensure that it complies with requirements or regulations.
Cloud Identity Wallet	Cloud-Identitäts-Wallet	All personal or product information is stored and managed within a cloud-based wallet. Companies or individuals can easily upload their data and have complete control over what information is shared with who, where and when. (European Commission 2023c)
Community	Gemeinschaft	A group of people sharing the same values, attitudes and interests working towards a common goal.

Term (English)	Term (German)	Definition
Consumer	Konsument*in	A person who purchases goods and services for personal use.
Data carrier	Datenträger	A medium that can save and store data for e.g., distribution.
Data custodian	Datenverwaltende*r	A data custodian oversees the storage, transfer, and transport of data, ensuring that these processes adhere to the rules specified by the organisation. (Techslang 2022)
Data control	Datenkontrolle	Data control means having visibility and control over all access to the data.
Data exchange	Datenaustausch	Data exchange denotes the process of sending and receiving data.
Data encryption	Datenverschlüsselung	Data encryption is the process of translating data from a readable format into an encoded format.
Data owner	Datenbesitzende*r	The data owner is in charge of the data and must guarantee that the information is correctly maintained across various platforms and business processes. (C. Reed 2022)
Data source	Datenquelle	A data source is the location or organisation where data that is being used originates. (Techopedia 2014)
Data storage	Datenspeicherung	Data storage is the collection and retention of digital information. (Redhat 2018)
Data user	Datennutzer*in	A natural or legal person who has lawful access to certain personal or non-personal data and has the right, including under Regulation (EU) 2016/679 in the case of personal data, to use that data for commercial or non-commercial purposes. (Lawinsider 2023)
Data validation	Datenvalidierung	Data validation means checking the quality of source data before using, importing or otherwise processing data. (Inofrmatica 2023)
Data verification	Datenverifizierung	Data verification refers to a process of checking data for accuracy and inconsistencies. (Editor 2022)
Digital Nameplate	Digitales Typenschild	The digital nameplate is the digital equivalent of an analogue nameplate, giving access to product information through certain identifier and data carrier combinations. (DKE 2022)
Digital Identity	Digitale Identität	Digital identity is essentially any personal or organisation data existing online that can be traced back to the real-world person or organisation. (Avast 2020)
Digital Signature	Digitale Signatur	Digital signatures represent a cryptographic analogue to handwritten signatures that can be used e.g., in digital contracts or authorisation.

Term (English)	Term (German)	Definition
Digital Twins	Digitaler Zwilling	A digital twin is a digital representation of a real-world entity or system. The implementation of a digital twin is an encapsulated software object or model that mirrors a unique physical object, process, organisation, person or other abstraction. (Gartner 2023)
End-of-life	Ende des Lebenszyklus	Waste collection > Preparation for reuse / Disassembly > Waste treatment > Recycling Nutzer > Abfallsammlung > Vorbereitung zur Wiederverwendung/Demontage > Abfallbehandlung > Recycling
Enterprise Identity	Unternehmensidentität	An Enterprise Identity is a Digital Identity of an Enterprise.
EPC code	EPC-Code	An Electronic Product Code (EPC) is a universal identifier that gives a unique identity to a specific physical object. (EPC-RFID 2019)
Global Unique Identification (GUID)	GUID	See UUID
GraphQL	GraphQL	GraphQL is a query language for APIs. It simplifies the search queries for human users compared to other query languages.
Granularity	Granularität	The concept of granularity in the context of product information systems describes whether the product information is attached on product model, batch or item level.
GTIN	GTIN	The GTIN describes a family of GS1 (EAN.UCC) global data structures that employ 14 digits and can be encoded into various types of data carriers (GTIN INFO Global Trade Item Number 2022)
Global Warming Potential (100) (GWP(100))	Treibhausgaspotenzial (100)	The term global-warming potential, abbreviated as GWP, is used to describe the relative potency, molecule for molecule, of a greenhouse gas, taking account of how long it remains active in the atmosphere. The global-warming potentials (GWPs) currently used are those calculated over 100 years. Carbon dioxide is taken as the gas of reference and given a 100-year GWP of 1. (eurostat 2023)
Hosting	Hosting, Bereitstellung	Hosting is a service through which storage and computing resources are provided to an individual or organisation for the accommodation and maintenance of one or more websites and related services. (Techopedia 2012)
Identifier (ID)	Identifikator	Can be a unique name, a serial number to identify a product.

Term (English)	Term (German)	Definition
Industry 4.0	Industrie 4.0	Industry 4.0 describes the internet-based intelligent networking between machines and processes. The availability of data is expected to lead to more flexible solutions, optimised logistics and a resource-saving circular economy. This innovation is seen as the 4th industrial revolution, hence the name. (Was ist Industrie 4.0?, Plattform Industrie 4.0, available from (Plattform Industrie 4.0 2023)
International Material Data System (IMDS)	Internationales Materialdatensystem	The IMDS is the automobile industry's material data system.
Internet of Things	Internet der Dinge	The Internet of Things is the concept of connecting any device (so long as it has an on/off switch) to the Internet and to other connected devices. The IoT is a giant network of connected things and people – all of which collect and share data about the way they are used and about the environment around them. (Clark 2016)
Interoperability	Interoperabilität	Refers to the ability of apps, equipment, products, and systems from different companies to seamlessly communicate and process data in a way that does not require any involvement from end-users. (Hare 2021)
ISO	ISO	ISO is an independent, non-governmental international organisation that brings together experts to share knowledge and develop voluntary, consensus-based, market relevant international standards for a variety of different sectors and use cases. Amongst these are a list of standards relevant for product and material information, a selection of which has been named by the workshop participants and is described in the following https://www.iso.org/home.html
IT compliance	IT-Konformität	IT Compliance describes the adherence to laws, standards, guidelines and regulations of companies in the context of information technology. It calls for measures to prevent rule violations, especially in the areas of information security, information availability, data retention and data protection. (t2informatik. We develop software. 2019)
International Panel on Climate Change IPCC	IPCC	The Intergovernmental Panel on Climate Change is an intergovernmental body of the United Nations. It aims to advance scientific knowledge about climate change caused by human activities. The United Nations Environment Programme and the World Meteorological Organization established the IPCC in 1988. (IPCC 2023)
IP protection	Schutz geistigen Eigentums	IP Protection means registration, application, filing, prosecution or maintenance of patent or copyright protection for Intellectual Property. (Law Insider 2023)

Term (English)	Term (German)	Definition
Life Cycle Assessment (LCA)	Umweltbilanzierung	Life-cycle assessment (LCA) is a process of evaluating the effects that a product has on the environment over the entire period of its life thereby increasing resource-use efficiency and decreasing liabilities. (European Environment Agency 2023)
Market surveillance	Marktbeobachtung	An authority that ensures that products on the market conform to applicable laws and regulations.
Multi-Factor-Authentication (MFA)		Multi-factor-authentication where the user needs to verify their identity through multiple channels of authentication factors. (Ledbetter 2021)
Near Field Communication (NFC)	Nahfeldkommunikaito n	Near Field Communication (NFC) is a radio-frequency technology that allows the transmission of data between an NFC tag and NFC-enabled device. (IDSuperstore 2023)
Open Digital Rights Language (ODRL)		The Digital Rights Management (DRM) community has proposed ODRL as the language for standardising rights information about content and is a W3C recommendation. It is available free of charge as open-source software. According to the W3C, the ODRL is both a model and a vocabulary with fixed semantics. It is intended to serve the interoperable use and communication of digital resources. (Iannella 2018)
Ontology	Ontologie	In the context of information science, ontologies provide background information for a certain domain. This comes in the form of definitions for terms, classes, relations between terms and specific attributes or properties. (Gruber 2009) Ontologies can also include a formal hierarchy between the terms, classes and rules or “facts” that apply within a domain. (Georgieva) Example: A t-shirt is a form of a shirt that comes with the property of having short arms.
Private Key	Privater Schlüssel	A private key is a cryptographically created string that a signer in a digital signature process uses to sign a message. It is paired with a public key.
Producer	Hersteller	According to the definition of the WEEE, a producer means any natural or legal person who, irrespective of the selling technique used, (...) (i) is established in a Member State and manufactures Electrical and Electronic Equipment (EEE) under his own name or trademark, or has EEE designed or manufactured and markets it under his name or trademark within the territory of that Member State; (ii) is established in a Member State and resells within the territory of that Member State (...) (iii) is established in a Member State and places on the market of that Member State, on a professional basis, EEE from a third country or from another Member State; or (iv) sells EEE by means of distance communication directly to private households or to users other than private households in a Member State, and is established in another Member State or in a third country”

Term (English)	Term (German)	Definition
Product	Produkt	An article that is manufactured or even remanufactured for the purpose of sale.
Product Designer/ Developer	Produktdesigner*in/ -entwickler*in	A person that designs and creates a product based on latest trends and market research to make it attractive for consumers to purchase.
Product Environmental Footprint	Ökologischer Fußabdruck (eines Produktes)	The Product Environmental Footprint (PEF) is a multi-criteria measure of the environmental performance of a good or service throughout its life cycle. PEF information is produced for the overarching purpose of seeking to reduce the environmental impacts of goods and services taking into account supply chain activities (from extraction of raw materials, through production and use, to final waste management). (Manfredi et al. 2012)
Product ID	Produkt-ID	Product identifiers are a series of numerical or alphanumerical digits that are used to identify a specific product. (Linnworks 2023)
Public Key	Öffentlicher Schlüssel	A public key is a cryptographically created string that a verifier uses in a digital signature process to verify a message. The public key is generated together with a private key by a signer.
Public Key Infrastructure	Public-Key-Infrastruktur	The collection of files and associations between the documents, keypairs and partners in a digital signature scenario.
QR Code	QR-Code	A quick response (QR) code is a type of barcode that can be read easily by a digital device and which stores information as a series of pixels in a square-shaped grid. QR codes are frequently used to track information about products in a supply chain and often used in marketing and advertising campaigns. (Hayes 2015)
Radio Frequency Identification (RFID)	Identifikation mithilfe elektromagnetischer Wellen	RFID refers to a sender-receiver technology for automated and contact-free identification of objects using electromagnetic fields. (BSI 2021)
RAMI 4.0	RAMI 4.0	The RAMI 4.0, Reference Architecture Model Industrie 4.0 (Industry 4.0), was developed by the German Electrical and Electronic Manufacturers' Association (ZVEI) to support Industry 4.0 initiatives. It is a three-dimensional map showing how to approach the issue of an Industry 4.0 in a systematic and structured way.
Recycler	Recycler	A person or company who recycles or uses machines to recycle.

Term (English)	Term (German)	Definition
Recycling	Recycling	WFD: “means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations;”(KR Architecture World 2021)
Reference Data Models (RDM)	Referenzdatenmodell	A Reference Data Model (RDM) is an abstract model that organises Business Information Entities (BIEs) and standardises how they relate to one another and to the real world. The model provides a standard means by which data may be described, categorised and also share (UNECE 2017a)
Remanufacturer	Wiederaufbereiter	A party that is rebuilding a product by using a combination of reused, repaired and new parts. Through various processes the original product can be returned to a “like-new” condition.
Reverse Supply Chain	Rücklaufende Lieferkette	Processes required to retrieve a product from customers for reuse/ recycling etc.
Semantics	Semantik	Semantic is the study of meaning in a language. This can refer either to single words within the vocabulary or terminology used or data generated according to syntax rules (Kubicek et al. 2019).Example: Saying “this t-shirt is red” refers to the attribute “colour” of the t-shirt.
Sorter	Sortierbetrieb	A party that is dividing all textile post-consumer waste deciding whether a garment is resold or recycled. Sorters can also be waste disposal provider and recycler.
SSO	Single-Sign-On	Single-Sign-On is a user authentication option for getting access to multiple systems eliminating the need to repeatedly log in with credentials. (Roy 2021)
Supplier	Zulieferer	According to the definitions of EEL and WEEE, a supplier is a manufacturer or an importer who places a substance, mixture or product on the Union market.
Supply Chain	Lieferkette	All processes used to source, produce and distribute a product.

Term (English)	Term (German)	Definition
Syntax	Syntax	The syntax allows to put the vocabulary in a meaningful order. It gives a grammar to a string of characters to perform a function. It sets rules according to which data can be used. A language is built to be read and functionalized by different stakeholders. The syntax is devoid of meaning. It describes the structure and the composition of characters and conveys information about their valid order so that they can be decomposed. (Georgieva)http://wwwmayr.in.tum.de/konferenzen/Jass05/courses/6/Papers/04.pdf Example: machine-readable json-file: {..., "product_class": "t-shirt", ...}
Taxonomy	Taxonomie	Taxonomy is a classification of objects described by terms. The assignment of an object to a class based on its attributes is referred to as classification. Classification systems are usually built with inheritance (is-a relationship). A class can be defined as being broader than or narrower than another class (Georgieva). Example: A t-shirt is a subclass of a top, which is a subclass of the product category clothing.
Terminology	Terminologie	See vocabulary
UHF (Ultra High Frequency)	Ultrahochfrequenz	UHF describes radio frequencies in the range between 300 megahertz and 3 gigahertz.
Unique identifier (UID)	Eindeutiger Identifikator	A UID is a Unique Identifier, which is a globally unique sequence of characters or numbers that is assigned to a single item (U 2020)
UUID	UUID	The UUID, also referred to as globally unique identifier (GUID), is a 128 bits long identifier that can guarantee uniqueness across space and time and does not require a central registration or administration process. It can instead be generated by an openly available generation algorithm. (IETF Datatracker 2005)
Vocabulary	Vokabular	An organisation, initiative, industry or sector uses a number of common words as a terminology for communicating 'internal' topics (datos.gob.es 2021).This is their reference vocabulary. The terms are used for communication and sharing data. Through consistent vocabulary the communication can be kept easily understandable and as short as possible (datos.gob.es 2021). The stand-alone terms are not necessarily associated with a specific meaning. Example: The term "t-shirt".
User	Nutzer:in	A person who uses for example a website or platform creating credentials to access.
WEEE (Waste of Electrical and Electronic Equipment Directive)	Waste of Electrical and Electronic Equipment Directive	The WEEE Directive 2012/19/EU regulates distribution, take-back and proper disposal of waste electrical and electronic equipment within the European currency area.

A Annexes

1. Regulatory profiles
2. Voluntary approaches
3. Workshop Slides Expert Workshop
4. Expert Workshop
5. Questionnaire Expert Interviews
6. Information Sources
7. Results Stakeholder Survey
8. Workshop Slides Front-end Demonstrator Workshop
9. Results Front-end Demonstrator Workshop
10. Roles and Access Management
11. Access Management
12. Screenshots Demonstrator Frontend