Guideline Data for a Raw Material & Product Passport

Managing Value Chain Risks and Opportunities

Version 3.0 Mechanical Engineering

Partners for Innovation, Hygienic Design Networks, Binnenklimaat Nederland en TNO

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About this guideline

You are reading the *Guideline – Data for a Raw Material & Product Passport – Mechanical engineering*, prepared on behalf of TKI CLICKNL within the Circonnect program, funded by the Ministry of Economic Affairs.

This guideline is intended for companies in the machinery value chain and supports them in proactively responding to European and national regulations concerning circularity, sustainability, and toxicity. It provides guidance on collecting, structuring, and applying circular product data, thereby contributing both to regulatory compliance and to strengthening the strategic position of companies within the value chain.

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List of Abbreviations

Abbreviation	Full Name / Description
AEEA	Waste Electrical and Electronic Equipment
CE	Conformité Européenne (European Conformity)
GPP	Raw Materials and Product Passport
CPR	Construction Products Regulation
CRMA	Critical Raw Materials Act
DPP	Digital Product Passport
EF	Environmental Footprint
EPBD	Energy Performance of Buildings Directive
EPD	Environmental Product Declaration
ESPR	Ecodesign for Sustainable Products Regulation
GHG	Greenhouse Gas
GMP	Good Manufacturing Practice
ISO	International Organisation for Standardization
KRW	Water Framework Directive
LCA	Life Cycle Assessment
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RoHS	Restriction of Hazardous Substances
TCO	Total Cost of Ownership
ZZS	Substances of Very High Concern

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1. Introduction

1.1 European and Dutch objectives for sustainability and the circular economy

The European Union and the Netherlands aim to achieve a fully circular and climate-neutral economy by 2050, with an intermediate milestone by 2030. These ambitions form part of the European Green Deal, which sets the strategic direction for a sustainable and competitive European economy.

In alignment with these European objectives, the Netherlands is implementing the National Circular Economy Programme 2023–2030 (Nationaal Programma Circulaire Economie 2023–2030), accelerating the transition towards a circular economy. Within this programme, the manufacturing industry has been identified as one of the priority sectors.

The Dutch government has also adopted the National Raw Materials Strategy (Nationale Grondstoffenstrategie, Parliamentary Document 32 852, No. 224), aimed at strengthening security of supply of critical raw materials in the medium term. This strategy is based on five strategic action lines: (1) Circularity and innovation (2) Sustainable EU mining and refining (3) Diversification (4) Sustainability of international value chains (5) Knowledge development and monitoring. This guideline primarily contributes to the first action line: circularity and innovation. By applying R-strategies (EU circularity strategy framework), security of supply can be enhanced while simultaneously reducing the negative environmental impact of value chains.

1.2 Legislation and regulations

Companies in the manufacturing sector and related industries are confronted with a wide range of European and national legislation toxicity. This regulatory framework is extensive and affects multiple aspects of business operations, including product design, production processes, use phase performance and end-of-life management. Many of these legislative instruments require companies to collect, structure and report detailed material and product data.

Key examples include:

- Regulation on Waste Electrical and Electronic Equipment (WEEE) (national implementation of Directive 2012/19/EU)
- Ecodesign legislation, including the Ecodesign for Sustainable Products Regulation (ESPR)
- Machinery Directive and Regulation (EU) 2023/1230 on machinery
- Regulation (EU) 2023/1542 concerning batteries and waste batteries
- Critical Raw Materials Act (CRMA)
- Corporate Sustainability Reporting Directive (CSRD)
- Various additional regulations such as REACH (chemicals), RoHS (restriction of hazardous substances), energy labels and the energy performance of buildings, water management (Water Framework Directive), and many others.

These regulations have a significant impact on how companies collect, record and share product information. Interviews with Dutch companies in the HVAC systems and capital goods sector for the food industry show that upcoming sustainability regulations create substantial regulatory pressure. This pressure is further increased addressing

sustainability, circularity and because the requirements are evolving rapidly, are complex, and companies often do not yet have standardized methods to comply with them.

1.3 Purpose

Much of the new legislation requires the reporting of detailed product data on circularity, sustainability and toxicity — such as information on composition, origin, environmental impact and repairability. In this guideline, this information is referred to as raw material and product data[1].

This guideline supports companies within the machinery value chain in preparing in time for the growing amount of European legislation. It provides a clear overview of relevant and upcoming legislation and regulations, including the associated design requirements and circular data points.

In addition, the guideline helps with collecting, structuring and applying this data, using methods to make it measurable and transparent. It also highlights which information is still missing, enabling companies to determine which data is most urgent to collect and how it can be used strategically to strengthen their market position.

1.4 Target audience

The primary target audience of this guideline consists of parties that will be required to supply raw material and product data. However, the guideline also provides insights for parties that will ultimately need to use this raw material and product data.

- **Parties required to supply raw material and product data:** Compliance managers at manufacturers of HVAC systems, as well as suppliers throughout the entire value chain (for example material suppliers, recyclers, etc.).
- **Parties required to use raw material and product data:** Government authorities, purchasers, wholesalers, housing associations, property managers, installers, users, demolition companies, maintenance companies, repairers, refurbishers, transporters, sorters, recyclers, etc.

1.5 Why start now?

Although working with this guideline offers many advantages, it is important to also recognize the effort required. Collecting, organizing and updating raw material and product data requires staff capacity, collaboration with value chain partners and possibly adjustments to internal systems. Why start working on this now? Collecting raw material and product data in a timely manner with the help of this guideline offers several strategic advantages for organizations in the machinery sector:

- **Insight and steering:** Collecting raw material and product data makes it possible to measure, improve, and use the circular performance of products as a competitive advantage in the market.
- **Compliance and future readiness:** Companies become “compliance-ready” and are prepared for both existing and upcoming legislation related to circularity, sustainability, and toxicity.
- **Value chain insight and risk management:** The data provides in-depth insight into the entire

[1]The data points included represent a selection of information relevant to companies in the machinery manufacturing sector. This list is not exhaustive but contains data that is expected to be broadly applicable and aligned with upcoming legislation and reporting obligations, such as the ESPR and CSRD.

- value chain, including risks such as security of supply, dependence on critical raw materials, and the use of Substances of Very High Concern (SVHCs).
- **Targeted data collection:** The guideline helps identify the minimum required circular data points for products and services.
- **Well-informed strategic decisions:** The information supports decisions regarding reuse, repair, rental models, as-a-service models, modularity, and refurbishment.
- **Methodological foundation:** The guideline includes data points and methodological guidelines suitable as input for Life Cycle Assessments (LCA) and the Digital Product Passport (DPP).
- **External accountability:** Companies can substantiate their compliance with relevant legislation and are better prepared for questions from purchasers, regulators, and other stakeholders.
- **Transparency and trust:** Reliable and accessible raw material and product data increases trust among customers, partners, and other value chain actors.

1.6 Development of this guideline

Partners for Innovation, Binnenklimaat Nederland, Hygienic Design Network and TNO developed two guidelines entitled “Data for a Circular Product Passport”: one for capital goods and one for HVAC systems. Hygienic Design Network represented all key players in machinery manufacturing for the food processing industry. Binnenklimaat Nederland represented manufacturers, suppliers, and service providers in the HVAC system sector. TNO acted as a supervisory partner to ensure alignment of the guideline with European and national initiatives related to digital product passports and data infrastructure, with a strong focus on integration into ongoing developments.

The two guidelines “Data for a Raw Material & Product Passport” build on the UPCM Materials Passport Guideline (version 1, 2020) and the Circular Product Passport Guideline for Food Machinery (version 2, 2021), developed together with Hygienic Design Network.

In 2024, the existing needs of value chain stakeholders were mapped for both capital goods and HVAC systems. Based on desk research, interviews, a workshop with value chain stakeholders, and relevant literature, a plan of action was established for the collaborative development of the two guidelines. The content of these guidelines was elaborated through extensive desk research, case studies, surveys, and interviews with stakeholders across the value chain.

For the product group of capital goods, the cases and examples are drawn from machinery manufacturing for the food industry, as substantial practical experience has already been gained in this sector. The standardized decomposition and data points that result from this work have been designed in such a way that they are also relevant and applicable to other segments within the machinery sector. The guideline can therefore be applied to all types of machines and installations. CIRCONNECT manages the guideline and is responsible for its ongoing development. It also maintains a base dataset containing the data points used and the associated improvement options. Where relevant, the guideline is further specified for particular products in collaboration with value chain partners.

1.7 Structure of this guideline

Chapter 1 introduces the context, purpose, and structure of this guideline. It briefly addresses European and Dutch ambitions regarding circularity, sustainability, and toxicity, as well as the

role of legislation and the necessity for companies to collect circular product data. It also explains the intended target audience, the benefits of starting early with the collection of raw material and product data, and how the content of the guideline was developed.

Chapter 2 focuses on stakeholder needs to understand upcoming legislation in the areas of circularity, sustainability, and toxicity, and to support compliance. The concrete product requirements and implications of relevant legislation are summarized, and an overview is provided of key regulations expected in the coming years.

Chapter 3 describes how circularity in machinery manufacturing can be made measurable. Central to this is a standardized decomposition of capital goods and an overview of relevant circular data points, linked to measurement methods, standards, and KPIs. It also discusses a product passport system under the name Raw Material & Product Passport, as a to collect, exchange, and leverage data across the value chain.

Chapter 4 demonstrates how companies can improve their measured circular performance. It provides clear courses of action, practical tools, and inspiring examples from practice. In this way, organizations are given concrete guidance to strengthen circular design and value retention in practice.

2. Legislation and regulations

2.1 Introduction

This chapter discusses the most important European and national regulations relevant to capital goods in the food industry. It provides practical guidance for companies to help them manage changing requirements and addresses three key questions:

- Which existing and upcoming legislation related to sustainability, circularity and toxicity is relevant for capital goods in the food industry?
- Which product-specific design requirements result from this legislation?
- Which important developments in legislation and regulation require additional attention?

2.2 Legislation and regulation for sustainability, circularity and toxicity

Table 1 provides an overview of the most important European and national legislation relevant to the sustainability, circularity and toxicity of capital goods and machines in the food industry.

For reference, legislation and regulations are regularly updated. The table below generally includes only the current, active provisions at the time of writing. In some cases, however, replaced legislation may still partially remain in force because new rules have not yet fully entered into effect. This is the case, for example, with the Ecodesign Directive, which is gradually being replaced by the Ecodesign for Sustainable Products Regulation (ESPR). In such cases, both versions are included in the overview.

As mentioned earlier, this document focuses on policy at the product level. The Corporate Sustainability Reporting Directive (CSRD) applies at the company level. For customers of machinery manufactures, the environmental impacts of machines form part of their value chain emissions (Scope 3 emissions). For this reason, the CSRD is included in the legislative overview. However, the specific CSRD data points are not included, as these relate to the company level rather than the product level.

Legislation	Summary	Status
Battery Regulation Regulation (EU) 2023/1542	Contains sustainability requirements for the design, collection, processing and reporting of batteries.	In force since August 2023; phased implementation through 2030.
Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU	Restricts the use of harmful substances in electrical and electronic equipment.	In force since 2 January 2013; still applicable and regularly updated.

Table 1. Overview of legislation and regulations on sustainability, circularity, and toxicity, listed in alphabetical order

Legislation	Summary	Status
Construction Products Regulation Regulation (EU) 305/2011	Sets requirements for performance, safety and CE marking of construction products within the EU.	In force since 1 July 2013.
Construction Products Regulation (revised) Regulation (EU) 2024/3110	Expands requirements with circularity, CO_2 reduction and a mandatory digital product passport.	In force as of 7 January 2025; transitional rules apply for older standards.
Corporate Sustainability Reporting Directive (CSRD) Directive (EU) 2022/2464	Requires large companies to report on environmental, social and governance (ESG) aspects, including CO_2 emissions, circularity, material use and biodiversity. Machinery manufacturers may themselves be subject to reporting obligations or required to provide data to customers.	Adopted on 14 December 2022; phased implementation from financial year 2024 depending on company size and stock listing.
'Circular economy – Measuring and assessing circularity' ISO 59020	International standard (2024) providing guidelines for measuring and assessing circularity at product, organisational and system level.	Published in 2024; gradually being adopted internationally.
Critical Raw Materials Act (CRMA) Regulation (EU) 2024/1252	Promotes secure access, recycling and traceability of critical raw materials.	In force since 23 May 2024; implementation phase through 2030.
Detergents Regulation Regulation (EG) 648/2004	Regulates the biodegradability of detergents and cleaning agents to protect the environment.	In force since 31 January 2005.
Ecodesign Directive Regulation (EU) 2024/1781	Sets requirements for energy efficiency, product lifetime and repairability of energy-related products.	Replaced as of 18 July 2024 by the ESPR; transitional period until 2026–2030.
Ecodesign for Sustainable Products Regulation (ESPR) Directive 2009/125/EG	Establishes broad sustainability criteria, including information requirements and a digital product passport.	In force since 18 July 2024; implementation phase ongoing.
Energy Labelling Regulation 2017/1369	Requires energy information on labels for household appliances to promote efficiency.	In force since 11 July 2017.

Table 1. Overview of legislation and regulations on sustainability, circularity, and toxicity, listed in alphabetical order

Legislation	Summary	Status
Energy Performance of Buildings Directive 2018/844/EU	Establishes minimum requirements for energy performance of new buildings and renovations.	In force since 9 July 2010; ongoing revision process.
Fluorinated Greenhouse Gases (F-gases) Regulation (EU) 2024/573	Reduces the use and emissions of F-gases in cooling and HVAC systems.	Original regulation since 1 January 2015; revised limits from 11 March 2024.
Water Framework Directive (WFD) Directive 2000/60/EG	Directive aimed at protecting and improving the quality of water bodies within the EU.	In force since 22 December 2000; continuous implementation.
Plastics for Food Contact Regulation (EU) 10/2011 in conjunction with (EG) 2022/1616 (Recycled Plastics)	Sets composition requirements for the safe use of plastics in contact with food. The use of recycled plastic is restricted.	In force since 1 January 2011; updates introduced through Regulation 2022/1616.
Machinery Directive Directive 2006/42/EG	Contains essential safety requirements for the design and use of machinery within the EU.	In force since 29 December 2009; remains valid until replacement.
Machinery Regulation Regulation (EU) 2023/1230	Replaces the Machinery Directive in 2027 and introduces new rules for AI and IoT in machinery.	Published 10 November 2023; entry into application planned for 2027.
Food Contact Materials Regulation (EG) 1935/2004	Establishes general safety requirements for materials intended to come into contact with food.	In force since 27 October 2004.
Regulation (EC) No 1935/2004 Regulation (EG) (EU) 2024/590	Regulates the production and use of substances harmful to the ozone layer.	In force since 1 January 2010; revised 11 March 2024.
Ozone-Depleting Substances Regulation (EG) 1907/2006	Requires the safe use, risk management, and registration of chemical substances throughout the supply chain.	In force since 1 June 2007; still applicable, but continuously updated and under revision (REACH 2.0 forthcoming).
Registration, Evaluation and Authorisation of Chemicals (REACH) National implementation based on Directive 2012/19/EU	Obliges producers and importers to collect and ensure proper treatment of waste electrical and electronic equipment in accordance with the requirements of the scheme.	In force since 14 February 2014; expanded to cover all electronic equipment since 15 August 2018.

Table 1. Overview of legislation and regulations on sustainability, circularity, and toxicity, listed in alphabetical order

Table 1 provides a concise overview of relevant legislation and regulations but does not yet offer insight into the consequences for the design of HVAC systems. Therefore, a more detailed version of this table — including additional information on the design implications of the various regulations — is included in Annex A, *"Overview and Design Implications of Legislation and Regulations."* The ISO standard for measuring circularity and the CSRD are not included in that annex, as they do not impose direct requirements on machine design.

2.3 Recent developments

As shown in Table 1, several new laws and regulations have recently entered into force and are currently in the implementation phase. This section explains what this means in practice in terms of circular data.

Ecodesign for Sustainable Poduct Regulation (ESPR)

Although the ESPR has officially been adopted, the specific requirements per sector still need to be developed. On 16 April 2025, the European Commission presented the first ESPR work plan for the period 2025–2030. This plan includes a list of priority product groups for which ecodesign requirements will be developed first. Textiles, furniture, tyres, mattresses, steel and aluminium are the first product groups to be addressed.

Within the ESPR, product data plays a central role. The regulation requires manufacturers to register extensive information about the composition, origin, repairability, disassemblability, durability, energy use and recyclability of their products.

For capital goods in the food processing industry, no sector-specific product requirements have yet been established under the ESPR. However, it is expected that machinery manufacturing — including industrial installations — will be addressed in a later phase of the work plan, possibly from 2030 onwards. Until then, companies in this sector are not yet required to comply with specific ESPR requirements, but it is advisable to prepare for future data obligations.

Digital Product Passport (DPP)

Within several regulations, including the CRMA, the Battery Regulation and the ESPR, the Digital Product Passport (DPP) will be introduced in phases. The DPP is a digitally accessible document providing information about, among other things, the origin, composition, use and circularity of products.

In 2025, harmonized standards and rules for DPP systems will be further developed. The first sector in which the DPP will become mandatory is batteries, starting in 2027. Textiles and electronics (such as consumer electronics), as well as construction materials, will follow. For these sectors, the DPP will also become mandatory from 2027 onwards. The rollout to other product groups is expected to take place between 2027 and 2030. In its 2050 strategy for the European market, the European Commission indicates that it intends to develop and implement DPP policies for many product categories in the coming years. Product categories excluded from the ESPR, such as military goods, medicines and food, will likely not receive a DPP or only at a later stage. The exact requirements will depend on the sector and the implementing acts that still need to be developed.

The producer or importer placing a product on the EU market will be responsible for creating and maintaining the DPP. Depending on the sector, this may be done at the level of an individual product, a batch, or a product type. The DPP therefore contains product-specific

information. If the product later becomes part of another product — for example, a battery integrated into a device — the DPP of that component becomes part of the DPP of the final product.

*ISO Measuring circularity

In addition to increasing European legislation, there is also an international development related to the standardization of circular measurement methods. In June 2024, the standard ISO 59020:2024 – *Circular economy* — Measuring and assessing circularity was officially published. This standard provides an internationally recognized framework for consistently and reproducibly measuring and assessing circularity.

Where much legislation focuses mainly on mandatory product data and supply chain transparency, ISO 59020 provides the methodological foundation for a robust assessment of circular performance.

Although application of ISO 59020 is not mandatory, from a strategic perspective it is advisable to incorporate the indicators from this standard. For this reason, these indicators are included in Chapter 3 of this guideline. Depending on the specific sector, organization, and value chain partners, additional standards and norms may also apply. These cannot be fully included in Chapter 3, but when implementing circular methods and product passports, it is advisable to align with them as much as possible to minimize additional work and enhance interoperability.

3. Measuring circularity

3.1 Introduction

Chapter 2 describes the key legislation and regulations concerning circularity, sustainability, and toxicity. Chapter 3 translates these frameworks into practice: what data is required, how reliable that data is, and how to organize its collection and exchange within the value chain.

Section 3.2 provides an overview of circular data points that should ideally be recorded based on existing and anticipated legislation. This comprehensive list functions as a “wish list” of data considered relevant for monitoring circular performance. For each data point, a method or standard is suggested to ensure that the information is recorded and shared in a consistent and usable way.

Section 3.3 structures this list by prioritizing the data points, ranging from legally mandatory to voluntary. Section 3.4 addresses data quality. Not all information is equally reliable, up to date, or detailed, and sometimes data may be entirely lacking. Therefore, a distinction is made between different levels of data quality.

Finally, Section 3.5 explains how the collection and sharing of data can be organized in practice. Because the list of data points is extensive, collaboration between value chain partners is essential. In practice, data is collected by different parties, who exchange it among themselves and make it available to organizations for which it is legally required. Not every organization therefore needs to collect all data independently. Section 3.5 also explains the techniques and methods that can enable data exchange, with emphasis on which specific data are shared.

3.2 Circular data points

This section provides an overview of circular data points that should ideally be collected based on existing and future legislation described in Chapter 2. It concerns an extensive list that can be regarded as a “wish list” of desired data.

For each data point, a suggestion is provided for relevant assessment methods or standards. In this way, information can be recorded and shared within the value chain in a consistent, verifiable, and usable manner.

Circular data categories

To provide direction for the collection of raw material and product data, the required data points are divided into three main categories. The three circular data categories are:

- **Category A – Product Information:**
  Describes, at a high level, the general technical, operational, and circular characteristics of the machine. This includes, for example, raw material composition, consumption data, lifetime, warranties, maintenance and support, as well as the potential for reuse, repair, and recycling.
- **Category B – Life Cycle:**
  Takes a further step by focusing on the different flows throughout the life cycle. It includes all quantitative data on material, energy, water, waste, and transport flows that occur during the production, installation, use, and end-of-life phases of the machine.

- **Category C – Environmental Impact:**
  Contains the calculated or measured environmental impacts of the Category B data points across the full life cycle of the machine. These are expressed in recognized impact categories such as climate change, acidification, eutrophication, toxicity, resource use, and land use, broken down by life cycle phase.

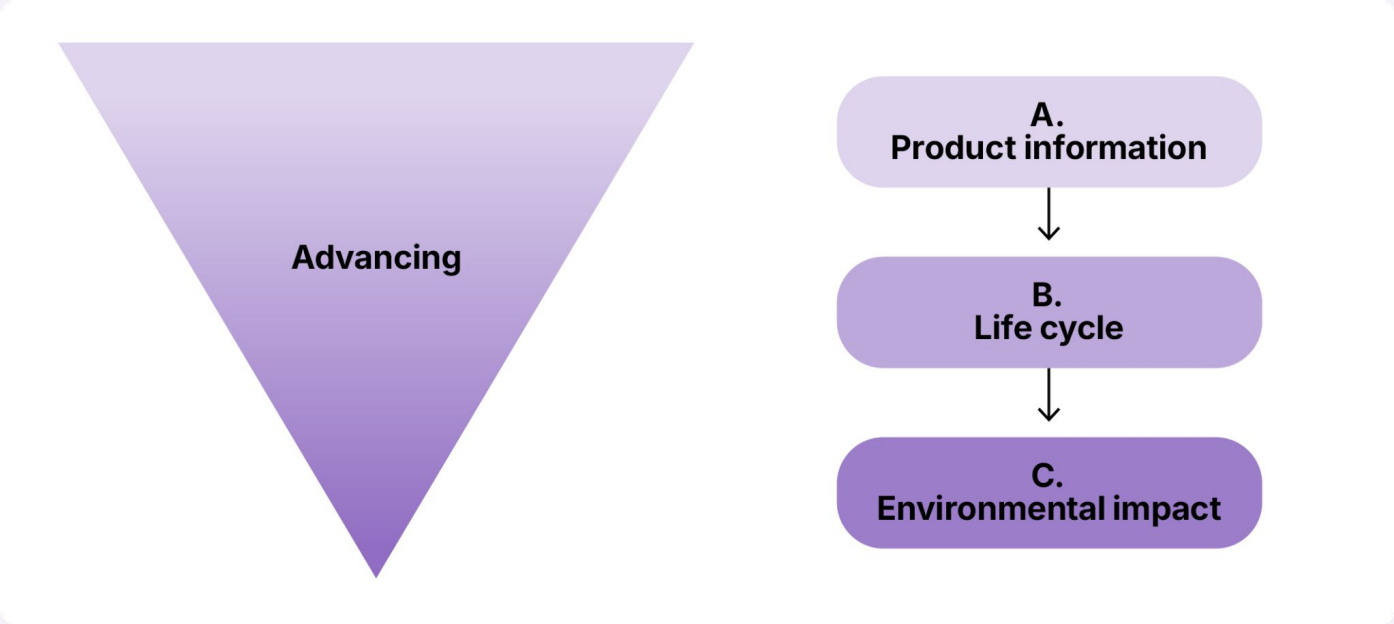

Figure 1. Overview of circular data categories

Overview of circular data points per circular data category

The circular data points are as follows:

A. Product Information Circular data category	
A1 Raw Material Composition	**A1.1** List of Raw Mate-rials
	A1.2 Share of Recycled Raw Materials
	A1.3 Share of Critical Raw Materials
	A1.4 Share of Sub-stances of Very High Concern
	A1.5 Share of Renewa-ble Raw Materials
	A1.6 Share of Reused Content
A2 Operational Consumption	**A2.1** Energy Consumption
	A2.2 Water Consumption
	A2.3 Consumables
	A2.4 Energy Label
	A2.5 Standby Consumption
A3 Lifetime	**A3.1** Expected or Agreed Lifetime
	A3.2 Age of device
	A3.3 Current Lifecycle
A4 Warranty and Support	**A4.1** Product Warranty
	A4.2 Product Support
	A4.3 Software Support
A5 Management	**A5.1** Repair and Maintenance Instruc-tions
	A5.2 Maintenance Plan
	A5.3 Performed Re-pairs and Maintenance
	A5.4 Circular Plan
	A5.5 Responsibilities
A6 Potential for Value Retention	**A6.1** Repairability, Maintenance and Re-furbishment Potential
	A6.2 Explanation of Upgradability and Re-manufacturing Poten-tial
	A6.3 Explanation of Recyclability
	A6.4 Explanation of Reuse Application

B. Lifecycle Circular data category	
B1 Material Consumption	**B1.1** Product Materials
	B1.2 Consumables
	B1.3 Auxiliary Raw Materials
	B1.4 Packaging Material Consumption
B2 Energy	**B2.1** Energy Consumption
	B2.2 Share of Renewa-ble Energy
B3 Water	**B3.1** Water Consumption
	B3.2 Circular Water Use
	B3.3 Ratio of Water Reuse or Recirculation
	B3.4 Discharged Water According to Quality Standards
B4 Waste	**B4.1** Waste Production
B5 Transport	**B5.1** Transport Movements
B6 End-of-Life Ma-chine	**B6.1** Reuse Fraction at End-of-Life
	B6.2 Recycling Fraction at End-of-Life
	B6.3 Explanation of Use of Recycled Raw Mate-rials
	B6.4 Incineration Frac-tion at End-of-Life
	B6.5 Landfill Fraction at End-of-Life
	B6.6 Material Recircu-lation Fraction at End-of-Life
	B6.7 Recovered Critical Raw Materials

Figure 2. Overview of circular datapoints per circular data category

C. Environmental Impact Circular data category	
C1 Impact on Climate Change	**C1.1** Total Impact
	C1.2 Production Phase Impact
	C1.3 Installation Phase Impact
	C1.4 Use Phase Impact
	C1.5 End-of-Life Impact
C2 Impact on Other Environmental Indica-tors	**C2.1** Ozone Depletion
	C2.2 Ionising Radiation (Human Health)
	C2.3 Photochemical Ozone Formation (Hu-man Health)
	C2.4 Particulate Matter Formation
	C2.5 Acidification
	C2.6 Terrestrial Eutrophication
	C2.7 Freshwater Eutrophication
	C2.8 Marine Eutrophication
	C2.9 Freshwater Ecotoxicity
	C2.10 Marine Ecotoxicity
	C2.11 Human Toxicity (Cancer)
	C2.12 Human Toxicity (Non-Cancer)
	C2.13 Land Use
	C2.14 Material Use – Fossil Fuels
	C2.15 Material Use – Metals and Minerals
C3 Summary Environ-mental Impact Score	**C3.1** Single Score Indi-cator (nPt)

Figure 2. Overview of circular datapoints per circular data category

Category A - Product information

A1 Raw Material Composition

- **A1.1 Raw Materials List:** A list of all raw materials incorporated into the product, expressed in kilograms.
    - Collect CAD/BOM data of the machine in question, including linked material properties, to determine as much of the material composition as possible.
    - Where necessary, request material specifications or a bill of materials from suppliers of purchased components.
    - If required, dismantle a component and weigh the materials separately to verify reported values.
    - Structure the data in a list documenting kilograms per material, the source, and any supporting evidence.
- **A1.2 Share of Recycled Raw Materials:**
  The weight in kilograms of all recycled raw materials incorporated into the product and the fraction as a percentage of the total weight of the respective raw material.
    - Determine per material whether recycled content is present; request material certificates or ISO 14021 (self-declared environmental claims) from suppliers.
    - For plastic products in contact with food: verify compliance with EC 10/2011 in conjunction with Regulation EC 1935/2004 regarding migration limits and process registration.
    - Use averages from LCA databases (Ecoinvent, GaBi, Idemat) or sector reports (Ellen MacArthur Foundation, European Aluminium / World Steel Association, PlasticsEurope).
- **A1.3 Share of Critical Raw Materials:**
  The weight in kilograms of all critical raw materials incorporated into the product and their total fraction as a percentage of the total weight of the respective raw material.
    - Use the “2020 EU Critical Raw Materials list” to identify critical raw materials in the composition listed under A1.1.
- **A1.4 Share of Substances of Very High Concern (SVHCs):**
  The weight in kilograms of all SVHCs incorporated into the product and their total fraction as a percentage of the total weight of the respective raw material.
    - Use the RIVM “Total list of Substances of Very High Concern” to identify SVHCs in the composition listed under A1.1.
- **A1.5 Share of Renewable Raw Materials:**
  The weight in kilograms of all renewable raw materials incorporated into the product and their total fraction as a percentage of the total weight of the respective raw material.
    - Determine per material whether the raw material is renewable based on origin (biogenic vs. fossil/mineral). Use standards such as EN 16785-1, ISO 59020, or “Renewable Raw Materials and Materials for Construction” (Agrodome, 2022) as reference.
    - Request certificates or declarations of renewable origin (e.g., FSC, biobased label).
- **A1.6 Share of Reused Content:**
  The weight in kilograms of all reused components incorporated into the product and their fraction as a percentage of the total weight of the machine.
    - Identify whether components from a previous life cycle have been reused (remanufactured, refurbished, reused) and collect data through supplier declarations, internal traceability systems, or maintenance history. ISO 59020 provides guidance.

A2 Operational consumption

- **A2.1 Energy consumption:** Energy consumption in kWh per hour during normal operation.
  - Measure under representative operating conditions using calibrated measuring equipment.
  - Conduct measurements over a sufficiently long period to average out variations caused by load or ambient temperature.
  - Document the measurement method, measurement duration and conditions.
- **A2.2 Water consumption:** Water consumption in litres during normal operation.
  - Measure using calibrated flow meters over a full operating cycle or multiple cycles.
  - Record the measurement setup, measurement period and conditions.
- **A2.3 Consumables:** Consumables used during normal operation.
  - Determine the type and quantity based on manuals, maintenance plans or supplier information.
  - If possible, validate by monitoring consumption over a representative period.
  - Document the sources used, units and the frequency of replacement or refilling.
- **A2.4 Energy label:** The European Energy Label indicating the product's energy efficiency class.
  - Verify whether the product falls under the EU energy labelling requirement (Directive 2017/1369). If not applicable, indicate this and provide alternative efficiency data.
  - Determine the energy class according to the EU regulation applicable to the specific product type.
  - Use accredited testing methods and document the results.
  - Verify that the reported class corresponds to the official label.
- **A2.5 Stand-by consumption:** The average electricity consumption (in W) of a device when connected but not actively used, including both "off-mode ready" and network standby.
  - Measure using calibrated equipment according to the relevant standard (such as IEC 62301) under standard conditions.
  - Measure separate standby modes and calculate a weighted average based on the usage profile.
  - Document the measurement method, duration and results.

A3 Lifetime

- **A3.1 Expected or agreed lifetime:** The expected or agreed lifetime during which the machine will remain in use, expressed in years. The lifetime refers to the total use phase of the product.
  - Document what has been agreed with the end user of the machine; where necessary, discuss this with the customer.
  - If required, estimate the lifetime based on the lifetime of machine components or contractual specifications from component suppliers.
  - Make an estimate based on the design or applicable usage standards.
- **A3.2 Age of the device**: The current age of the machine in years, starting from the moment of original production.
  - Users collect this information through maintenance logs or the original installation date / delivery documentation.
- **A3.3 Current lifecycle:** The current life cycle of a product. In other words, whether the device is newly built (first life cycle) or has been reused after refurbishment or remanufacturing (second life cycle).
  - Record the reuse status using internal asset management systems or supplier declarations.

- If necessary, use tracking data, maintenance history or serial number registration.

A4 Warranty and support

- **A4.1 Product warranty:** The warranty for the correct functioning of the machine, expressed in years (possibly legally required).
  - Record the manufacturer's or sales warranty as stated in the contract or technical specifications.
  - Verify using warranty conditions or CE declarations of conformity.
- **A4.2 Product support:** Number of years of product support offered by the manufacturer, such as service visits and availability of spare parts.
  - Request information from the (parts) supplier or manufacturer.
  - Check the spare parts policy or availability statements.
- **A4.3 Software support:** Number of years of software support (updates and upgrades) offered by the manufacturer.
  - Verify in the SLA (Service Level Agreement) or maintenance contracts.
  - Explicitly ask (parts) supplier(s) about end-of-support/end-date policy.

A5 Management

- **A5.1 Repair and maintenance instructions:** The machine's repair and maintenance instructions, provided as a link or attachment.
  - Request technical documentation for subcomponents from the manufacturer or parts suppliers.
  - Manufacturers document and provide the repair and maintenance instructions.
- **A5.2 Maintenance plan:** An overview of the planned maintenance and software updates required to safeguard the product's operation, safety, and lifetime during the use phase.
  - Record maintenance intervals, type of maintenance (preventive/corrective/software-related), and the required parts and tools.
  - Indicate who is responsible for execution (user, manufacturer, third party).
  - Refer to maintenance instructions, manuals, or service links.
- **A5.3 Repairs and maintenance performed:** An overview of the maintenance that has actually been carried out during the product's use phase. This may include preventive or corrective maintenance, as well as upgrades, replacements, or overhauls.
  - Use maintenance logs, asset management systems, or reports from maintenance providers to record this information.
  - Record frequency, date, and type of maintenance (preventive, corrective, inspection-based).
  - Specify which components were replaced, repaired, or modified.
  - Link data, where possible, to the serial number or product ID.
- **A5.4 Circular plan:** A description of the plan or ambition to retain as much value as possible from a device or installation throughout its entire life cycle.
  - The selling party and the user jointly assess the (expected) life cycle of the product and develop a plan to maintain the product's value at the highest possible level.
  - Determine together at which stage which circular strategy should preferably be applied (see Section 4.3 for more information).
- **A5.5 Responsibility:** Record the agreements made regarding the transfer of responsibility to a new party when the machine is transferred, including any supporting documentation. This applies, for example, in cases of reuse or refurbishment. Ensure

that the original producer, designer, and/or previous user are indemnified from liability after transfer.

    - Determine jointly with the receiving party who is responsible for what after the transfer.

A6 Potential for Value Retention

- **A6.1 Reparability, maintenance and refurbishment potential:** A description of the product's reparability and maintenance possibilities. Consider aspects such as modularity; compatibility with readily available tools and spare parts; availability of repair and maintenance instructions; number of materials and components used; use of standard parts; use of coding standards to identify components and materials; number and complexity of required processes; whether specialized tools are needed; ease of non-destructive disassembly and reassembly; conditions for access to product data; conditions for access to or use of necessary hardware and software; and insight into product aging mechanisms.
    - Assess based on modular design, availability of parts and instructions, and level of standardization.
    - Use criteria from ISO 59020 or reparability scores (such as iFixit or EU Ecodesign guidelines).
    - Request technical sheets and disassembly information from the manufacturer.
- **A6.2 Explanation of upgradability and remanufacturing potential:** A description of the product's potential for improvement and remanufacturing. Consider aspects such as the use of standard components, coding standards, number and complexity of processes, accessibility of data and tools, guarantees for reuse, and modularity.
    - Request (component) supplier(s) to provide information on modularity, standardization, upgradability, and remanufacturing policy.
    - Assess the accessibility of components, tools, and data, as well as the availability of documentation and coding standards. Use remanufacturing criteria from ISO 59020.
- **A6.3 Explanation of recyclability:** A description of the extent to which (parts of) the product can be recycled and are designed for recycling. Consider aspects such as the use of easily recyclable materials, accessible and non-destructive disassembly, the presence of coding standards, standardization, and access to necessary data and software.
    - A description of the extent to which (parts of) the product can be recycled and are designed for recycling. Consider aspects such as the use of easily recyclable materials, accessible and non-destructive disassembly, the presence of coding standards, standardization, and access to necessary data and software.
- **A6.4 Explanation of reuse application:** A description of the extent to which components of the product can be reused and/or are reused when the entire product is no longer usable. For example: percentage of reused components, list of reused components, and specific reuse applications.
    - In collaboration with suppliers or service partners, determine which components are suitable for reuse during disassembly or are currently already being reused.

Categorie B – Lifcycle[2]

B1 Material consumption

- **B1.1 Product materials:** Consumption of materials that form part of the machine itself, measured at the time of installation. Includes only the physical machine composition and excludes consumables, auxiliary materials, and packaging materials.
    - Use the data identified under A1.1.
- **B1.2 Consumables:** Consumption of items that must be regularly replaced or refilled during the use phase of the machine, such as filters, cartridges, gaskets, additives, or lubricating oil for operational use.
    - Use the data identified under A2.3.
- **B1.3 Auxiliary materials:** Raw materials required for production, installation, or use, but which do not become a direct part of the product or are not directly consumed during use. Examples include lubricants used during production, coolants in machining equipment, and cleaning agents.
    - Inventory based on production and installation documentation, supplier information, or process descriptions.
    - Request information from suppliers, installation companies, and users regarding type, quantity, and application of these substances.
- **B1.4 Packaging material consumption:** The quantity and type of packaging materials used for transport, storage, and delivery of the machine and its components.
    - Collect data via procurement, production, and logistics documentation.
    - Request specifications, quantities, and reuse or waste treatment information from suppliers or logistics partners.

B2 Energy

- **B2.1 Energy consumption:** A list of the amount of energy directly or indirectly used during the production, installation, use, and end-of-life processing of the machine. This includes electricity as well as other energy carriers such as gas, steam, or fuels.
    - Collect data on the use phase via energy meters, process registrations, or monitoring software at your own facilities.
    - Collect data on energy use during installation from installation companies.
    - Request data on energy consumption during end-of-life processing from dismantling companies.
    - Ask suppliers about energy consumption in production processes for supplied materials or components (e.g., via LCA reports and EPDs).
    - Use secondary data from LCA databases such as Ecoinvent, GaBi, or Idemat if primary data is unavailable.
- **B2.2 Share of renewable energy:** The fraction of renewable energy as a percentage of total energy consumption as described above.
    - Collect primary data on the share of renewable energy in your own energy supply (e.g., via energy suppliers or Guarantees of Origin).
    - Ask suppliers about their share of renewable energy use, supported where possible by certificates or reports.
    - Use secondary sources (CBS, Eurostat, Ecoinvent, GaBi) to estimate renewable energy mixes if direct information is unavailable.

[2]In this list, the lifecycle is divided into production, installation, use, and end-of-life, following the system boundaries defined in EN 15804. See Appendix B for more information.

B3 Water

- **B3.1 Water consumption:** A list of the quantity of water in liters used during production, installation, use, and end-of-life processing of the machine.
    - Collect data on water use during the use phase via water meters, process registrations, or monitoring software.
    - Request installation companies to provide water use data during installation.
    - Request dismantling or recycling companies to provide water use data during end-of-life processing.
    - Ask suppliers about water use in their production processes for components or materials (e.g., via LCA reports or EPDs).
    - Use secondary data from LCA databases such as Ecoinvent, GaBi, or Idemat if primary data is unavailable.
- **B3.2 Circular water use:** The fraction of water (%) originating from circular sources, such as reused process water or rainwater.
    - Collect data on reused water streams via internal water management records.
    - Ask suppliers and installation companies about their share of circular water use, supported by process documentation or certificates.
    - Use secondary sources or sector averages if direct data is unavailable.
- **B3.3 Water reuse or recirculation ratio:** The average number of times water is reused within an installation or process before being discharged or replaced, as a measure of water circulation and efficiency.
    - Determine based on internal process or water balance data in production or use phase.
    - Request suppliers to provide process data on water recirculation.
    - Use secondary data or technical references if primary data is unavailable.
- **B3.4 Water discharged according to quality standards:** Percentage (based on volume) of total abstracted water that is discharged in accordance with circularity principles.
    - Collect data via internal discharge reports or measurements from water authorities.
    - Request installation, production, and recycling partners to provide discharge quality and quantity data.
    - Use secondary sources such as CBS, Eurostat, or LCA databases for estimates if data is missing.

B4 Waste

- **B4.1 Waste generation:** An overview of waste such as packaging waste, material losses, etc., generated during production, installation, use, and end-of-life of the machine (excluding the machine itself), including a description of the treatment method.
    - Collect data on waste generation during the use phase via internal waste records or collection reports.
    - Request installation companies to provide waste flow data during installation and processing.
    - Request dismantling or recycling partners to provide waste generation data during end-of-life.
    - Ask suppliers about waste streams in their production processes for components and materials.
    - Ask users about waste streams during use.
    - Use data from LCA databases (Ecoinvent, GaBi, Idemat) or sector reports if other data is unavailable.

B5 Transport

- **B5.1 Transport movements:** An overview of transport movements occurring during production of the machine and its components, as well as installation and end-of-life phases.
    - Collect data from internal logistics records or transport management systems.
    - Request suppliers and installation companies to provide transport distances, modes, and frequencies.
    - Request end-of-life processors to provide transport data for return or disposal movements.
    - Use data from logistics sector reports if other data is unavailable.

B6 End of life of the machine

- **B6.1 Reuse fraction at end-of-life:** Percentage of material from the machine that is actually reused at the end of the life cycle, expressed as a percentage of total weight.
    - Ask suppliers or recycling partners about the application of recovered materials. Use practical data or value chain studies as supporting evidence.
- **B6.2 Recycling fraction at end-of-life:** Percentage of material actually recycled at the end of the life cycle, expressed as a percentage of total weight.
    - Ask suppliers or recycling partners about the application of recovered materials. Use practical data or value chain studies as supporting evidence.
    - Recovered critical raw materials
- B6.3 **Explanation of recycled material application:** A description of the application for which recovered raw materials are used after recycling. Indicate whether recycled materials are used for higher-value, equivalent, or lower-value applications.
    - Ask suppliers or recycling partners about the application of recovered materials. Use practical data or value chain studies as supporting evidence.
- **B6.4 Incineration fraction at end-of-life:** Percentage of total machine weight that is incinerated for energy recovery or waste treatment.
    - Ask suppliers or recycling partners about the treatment of recovered materials. Use practical data or value chain studies as supporting evidence.
- **B6.5 Landfill fraction at end-of-life:** Percentage of total machine weight that is landfilled.
    - Ask suppliers or recycling partners about the treatment of recovered materials. Use practical data or value chain studies as supporting evidence.
- **B6.6 Biological recirculation fraction at end-of-life:** Fraction of biodegradable materials that safely return to the biosphere at end-of-life. This includes only materials that demonstrably decompose without harmful effects and meet conditions for biological recirculation, such as compostability and environmental safety.
    - Ask suppliers or recycling partners about the treatment of recovered materials. Use practical data or value chain studies as supporting evidence.
- **B6.7 Recovered critical raw materials:** The weight in kilograms of all critical raw materials recovered at the end-of-life of the product, and their share as a percentage of the originally incorporated amount of that raw material in the product.
    - Combine data from A1.3 with recycler data.
    - If unavailable, use recycling data from sector reports (e.g., for cobalt, lithium, neodymium) and studies from the EU CRM Alliance, EEA, and annexes to the CRMA.
    - Determine for each critical raw material the originally incorporated amount and the expected recovery fraction at end-of-life.

Category C - Environmental impact

C1 Climate Change Impact

- **C1.1 Total climate impact:** The total impact of the complete life cycle of the machine on climate change, expressed in kilograms of CO_2 equivalents.
    - Calculate the sum of points C1.2 through C1.5.
- **C1.2 Production phase:** The amount of kilograms of CO_2 equivalents in the production phase and the percentage relative to the total kilograms of CO_2 equivalents over the entire life cycle.
    - If available, request LCAs or EPDs for materials, components, or from suppliers.
    - Use the data from Category B to conduct an LCA using the CIRCO "Self-Assessment Tool."
    - Use secondary data from LCA databases (Ecoinvent, GaBi, Idemat) for missing sources.
- **C1.3 Installation phase:** The amount of kilograms of CO_2 equivalents in the installation phase and the percentage relative to the total CO_2 emissions over the entire life cycle.
    - If available, request LCAs or EPDs for materials, components, or from suppliers.
    - Use the data from Category B to conduct an LCA using the CIRCO "Self-Assessment Tool."
    - Use secondary data from LCA databases (Ecoinvent, GaBi, Idemat) for missing sources.
- **C1.4 Use phase:** The amount of kilograms of CO_2 equivalents in the use phase and the percentage relative to the total CO_2 emissions over the entire life cycle.
    - If available, request LCAs or EPDs for materials, components, or from suppliers.
    - Use the data from Category B to conduct an LCA using the CIRCO "Self-Assessment Tool."
    - Use secondary data from LCA databases (Ecoinvent, GaBi, Idemat) for missing sources.
- **C1.5 End-of-life phase:** The amount of kilograms of CO_2 equivalents in the end-of-life phase and the percentage relative to the total CO_2 emissions over the entire life cycle.
    - If available, request LCAs or EPDs for materials, components, or from suppliers.
    - Use the data from Category B to conduct an LCA using the CIRCO "Self-Assessment Tool."
    - Use secondary data from LCA databases (Ecoinvent, GaBi, Idemat) for missing sources.

C2 Impact on Other Environmental Indicators

- For impacts on other environmental indicators, use the LCA model or the requested EPDs/LCAs from C1.
- **C2.1 Ozone depletion:** The total impact of the complete life cycle of the machine on ozone depletion, expressed in kg CFC-11 equivalents.
- **C2.2 Ionizing radiation (human health):** The total impact of the complete life cycle of the machine on ionizing radiation, expressed in kBq U235 equivalents.
- **C2.3 Photochemical ozone formation (human health):** The total impact of the complete life cycle of the machine on photochemical ozone formation, expressed in kg NMVOC equivalents.
- **C2.4 Particulate matter formation:** The total impact of the complete life cycle of the machine on particulate matter formation, expressed in disease incidences.

- **C2.5 Acidification:** The total impact of the complete life cycle of the machine on acidification.
- **C2.6 Terrestrial eutrophication:** The total impact of the complete life cycle of the machine on terrestrial eutrophication.
- **C2.7 Freshwater eutrophication:** The total impact of the complete life cycle of the machine on freshwater eutrophication.
- **C2.8 Marine eutrophication:** The total impact of the complete life cycle of the machine on marine eutrophication, expressed in kg N equivalents.
- **C2.9 Freshwater ecotoxicity:** The total impact of the complete life cycle of the machine on freshwater ecotoxicity, expressed in CTUe.
- **C2.10 Marine ecotoxicity:** The total impact of the complete life cycle of the machine on marine ecotoxicity, expressed in CTUe.
- **C2.11 Human toxicity (cancer effects):** The total impact of the complete life cycle of the machine on human toxicity, cancer effects, expressed in CTUh.
- **C2.12 Human toxicity (non-cancer effects):** The total impact of the complete life cycle of the machine on human toxicity, non-cancer effects, expressed in CTUh.
- **C2.13 Land use:** The total impact of the complete life cycle of the machine on land use, expressed in points (soil quality).
- **C2.14 Resource use – fossil fuels:** The total impact of the complete life cycle of the machine on fossil resource use, expressed in MJ.
- **C2.15 Resource use – metals and minerals:** The total impact of the complete life cycle of the machine on resource use – minerals and metals, expressed in kg Sb equivalents.

C3 Summary Environmental Impact Score

- **C3.1 Single score indicator (nPt):** The aggregated environmental impact of the life cycle of a product. This value is expressed in dimensionless points.
    - Use the LCA model or the requested EPDs from C1 to report the single score.

Although this list is extensive, not every data point is equally urgent. Therefore, a prioritization overview based on legal obligation follows.

3.3 Priority datapoints

In light of recent and upcoming European legislation and regulations, it is essential to distinguish between data points that are legally required and those that are (for the time being) voluntary or sector-specific recommendations.

In this section, we provide guidance on prioritization by focusing solely on the degree of legal obligation. Table 2 presents the three priority categories. Table 3 provides an overview of the legal obligation per data point or set of data points.

Priority	Explanation
Mandatory	The data point must be legally collected and reported based on applicable EU legislation.
Upcoming or Sector-Specific Obligation	The data point may become mandatory under sector-specific ESPR measures or emerging legislation.
Not Mandatory	The data point is not legally required but may be valuable for internal monitoring or supply chain collaboration.

Table 2. Explanation of the prioritisation of circular data points

Included in MPG / EN 15804	Explanation
Yes	Is standardly weighted in the Environmental Performance of Buildings assessment method (MPG calculation method).
Optional	May be weighted in the Environmental Performance of Buildings assessment method if applicable to the product.
No	Is not weighted in the Environmental Performance of Buildings assessment method, even if applicable to the product.

Table 3. Explanation of the column "MPG inclusion" in Table 4

Indicator	Verplichting?	Toelichting
A1.1, B1.1 Raw material list	ESPR CRMA	Required under the ESPR as content for the Digital Product Passport (DPP); the CRMA promotes transparency for critical and strategic raw materials. ISO 59020 considers this a basic indicator for circularity. The raw material composition forms the basis of LCAs.
A1.2 Recycled raw materials	ESPR ISO 59020 Batterij-verordening	The ESPR sets requirements for recycled content and inclusion of the data in a DPP; the Battery Regulation mandates minimum recycled material content in certain batteries. ISO 59020 includes this as a circular material indicator.
A1.3 Critical raw materials	CRMA ESPR	The CRMA requires reporting only where mandated via sector-specific legislation. The ESPR may require reporting and inclusion in the DPP.
A1.4 SVHC (substances of very high concern)	REACH ESPR RoHS	REACH requires a duty to provide information where SVHC content exceeds 0.1%. The ESPR requires inclusion of substances of concern in the DPP.
A1.5 Renewable raw materials	ESPR ISO 59020	The ESPR mentions this as a sustainability criterion, but there is not yet a generic documentation requirement. ISO 59020 includes it as an optional indicator.
A1.6 Reused components	ESPR ISO 59020	The ESPR may require inclusion in the DPP for specific product groups. ISO 59020 considers this essential for the circularity score.
A2.1 Energy use	ESPR ISO 59020 Energielabel Ecodesign	Operational energy use is a core indicator in the ESPR, Ecodesign and energy labelling, and ISO 59020. Relevant for carrying out LCAs.
A2.2 Water use	ESPR ISO 59020	No generic obligation in the ESPR. ISO 59020 includes this as an indicator.
A2.3, B1.2 Consumables	ESPR	Only mandatory if specified in sector-specific ESPR measures. Relevant for carrying out LCAs.
A2.4 Energy label	Energielabel Richtlijn	Legally required under the EU energy labelling directive.
A2.5 Stand-by consumption	ESPR Ecodesign	Mandatory under Ecodesign product rules under the ESPR/ Ecodesign regulations.

Table 4. Overview of legal obligations per data point, in relation to relevance for MPG/EN 15804

Indicator	Verplichting?	Toelichting
A3 + A4 Lifetime & support	ESPR Batterij-verordening	Reporting on technical and functional lifetime, including support, is mandatory under the ESPR and the Battery Regulation.
A5.1, A5.2, A5.3 Maintenance	ESPR	The ESPR requires transparency about planned and performed maintenance, as part of DPP data.
A5.4 and A5.5 Circular plan and responsibility		No legal obligation. Recommended for clear supply chain communication and good handover when implementing circular strategies.
A6.1 Repairability	ESPR	The ESPR requires information on maintenance and repairability. A repairability score will become an information requirement in the DPP.
A6.2 to A6.4 Explanation of value retention	ESPR Bouwproducten-verordening	Explanatory statements are mentioned in the ESPR and CPR, but are not mandatory. This indicator may, over time, become mandatory for certain product groups.
B1.3 Auxiliary materials	REACH ESPR	REACH requires registration only for SVHC substances >0.1% in machines. The ESPR may require registration in a sector-specific way.
B1.4 Packaging	ESPR	The ESPR may impose sector-specific requirements for reporting packaging material. These data are relevant for LCAs.
B2.1 Renewable Energy use	ESPR ISO 59020	Energy use is a core indicator in the ESPR and ISO 59020. Relevant for carrying out LCAs.
B2.2 Renewable energy use	ESPR	Encouraged in the ESPR, not required. ISO 59020 asks for substantiation of the share of renewable energy use.
B4.1 Waste	ESPR	Reporting on waste streams is required under the ESPR if prescribed sector-specifically. Relevant for LCAs.
B5.1 Transport	ESPR ISO 59020	ESPR (if specified sector-specifically). Relevant for LCAs.
B6.1 Reuse of parts	ESPR CRMA	Encouraged in the ESPR; may become mandatory for specific product groups. ISO 59020 emphasises reuse as an indicator.
B6.2 to B6.6 Recovered materials	Batterij-verordening ISO 59020	The Battery Regulation and the CRMA mandate specific recovery percentages for critical raw materials in batteries. For other products this is still optional under the ESPR. ISO 59020 includes all indicators as measurement points.

Table 4. Overview of legal obligations per data point, in relation to relevance for MPG/EN 15804

Indicator	Verplichting?	Toelichting
B6.7 Recovered critical raw materials	CRMA ESPR	Mandatory under the CRMA for strategic/critical materials and under the Battery Regulation for relevant batteries. The ESPR may impose a sector-specific obligation.
C1.1 to C1.5 CO_2 emissions	ESPR EPBD Batterij-verordening	The ESPR will require manufacturers to report the full life-cycle CO_2 emissions of products via the Digital Product Passport (DPP). The EPBD requires building owners to report the total CO_2 emissions of buildings via life-cycle assessment in the form of Whole Life Carbon Global Warming Potential (WLC-GWP). The EU Battery Regulation mandates, in phases from 2024, CO_2 reporting, recycling rates and a digital battery passport (from 2027) for, among other things, industrial batteries in HVAC and storage applications.
C2.1–C2.15 Environmental indicators	ESPR ISO 59020	The ESPR allows room for broader environmental indicators but does not make them mandatory.
C3.1 Single score (nPt)		Not mandatory. Used in LCA software for internal decision-making.

Table 4. Overview of legal obligations per data point, in relation to relevance for MPG/EN 15804

As previously mentioned in Section 3.2, the list of circular data points covers a large number of topics. Even when considering only the priority data points, it is not feasible in practice to collect complete, up-to-date, and detailed data for every item. This is due, among other factors, to differences in access to information, a lack of standardization, or the simple absence of available data.

At the same time, the absence of data is meaningful in itself: it highlights where the largest gaps exist and where further development is needed. This is an important signal for organizations to design their internal data systems accordingly, so that missing data can become available in the future.

To effectively use the data that is available, two aspects are important. First, it is crucial to distinguish between the quality and origin of data (Section 3.4). Second, it must be clear how that data is collected and shared among value chain partners (Section 3.5).

It is not realistic to expect a single party to collect all required data. The data demand is too extensive, and the information is distributed across different links in the value chain. For this reason, these two aspects are closely interconnected: high data quality can only be achieved if value chain partners actively collaborate and each take responsibility for their own part of the data.

3.4 Data quality

Due to differences in measurement methods, data sources, and availability, it is not realistic to expect high-quality information for all circular data points at all times. To deal with these differences in a careful and transparent way, insight into data quality is essential. Not all information has the same level of reliability or accuracy.

Within this guideline, we therefore distinguish between four types of data quality. This helps to assess the value of available data and makes clear where further improvement is possible:

1. **Primary data:** Primary data are data that are directly measured or collected at the actual source of a specific activity, process, or product and are representative of that situation. It does not matter whether the measurement is performed by your own organization or by a supplier, as long as it takes place in the facility or process that is relevant to your product. Clearly documenting the measurement method, data source, and time period over which the data was collected is crucial for reliability and traceability. Examples include:
    a. Raw material consumption reported directly by the supplier of a component
    b. Measured energy consumption of a production line
    c. Directly measured CO_2 emissions from the process in which your product is manufactured
    d. Measured water consumption, emissions, or waste generation at the factory where your product is produced
2. **Secundary data:** If primary data is not available, secondary data is used. Secondary data consists of averages, standard values, or reference indicators that have previously been collected by others, usually for a purpose other than your specific application. These data often originate from databases, literature, sector reports, or other published sources. Because this data is not specific to your situation, the following must always be clearly stated: the source, the assumptions, the calculation methods used, and any

uncertainties. Examples include:

- CO_2 emissions per kilogram of aluminum from the Ecoinvent database
- Average emission factors for B7 diesel from CO2emissiefactoren.nl
- Standard values for recycling rates from a sector report

3. **No data**: Sometimes there is simply no information available for a particular data point, for example because measurements are technically not possible, because suppliers do not (yet) provide the information, or because the topic is new in regulation. This does not necessarily have to be problematic, but it is important to explicitly acknowledge the absence of data. Doing so makes visible where the largest gaps exist and where efforts are needed to enable future measurements.
4. **Mix of data sources:** In practice, a combination of primary and secondary data is often used. For example, you may measure the energy consumption of your own production process (primary data) and use emission factors from an LCA database (secondary data) to calculate CO_2 emissions. In such combinations, transparency is essential: for each data point, indicate which data are primary and which are secondary, and clearly state the source, assumptions, and any calculations used. This ensures that the analysis remains verifiable and that the reliability of each component can be properly assessed.

3.5 Sharing data with a Raw Material and Product Passport

s mentioned earlier, it is not realistic to expect a single party to collect all raw material and product data. The information is extensive and dispersed across different links in the value chain. Collecting it is therefore a shared responsibility: each supply chain partner provides data on the products or processes for which it is responsible. At the same time, not every party is able or willing to do this independently. In practice, one party—often the producer or the party ultimately responsible—will therefore need to coordinate the process. Central coordination is required to achieve a complete and coherent whole, ideally consolidated in a single central data structure. This promotes transparency and collaboration within the value chain.

What is currently still lacking is an accessible and uniform way to share this data among parties. The Digital Product Passport (DPP) has been designated in Europe as the key instrument to make this type of information accessible. According to the European Commission, the DPP is a digital, value chain–wide accessible system in which product information is registered, processed, and shared with other value chain partners, authorities, and consumers. This includes data on origin, composition, repairability, and recycling options—information that is crucial for circular strategies such as reuse, repair, and remanufacturing (CIRPASS2, 2024).

Although the DPP also contains circular data points, initially only a limited number of these will be mandatory. In addition, the DPP also includes data points that are not related to circularity. Moreover, the DPP itself is still under development: different industry organisations and governments are simultaneously working on various implementations. This currently makes it difficult to directly align our full list of circular data points with the DPP. What we can do, however, is use the underlying concept of the DPP to collect and share our list of circular data points within the value chain in a structured way.

For this purpose, we introduce the concept of a **Raw Material & Product Passport (GPP)**: a tool specifically aimed at recording and transferring raw material and product data between value chain partners in a manner similar to the DPP. At present, this is separate from the DPP but could easily be integrated into it in the future. It is expected that the circular data points included in the DPP will gradually expand and eventually encompass most of the data points outlined in Chapter 3.

The GPP therefore complements the DPP by specifically focusing on circular data. In the future, the two systems may potentially merge.

For clarity, the differences are summarized below. For completeness, the Environmental Product Declaration (EPD), which is used in practice as an instrument for documenting environmental information, is also included:

- **Digital Product Passport (DPP):**
  The DPP is an EU-mandated digital system in which product information — such as origin, composition, safety information, and sustainability data — is shared between value chain partners, authorities, and consumers. A European data-sharing solution is being developed to enable rapid data exchange.
- **Raw Material & Product Passport (GPP):**
  The GPP is a voluntary tool specifically focused on collecting and exchanging raw material and product data between value chain partners, as preparation for and complement to the future DPP. The technical method of data sharing is not prescribed; it may use systems similar to the DPP, but other technical solutions are also possible.
- **Environmental Product Declaration (EPD):**
  An EPD is a standardized and verified document that provides insight into the environmental performance of a product over its entire life cycle. It reports not only CO_2 emissions but also other environmental indicators based on a Life Cycle Assessment (LCA). Its structure follows international standards, such as ISO 14025 and, specifically for construction products, EN 15804. An EPD therefore contains the majority of the data points included in Category C “Environmental Impact” in this document.

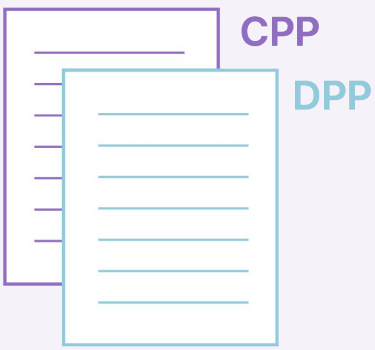

Figure 3. Overview of data points in the GPP compared to the DPP.

Creating a Raw Material & Product Passport offers the following advantages:

- **Promotes collaboration and transparency within the value chain:** Each link in the manufacturing industry can contribute product data, strengthening communication and making it easier to address questions related to value chain data.
- **Provides integrated insight into supply security and dependence on critical raw materials and the use of Substances of Very High Concern (SVHCs).**
- **Supports circular and sustainability analyses**, such as Life Cycle Assessments (LCA), organizational-level footprints, circularity scores, CO_2 emission analyses per year of use, and audits in the field of circularity and sustainability.
- **Introduces structure and uniformity in data:** collects relevant information on circularity and sustainability based on current insights, standards, and regulatory frameworks.
- **Supports decision-making and strategy development:** provides insight into the circular performance of value chain partners and serves as a reference point in tenders, procurement processes, and discussions on total cost of ownership, residual value, and sustainability ambitions.
- **Provides insight into material and raw material flows:** including the use of recycled or alternative raw materials, material composition, and the use of critical or hazardous substances.
- **Strengthens transparency towards customers and stakeholders:** through the availability of reliable and up-to-date circular data.

Standardized Decomposition

As mentioned earlier, the collection of raw material and product data will not be carried out by a single party, but through close collaboration across the entire value chain. A standardized decomposition is indispensable in this context: it ensures that a machine is divided in a uniform way into recognizable sub-levels.

The decomposition used in this document has been developed by the Hygienic Design Network, based on a classification widely used within the sector, and is recommended as an approach for all parties in the value chain. By using this structure, all stakeholders apply the same terminology, components are identified and recorded consistently, and a uniform exchange of information is guaranteed. The decomposition in Figure 4 illustrates these sub-levels using an example of a brewery.

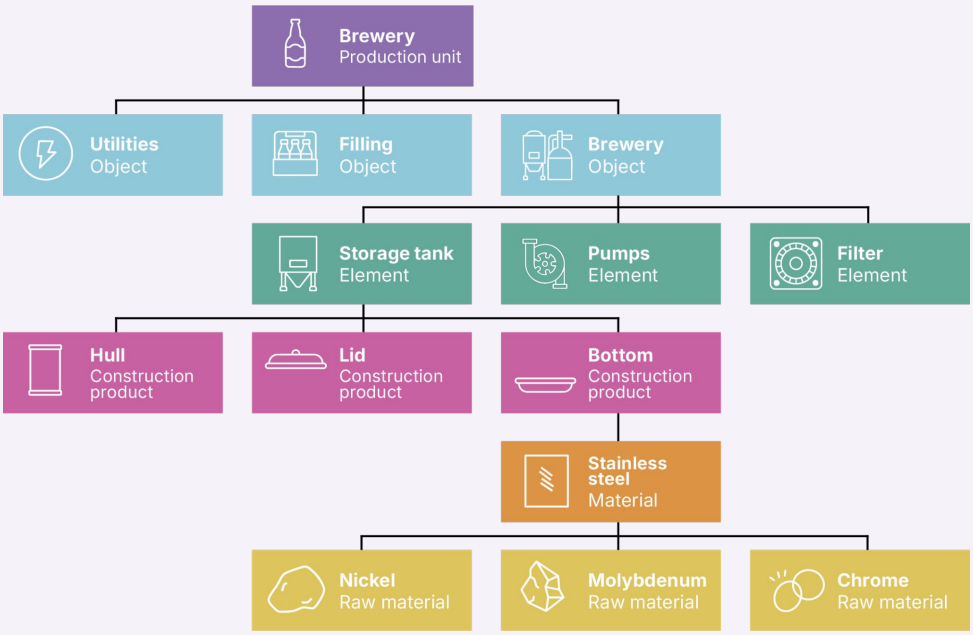

Figure 4. Decomposition of a brewery

Decomposition Level	Description	Example Products
Raw Material	Raw, unprocessed or minimally processed natural resources.	Iron ore, bauxite, crude oil, limestone
Material	Industrial primary processing of raw materials into a material without a specific application.	Stainless steel sheet, plastic granulate, glass tube, aluminium profile
Component	Technically formed part for assembly, without an independent function.	Flange, sealing ring, bracket clamp, heat exchanger plate
Element	A composed technical unit with its own function that operates independently within a larger system.	Pump, filter, sensor, PLC, valve, electric motor, storage tank
Installation Component	Composite, functionally defined unit within a production unit. Consists of multiple components and performs a single identifiable operational task.	Filling line, brewhouse, CIP system, filtration unit, pasteurization unit, fermentation module
Object	Fully integrated installation with an independent process function, consisting of multiple objects and subsystems.	Brewery, soft drink production line, dairy factory, turnkey food processing installation

Table 4. The different sublevels of a capital good in the food processing industry

The decomposition structure forms the foundation for the implementation of a GPP. This approach is a proposal for sharing a GPP with value chain partners in a structured and manageable way. An alternative structure or approach may also be chosen, as long as the ultimate goal, the complete and consistent recording of circular data, is achieved.

To make this proposed approach workable, a separate passport is created for each level in the decomposition structure, containing the relevant associated data. This passport is delivered to the buyer of the product. The buyer then collects the received passports and supplements them with their own data in order to create a new passport. This new passport can subsequently be passed on to the next buyer, who in turn follows the same process. When all data ultimately come together in the circular product passport at the highest level of the decomposition (object level), a complete overview of the circular performance of the installation is achieved.

Each level in the decomposition structure therefore has its own passport. The following passports can be distinguished: the raw material passport, material passport, component passport, element passport, installation component passport, building system passport, and object passport. Figure 5 visualizes the structure of a production unit composed of the various passports. Table 6 provides an overview of all stakeholders and the way in which they contribute data.

In practice, a component may be considered an integral part of an element. Nevertheless, creating a decomposition remains valuable, as it supports various circular R-strategies, life-extension strategies such as repair and refurbishment. In this way, life-extending interventions can be implemented at different levels of the decomposition structure.

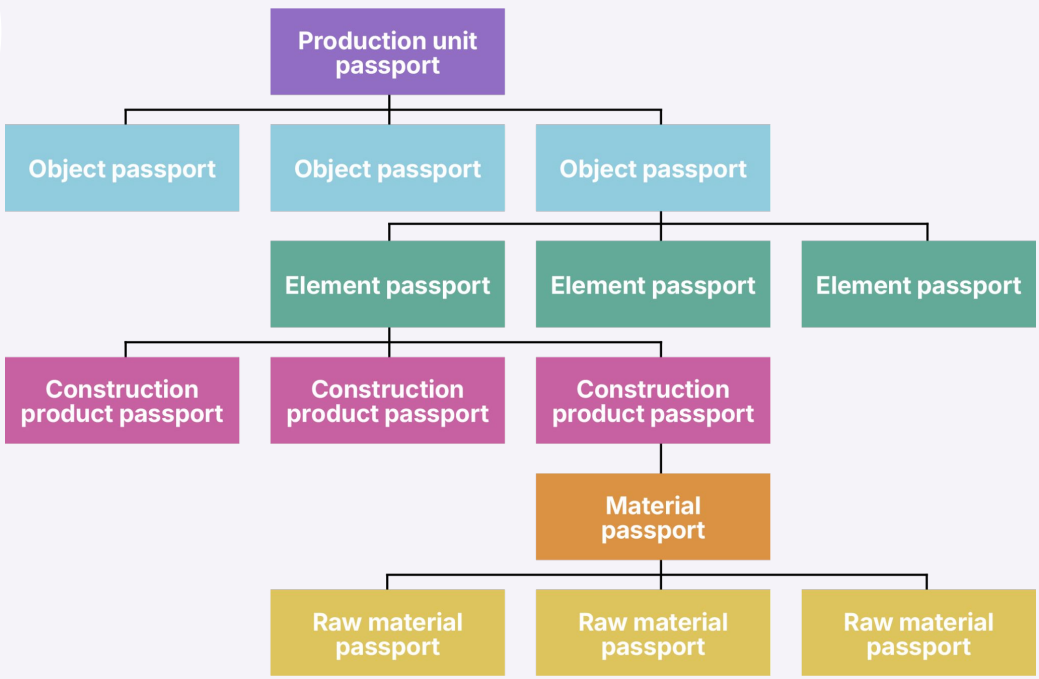

Figure 5. Structure of the GPP production unit passport based on underlying passports

Stakeholders + Passport	Description	Involved in the Following Data Points
Raw Material Suppliers > Raw Material Passport	Suppliers of raw or natural materials such as ores, oil or minerals. They are responsible for transparency regarding origin, extraction method, auxiliary materials, energy and water consumption in this process, declaration of critical raw materials and the environmental impact of extraction and processing.	A1.3–A1.5, B1.1–B6.6, C1.2, C2.1–C2.15
Material Manufacturers > Material Passport	These parties process raw materials into usable materials such as steel types, plastics or ceramics. They collect raw material passports and provide technical specifications on critical raw materials per kg of material, environmental impact per kg, share of recycled content, recyclability of the material, energy and water consumption in their processes, transport movements and environmental impact of transport per kg of material.	A1.2–A1.5, B1.1–B6.6, C1.2, C2.1–C2.15
Component Producers > Component Passport	Manufacturers of components such as drive motors, rotors, etc. These parties collect material passports and document the composition of the component from materials. They provide information on their own production processes, coatings or additives, transport of materials for production, associated environmental impact, energy and water consumption, recyclability of components and intended use.	A1.1–A1.5, B1.1–B6.5, C1.2, C2.1–C2.15
Element Manufacturers > Element Passport	Manufacturers of heat wheels, fans, etc. collect component passports and provide insight into the composition of their element. They are transparent about materials used, origin, share of recycled and renewable raw materials and presence of critical or hazardous substances. They also clarify additions such as coatings, joints or composite components, provide information on auxiliary materials, energy and water consumption, environmental impacts in all life phases, and on lifetime, maintenance, repairability and reuse and recycling options.	A1.1–A1.6, A3.1, A4.1–A4.3, A5.1, A6.1–A6.4, B1–B6, C1.2, C2.1–C2.15
Object builders / module builders >	Object builders or module builders, who assemble multiple components and construction products into functional units such as a filling line or brewhouse, prepare an object passport. They collect element passports and provide insight into the structure of the object, including its configuration and the possibilities for assembly and disassembly. They also add information about their own production processes and any coatings or composite components used. They provide data on material use, recycled and renewable content, energy and water consumption, and the environmental impacts of production, transport, use, and end-of-life. In addition, they supply information on the intended use, maintenance, performance specifications, repairability, and possibilities for reuse and recycling.	A1.1–A1.6, A3.1, A4.1–A4.3, A5.1, A6.1–A6.4, B1–B6, C1.2, C2.1–C2.15

Table 5. Overview of stakeholders and their contribution to product passports

Stakeholders + Passport	Description	Involved in the Following Data Points
System integrators / unit builders > Production Unit Passport	System integrators or unit builders, who assemble complete production units such as a brewery or soft drink production line, prepare a production unit passport. They collect object passports and document how these objects are integrated into one functioning unit. They also provide insight into their own processes and additions. They ensure transparency regarding material use, origin of components, possible coatings or composite components, and the use of recycled and renewable materials. They also provide data on energy and water consumption, environmental impacts across all phases of the life cycle, and the expected service life of the unit. Finally, they supply information about performance specifications, maintenance, repairability, updates, and the degree of reuse or recycling of components and materials.	A1, A2, A3, A4, A5, A6, B1, B2, B3, B4, B5, B6, C1, C2, C3
Maintenance companies and service teams > Production Unit Passport	Maintenance companies and service teams provide data for the production unit passport on planned and performed maintenance, replacements, upgrades, and the actual service life of the unit. They provide insight into repairability, maintenance requirements, and improvements to operational lifetime. They also report the energy consumption of maintenance during the use phase and the use of consumables such as lubricants or filters.	A1.6, A3.2, A3.3, A4.1 to A4.3, A5.1 to A5.5, B1.2 to B1.4, B2.2, B3, B4, B5, C1.3, C1.4, C2, C3
End users (Food producers) > Production Unit Passport	End users, such as food producers, provide data for the production unit passport based on the use, management, and end-of-life of the unit. They report on energy and water consumption, including the share of renewable sources, and the use of consumables such as filters or additives. In addition, they provide insight into performance and environmental impact during the use phase and at end-of-life, and contribute to the registration of information on lifetime, maintenance, upgrades, and completed repairs. Finally, they supply data on recycling, reuse, and the final status of the unit, including the required release or liability documents.	A3.1, A3.2, A3.3, A5.2 to A5.5, B1.2 to B1.4, B2.1, B2.2, B3.1 to B3.4, B4.1, C1.4, C2, C3.
Disassembly and dismantling companies > Production Unit Passport	Disassembly and dismantling companies provide data for the production unit passport based on the dismantling and processing of decommissioned production units. They record which components and materials are reused or recycled, including quantities, applications, and waste streams. They also provide insight into water and energy consumption during dismantling and report on the environmental impact of the end-of-life phase. In addition, they document the actual service life of the unit. Finally, they ensure that release or liability documents are provided where required.	B1.2, B1.3, B2 to B6, C1.5, C2, C3

Table 5. Overview of stakeholders and their contribution to product passports

Stakeholders + Passport	Description	Involved in the Following Data Points
Recyclers / waste processors > Production Unit Passport	Recyclers and waste processors provide data for the production unit passport regarding the processing of materials at the end of their life cycle. They report which raw materials and critical materials are recovered, in what quantities, and with what reuse or recycling percentage. They also provide insight into energy and water consumption during processing and the environmental impact of the end-of-life phase. In addition, they supply information about the degree of recirculation and the new applications of recycled materials. Where relevant, they provide documentation to release previous users or producers from liability.	B1.2, B1.3, B2 to B6, C1.5, C2, C3

Table 5. Overview of stakeholders and their contribution to product passports

*At this moment, according to the table above, every party is involved in category C – environmental impact. Preparing a life cycle analysis (LCA) is a shared responsibility, as nearly all stakeholders are required to collect and analyze accurate data. However, it is expected that it will mainly be carried out by producers within the supply chain.

4. Improving Circular Performance

4.1 Introduction

Improving circular performance begins with creating insight into the current situation. In order to select targeted strategies, it is essential to understand how a product, process, or system currently performs within the circular framework. Chapter 3 helped to generate this insight and to measure the circular performance of a product, process, or system.

In this chapter, we explore how these circular performances can be improved through circular strategies, concrete interventions, and informed choices.

First, four circular strategies are discussed: narrowing, substituting, slowing, and closing the loop. Subsequently, tools for design, monitoring, and collaboration are addressed. The chapter concludes with practical examples from the sector.

4.2 Working with circular strategies

The current economic system still largely operates according to the linear model: raw material extraction, production, use, and waste processing, also known as the “take-make-waste” principle. This results in the loss of valuable materials, environmental pressure, and dependence on new, often scarce raw materials.

In line with European and national objectives, a circular model aims to preserve and extend the value of raw materials and products. The focus is on preventing waste and keeping products and materials in use for as long as possible, as illustrated in Figure 7.

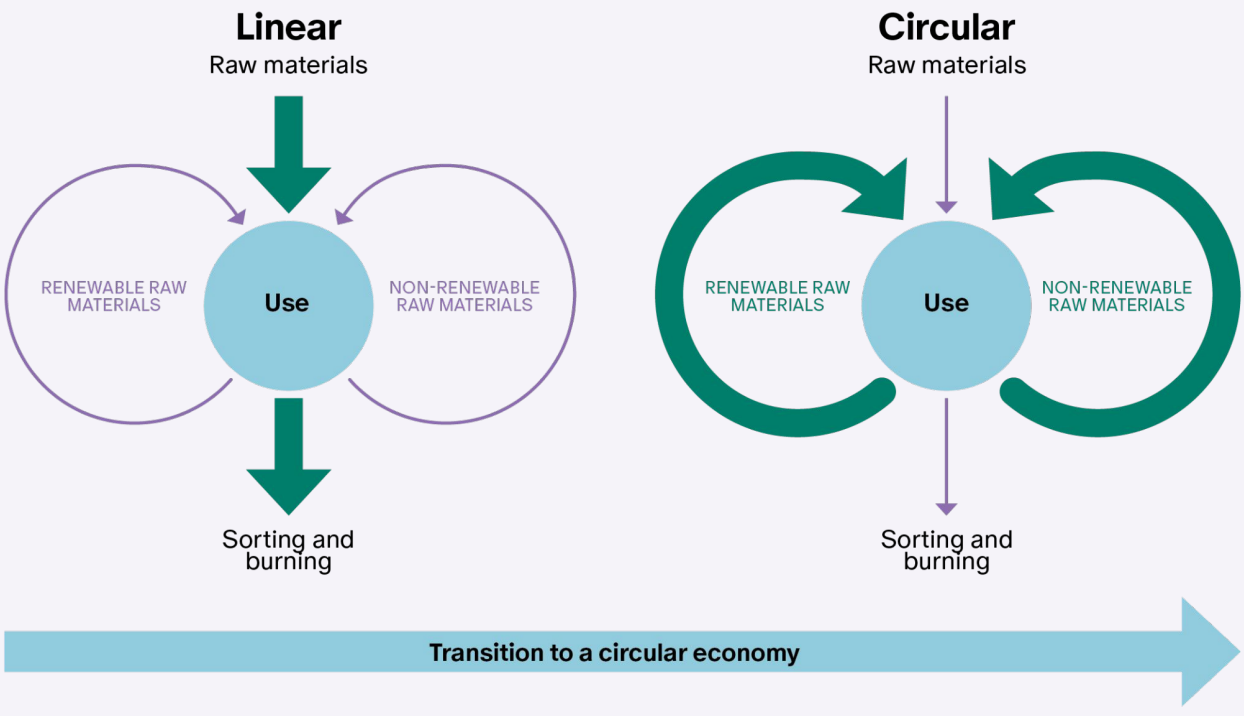

Figure 7. A linear economy versus a circular economy (PBL, 2016).

The transition from a linear economy to a circular economy in the manufacturing industry requires a fundamental system change. The way we design, produce, and collaborate must be rethought. This transformation also creates opportunities that go beyond merely reducing waste and complying with legislation. It contributes to competitive advantage, raw material and cost savings, process optimization, innovative business models, complexity reduction, and future resilience.

The action perspective “circularity & innovation” within the Dutch National Raw Materials Strategy outlines four strategies that together form the core of the circular economy (National Raw Materials Strategy, Parliamentary Document 32 852, no. 224):

1. **Narrowing the loop (reducing input).**
   The goal is to prevent raw material use through smart product design. This includes avoiding unnecessary components (*refuse*), rethinking product functions (*rethink*), and reducing material use (*reduce*). This step generates environmental benefits because fewer raw materials are ultimately required to deliver the same functions.
   Example: A sorting line is designed modularly without overdimensioning, so only necessary components are included; or switching to “sorting-as-a-service,” which avoids unnecessary replacement.
2. **Substitution (replacing raw materials).**
   This strategy focuses on replacing finite or environmentally harmful raw materials with sustainably produced, renewable, or less harmful alternatives. This avoids the use of primary, often fossil-based or scarce materials and lowers the environmental impact of resource use.
   Example: In the sorting line, traditional metal components are replaced with bio-based composites or high-quality recycled stainless steel and aluminum. Plastic parts are made from recycled polymers instead of virgin plastic.
3. **Slowing the loop (extending product lifetime).**
   The focus here is on extending the lifetime and intensifying the use of products and components, keeping valuable materials in circulation longer. Strategies include reuse, repair, refurbishment, remanufacturing, and repurposing.
   Example: The sorting line is built modularly so components like air hoses and wiring can be easily replaced or repaired. Worn parts are refurbished rather than fully replaced.
4. **Closing the loop (preventing losses).**
   When products or materials have truly reached the end of their life, the loop is closed by recycling materials or recovering energy from residual waste streams. This is the final step in the system, as energy costs and quality losses occur at this stage.
   Example: Decommissioned components of the sorting line are recycled into raw materials for new machines.

4.3 Circulair design with the Framework Circular Design

These four circular strategies provide direction for increasing supply security and reducing the negative impact of value chains (National Raw Materials Strategy, Parliamentary Document 32 852, no. 224). CIRCONNECT offers a structured design framework — the Framework Circular Design (FCD) — which enables integration of these strategies from the very earliest design stage (Figure 8). Through three design dimensions (product-service, business model, and value system) and the different product life cycle phases (from “rethink” to end-of-life), the FCD helps determine when and how to apply narrowing, slowing, closing, or substitution

strategies. In this way, circular principles are systematically embedded into the product, the organization, and the value chain.

Applying the FCD in product, service, and value chain design directly supports the objectives of the National Raw Materials Strategy. The NGS establishes the policy rationale and ambition ("why"), after which the framework helps translate these ambitions into practical implementation.

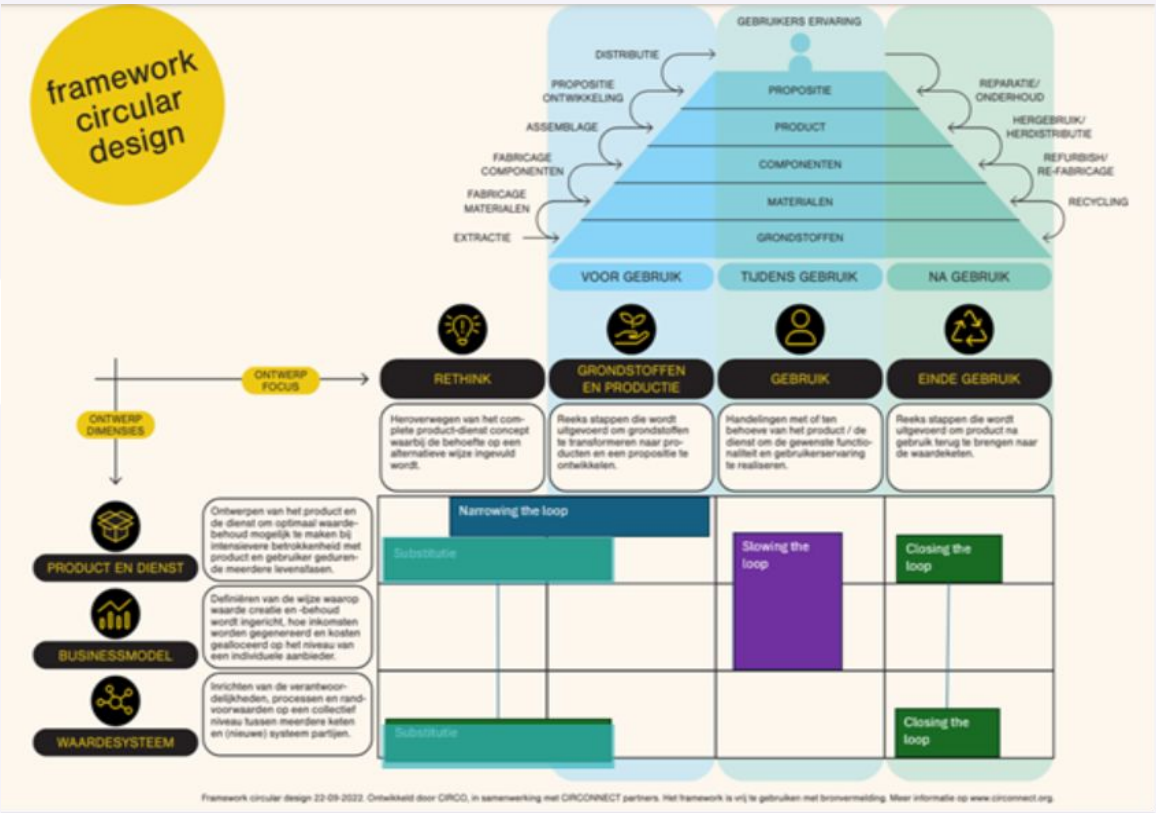

Figure 8. The CIRCONNECT Circular Design Framework (2022).

A circular design focuses on value retention and value creation throughout the entire life cycle of a product. To make this concrete, CIRCONNECT developed the Framework Circular Design (FCD) as a matrix consisting of three design dimensions and four design focuses.

Design dimensions

Making your design solutions more circular can take place at different levels/dimensions:

- **Product & service**: How you design your product or service in such a way that materials, components, and functionality are preserved, with attention to reuse, modularity, reparability, and high material quality.

  Example: You design a sorting line so that modules like conveyor belts, separation units, compressed air modules, and control panels are detachable. Instead of welding everything permanently, make components demountable. This way, wear parts can be easily replaced and modules can be redeployed.

- **Businessmodel**: How you organize value creation and retention throughout the entire lifetime, for example through service concepts, maintenance, leasing, or take-back schemes, to ensure economic sustainability.

  Example: Instead of selling the sorting line, you offer it as "sorting-as-a-service" or

through a leasing construct. The packaging processor rents the sorting line for a project, and after use, the provider takes the machine back for refurbishment and redeployment to another client.

- **Value system**: the chain as a whole, including agreements between partners, collection systems, standardization, and collaboration to collectively embed circular principles and manage value flows even after use.

  Example: Together with suppliers, maintenance companies, and recycling partners, you set up a take-back chain. This allows components such as conveyor belts and air hoses to be reused or recycled after disassembly.

Design focus

The four design focuses correspond to phases in the lifecycle, from need to end-of-use:

- **Rethink**: reconsider whether needs can be fulfilled differently, for example with a service instead of a product, or an alternative solution that avoids product use.

  Example: Is it necessary to own a sorting line? Perhaps you can work with a shared pool or procure a service from a provider who operates sorting lines across multiple locations.

- **Materials & production**: material choices, production processes, and efficiency during manufacturing.

  Example: When manufacturing the sorting line, choose more sustainable materials like recycled stainless steel, minimize the use of virgin plastics, and design efficiently to limit environmental impact during production.

- **Use**: optimize the usage phase, such as designing for long life, maintenance, repairability, modularity, or upgrade possibilities.

  Example: Design the sorting line for a long lifetime: robust frames, easily replaceable air hoses, modular sensors and control panels, so that maintenance and upgrades are simple.

- **After use**:plan for take-back, reuse, or recycling of products/components/materials once the product reaches end-of-life, to retain value and close material loops.

  Example: When the sorting line reaches the end of its lifecycle, provide a take-back and recycling system, allowing components to be reused or materials to be recycled.

4.4 Working with circular strategies

But how do you determine which of the four circular strategies you should focus on?
In Chapter 3, priority data points were identified based on legislation and regulations concerning sustainability, circularity, and toxicity. These priority data points are indicated with a “J” in Table 6.

Data points out of GPP			Distinctive ability as a motivator	Priority	Substitution	Narrow the loop	Slow the loop	Close the loop
A. Product information	A1. Raw materials composition	**A1.1** Raw materials list		J				X
		A.1.2 Share recycled raw materials	Reducing reliance on virgin materials, contributing to environmental objectives, complying with legislation	J		X		
		A.1.3 Share critical raw materials	Increasing supply security		X			
		A1.4 Share Substances of Very High Concern	Improving reuse options	J	X			
		A1.5 Share renewable raw materials	Reducing reliance on virgin materials, contributing to environmental objectives, complying with legislation			X		
		A1.6 Share reused content	Reducing reliance on virgin materials, contributing to environmental objectives, complying with legislation			X		
	A2. Operational consumption	**A2.1** Energy use	Cost savings, contribution to environmental objectives	J				
		A2.2 Water use	Ditto					
		A2.3 Consumables	Ditto					
		A2.4 Energy label	Ditto	J				
		A2.5 Stand-by consumption	Ditto	J				
	A3. Lifetime	**A3.1** Expected and agreed lifetime	Create opportunities for additional revenue after the point of sale	J			X	
		A3.2 Device age	Ditto	J			X	
		A3.3 Current lifecycle	Ditto	J			X	
	A4. Warranty and support	**A4.1** Product guarantee		J				
		A4.2 Product support		J				
		A4.3 Software support		J				
	A5. Contol	**A5.1** Repair and maintanance instructions	Option to sell spare parts	J				
		A5.2 Maintanance plan	Point of contact and revenue opportunity	J				
		A5.3 Performed repairs and maintanance	Point of contact and revenue opportunity	J				
		A5.4 Circular plan						
		A5.5 Responsabilities						
	A6. Potential for value retention	**A6.1** Repairability, main tenance and refurbishment possibilities		J				
		A6.2 Explanation of improvability, reproducibility						
		A6.3 Explanation recyclability	Environmental objectives, compliance with regulations, making secondary materials available			X		X
		A6.4 Explaination application of reuse				X		X

Table 6. Priority data points according to legislation and regulations for sustainability, circularity, and toxicity, and the corresponding strategies to improve them.

Data points out of GPP			Distinctive ability as a motivator	Priority	Substitution	Narrow the loop	Slow the loop	Close the loop
B. Lifecycle	B1. Material consumption	**B1.1** Product materials	Cost savings, lower production costs	J	X			
		B1.2 Consumables						
		B1.3 Auxiliary materials		J				
		B1.4 Consumption of packaging material						
	B2. Energy	**B2.1** Energy consumption	Lower operating costs	J				
		B2.2 Share renewable energy	Contribution to environmental objectives					
	B3. Water	**B3.1** Water consumption						
		B3.2 Circular water consumption	Contribution to environmental objectives					
		B3.3 Ratio of reused or recirculated water						
		B3.4 Distcharged water according to quality standards	Compliance with legislation and regulations					
	B4. Waste	**B4.1** Waste production						
	B5. Transport	**B5.1** Transport movements	Lower costs, contribution to environmental objectives					
	B6. End of life machine	**B6.1** Fraction reuse at end-of-life	Revenue model options: refurbishment, remanufacturing			X		X
		B6.2 Fraction recycling at end-of-life	Utilising material value, secondary stream	J		X		X
		B6.3 Explaination application of recycled raw materials		J		X		X
		B6.4 Fraction burning at end-of-life	Compliance with laws and regulations	J		X		X
		B6.5 Fraction landfill at end-of-life	Compliance with laws and regulations	J		X		X
		B6.6 Fraction recirculate materials at end-of-life		J		X		X
		B6.7 Recovered critical raw materials	Diversification, secondary stream, material value	J	X	X		X

Table 6. Priority data points according to legislation and regulations for sustainability, circularity, and toxicity, and the corresponding strategies to improve them.

Data points out of GPP			Distinctive ability as a motivator	Priority	Substitution	Narrow the loop	Slow the loop	Close the loop
C. Evironmental impact	**C1 Impact on climate change**	**C1.1** Total impact	Contribution to environmental objectives	J				
		C1.2 Impact production phase	Contribution to environmental objectives	J				
		C1.3 Impact installation phase	Contribution to environmental objectives	J				
		C1.4 Impact use phase	Contribution to environmental objectives	J				
		C1.5 Impact end-of-life	Contribution to environmental objectives	J				
	C2 Impact on other environmental indicators	**C2.1** Onzone depletion	Contribution to environmental objectives					
		C2.2 Ionizing radiation (human health)	Contribution to environmental objectives					
		C2.3 Photochemical ozone formation (human health)	Contribution to environmental objectives					
		C2.4 Particulate matter formation	Contribution to environmental objectives					
		C2.5 Acidification	Contribution to environmental objectives					
		C2.6 Eutrophication land	Contribution to environmental objectives					
		C2.7 Eutrophication of freshwater	Contribution to environmental objectives					
		C2.8 Eutrophication of marine environment	Contribution to environmental objectives					
		C2.9 Ecotoxicity fresh water	Contribution to environmental objectives					
		C2.10 Ecotoxicity marine environment	Contribution to environmental objectives					
		C2.11 Toxicity human (cancer)	Contribution to environmental objectives					
		C2.11 Toxicity human (not cancer)	Contribution to environmental objectives					
		C2.13 Land use	Contribution to environmental objectives					
		C2.14 Material consumption – fossil fuels	Contribution to environmental objectives					
		C2.15 Material consumption – matals and minerals	Contribution to environmental objectives		X			
	C3 Summary environmental impact score	**C3.1** Single score indicator (nPt)	Contribution to environmental objectives					

Table 6. Priority data points according to legislation and regulations for sustainability, circularity, and toxicity, and the corresponding strategies to improve them.

Figure 9 shows how the circular data points from Chapter 3 are positioned within the FCD framework. Identify where your priority data points are located within the FCD.

Next, ask yourself the design questions associated with these data points in order to improve your circular performance score. These design questions are based on the relevant circular strategies. They provide insight into where opportunities lie and in which areas improvement steps can be taken.

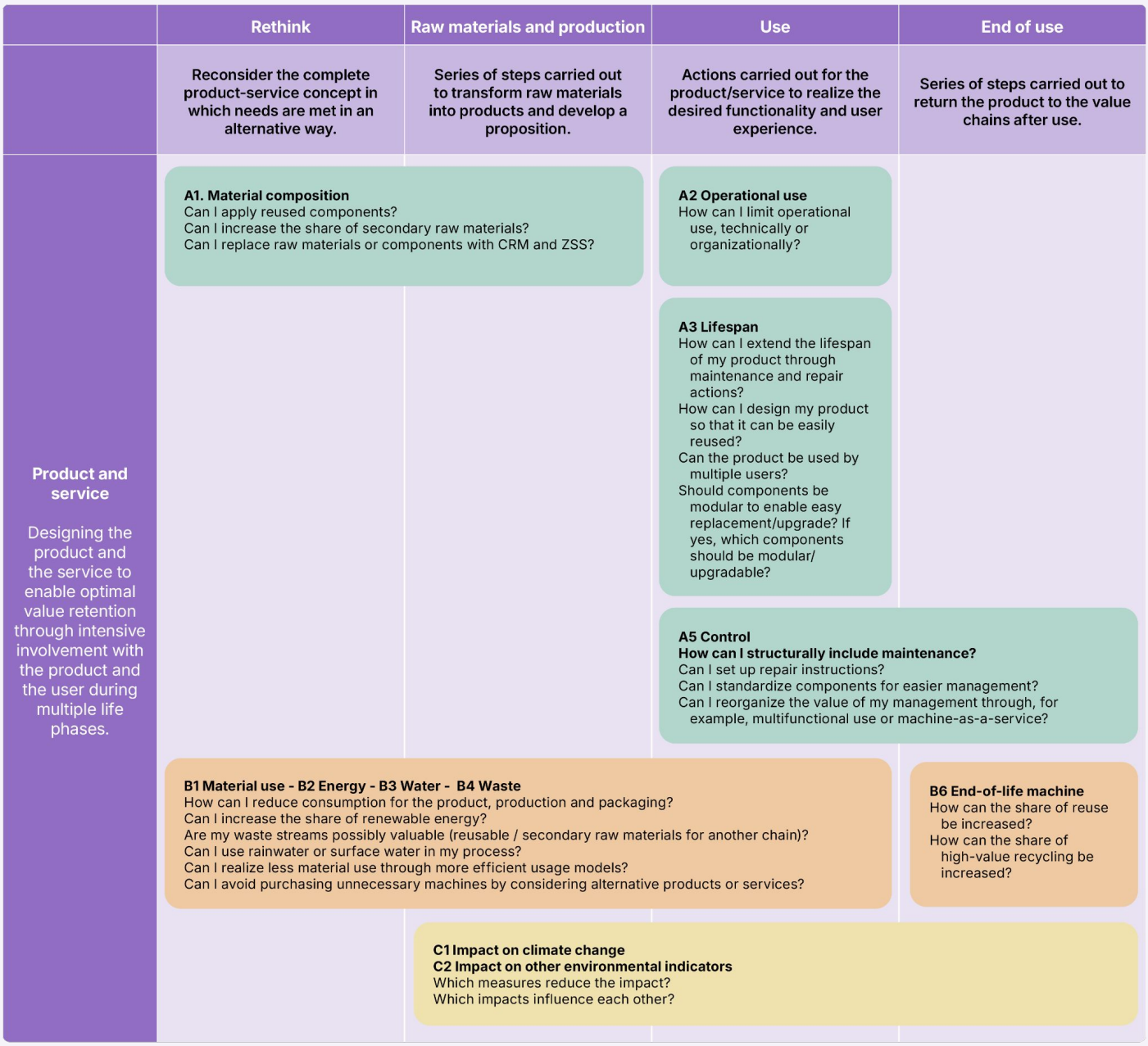

Figure 9. Design questions to improve circular performance.

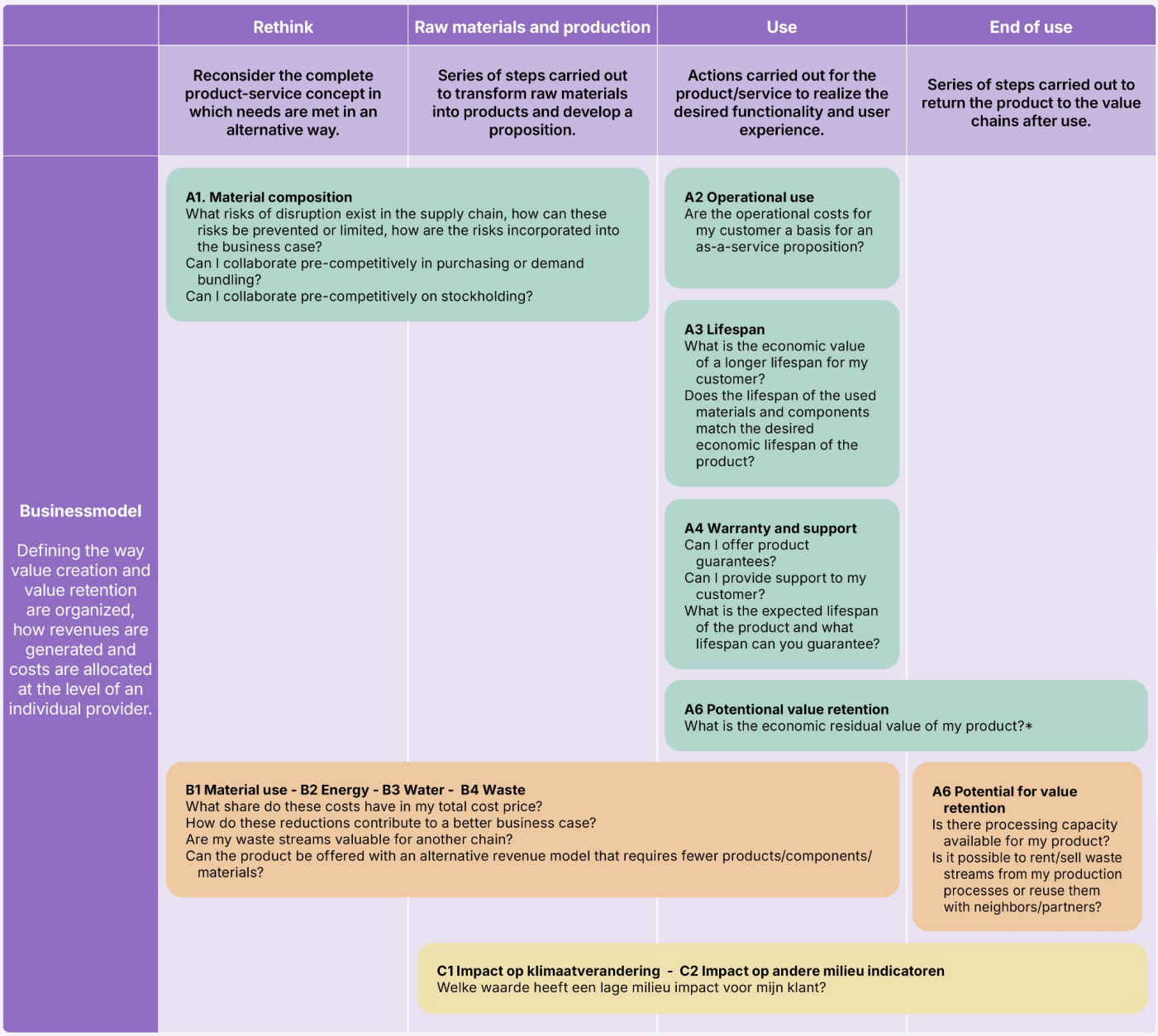

Figure 9. Design questions to improve circular performance.

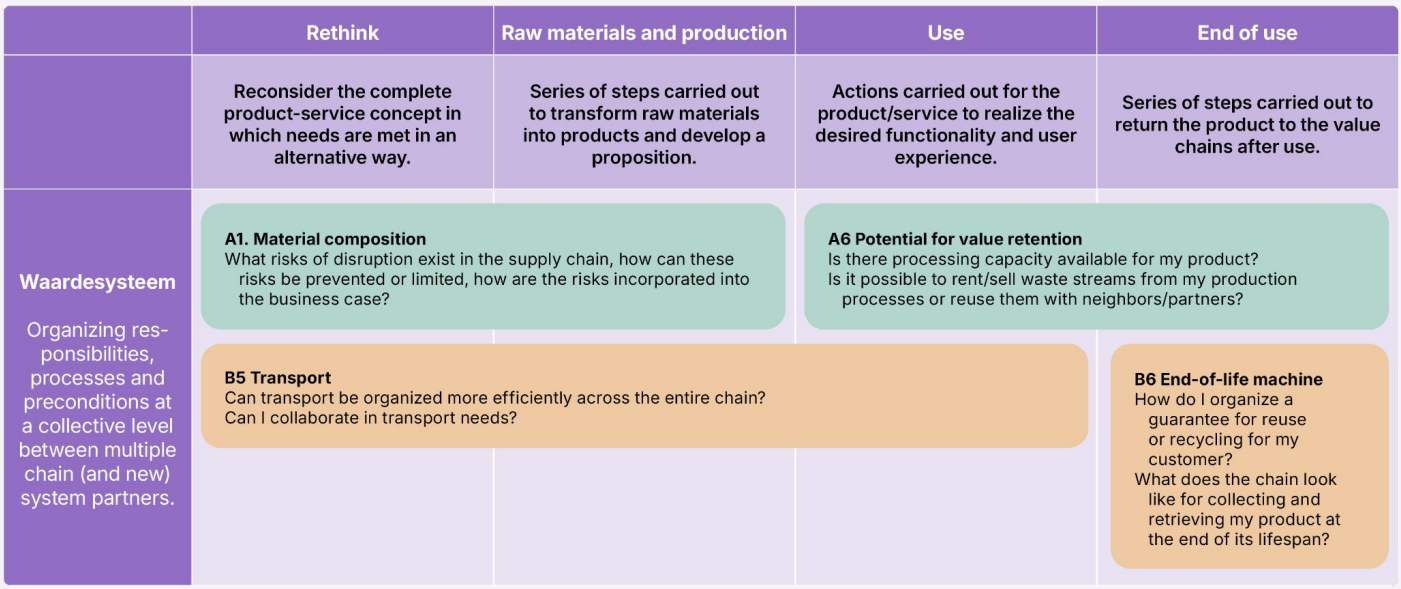

Figure 9. Design questions to improve circular performance.

4.5 Useful tools

To support you in answering the design questions, various practical tools can be used. Among others, CIRCONNECT and the Circular Manufacturing Implementation Program offer a range of accessible and practice-oriented tools and tracks (CIRCONNECT, n.d.; Stichting Circulaire Maakindustrie, n.d.). These instruments and workshops help manufacturing companies translate circular ambitions into concrete design choices, strategies, and forms of collaboration.

Although many of these tools align with circular strategies, there is not always a one-to-one relationship; some tools overlap multiple strategies or approach circularity from a broader perspective. The table below provides an overview of the mentioned tools, organized according to their thematic scope.

Circular data category	Purpose of the tool	Scope
Framework Circular Design	Need a more detailed explanation of the FCD? The Framework Circular Design (FCD) tool helps you apply circular design principles to your products, services, and business models. It provides practical guidance and is based on the "Products that Last" methodology developed by TU Delft.	Overarching
CIRCO Track	Do you want to develop circular business models and redesign your product or service? The CIRCO Track is a three-day workshop in which you, together with other companies and under the guidance of experienced trainers, discover circular opportunities and transform them into concrete plans. The Track is suitable for manufacturing companies that want to start with circular business practices.	Overarching
Circular Filter Programme of Requirements Tool	Do you want to firmly embed circular principles in your Requirements Program? By applying a circular filter, you examine the set of requirements your product must meet, making circular economy principles tangible and integrated into the design process.	Overarching
Rethink & Reuse Tool	Do you dare to approach your design challenges differently and critically reflect on the primary function of your product? The Rethink & Reuse Tool helps you practically shape this process, directly aligning with the R-ladder strategies Rethink and Reuse.	Rethink
Safe by Design & SVHC Tool	Do you want to exclude potential risks of hazardous substances early in the design process while preserving circular value? The Safe by Design & Substances of Very High Concern (SVHC) Tool supports designers in identifying risks of SVHCs in products and processes, and offers design strategies to safely avoid these substances.	Product & Service
Circular Design & User Influence Tool	Do you want to use design and communication to effectively encourage your customers to make circular choices? The Circular Design & Influence on Users Tool helps you understand how end users can be motivated to use products longer, return them, or reuse them.	Rethink/Reuse/End-of-use
Design for Maintenance	Do you want to design installations that are easy to maintain, refurbish, and upgrade, thereby extending their lifetime? The design principles from Mulder et al. (2012) help improve maintenance, reliability, and support throughout the entire lifecycle. Think modular construction, good accessibility, and standardization of components.	Product & Service + Use
Closing the Loop	Do you want to effectively integrate circular collection systems into your supply chain? With the Closing the Loop Tool, you gain insight into two archetype collection systems and learn how to organize them effectively within your chain. The tool provides practical guidance to preserve and enhance circular value.	Value System + End-of-use
Circular Maturity Assessment	Do you want to know where your organization stands in the transition to circularity? The Circular Maturity Assessment provides insight into your circular performance across ten key themes, such as strategy, supply chain collaboration, and environmental impact, and offers practical recommendations for improvement.	Overarching
Circularity Calculator	Do you want to map the circularity and economic value of your design at a glance? The Circularity Calculator gives insight into material flows, reuse, recycling, and potential value capture of your product. With clear scores, you can compare and evaluate circular design options in the early design phase.	Overarching

Table 7. Overview of available tools

Circular data category	Purpose of the tool	Scope
Environmental Impact Tool	Do you want to understand how circular design choices can reduce the environmental impact of a climate installation? This life cycle assessment-based tool allows users to compare different design options and understand where the largest environmental impacts occur.	Overarching
Raw Materials Scanner	Curious about which raw materials may become scarce or pose risks to people and the environment in the future? The Raw Materials Scanner provides insight into supply security, price volatility, and environmental and social risks per material or product. After answering a few questions, you receive a risk profile with up-to-date data and recommended actions to use materials more sustainably and resiliently.	Product & Service + Rethink/ Raw materials & Production
Residual Value Tool	Do you want to know the value of your climate installation at the end of its lifecycle? The Residual Value Tool provides insight into both the reuse value and recycling value at the material level. This tool helps underpin circular business models, optimize procurement, and attract circular financing.	Business model
Quick Scan Circular Business Models	Do you want to know where your organization stands in the transition to a circular economy? The Quickscan Circular Business Models provides insight into your current position and helps formulate a circular ambition. The result is a concise analysis of your organization's circular activities, your ambition for the coming years, and an exploration of the business model that best supports it.	Business model
Circular Legislation Guide	Do you want to gain control over legal frameworks and design obligations? This guide provides clear insight into existing and upcoming European and national regulations on circular design – essential knowledge for designers and companies aiming to comply with increasingly strict sustainability standards.	Overarching
Roadmap Remanufacturing	What challenges arise when starting with remanufacturing, and how do you solve them? The Remanufacturing Roadmap offers a practical seven-step guide, from retrieving used products to developing a continuous business model. This roadmap is a valuable resource for implementing the Remanufacture R-ladder strategy.	Business model
CESI supply Tool	Are you a supplier aiming to stimulate circular value creation in the manufacturing industry? The CESI Supply Tool helps you gain insight into opportunities for circular supply chain collaboration with your customers. By completing two targeted questionnaires, you get a clear picture of your customer relationship and the potential for circular cooperation. The tool provides practical recommendations for initiating conversations about circularity.	Value System
Supply Chain Collaboration Tool	Do you want to improve collaboration within your chain and create circular value? The Supply Chain Collaboration Tool provides quick insight into the success factors and barriers of collaboration. This tool is developed for manufacturing companies looking to start or improve circular collaboration. By working together with suppliers, retailers, consumers, waste processors, and logistics providers, you can manage resources	Value system

Table 7. Overview of available tools

4.6 Practical Examples

Introduction

An increasing number of companies are discovering that circular business practices not only contribute to a more sustainable environment, but also strengthen their own competitive position. By organizing products and processes in such a way that value is retained and waste is minimized, companies can achieve both economic and environmental benefits.

In this section, we highlight several examples of companies that have successfully integrated circular principles into their operations. These examples demonstrate how innovation, collaboration, and smart strategies can lead to both economic advantages and positive environmental impact.

Case 1: Lely

Lely offers certified second-hand milking robots through their platform used.lely.com (Reuse). Farmers can choose a standard overhaul (Repair) or the premium Taurus Certified program (Remanufacture and Refurbish). Overhauled robots receive the latest software updates and deliver comparable functionality to new machines, including a maintenance contract and warranty, but at only a fraction of the new price. Farmers can also trade in their current robot.

Figure 7. Lely Astronaut Taurus Certified automatic milking system

Case 2: Schelde Exotech

Schelde Exotech, a manufacturer of industrial pressure and vacuum equipment, has embedded refurbishment and remanufacturing structurally into its business model. Through a CIRCO track, they developed a commercial proposition in which used devices are thoroughly renovated or upgraded, providing customers with an “as good as new” product at only a third to half the price of a new unit. In 2020, this service already generated 5–10% of revenue—offering higher margins and less competition compared to the sale of new equipment.

Figure 8. A machine produced by Schelde Exotech

Case 3: Aebi Schmidt

Aebi Schmidt no longer offers municipalities snow-clearing or sweeping machines as a product, but instead provides performance-based services (**Rethink**) and charges based on results: 100% availability and reliability. Through modular design, data-driven maintenance, refurbishing, and remanufacturing, they significantly extend the lifetime of machines and help municipalities save up to 80% CO_2 compared to a new spreader, while preserving raw materials and material value.

Figure 9. The Swingo 200 sweeper from Aebi Schmidt

Case 4: Meulenbroek Machinebouw

Meulenbroek Machinebouw produces waste compactor containers that are modular, robust, and maintenance-friendly, aiming for maximum lifetime (**Reuse**) and easy repair (**Repair**). Customers can choose between rental (**Rethink**), where Meulenbroek remains the owner, or purchase with a buy-back guarantee. This keeps the containers in the loop, allowing Meulenbroek to maintain control over collection and how containers are reused or technically refurbished.

Figure 10. A waste press container made by Meulenbroek Machinebouw English

More inspiration

Curious for more inspiring examples of circular business? The website of the Circular Manufacturing Program (Uitvoeringsprogramma Circulaire Maakindustrie) features dozens of case studies from companies in the manufacturing industry that have successfully integrated circular principles into their operations.

In addition, the Circular Database of the Circular Manufacturing Program offers a rich source of inspiration, with hundreds of examples of sustainable and circular initiatives across various sectors.

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Annex A. Overview and Design Implications of Laws and Regulation

Legislation + status	Summary	Product design-related implications
Battery Regulation Regulation (EU) 2023/1542 In force since August 2023; phased implementation through 2030.	This Regulation sets requirements on sustainability, safety, labelling, marking and information in order to allow batteries to be placed on the market or put into service in the Union. In addition, it sets minimum requirements for extended producer responsibility, the collection and treatment of waste batteries, and reporting. The aim of the Regulation is to achieve harmonised European product standards for all types of batteries, to establish a well-functioning internal European market for secondary raw materials for batteries, and to significantly reduce negative environmental impacts in the production, use and end-of-life phases of all batteries.	The Battery Regulation (EU) 2023/1542 has several product-specific implications: • **Scope:** The Regulation applies to all batteries, including portable batteries, starter, lighting and ignition batteries, industrial batteries, electric vehicle batteries and batteries for light means of transport. • **New categories:** Two new categories have been added: electric vehicle batteries and batteries for light means of transport. • **Performance standards:** Batteries must meet specific performance standards to ensure long lifetime and good energy efficiency. • **Verwijderbaarheid:** Draagbare batterijen in apparaten moeten door de eindgebruiker kunnen worden verwijderd en vervangen. Voor lichte vervoermiddelen moeten batterijen door een onafhankelijke professional kunnen worden verwijderd en vervangen. • **Removability:** Portable batteries in appliances must be removable and replaceable by the end user. For light means of transport, batteries must be removable and replaceable by an independent professional. • **Spare parts:** Batteries for light means of transport must remain available as spare parts for at least one year. • **Labelling:** New requirements for labelling and marking of batteries. • **Sustainability:** The Regulation sets requirements for the sustainability, safety and recyclability of batteries.

Legislation + status	Summary	Product design-related implications
Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU In force since 2 Jan 2013; still applicable and regularly updated.	The Directive aims to prevent risks to human health and the environment associated with the management of electrical and electronic waste. The RoHS Directive sets limits on the use of hazardous substances such as heavy metals (lead, mercury, cadmium, hexavalent chromium), flame retardants (PBB, PBDEs) and plasticisers (DEHP, BBP, DBP and DIBP). A number of legal obligations follow from the Directive. These obligations relate to: • Product conformity or conformity assessment; • Technical documentation; • Indication of product identification numbers and the manufacturer's and importer's name/postal address on the product; • CE marking; • EU declaration of conformity. Equipment falling under the RoHS Directive may also be subject to other Directives requiring CE marking (for example, the Electromagnetic Compatibility Directive, the Low Voltage Directive, etc.).	De RoHS-richtlijn 2011/65/EU, aangevuld door Gedelegeerde Richtlijn (EU) 2015/863, bevat de volgende product-gerelateerde implicaties: • **Scope:** Applies to electrical and electronic equipment (EEE) placed on the EU market, with certain exceptions. • **Restricted substances:** Maximum permitted concentrations of 0.1% (0.01% for cadmium) for lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE) and four phthalates (DEHP, BBP, DBP, DIBP). • **CE marking:** Products that meet the RoHS requirements must bear the CE marking. • **Declaration of conformity:** Manufacturers must draw up an EU declaration of conformity for each product. • **Technical documentation:** Producers must keep technical documentation to demonstrate compliance. • **Traceability:** Products must carry a type, batch or serial number for identification. • **Exemptions:** Certain applications are exempt from the restrictions, such as some medical equipment and military applications. • **Repair and reuse:** Specific provisions for the repair and reuse of older equipment. • **Product categories:** Applies to multiple categories including household appliances, IT equipment, consumer electronics, lighting equipment and power tools. • **Enforcement:** Member States are responsible for market surveillance and enforcement of the Directive.

Legislation + status	Summary	Product design-related implications
Construction Products Regulation Regulation (EU) 305/2011 In force since 1 July 2013.	This Regulation lays down harmonised conditions and a number of basic requirements for marketing construction products within the European Union. Companies must draw up declarations of performance for their products, stating essential characteristics and performance, thereby ensuring the quality and safety of construction products (e.g., behaviour in fire, thermal conductivity or sound insulation). This means, among other things, that they are required to prepare: • **Declaration of Performance:** Manufacturers must draw up a declaration of performance stating essential characteristics and performance. Technical documentation is also specified describing all applicable elements relating to the assessment and verification system for constancy of performance. • **CE marking:** Construction products within the scope of the Regulation must bear the CE marking indicating compliance with the declared performance and applicable EU rules. • **Information on hazardous substances:** Manufacturers must provide information on any hazardous substances in construction products in accordance with the REACH Regulation.	Regulation 305/2011/EU (Construction Products Regulation) has several product-specific implications: • **Scope:** Applies to all construction products that are permanently incorporated into construction works, such as buildings and civil engineering works. • **Declaration of Performance:** Manufacturers must draw up a Declaration of Performance (DoP) for construction products covered by a harmonised European standard or for which a European Technical Assessment has been issued. The DoP must include the product's performance for the essential characteristics. • **CE marking:** Affixing the CE marking is mandatory for construction products for which a DoP is drawn up. • **Harmonised technical specifications:** The Regulation provides a system of harmonised technical specifications (hEN and ETA) for testing and assessing construction products. • **Conformity assessment:** An agreed system of conformity assessment exists for each construction product (European Assessment Documents). • **Factory production control:** Manufacturers must implement a factory production control system to ensure consistent product performance. • **Simplified procedures:** For individually designed and manufactured construction products, manufacturers may apply simplified performance assessment procedures. • **Traceability:** Construction products must be marked with a type, batch or serial number or other identification. • **Information on hazardous substances:** Manufacturers must provide REACH information as part of the documentation for construction products.

Legislation + status	Summary	Product design-related implications
Construction Products Regulation (revised) Regulation (EU) 2024/3110 In force as of 7 Jan 2025; transitional rules for old standards.	The 2024 Construction Products Regulation is a planned revision of the 2011 CPR and will introduce additional requirements for sustainability and circularity. The new Regulation introduces requirements for CO_2 emissions, environmental impact and recyclability of construction materials throughout the entire product life cycle. It will require manufacturers to provide digital product passports with detailed information on the composition and origin of raw materials, as well as recycling and reuse options. In addition, stricter rules will apply for safety and health in construction products, including restrictions on hazardous substances.	Regulation (EU) 2024/3110 (the new Construction Products Regulation) introduces the following changes compared with Regulation 305/2011/EU: • **Digital product passports:** Introduction of digital passports containing all relevant product information, including the declaration of performance, declaration of conformity and instructions for use. • **Sustainability criteria:** New rules for statements on ecological sustainability of construction products and the possibility to set threshold levels and classes for environmental performance. • **Extended market responsibility:** Extension of legal obligations to service providers such as fulfilment service providers and online marketplaces. • **Support for innovation:** Explicit support for innovative construction techniques, including prefabricated and modular elements. • **Harmonisation with EU legislation:** Reduction of overlaps and inconsistencies with other EU legislation to increase legal certainty. • **Circular economy:** Promotion of circularity of construction products and support for the transition to a more sustainable built environment. • **Simplification:** Reduction of administrative burdens for market operators through simplified procedures. • **Digitalisation of information:** Improved information flows in the supply chain using electronic and machine-readable formats. • **Implementation timeline:** The new Regulation enters into force on 7 January 2025 and applies from 8 January 2026. • **Competitiveness:** Measures aimed at improving competitiveness and productivity of the construction sector.

Legislation + status	Summary	Product design-related implications
Critical Raw Materials Act (CRMA) Regulation (EU) 2024/1252 In force since 23 May 2024; implementation phase through 2030.	The EU Critical Raw Materials Act (CRMA) focuses on securing a sustainable and reliable supply of critical raw materials such as lithium, aluminium, silicon, copper and rare earths, which are essential for sectors like renewable energy and digital technology. The objective of CRMA is to address challenges around critical materials. Organisations must identify which critical materials they use, develop strategies to mitigate risks (such as supply chain diversification and raw material efficiency), and meet social, environmental and governance standards in procurement practices. The Act also promotes strategic projects, recycling and international cooperation to strengthen European value chains and reduce dependence on imports.	The CRMA has the following product-specific implications: • **Insight into material use:** Organisations must identify and report which critical materials are used in their products, such as lithium, aluminium, silicon, copper and rare earths. • **Risk management strategies:** Obligation to develop strategies to mitigate risks, including supply chain diversification, substitution of materials and improving resource efficiency. • **Responsible sourcing:** Organisations must follow responsible sourcing practices, whereby extraction, processing and trade of critical raw materials meet social, environmental and governance standards. • **Recycling and circularity:** Stimulation of recycling processes to recycle at least 25% of annual demand by 2030, which may lead to design changes to improve recovery. • **Production and processing targets:** EU targets by 2030 to extract at least 10% and process at least 40% of annual demand for strategic raw materials, potentially affecting production locations and supply chains. • **Diversification of import sources:** y 2030, no more than 65% of a critical raw material may be imported from a single non-EU country, affecting sourcing strategies. • **Accelerated permitting:** Strategic projects receive accelerated permitting, enabling companies to launch new production facilities and recycling initiatives more quickly.

Legislation + status	Summary	Product design-related implications
Detergents Regulation Regulation (EC) 648/2004 In force since 31 Jan 2005.	The European Detergents Regulation (648/2004/EC) applies to all laundry and cleaning agents across all EU countries. The Regulation sets environmental requirements (biodegradability). Biodegradation occurs, for example, in a wastewater treatment plant or a compost heap.	There are few design-specific implications arising from the Detergents Regulation, except that HVAC systems must be suitable for use with hygienically certified cleaning and lubricating agents (ISO 21469).
Ecodesign for Sustainable Products Regulation (ESPR) Regulation (EU) 2024/1781 In force since 18 July 2024; in implementation phase; old requirements remain in force during the transition period until 2026–2030.	The ESPR broadens the scope of Ecodesign (2009) from energy to requirements concerning product lifetime, reusability, upgradability, repairability, the presence of substances that hinder circularity, energy and material efficiency, recycled content, remanufacturing and recycling, CO_2 and environmental footprints and, lastly, information requirements including a digital product passport. New policy instruments are also introduced, such as the Provisions of Unsold Consumer Goods, which prohibits the destruction of unsold consumer goods. For companies, this Regulation means that products must be designed with minimal ecological impact across the entire life cycle. Moreover, companies must be more transparent about the environmental effects of their products. The European Commission will progressively adopt delegated acts with specific product rules. The first work plan, to be published by 19 April 2025 at the latest, will focus on product groups such as iron and steel, aluminium, textiles, furniture, tyres, detergents, paints, lubricants, chemicals and energy-related products.	Over time, product-group-specific requirements may be set for the following product aspects: **Performance and information requirements:** • Improve product durability and lifetime • Increase repairability, including availability and affordability of spare parts • Increase reusability and recyclability • Improve energy and resource efficiency • Increase recycled content • Reduce carbon and environmental footprints **Digital Product Passport (DPP):** • Mandatory digital identity card for products, parts and materials • Contains information on technical performance, material origin, repair activities and recycling options • Accessible via a code on the packaging or the product itself **Additional measures:** • Ban on the destruction of unsold textiles and footwear, with possible extension to other product groups • Obligation for large and medium-sized companies to provide annual information on discarded products.

Legislation + status	Summary	Product design-related implications
Ecodesign Directive Directive 2009/125/EC Replaced as of 18 July 2024 by the ESPR; a transition period keeps some old requirements in force until 2026–2030.	The purpose of the directive is to reduce energy consumption for both product design and production, transport and packaging. It is also an important instrument to stimulate manufacturers and importers to develop more efficient energy-related products. In addition, there are now requirements for product lifetime and availability of spare parts. The Ecodesign Directive works together with the Energy Label Directive (Directive 2017/1369) to improve energy efficiency and environmental performance. This requires products to carry energy labels indicating their energy-efficiency class. This directive formed the basis for the new, broader Ecodesign Regulation that will enter into force in 2026 and will cover a wider range of products and sustainability aspects. standards for different product categories, such as minimum efficiency for electric motors. Standby consumption: Limits on energy consumption of products in standby or off mode.	The Ecodesign Directive 2009/125/EC, now replaced by the new Ecodesign Regulation, contained the following main points: • **Energy efficiency requirements:** Products must comply with specific energy-efficiency standards, often expressed in maximum energy consumption or minimum efficiency levels. • **Information provision:** Producers must provide specific product information, such as energy consumption and instructions for efficient use. • **CE marking:** Products that met the requirements were allowed to carry the CE marking. • **Performance standards:** Specific performance standards for different product categories, such as minimum efficiency for electric motors. • **Standby consumption:** Limits on the energy consumption of products in standby or off mode.

Legislation + status	Summary	Product design-related implications
Energy Labelling Regulation 2017/1369 In force since 11 July 2017.	The Energy Labelling Regulation (EU 2017/1369) requires manufacturers to provide energy efficiency information on household appliances such as refrigerators, washing machines, dishwashers and lighting. Energy labels must show the energy efficiency class (A to G), annual energy consumption and additional performance characteristics. This enables comparison between products based on energy use and other environmental impact factors. Manufacturers must register their products in the EPREL database (European Product Database for Energy Labelling), where detailed product information is publicly available.	Directive 2017/1369 and the latest version, Directive (EU) 2023/1791, set various product-specific requirements for energy-related products: • **Labelling:** ppliers must provide labels and product information sheets using an A–G scale. • **Product information:** Retailers must display labels and make product information available, including online. • **European database:** Suppliers must enter data before placing new products on the market. • **Software updates:** Consumers must be informed if updates reduce energy efficiency. • **Ban on manipulation:** The use of manipulation devices that alter a product's performance under test conditions is prohibited.

Legislation + status	Summary	Product design-related implications
Energy performance of buildings Directive 2010/31/EU In force since 19 May 2010, supplemented by subsequent versions.	This Directive establishes a framework to improve the energy performance of buildings in the Union, taking into account both the climatic and local conditions outside the building and the requirements for indoor climate and cost-efficiency. It provides for minimum requirements regarding, among other things, the energy performance of buildings.	Directive 2010/31/EU on the energy performance of buildings (EPBD) has the following main product-specific implications: • **Nearly Zero Energy Buildings:** Requires all new buildings to be nearly Zero Energy (NZE) from 2021 onwards • **Renovation requirements:** Extension of the scope to smaller renovations where part of the building envelope is replaced • **Alternative energy systems:** Obligation to investigate the feasibility of alternative energy generation systems for each new building • **Energy performance certificates:** Establishment of an independent control system for certificates and inspections • **Calculation methodology:** Establishing a common framework for the calculation of the energy performance of buildings • **Minimum requirements:** ntroduction of minimum requirements for the energy performance of new buildings, building units and elements of existing buildings undergoing major renovation • **Technical building systems:** Definition and requirements for technical systems such as heating, cooling, ventilation and lighting

Legislation + status	Summary	Product design-related implications
Fluorinated greenhouse gases (F-gases) Regulation (EU) 2024/573 Original regulation since 1 Jan 2015; revised limits and rules from 11 March 2024.	This Regulation lays down rules concerning fluorinated greenhouse gases (F-gases) within the European Union. Key provisions include: • Aimed at reducing F-gas emissions • Phasing out HFCs on the EU market • Ban on the use of F-gases in certain new equipment • The latest version of this Regulation, Regulation (EU) 2024/573, contains the following key points: • Further tightening of rules for F-gases • Drastic reduction in permitted F-gas production and imports • Expansion of certification requirements for technicians, including for natural refrigerants	The Integrated F-Gas Regulations 517/2014 and 2024/573, building on previous regulations, have the following key implications: • **Quota system:** Strict quotas for the production and import of HFCs, based on CO2 equivalents, with accelerated phase-out until 2050 • **Certification:** Expanded certification and training requirements, now also applicable to HFOs and natural refrigerants • **Product bans:** Comprehensive list of prohibited applications, including high-GWP refrigerants in specific systems • **GWP limits:** Strict limits for GWP in various applications, such as heat pumps and air conditioning • **Reporting:** Strengthened obligation to monitor and report on production, import, export and use of F-gases • **Leak detection:** Mandatory regular leak checks for systems with certain amounts of F-gases • **Recovery:** Obligation to recover F-gases from equipment during maintenance and at end of life • **Labelling:** Clear labelling required for products and equipment containing F-gases These measures aim to drastically reduce emissions of fluorinated greenhouse gases and encourage the transition to more environmentally friendly alternatives.

Legislation + status	Summary	Product design-related implications
Water Framework Directive (WFD) Directive 2000/60/EC In force since 22 Dec 2000; continuous implementation by Member States.	Directive 2000/60/EC, known as the Water Framework Directive (WFD), is the foundation of European water policy and aims to achieve good ecological and chemical status for all water bodies within the EU. Although the WFD itself does not prescribe specific harmonised standards, various standards and guidelines have been developed to support the implementation of and compliance with the WFD.	The WFD focuses primarily on environmental and water quality management, but has indirect implications for product design and use, particularly for sectors that cause emissions to water. Important implications are: • **Use of hazardous substances:** Products that contain substances that can end up in surface or groundwater (via discharge, runoff or leakage) must be reconsidered. Examples include microplastics, heavy metals and persistent organic pollutants. • **Wastewater emissions:** Products that may result in emissions to water must be designed to prevent or minimise such emissions. • **Substitution of harmful substances:** Incentive for design without WFD priority substances such as PFAS, cadmium, lead or mercury. • **Environmental information:** Producers may be required to provide insight into the water-related environmental impact of their products. • **Chain cooperation:** Sectors with a major water impact are expected to take measures in the production chain that prevent or reduce discharges. Although the WFD does not directly regulate product design, it forces producers in water-sensitive sectors to adopt cleaner design, cleaner processes, and transparency about environmental impacts.

Legislation + status	Summary	Product design-related implications
Plastics for food contact Regulation (EU) 10/2011 in combination with (EC) 2022/1616 (Recycled plastics) In force since 1 January 2011; updates introduced through Regulation 2022/1616.	Commission Regulation (EU) No. 10/2011, adopted on 14 January 2011, concerns plastic materials and articles intended to come into contact with food. This regulation establishes specific requirements for the composition and properties of such materials in order to ensure consumer safety.	From Regulation (EU) 10/2011 in combination with (EC) 2022/1616 (Recycled plastics) the following design implications for machine builders follow: Material selection on the positive list. Specify polymers and additives listed in 10/2011. Request a declaration of compliance per part number stating SML checks. Store this in the technical dossier. • **Design for migration.** Use the overall migration limit of 10 mg per dm^2 and relevant specific limits. Pay attention to high surface-to-volume ratios for small parts such as gaskets and hoses. Choose material and wall thickness so that worst-case testing is met. • **Include test conditions in the design.** Define contact time, temperature and food simulant according to 10/2011. Record that a recipe change or change of supplier requires reassessment. • **Functional barrier only with justification.** Application is possible, but under the conditions of 10/2011 and with proof that migration remains below the limits. Inks, adhesives, coatings. No direct food contact zone. Where unavoidable, the layer must comply with 10/2011 and 1935/2004 and be covered in the DoC. • **Only approved processes:** Use recycled plastic exclusively from EU-approved recycling processes with EFSA assessment. Record the process identity and authorization. • **Quality system and traceability:** Require your supplier to have a demonstrable quality system for collection, sorting, decontamination and batch traceability. Include lot numbers in your machine dossier. • **Demonstrate decontamination:** Request challenge test reports and process control data. Do not use recycled material in critical contact zones if this substantiation is missing. • **Include CIP and SIP:** Choose plastics that withstand cleaning and disinfection without increasing migration. Record aging tests in the dossier. (Requirement follows from 10/2011)

Legislation + status	Summary	Product design-related implications
Machinery Regulation Regulation (EU) 2023/1230 Published on 10 Nov 2023; entry into force planned for 2027.	The Machinery Regulation replaces the Machinery Directive (2006/42/EC). This regulation (note: it was a directive) establishes uniform safety and health requirements for machinery on the EU market to protect workers and consumers. Manufacturers must carry out a conformity assessment and affix a CE marking to demonstrate conformity. Some important changes that should be taken into account are that new technologies such as AI and IoT are covered by the Machinery Regulation as far as the safety of machines is concerned. In addition, the new regulation introduces a new list of 'high-risk machinery', which repeals the old list. This Regulation introduces limited changes to product design requirements compared to the previous directive, but does set requirements for, for example, the user manual (which can now be done digitally). For machines that use artificial intelligence, the 'Internet of Things' or robotics, there are product safety requirements that a manufacturer must take into account.	The Machinery Regulation (EU) 2023/1230 introduces important changes compared to the previous Machinery Directive 2006/42/EC: • **Extension of scope:** The regulation now also applies to new technologies such as AI, IoT and cybersecurity as far as they relate to the safety of machines. • **Digital documentation:** Manuals may be provided in digital, printable format. However, manufacturers must ensure that paper versions are available free of charge upon request. • **High-risk machinery:** A new list of 'high-risk machinery' has been introduced, subject to specific conformity assessment procedures • **Conformity assessment:** New procedures have been introduced, including conformity based on full quality assurance. • **Risk assessment:** Manufacturers should consider future software updates and the development of autonomous behaviour over the v of the product

Legislation + status	Summary	Product design-related implications
Materials in contact with food Regulation (EC) 1935/2004 in conjunction with GMP Regulation (EC) 2023/2006 In force since 27 October 2004.	Regulation (EC) No. 1935/2004, also known as the Framework Regulation for materials and articles intended to come into contact with food, establishes general safety and compliance requirements for all materials and articles that are intended to come into contact with food. This regulation forms the basis for specific measures that apply to different materials, such as plastics, ceramics, and metals.	From Regulation (EC) 1935/2004 in combination with GMP Regulation (EC) 2023/2006 the following design implications for machine builders in the food industry follow: • **Basic safety:** Materials in food contact must not transfer substances that endanger health or unacceptably change the composition, smell or taste of the food. Design and material selection must be assessed against this principle. • **Labeling and symbols:** For loose parts and interchangeable components that are not obviously intended for food contact, use the text for food contact or the glass and fork symbol. • **Traceability:** Record per contact part: material, supplier, batch, DoC and applicable specific measure such as 10/2011. This must be traceable throughout the chain. • **Documented quality system:** Procedures for purchasing, incoming inspection, processing, cleaning, storage and change management. Training and records are mandatory. • **Change management:** Any change in material, supplier, formulation or process requires reassessment of conformity and, if necessary, new migration testing. • **Supplier declarations:** Collect and maintain declarations of compliance for all contact materials and incorporate these into the machine dossier and spare parts management.

Legislation + status	Summary	Product design-related implications
Machinery Directive Directive 2006/42/EC In force since 29 Dec 2009 (revised); remains valid until replacement.	The Machinery Directive 2006/42/EC is an important European directive for the machinery industry that sets uniform safety requirements for machines in the European Union. It sets out essential health and safety requirements for the design and production of machinery, and contributes to a level playing field for manufacturers, importers, distributors and suppliers. Important aspects of the Machinery Directive 2006/42/EC are: • **Scope:** The directive applies to machinery, incomplete machinery, hoisting and lifting equipment, and safety components. • **Obligations:** Manufacturers must compile a technical construction file, provide instructions for use, draw up an EC declaration of conformity and affix CE marking. • **Supervision:** In the Netherlands, the Dutch Labour Inspectorate (formerly the Inspectorate SZW) is responsible for monitoring compliance with the directive. • **Replacement:** The Machinery Directive 2006/42/EC will be replaced by the new European Machinery Regulation, which will be fully applicable from 20 January 2027. The directive promotes the free movement of machinery in the internal market and ensures a high level of protection for workers and consumers in the EU	The Machinery Directive 2006/42/EC has specific implications for products that fall within its scope: • **CE marking:** Machinery, safety components, hoisting and lifting equipment, chains, cables, straps, removable mechanical transmission systems and incomplete machinery must meet the essential safety and health requirements of the Directive. Only after compliance may the CE marking be affixed, declaring that the product complies with the directive. • **Risk assessment:** Manufacturers are required to conduct and document a risk assessment to ensure that their products are safe. • **Technical file:** A technical construction file must be drawn up for each machine and kept for 10 years. This file contains, among other things, design drawings, standards used and test results. • **Operating Instructions:** Machines must be supplied with an instruction manual in the language of the end user. This manual should include clear instructions on safe use, maintenance, and installation. • **EC declaration of conformity:** Manufacturers must draw up a declaration confirming that the product complies with the Directive. For completed machines, this is a Model IIA statement. • **Free movement within the EU:** Products with CE marking can be traded freely within the European Economic Area (EEA).

Legislation + status	Summary	Product design-related implications
Ozone-depleting substances Regulation (EC) (EU) 2024/590 In force since 1 January 2010; revised on 11 March 2024.	Regulation (EC) No 1005/2009 regulates the production, trade and use of ozone-depleting substances (OAS) in the EU. Key provisions include: • Focused on eliminating chlorofluorocarbons (HCFCs) • Limiting OAS where alternatives are available • Accelerating the transition to natural refrigerants • Expansion of qualification requirements for technicians • Compliance with the Montreal Protocol Both regulations contribute to the protection of the ozone layer and the mitigation of climate change, in line with the EU Green Deal. They ensure strict regulation of harmful substances, stimulate innovation in environmentally friendly alternatives, and strengthen Europe's commitment to global environmental protection.	The Integrated Regulations 1005/2009 and 2024/590 on ozone-depleting substances (OAS) have the following important product-specific implications: • **Production ban:** Ban on the production of ozone-depleting substances, with some exceptions for essential uses • **Import restrictions:** Strict restrictions on the import of OAS, only allowed for specific purposes such as use as raw material or for laboratory applications • **Export control:** Regulation of OAS exports to limit global spread • **Prohibitions of use:** Comprehensive list of prohibited uses for OAS, with some exceptions for critical uses • **Recovery:** Obligation to recover and destroy OAS from equipment and products • **Insulation foam:** New obligation for careful processing of certain types of insulation foam from buildings to prevent gas emissions • **Reporting:** Mandatory reporting on production, import, export and use of OAS • **Licensing system:** Introduction of a licensing system for certain uses of OAS These measures are aimed at further reducing the use of ozone-depleting substances, protecting the ozone layer and reducing its environmental impact, in line with international agreements such as the Montreal Protocol

Legislation + status	Summary	Product design-related implications
Waste Electrical and Electronic Equipment (WEEE) Regulation based on Directive 2012/19/EU In force since 14 Feb 2014; extended to all electronic devices since 15 Aug 2018.	The Waste Electrical and Electronic Equipment Regulation makes producers or importers of electrical and electronic equipment (partly) responsible for the management of that product in the waste phase. At least 65% of the average weight of electrical and electronic equipment placed on the market in the Netherlands in the previous three years of waste electrical and electronic equipment (WEEE or e-waste) must be collected and treated. For companies, this is an incentive to think more carefully about how raw materials can be recovered properly after the life of a product in product design, and to minimise electronic waste.	The Waste Electrical and Electronic Equipment (WEEE) Regulation implements the European WEEE Directive in the Netherlands. This regulation makes producers, importers, distributors and processors responsible for the management of electrical and electronic equipment in the waste phase. The main product-specific implications are as follows: • **Scope of application:** Applies to most electrical and electronic devices, with some exceptions such as certain fixed installations and medical devices. • **Marking:** Appliances must be marked with a symbol indicating that they must not be disposed of with household waste. • **Distributors' obligation to take back:** When selling a new appliance, an old, equivalent appliance must be taken back free of charge. • **Retail collection obligation:** Large retail businesses must take in small WEEE free of charge without any obligation to purchase. • **Built-in batteries and accumulators:** These should be easily removable unless necessary for safety, performance, medical reasons, or data integrity. The instructions for use must include instructions for disposal. • **Registration obligation:** Producers, importers and processors must register with the National (W)EEE Register and report annually on the quantities of equipment placed on the market, collected and processed. • **Collection Targets:** Producers must meet specific collection targets, such as collecting and processing at least 65% of the average amount of equipment placed on the market annually from 2019.

Legislation + status	Summary	Product design-related implications
Registration, Evaluation and Authorisation of Chemicals (REACH) Regulation (EC) 1907/2006 In force since 1 June 2007; still in force and subject to continuous updates and revision	REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. REACH is a European Union regulation that was adopted to better protect human health and the environment from hazards posed by chemicals and to strengthen the competitiveness of the EU chemical industry. To comply with the regulation, organisations must identify and monitor the risks posed by the chemicals. As a producer or importer of chemical substances, it must be demonstrated how the substances can be used safely. In addition, a safety data sheet must be drawn up, which informs users in the supply chain about any safety measures they need to take. As a downstream user (distributor/user), risk management measures must be put in place, as specified in the safety data sheets. To do this, check whether the use of the substance is included in the registration dossier and contact your suppliers and customers in the supply chain. More information can be found on the website of the European Chemicals Agency (ECHA) or on the website of the Dutch government. The Substances of Very High Concern (SVHC) scheme coincides with the framework provided by REACH. Other relevant frameworks are the OSPAR Convention, the Water Framework Directive and the POP Regulation (Persistent Organic Pollutants Regulation). These lists have been combined by the RIVM into a SVHC list. For products using these chemicals, strategies such as substitution could be considered in order to comply with the Regulation	The REACH Regulation (EC) No. 1907/2006 contains the following product-related implications: • **Scope:** Applies to virtually all chemicals produced, imported, traded or used in the EU, with some exceptions. • **Registration requirement:** Producers and importers must register substances with the European Chemicals Agency (ECHA) if they produce or import more than 1 tonne per year. • **Safety information:** Companies must collect and share information about the properties and risks of substances, including safe use. • **Authorisation:** Substances of very high concern (SVHCs) require a specific authorisation for use or placing on the market. • **Restrictions:** REACH may impose restrictions on the production, use or import of certain harmful substances. • **Obligation to provide information:** Suppliers must provide information on SVHCs in products if the concentration exceeds 0.1% by weight. • **Duty to notify:** Producers and importers must inform ECHA about SVHCs in articles above certain thresholds. • **Safety Data Sheets:** Mandatory for hazardous substances and mixtures, with information on safe use for professional users. • **Consumer information:** Information on SVHCs in products must be provided to consumers within 45 days upon request. • **Evaluation:** ECHA and Member States assess the information provided by companies to ensure the safety of substances.

Annex B. EN 15804

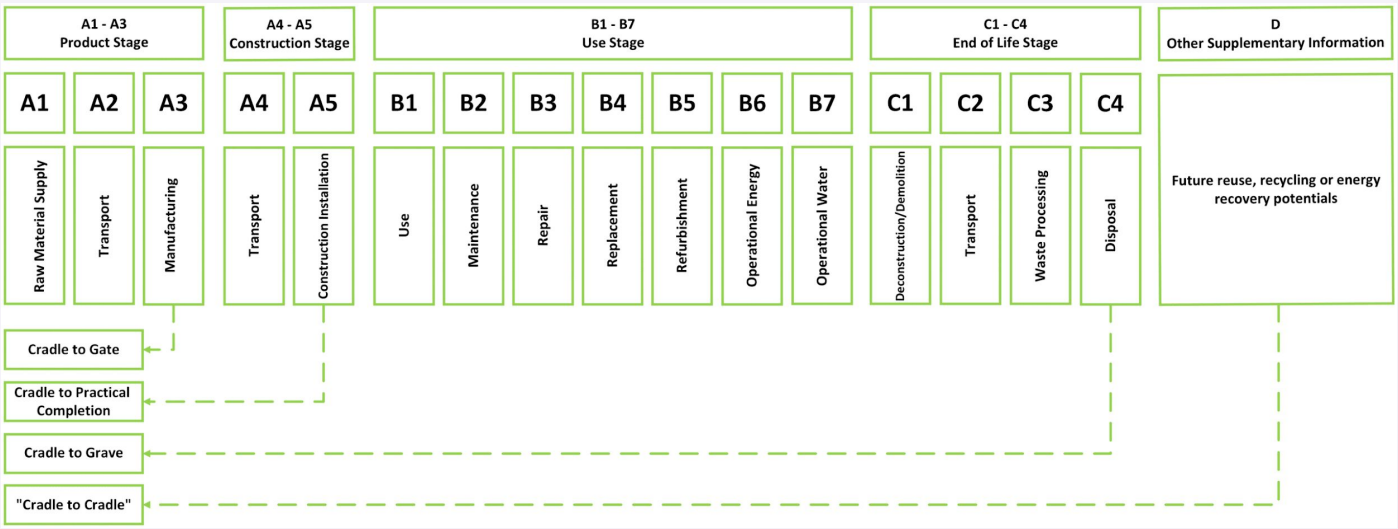

Figure B.1 System boundaries and scope of an EPD according to EN 15804

EN 15804 is the European standard that defines the core rules for preparing **Environmental Product Declarations (EPDs)** for construction products. The standard ensures that EPDs are developed in a uniform way so that data on different products are transparent, consistent, and comparable. These characteristics also make the modular structure suitable for applications in machine engineering. The standard describes, among other things, the division of the life cycle into modules and phases:

- **A1–A3 Production stage:**
  - **A1** – Extraction and production of raw materials, including energy and auxiliary materials.
  - **A2** – Transport of raw materials to the manufacturing location.
  - **A3** – Manufacturing of the product, including all internal processes and resources.
- **A4–A5 Installation stage:**
  - **A4** – Transport of the product to the construction site or place of use.
  - **A5** – Installation or assembly, including material losses and installation-related energy and water consumption.
- **B1–B7 Use fase:**
  - **B1** – Direct emissions and effects during use.
  - **B2** – Maintenance.
  - **B3** – Repair.
  - **B4** – Replacement of parts or components.
  - **B5** – Refurbishment.
  - **B6** – Energy use during operation.
  - **B7** – Water use during operation.
- **C1–C4 End-of-life stage:**
  - **C1** – Deconstruction or demolition.
  - **C2** – Transport to waste processing.
  - **C3** – Waste processing for reuse, recycling, or other recovery.
  - **C4** – Disposal (landfill or incineration without energy recovery).
- **Module D (beyond the system boundaries:**
  - Information on potential benefits and burdens outside the considered system, such as energy or material recovery that can substitute other processes.

Annex C - Calculating Residual Value per Phase

The residual value of a machine varies significantly per phase, as each level offers different recovery or reuse options. There is a general formula for calculating residual value, shown below. However, the costs involved differ for each circular strategy. For that reason, this guideline also provides a specific formula and example for each circular strategy.

Residual value is expressed in two different ways and depends on the object and the phase in which it is assessed. We distinguish between:

- **Recycling value**
- **Reuse value**

Recycling Value

The recycling value (RV) represents the value of the remaining material. It is calculated by multiplying the total weight by the current scrap value and subtracting demolition and transport costs.

Formula:

$RV=\sum(sPi\times sgi)$

Where:

- $\mathbf{sP_i}$ = scrap price of product component *i* per kg [€]
- $\mathbf{sg_i}$ = weight of product component *i* [kg]

The recycling value applies only at the material level. An object or element must be dismantled into separate components that are sorted by material type, without permanent connections, so that recycling remains possible.

Reuse Value

Reuse value refers to the financial residual value of a product or component when it is reused instead of being treated as waste or scrap. In this case, the theoretical value of the product for a second use is assessed, for example in the same or another project. Various costs are then deducted from this value, including dismantling, inspection or refurbishment, transport, and possible storage. The result is the reuse value, which is generally significantly higher than the pure recycling or scrap value, as not only the material but also the function is retained.

The reuse value is a theoretical value that depends on the intended use and the associated conditions. This value is assigned to construction products. Materials are applied once and then transformed into a construction product. This construction product is subsequently integrated into an element, object, or ultimately a unit.

The reuse value is calculated as the sum of all cost prices (value build-up), reduced by a series of correction factors (value loss).

Value build-up (AK):

1. Material purchase costs
2. Labor costs

Value loss (V):

- **KR** = quality reduction percentage of the purchase value
- **DK** = dismantling costs (hours × average hourly rate)
- **RK** = refurbishment costs (percentage of the quality reduction)
- **TK** = transport costs (average distance in km × cost per m^3 or kg/ton)
- **OK** = storage costs (average storage cost per m^2 per month × storage duration)
- **VM** = number of times the product is replaced

General formula for calculating reuse value (HW):

$HW=(AK-V-KR-DK-RK-TK-OK)\times VMHW=(AK-V-KR-DK-RK-TK-OK)\times VM$

Per circular strategy, the formula may differ depending on the specific impact of costs and contractual agreements.

Specifieke calculation per circular strategy:

Narrow the loop		
Refuse	Avoid product	No residual value (machine will not be purchased).
Reduce	Using less material	No specific formula; savings on initial material use are taken into account.

Slow the loop		
Reuse	**Reuse of the entire machine. → 90% is intact.** You reuse the machine or component without major modifications. The residual value depends on the degree of wear (ageing) and the value of directly reusable parts.	HW = (AK - KR - DK - TK - OK) * VM
Repair	**Repairing defects. RK = <30%*AK.** The machine is repaired so that it can be put back into service. The costs of C repairs reduce the residual value.	
Refurbish	**Refurbishment and overhaul. 70-80% intact. RK <50%*AK** The machine is thoroughly inspected and refurbished, possibly with the replacement of key components. Overhaul costs reduce the residual value, but some components can be reused.	
Remanufacture	**Refurbishment of components or modules. 50-80% reusable.** Parts are dismantled, repaired or replaced, and reassembled into a "new" machine or module.	
Repurpose	**Repurposing of machinery or parts. Approximately 50% retention.** Repurposing involves giving the machinery a completely new purpose with a different objective.	

Close the loop		
Recycle	**Material recovery. 40-80% of raw materials.** During recycling, the machine is broken down into raw materials (e.g. steel, copper) with a residual value based on material prices.	HW = (AK - KR - DK - TK - OK) + RW
Recover	**Recovery of energy or raw materials. 30-40% efficiency.**	HW = AK - KR - DK - TK - OK

Why Monitoring is Essential per Circular Strategy

- **Optimizing circular processes:** With the help of IoT technology and sensors, aging and maintenance costs can be continuously monitored. This makes it possible to choose reuse or refurbishment at the right moment, enabling more efficient deployment of materials and components.
- **Maximizing value:** By consciously selecting an appropriate circular strategy — for example choosing *Refurbish* instead of *Recycle* — the residual value of machines or components can be significantly increased. In this way, more value is retained within the value chain.

Make clear agreements with the supplier and jointly develop a circular plan. Together, define the criteria for the Raw Material & Product Passport so that circularity becomes measurable and transparent.

Colofon

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Guideline – Data for a Raw Material & Product Passport
Managing Value Chain Risks and Opportunities

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