UNITED NATIONS ECE/CES/2023/3
ECONOMIC COMMISSION FOR EUROPE

CONFERENCE OF EUROPEAN STATISTICIANS
Seventy-first plenary session
Geneva, 22-23 June 2023

JOINT UNECE/OECD GUIDELINES FOR MEASURING CIRCULAR ECONOMY PART A: CONCEPTUAL FRAMEWORK, STATISTICAL FRAMEWORK AND INDICATORS

D R A F T

Prepared by the Task Force on Measuring Circular Economy

This document was drafted by the Task Force on Measuring Circular Economy (chaired by Finland). The CES Bureau established the Task Force in February 2021 to draft practical guidelines for measuring circular economy, including clarification of key terms and definitions, identifying the data sources and key statistics and indicators needed from the policy point of view, and describing the required institutional collaboration.

Since the beginning the Task Force has been collaborating closely with the OECD Expert Group on a new generation of information for a Resource Efficient and Circular Economy (RECE-XG). One of the objectives of the RECE-XG is to develop a harmonised framework and indicators for monitoring progress and provide guidance on how to produce, use and communicate circular economy information. Therefore, both groups decided to join forces and to draft "Joint UNECE/OECD Guidelines for Measuring Circular Economy".

This document presents the draft conceptual framework (including a headline definition of a circular economy), a statistical framework and a proposed indicator set for monitoring progress towards a circular economy (Part A). Guidance on data sources and on using indicators, the required institutional collaboration, and more case examples (Part B) will be prepared once Part A has been endorsed by the CES.

The guidelines are the result of in-depth discussions with experts represented in the mentioned expert groups of OECD and UNECE, and take into account related activities of other international organisations and their expert groups (for example, European Environment Agency, Eurostat, ISO, UNCEEA, UNEP, etc.). However, as measuring circular economy is still an area of development, it will benefit from comments received in the planned electronic consultation as well as from comments received in the ongoing consultation of the OECD Working Party on Environmental Information and the OECD expert group.

The Bureau reviewed the draft Guidelines in February 2023 and asked the Secretariat to send it for electronic consultation to all CES members and other stakeholders before the 2023 CES plenary session. Subject to a positive outcome of the consultation, CES will be asked to endorse the document.

Please provide your comments by 6 May 2023 using the online feedback form.

Table of Contents

Acknowledgements

The main authors of this document are Johanna Pakarinen (Statistics Finland, Chair of UNECE Task Force), Arturo de la Fuente (Eurostat), Roel Delahaye (Statistics Netherlands), Therese El Gemayel (UNEP), Peder Jensen (European Environment Agency), Myriam Linster (OECD), Renato Marra Campanale (Italian Institute for Environmental Protection and Research), Michele McMillan (Statistics Canada), Milla Neubauer (Statistics Austria), Michael Nagy (UNECE) and Niels Schoenaker (Statistics Netherlands).

Furthermore, the work benefited from active contributions of the following individuals who are members of the task force or provided substantive inputs: Alessandra Alfieri (UNSD), Kees Baldé (UNITAR), Renilde Becque (World Resources Institute), Murray Cameron (Statistics Canada), Llorenc Mila I Canals (UNEP), Jessica Ying Chan (UNSD), Diego Cobaleda (National Statistical Service of Colombia DANE), Camilo Andres Mendez Coronado (DANE), Steven Dubaere (Statistics Belgium), Luis Eduardo Gonzalez Lozano (DANE), Erashree Gautam (Ministry of Environment, Forests and Climate Change of India), Sudeepta Ghosh (Ministry of Statistics & Programme Implementation of India), Michelle Hughes (Statistics Canada), Lotte Holvast (PACE), Alicja Kacprzak (UNECE/FAO), Frithjof Laubinger (OECD), Ole Gravgård Pedersen (Statistics Denmark), Achille Pegoue (International Monetary Fund IMF), Sjoerd Schenau (Statistics Netherlands), Louise Sörme (Statistics Sweden) and Vivian Tunn (Statistics Netherlands).

We also thank the experts from the following countries who contributed with case examples on measuring circular economy: Belgium, Canada, China, Colombia, Denmark, Finland, France, Japan and the Netherlands.

Acronyms

CE	Circular Economy
CES	Conference of European Statisticians
EEA	European Environment Agency
EPR	Extended producer responsibility
EU	European Union
FDES	Framework for the Development of Environment Statistics
FDI	Foreign Direct Investment
ISIC	International Standard Industrial Classification of All Economic Activities
IRP	International Resource Panel of the United Nations
ISO	International Organization for Standardization
IWRM	Integrated Water Resources Management
NSO	National Statistical Office
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
PACE	Platform for Accelerating the Circular Economy
PAYT	Pay-as-You-Throw scheme
PSR	Pressure – State - Response
R&D	Research and development
RECE-XG	OECD Expert Group on a new generation of information for a resource efficient and circular economy
SDG	Sustainable Development Goal
SEEA	System of Environmental Economic Accounting
SEEA-CF	System of Environmental Economic Accounting – Central Framework
UNECE	United Nations Economic Commission for Europe
UNECE-TF	UNECE Task Force on Measuring Circular Economy
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division

Executive Summary

Part A of the *UNECE/OECD Guidelines for Measuring Circular Economy* (CE) clarifies the headline definition, conceptual monitoring framework and statistical boundaries of a CE, proposes a set of harmonised indicators to monitor progress, and guides their measurement.

CE is defined as an economy where the value of materials in the economy is maximised and maintained for as long as possible; the input of materials and their consumption is minimised; and the generation of waste is prevented and negative environmental impacts reduced throughout the life-cycle of materials. This definition reflects the 9R-Framework and the three mechanisms for a CE aiming to closing, slowing and narrowing resource loops. The "*value of materials in the economy*" is understood to encompass the value for society as a whole, taking into account economic efficiency, environmental effectiveness and social equity.

The conceptual monitoring framework is built to ensure a balanced coverage of dimensions and features of a CE, identify key aspects relevant to resource efficiency and CE policies, and define a flexible structure and indicators. The framework implements the Bellagio principles and is composed of the following four building blocks:

Material life-cycle and value chain, which includes three themes to structure CE indicators: material basis of the economy; circularity and management efficiency of material flows & waste; and interactions with trade;

Interactions with the environment, which includes the implications of material flows on resource stocks/the natural asset base as well as the implications of materials extraction, processing, use and end life on environmental quality;

Responses and actions, which include six themes that indicators should consider to cover the variety of policy tools: Support circular use of materials, promote recycling markets and optimise design; Improve the efficiency of waste management and close leakage pathways; Boost innovation & orient technological change for more circular material lifecycles; Target setting and planning; Strengthen financial flows for a circular economy and reduced leakage; Inform, educate, and train;

Socio-economic opportunities for a just transition, which structure CE indicators around four themes: Market developments and new business models; Trade developments; Skills, awareness and behaviour; and Distributional aspects of CE policies.

The statistical framework translates the CE headline definition and conceptual framework into concepts, terms and definitions which are used in statistical frameworks including the System of Environmental-Economic Accounting (SEEA), Economy-wide Material Flow Accounts (EW-MFA), and the System of National Accounts (SNA). Specifically, 'Materials' is aligned to EW-MFA to include all relevant stages of the material life cycle; 'Natural resources' is aligned to SEEA to cover a broader perspective though ´domestic extraction` will be defined from EW-MFA; 'life-cycle of materials` includes all phases of the material cycle and the associated waste management activities and R strategies; 'Products' are goods as defined in the SNA; 'Product cycle' consists of seven phases from raw materials to recycling; 'Value of materials' is broader than economic value to environmental effectiveness and social equity; ´Minimising the input of materials and their consumption` covers both qualitative and quantitative dimension; and 'By-products' is aligned to EW-MFA.

The statistical framework also describes the interplay between and within the four building blocks of the conceptual framework at the macro, meso and micro levels to reflect the relationship between the statistical concepts and 9R-Framework. The scope of the statistical framework is broader and more detailed than the Central Framework of the SEEA (SEAA-CF). For example, it includes micro level measurements. The socio-economic pillar of sustainable development is important for the transition to a CE. For example, innovation and technology development, education, training and skills development, and consumer behaviour can all contribute to the transition. The statistical framework draws on selected economic and environmental classifications, which should be complemented with green/sustainability taxonomies such as the EU taxonomy to identify CE activities, products and processes. Improved economic classifications will benefit CE metrics if they can separately identify the contribution of primary and secondary raw materials to manufacturing of goods, and the production of energy saving or long lasting and conventional goods.

The development of physical supply and use tables is recommended for measuring CE material flows, with the following clarifications:

- Extraction of natural resources or 'domestic extraction' is consistent with EW-MFA and the treatment of energy products and water is similar under this category;
- Residuals from national economies to the environment are covered by EW-MFA indicator 'domestic processed output';
- Waste flows and flows of secondary materials are part of the material flows within the economy and flows from and to the rest of the world;
- CE Flows, which are transactions carried out by CE, should be reflected in line with the 9R-Framework.

The SEEA can already be used to measure some macro and meso aspects of the CE including drivers and production/ consumption-related macro-goals; drivers of material life-cycle and value chain block; effects of interactions with the environment block; levers of responses and actions block; and macro- and meso- goals of socio-economic opportunities.

The harmonized indicators framework is based on three key principles: policy relevance, analytical soundness, and measurability. These principles are used to pinpoint 23 core indicators, and additional complementary and contextual indicators, which are coherent with SDG indicators and Bellagio principles.

Future work to improve the Guidelines includes:

- Optimized classifications to consider CE activities and products;
- Gap filling to address indicator definitions and data quality; and
- Indicators research agenda.

1 Introduction

1. This document presents the draft conceptual framework, a statistical framework and a proposed indicator set for monitoring progress towards a circular economy (CE). It was developed in close cooperation between the informal *OECD Expert Group on a new generation of information for a resource efficient and circular economy* (RECE-XG) and the *UNECE Task Force on measuring circular economy* (UNECE-TF). The document also includes examples of measurement frameworks used by countries and other regional and national case examples on measuring the circular economy.

2. The main audience of this document are experts from National Statistical Offices and other government agencies being tasked with the measurement of circular economy. These are usually experts working in the areas of measuring sustainable use of natural resources, the implementation of the System of Environmental-Economic Accounting (SEEA) or environment statistics.

3. Another audience of this document are policy advisers and policy makers (e.g. national line ministries) involved in supporting the transition towards a circular economy and in using CE indicators.

4. The target audience benefits in particular from:

   a. The clarification of the conceptual understanding of a circular economy from the policy and monitoring points of view;

   b. A statistical framework which builds upon existing international standards and classifications, highlighting how existing statistics can be used and what needs to be further developed;

   c. A set of proposed indicators, which are internationally harmonised and support the monitoring of a transition towards a circular economy; and

   d. National and regional case examples.

5. The document is the result of in-depth discussions with experts represented in the expert groups of OECD and UNECE, and takes into account related activities of other international organisations and their expert groups (for example, EEA, Eurostat, ISO, UNCEEA, UNEP, etc.). However, as measuring circular economy is still an area of development, it will benefit from comments received in the planned electronic consultation as well as from comments received in the ongoing consultation of the OECD Working Party on Environmental Information and the OECD expert group.

6. The three main chapters of this document cover:

   I. The circular economy concept and a headline definition of a circular economy (chapter 3);

   II. The statistical framework (chapter 4); and

   III. A proposed list of indicators for measuring circular economy (chapter 5).

7. It is planned to draft “Part B: Guide on measuring progress towards a circular economy” which will provide guidance on data sources for the production of the core indicators, the required institutional collaboration, guidance on using indicators and more case examples once Part A has been endorsed by the CES.

2 Policy background

8. The type and scope of the information needed to support circular economy (CE) policies depend on **how a CE is defined** and on the **purpose** for which the information is needed (for example, policy development, policy monitoring and evaluation, awareness raising, communication, participation). They also depend on whether the information is to be used in international work or to support national policies and initiatives. With the world moving ahead to achieve the sustainability goals and targets, CE policies are relevant both at the national level as well as at the global level, especially given the fact that sustainability and environmental impacts respect no border.

9. The scope of CE objectives and policies varies across countries. Waste and materials management is usually a core element, together with energy efficiency for some countries. Water management and water use efficiency are also sometimes considered. CE policies typically cut across environmental issues and policy domains. They are also often seen as a means to address other environmental issues (e.g., climate change), improve supply security of energy and materials, and increase resource efficiency in production and consumption. Whilst environmental objectives are most prevalent, social and economic objectives are also often considered key components of a CE. CE policies can cover many different aspects of the life cycle of materials and their value chains, ranging from material extraction and product design to production and consumption processes, innovation and trade. Hence, the interlinkages, level of alignment and trade-offs between CE policies and other policies addressing these issues need to be well understood. The **Bellagio principles of circular economy monitoring** (EEA & ISPRA, 2020) provide such a framework where both material flows, environmental and socio-economic impacts as well as policy action is captured.

10. As CE policies can address a breadth of topics and mechanisms, it is important to clarify the scope of the monitoring and its statistical boundaries, and to build a consensus on a working definition for use in international work that could guide the monitoring of progress and the development of a harmonised indicators framework.

3 The circular economy concept and the headline definition of a circular economy

11. The CE concept relates to other concepts and principles, including but not limited to, resource productivity or resource efficiency [1], sustainable materials management and the so-called **R-framework** that now distinguishes 10 R strategies from the most circular to the least circular, including the 3Rs (reduce, reuse, recycle), and that can be applied to any stage of the production and consumption processes. But it goes beyond these concepts, as it pays greater attention to the circularity of the material flows and the socio-economic and environmental benefits that arise from it.

12. There is **no common definition nor terminology** for a circular economy (CE). Its meaning varies across countries and literature. It depends on the objectives pursued, and on the policies put in place. Most definitions in use **have in common the principle of circularity** and the goal of moving away from the traditional linear business models to more circular ones. A core view of a circular economy is that it can be defined relative to a traditional linear economic system, i.e. one that focuses on "closing" resource loops of current linear resource value chains. A second, slightly broader, view of a circular economy stresses the importance of "slower material flows", either within an economy with some degree of material circularity, or within an economy that is more linear through product life extension. The third, and broadest, view of a circular economy is one that involves a more efficient use of natural resources, materials and products within an existing linear system, also including reduction of their use (for example by buying services instead of products). Examples of commonly used CE definitions can be found in Annex 1: Examples of selected definitions of a circular economy.

3.1 The R-framework

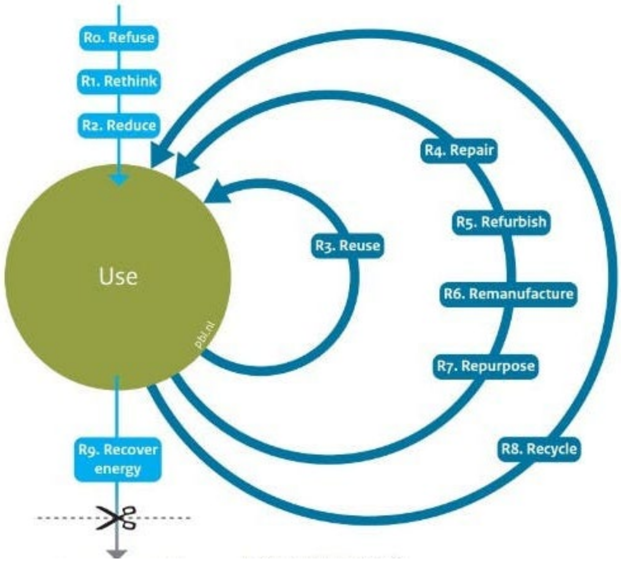
13. As time has gone on, the number of 'R's has multiplied. The Japanese Government's '3R Initiative' (reduce, reuse, recycle) dates from 2004. The European Union's waste hierarchy in its 2008 Waste Framework Directive has four Rs (reduce, reuse, recycle, recover). By 2017 nine separate Rs contributing to circularity had been identified. Today the reference is the more detailed R framework with 10 R strategies listed from the most circular to the least circular (Potting et al., 2017, p. 5).

14. Following Figure 1 presents the 10 broad strategies (**9R-Framework**), here in the form of a "Circularity Ladder". A description of these strategies can be found below.

- **Smarter product use and manufacture (R0-R2):**
  - **R0 Refuse:** Make product redundant by abandoning its function or by offering the same function with a radically different product.
  - **R1 Rethink:** Make product use more intensive (e.g., through sharing products, or by putting multi-functional products on the market).
  - **R2 Reduce:** Increase efficiency in product manufacture or use by consuming fewer natural resources and materials.

[1] Resource productivity refers to "the effectiveness with which an economy or a production process is using natural resources". In line with the *Recommendation by the OECD Council on Resource Productivity* (OECD, 2008b)) the term "resource productivity" is understood to contain both a quantitative dimension (e.g. the quantity of output produced with a given input of natural resources) and a qualitative dimension (e.g. the environmental impacts per unit of output produced with a given natural resource input).

Figure 1: A Circularity Ladder (source: Potting et al., 2018)



- **Expand lifespan of product and its parts (R3-R7):**
  - **R3 Reuse:** Reuse by another consumer of discarded product which is still in good condition and fulfils its original function.
  - **R4 Repair:** Repair and maintenance of defective product so it can be used with its original function.
  - **R5 Refurbish:** Restore an old product and bring it up to date.
  - **R6 Remanufacture:** Use parts of discarded product in a new product with the same function.
  - **R7 Repurpose:** Use discarded product or parts of it in a new product with a different function.
- **Useful application of materials (R08-R09):**
  - **R8 Recycle:** Process materials to the same (high-grade) or lower (low grade) quality.
  - **R9 Recover:** Incineration of materials with energy recovery.

3.2 Mechanisms for a circular economy

15. CE mechanisms take place at different levels, including different government levels, different firm/sector levels (different institutional sectors and different industries) and different geographical areas with overlapping boundaries. They may cover different time horizons depending on countries' policy objectives.

16. The OECD distinguishes the following mechanisms that contribute at varying degrees to a circular economy (Figure 2). These mechanisms can be related to the 9R framework (see section 3.1) and to the circular economy model and circularity strategies used in the Bellagio principles (EEA & ISPRA, 2020):

- **Closing resource loops** seeks to prevent waste from being generated by substituting virgin materials and new products by secondary raw materials (i.e. from recycled industrial or household waste) and second-hand, repaired or remanufactured products.

- **Slowing resource loops** seeks to slow down consumption and demand for primary raw (virgin) materials by extending the life of existing goods with the help of a more durable product design. This can be achieved by building long-lasting products that are easy to repair and the ownership of which can change during the course of their lifecycle.
- **Narrowing resource flows** seeks to increase resource efficiency, either by decreasing the total amount of resources used per unit of output or by making better economic use of existing capacity, and achieve a more efficient use of natural resources, materials, and products, either through the development and diffusion of new production technologies, the increased utilisation of existing assets, or shifts in consumption behaviour away from material intensive goods and services. Narrowing a resource flow does not necessarily imply circularity in the form of loops. It can also be implemented within a linear business model by producing products with less materials and thus achieving a higher or equal output with less material input.

17. A “transition to a circular economy” could therefore be seen as involving any process that might lead to lower rates of natural resource extraction and use, and to lower negative environmental impacts. A circular economy transition, to the extent that it results in lower resource extraction without an associated reduction of economic output, can result in improved resource efficiency and decoupling.

Figure 2: Mechanisms that contribute to a circular economy

Source: Adapted from: McCarthy, A., R. Dellink and R. Bibas (2018), "The Macroeconomics of the Circular Economy Transition: A Critical Review of Modelling Approaches", OECD Environment Working Papers, No. 130, OECD Publishing, Paris, https://doi.org/10.1787/af983f9a-en.

3.3 A headline working definition for use in international work

3.3.1 A hierarchy of definitions

18. For the purpose of international work on monitoring progress towards a resource efficient and circular economy (OECD, UNECE), it was agreed to define the CE in a harmonised way that, while pointing at the key features of a CE, would be general enough to serve both policy needs and measurement needs; and that could evolve into a **hierarchy of definitions**, starting with a simple high-level or headline definition.

19. **A definition for use in international work serves as a reference for work in countries**. It is not designed to become the definition that countries should use, but countries that do not yet have a definition, could adapt it to their context.

20. Such a **hierarchy of definitions** helps converge around common key features, and give sufficient flexibility to further adapt to different measurement needs and approaches, and to different levels of application (e.g. global, regional, national, sub-national, sectors, industries or firms, products).

21. It comprises a **headline definition**, which is accompanied by simple **explanatory notes** and references to the mechanisms and strategies underlying a CE, as well as details to guide statistical measurement (see chapter 4).

22. To develop the headline definition and its explanatory notes, existing CE definitions and descriptions were considered, together with advice from participants in the OECD RECE-XG and the UNECE Task Force. Particular attention was given to the working definition used by the OECD, the definitions used by European Commission and the European Environment Agency (EEA), and the suggested definition for measurement purposes by the UNECE Task Force/WP2 (see Table 1 and Annex 1 for the full selection considered).

Table 1: Main working definitions of a circular economy

***OECD** working definitions*	***European Union and EEA***	***UNECE-TF WP2 -** Jan.2022*
*A **circular economy** is an economy that seeks to:* *- Maximise the value of the materials in the economy.* *- Minimise material consumption, in particular virgin materials, hazardous substances.* *- Prevent waste from being generated and reduce hazardous components in waste and products.* ***Sustainable Materials Management** (SMM) is defined as "…an approach to promote sustainable materials use, integrating actions targeted at reducing negative environmental impacts and preserving natural capital throughout the life-cycle of materials, taking into account economic efficiency and social equity.*	**EU Action Plan for a Circular Economy** *A circular economy, maintains the value of products, materials and resources in the economy for as long as possible, and the generation of waste minimized.* **Bellagio declaration**, Circular economy monitoring principles: *A circular economy is an economy where the value of products, materials and resources is maintained in the economy for as long as possible. All outputs from one process is input for another. Thus, a move towards a circular economy entails reducing the intake of virgin materials and reducing the generation of waste.*	*A circular economy aims to minimize globally the input of natural resources and the generation of residuals by maintaining the value of goods and materials for as long as possible and by returning materials into the product cycle at the end of their use.*

3.3.2 Headline definition

23. The headline definition reads as follows:

A circular economy is an economy where:

- ***the value of materials in the economy is maximised and maintained for as long as possible;***
- ***the input of materials and their consumption is minimised; and***
- ***the generation of waste is prevented and negative environmental impacts reduced throughout the life-cycle of materials.***

Explanatory notes

- "*Materials*" are understood to include natural resources and the materials and products derived therefrom, i.e., materials at all points throughout their life-cycles.
- The "*value of materials in the economy*" is understood to encompass the value for society as a whole, taking into account economic efficiency, environmental effectiveness and social equity.
- "*Maintaining the value for as long as possible*" links to the circularity concept and to the higher-level R strategies that help close or slow material loops in the economy, such as reuse, repair or remanufacturing.
- "*Minimising the input of materials and their consumption*" is understood to contain both:
  - a *quantitative dimension*, e.g., reducing the quantity of materials extracted from natural resources (virgin materials/primary raw materials, unused extraction) and the quantity of materials used whether from domestic origin or from imports;
  - a *qualitative dimension*, e.g. reducing the use of materials that are potentially damaging to the environment or whose production and consumption processes have negative environmental impacts, and improving the productivity of materials use at all stages of their life-cycle.
    It links to the preservation, restoration and regeneration of natural assets. Improved productivity will also reduce demand pressure on natural resources more generally, and thereby contribute to more secure supplies of natural resources for everyone.

- The "*life-cycle of materials*" is understood to include all phases of the material cycle such as extraction, transportation, product design, manufacture, final consumption/use, reuse, end-of-life, recovery and final disposal, as well as the associated waste management activities and R strategies.
  By referring to the life-cycle of materials,
  (i) Waste prevention at all stages of the life-cycle is reflected and the importance of higher level Rs is highlighted.
  (i) All associated environmental impacts are reflected, including impacts on climate, on air, water and soil quality, on biodiversity, on natural assets, as well as underlying pressures in terms of emissions or discharges of pollutants, greenhouse gases, wastewater, and other residuals from production and consumption processes, including natural resource residuals (e.g. unused extraction).

24. The definition highlights **three interrelated features** of a CE, starting with a distinctive feature that refers to **maintaining the value of materials in the economy** for as long as possible, thus linking to the circularity principle, whilst ensuring a positive outcome to society. The two other features dwell upon particular aspects that link to the ultimate objective of a CE and whose monitoring is essential for the **preservation of natural capital** (natural resources, environmental quality).

3.4 The conceptual monitoring framework

25. **The main purpose of the conceptual framework is to organise thinking about indicators, to identify relevant metrics and to ensure that nothing important gets overlooked.** A framework reflects the integrated and cross-cutting nature of a CE while organising the indicators in a way useful to decision-makers and the public. A statistical framework, consistent with the System of Environmental-Economic Accounting (SEEA) where possible, will help to structure and combine underlying statistics, link CE terms and definitions to the terms and definitions used in official statistics, and ensure coherence among data sets (see chapter 4).

26. Furthermore, analysis around the conceptual monitoring framework helps identifying the needs for capacity building in developing countries and emerging economies, in particular to consolidate and strengthen their information base on waste and material flows, R-strategies and related environmental impacts.

3.4.1 Scope

27. The conceptual framework covers all dimensions of a CE and the whole lifecycle of materials, products and services. The monitoring scope is limited to "materials" in line with material flow analysis and accounting, i.e. minerals (metallic and non-metallic industrial minerals), biomass, and energy carriers (e.g. coal, oil, gas). Water resources and energy (beyond energy carriers) are only covered to the extent that they are part of an integrated approach to the entire resource cycle and the associated environmental impacts. This is in line with the definition of the *OECD Council Recommendation on Resource Productivity* (OECD, 2008). The monitoring scope encompasses monitoring in physical and in monetary terms.

28. The principles applied in drawing up the proposal for a conceptual monitoring framework were:

- A **balanced coverage** of the main dimensions of a circular economy and of their main features, aligned with the working definition.
- The identification of **key aspects** for which indicators are needed, i.e. those that are of common relevance to resource efficiency and circular economy policies in CES member countries and beyond.
- A **structure** and indicators that could be applied at different levels and geographical areas (multilevel monitoring).

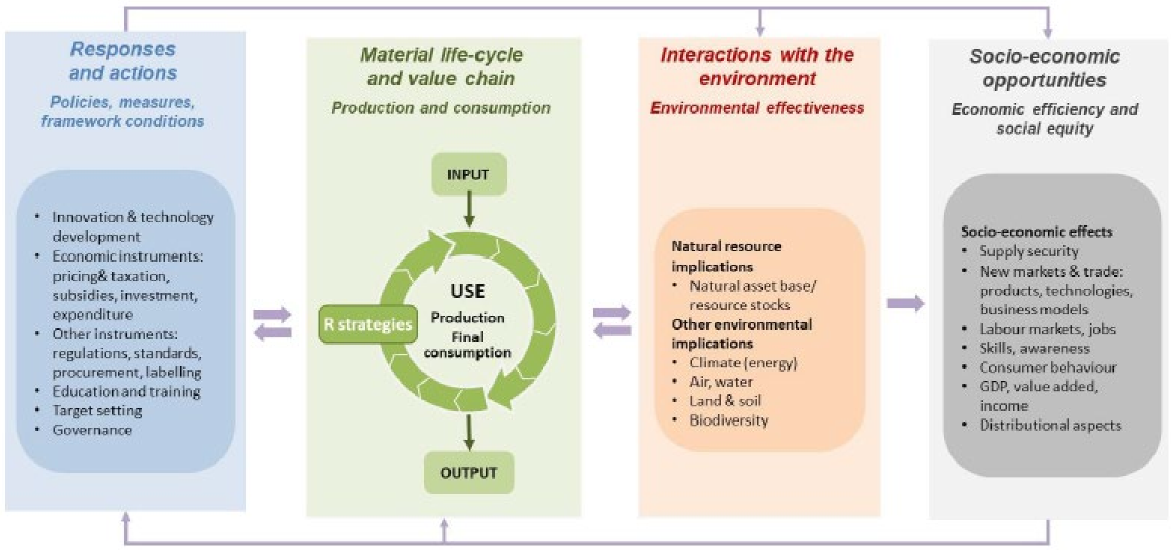
3.4.2 Structure

29. The framework combines the main features of a CE with the basic principles of accounting and the pressure-state-response (PSR) model used in environmental reporting and assessment. It has four

components centred on the material life-cycle and the economy's production and consumption functions, and describes the interactions with the environment (the natural asset base and environmental quality), policy actions and the derived socio-economic opportunities (Figure 3). It thus implements the full range of elements captured in the Bellagio principles.

30. Given the breadth of the topics that need to be covered within the four components, a further structuring has been applied by defining indicator themes and topics (Table 2)

Figure 3: Conceptual framework - building blocks



3.4.2.1 Material life-cycle and value chain

31. This component describes the various stages of the material life-cycle and value chain, from raw material inputs to solid waste generation, materials use in production and final consumption and the R strategies in place to keep the value of materials in the commercial cycle for as long as possible.

32. Related indicators show how materials enter, flow within and (eventually) leave the economy. They are related to reference values (benchmarks, thresholds, baselines, objectives, targets) and to environmental issues, including climate change, toxic contamination, biodiversity, natural resource management. They are to be complemented with information and indicators on the factors that drive demand for materials (population growth and structure, household size, economic growth and structure, income levels, final consumption expenditure) and on which policy levers can act.

33. Given the breadth of the topics to be covered, this building block is further structured around three themes:

- The **material basis and productivity of the economy**, i.e. indicators on the level and characteristics of materials supply and their use in the economy or in industries, paying particular attention to material inputs, including domestic extraction and imports, material consumption, including domestic material consumption and raw material consumption (footprints), and material accumulation in the economy (stocks, addition to stocks), as well as indicators relating material use to GDP, value-added or other socio-economic output variables through intensity or productivity ratios.
- The **management efficiency of materials and waste, and the circularity of material flows** with reference to R strategies and CE mechanisms when possible. Examples include indicators on waste generation (by source, by type); recycling rates; circular use rates; shares of secondary raw materials in material inputs or consumption; renewable content of material used in production processes, products diverted from the waste stream (repaired,

remanufactured, reused); materials leaving the economic cycle, i.e. waste going to final disposal.

- **Interactions with trade and globalisation** (international dimension of a CE), i.e. indicators on exports and imports of materials, second-hand goods, end-of-life products and waste, the physical trade balance and the material intensity of trade derived from material flow accounts and trade data.

34. Data availability permitting the selected indicators should be able to:

- distinguish between **primary and secondary raw materials**, and between **technical and biological materials**[2]. See also Box 1
- capture developments in materials that raise specific concerns as to:
    - their environmental significance, i.e. their significance with respect to natural resource management and waste and materials management issues, and to the environmental consequences of their production, use or end of life management.
    - their economic importance, i.e. their significance with respect to economic development, supply security, international trade.

  Examples include environmentally harmful materials such as plastics, components of electric and electronic equipment, heavy metals, and strategic raw materials such as certain metals and rare earths, food, energy carriers.

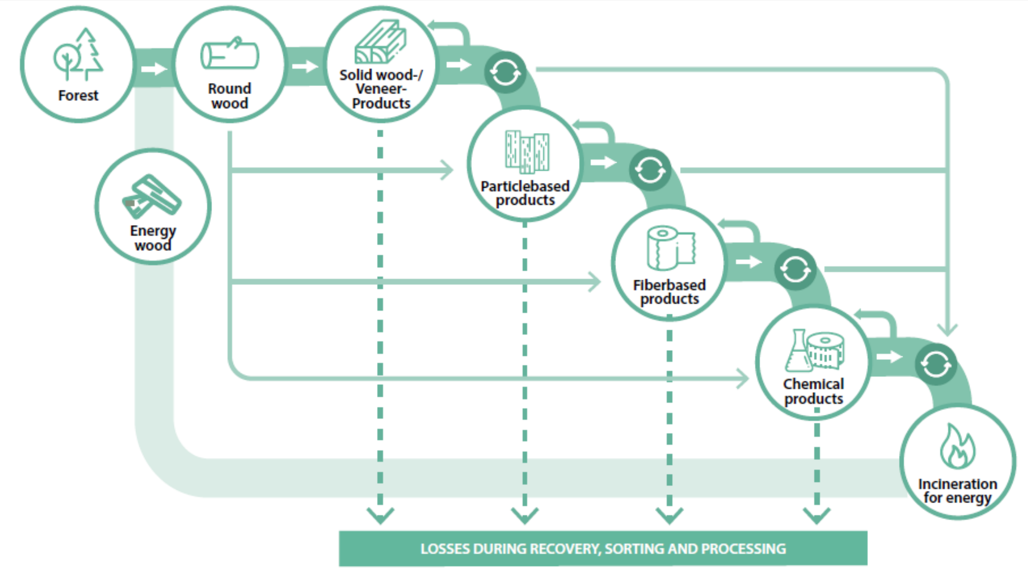
35. Relevant indicators can be derived from material flow accounts and waste statistics, complemented with new and improved indicators that capture the circularity of material flows in the economy and in production and consumption processes.

[2] Biological materials can, after use, safely flow back to the environment, where they will biodegrade. Technical materials such as metals, plastics, and synthetic chemicals, cannot flow back to the environment without negative impacts. These materials must be kept in the economic cycle and value chain as long as possible (Ellen Mc Arthur Foundation).

Box 1: Example ´cascading use` of wood (UNECE & FAO, 2021)

Not all materials can be recovered and recycled in the same way, and that measurement may need to distinguish between biological and technical materials. For example, when discussing the role of biomass (e.g. wood) in a circular economy, it is important to acknowledge that recycling it faces inherent limitations when compared to technical materials. While most metals and glass can be recovered and transformed into similar quality materials, once biomass is transformed, it usually cannot be reprocessed to form the same quality as the original. Therefore, for example wood requires an approach that maintains its structural integrity in as many applications as possible for as long as possible before it is shredded or incinerated. This approach is the **principle of cascading use**, where the use of a given piece of wood may span several reuse, recovery and/or recycling loops, with the products it is incorporated into being used for as long, as often and as efficiently as possible.

Cascading use is defined as the "*efficient utilization of resources by using residues and recycled materials for material use to extend total biomass availability within a given system*". Following this definition, cascading use applies principles of a hierarchical utilization of resources where high-quality raw material is used for high-value products with lower-value products employing degraded forms of the raw materials as they are repeatedly processed over their lifespans (see following figure).



Source: UNECE/FAO, adapted from Höglmeier *et al.*, 2015.

3.4.2.2 Interactions with the environment

36. This component describes the environmental and natural resource implications of material flows and the CE, considering the full life-cycle of materials. It is structured into two themes reflecting:

- The **physical evolution of natural assets** recognising that a declining asset base constitutes a risk to growth and well-being. Examples include: material extraction rates and changes in natural resource stocks, depletion ratios and regeneration rates (for renewable resources), freshwater abstraction for material extraction and processing, as well as natural resource residuals (unused extraction);
- The **environmental and human health impacts** due to materials extraction, processing, use and end of life management, including impacts on climate, on air, water and soil quality, on

biodiversity, and the underlying pressures. Examples include: material output flows such as greenhouse gas emissions, the carbon footprint of priority materials (e.g. plastics, food, ….), discharges of pollutants and other residuals from production and consumption processes (air emissions; pollutant discharges to water) and related effects on human health, impacts from material extraction, processing, use and end-of-life management on land, habitats and species (terrestrial and marine).

37. Relevant indicators can be derived from sets of environmental and green growth indicators, with some adjustments to be fit for CE purposes.

3.4.2.3 Responses and actions

38. This component describes policy responses (environmental, economic, sectoral, social) and other societal responses and actions to establish a resource-efficient and circular economy, including measures to change awareness and behaviour and to create new socio-economic opportunities (e.g. new markets, education and training, innovation) that help ensure a just transition.

39. Related indicators are to cover the variety of policy tools that can support a CE by setting the right framework conditions, provide incentives towards substituting away from scarce environmental resources and foster innovation, productivity and human capital. This includes economic, regulatory and information instruments and partnerships.

40. The measures to be considered are structured as follows:

- Measures to ***support or incentivise circular use of materials, promote recycling markets and optimise design***. Examples include:
  - Taxes, subsidies and regulations supporting circular business models, (e.g. sharing or product-service-system models); and instruments encouraging reuse, through second-hand markets, repair and remanufacturing.
  - Downstream policy instruments that create incentives for recycling and enhance sorting at source, such as extended producer responsibility (EPR) schemes, deposit-refund and Pay-as-You-Throw (PAYT) schemes.
  - Upstream policy instruments that help restrain demand for primary materials, make recycled materials more price competitive and incentivise design for circularity, extended lifespans, recycling & dismantling, such as recycled content targets, taxes on materials and products that raise particular concerns (e.g. plastics), circular (and green) public procurement, reforms of subsidies encouraging unsustainable use or extraction of materials, bans and guidelines on substances that restrict recycling.
- Measures to ***improve the efficiency of waste management and close leakage pathways*** such as investments in waste management infrastructure, waste collection and sorting; anti-littering instruments, including bans or taxes on frequently littered items (e.g. plastics); and instruments that enhance sorting at source, including bans or taxes on landfilling and incineration.
- Measures to ***boost innovation and orient technological change*** for more (efficient and) circular material lifecycles, enhanced recycling, and reduced leakage of residuals to the environment. Examples include: R&D budgets of governments and businesses; development and international diffusion of CE technologies (e.g. patented inventions related to recycling and secondary raw materials).
- ***Target setting and planning***, including resource productivity and recycling targets, targets on recycled content, waste reduction& prevention, landfilling; and the availability of CE plans and strategies.

- Measures to ***strengthen domestic and international financial flows*** for a circular economy and reduced leakage of residuals to the environment. Examples include: Business investments in CE activities, government budgets allocated to CE objectives; Official development assistance (ODA) and Foreign Direct Investment (FDI) dedicated to CE activities.
- Measures to ***inform, educate and train***, including product- and packaging-oriented information instruments and measures such as eco-labelling, certification schemes; integration of CE issues in school curricula and professional training.

41. It is recognised that these measures do not all lend themselves to being measured by indicators. Related indicators could also be grouped according to the type of instruments (economic, regulatory, etc.), the targeted objective as described above or in line with the CE mechanisms (closing resource loops, slowing resource loops, narrowing resource flows).

3.4.2.4 Socio-economic opportunities

42. This component describes the social and economic outcomes of a circular economy, taking into account aspects of economic efficiency and social equity that are central to a just transition.

43. Related indicators capture the development of new markets, trade and employment opportunities, supply security or autonomy, levels of education, skills development (closely linked to the capacity to innovate), and behavioural changes (households, consumers, firms). They also capture new developments, which are not visible through broader recycling and material flow indicators, such as the uptake of new circular business models and industrial ecology/symbiosis initiatives with links to entrepreneurship, and sharing economy initiatives, as well as distributional aspects of CE policies and actions, such as environmental justice.

44. The indicators are structured around four themes:

- Market developments and new business models
- Trade developments
- Skills, awareness and behaviour
- Distributional aspects of CE policies

Table 2: Overview of framework themes and indicator topics

Framework	Themes	Indicator topics - Aspects to be considered
Material life-cycle and value chain	**The material basis of the economy** *(level & characteristics of materials supply and their use in the economy)*	– Material inputs and consumption: share of renewable materials, recyclable materials – Material accumulation in the economy
	The circularity of material flows and the management efficiency of materials & waste *(with reference to R strategies and CE mechanisms)*	– Waste generation – Contribution of secondary raw materials to material inputs or consumption – Contribution of renewable materials to production processes – Products diverted from the waste stream through repair, remanufacture, reuse – Materials diverted from final disposal through recycling and recovery – Materials leaving the economic cycle
	Interactions with trade	– Material exports, imports, trade balance
Interactions with the environment	**Natural resource implications** *(physical evolution of natural assets)*	– Material extraction (used) – Natural resource residuals (unused extraction) – Changes in natural resource stocks; extraction rates, depletion ratios – Water abstracted for material extraction and processing – Intensity of use of forest resources
	Environmental quality implications *(effects of materials extraction, processing, use and end of life management on environmental conditions)*	– Impacts on climate and air quality: GHG emissions, carbon footprint of priority materials, air emissions – Impacts on water and soil quality: pollutant discharges to water from material extraction & processing; soil contamination due to material extraction & processing and end-of-life management – Impacts on biodiversity: land and habitats
	Impacts on human health	– Air pollution and water-related health impacts – Exposure to risks from waste management and production sites
Responses and actions	**Support circular use of materials, promote recycling markets and optimise design**	– Taxes, tax reliefs, transfers, regulations supporting circular business models and the use of repaired, refurbished, remanufactured goods – Reform of subsidies encouraging unsustainable use or extraction of materials – Circular Public Procurement; Green Public Procurement; Extended producer responsibility, Deposit-refund, Pay-as-You-Throw schemes – Design for extended lifespans, for recycling &dismantling – Taxes on materials/products raising particular concerns – Bans/guidelines on substances that restrict recycling
	Improve the efficiency of waste management and close leakage pathways	– Investments in waste management – Waste prevention and anti-littering instruments – Bans, taxes on frequently littered items (e.g. plastics) – Bans, taxes on landfilling, on incineration w/o energy recovery
	Boost innovation & orient technological change for more circular material lifecycles	– CE R&D budgets of governments and businesses – Development and international diffusion of CE technologies
	Target setting and planning	– Targets on: resource productivity, recycling, recycled content, waste reduction& prevention, landfilling – CE plans and strategies
	Strengthen financial flows for a circular economy and reduced leakage	– Domestic flows: Government & business expenditure on CE activities; government budgets allocated to CE objectives (link to green budgeting) – International flows: CE related Official Development Assistance (ODA); Foreign Direct Investment (FDI).
	Inform, educate, train	– Product & packaging instruments: eco-labelling, certification schemes, … – Integration of CE issues in school curricula & prof. training – Other information and communication instruments
Socio-economic opportunities for a just transition (economic efficiency and social equity)	**Market developments and new business models**	– CE entrepreneurship, goods and services; business models, start-ups, industrial ecology/symbiosis initiatives – Employment markets and jobs; Recycling markets
	Trade developments	– Trade in CE related goods and services – Supply security/autonomy/resilience
	Skills, awareness and behaviour	– CE literacy and skills – Public opinion on CE issues – Behavioural changes (households, consumers, firms)
	Inclusiveness of the transition *(distributional aspects of CE policies)*	to be defined; to reflect how different territories and population groups are affected or benefit from CE policies and actions (young people, women, vulnerable communities, etc.).

4 The statistical framework

45. This chapter discusses the scope of a circular economy from the statistical measurement point of view. It translates the headline definition (section 3.3.2) and conceptual monitoring framework (section 3.4) into concepts, terms and definitions which are used in statistics, so that existing statistics from various domains can be used or further developed for measuring circular economy from different perspectives. It advocates a statistical framework that is as much as possible aligned with the principles of Economy-wide Material Flow Accounting (EW-MFA) and the System of Environmental-Economic Accounting (SEEA) with regard to definitions, system boundaries and classifications.

46. The chapter presents:

- Key terms and definitions (section 4.1)
- The scope of the statistical measurement (section 4.2)
- The role of international statistical frameworks and classifications (section 4.3)
- Measuring flows of a circular economy (section 4.4)
- Role of the System of Environmental-Economic Accounting (SEEA) (section 4.5)

4.1 Key terms and definitions

47. This section describes the terms and definitions that apply to a circular economy, starting with the headline definition and its explanatory notes, and translates them into statistical terms.

48. The headline definition of a circular economy (section 3.3.2) is as follows:

A circular economy is an economy where:
- *the value of materials in the economy is maximised and maintained for as long as possible;*
- *the input of materials and their consumption is minimised; and*
- *the generation of waste is prevented and negative environmental impacts reduced throughout the life-cycle of materials.*

49. This headline definition is policy-oriented and leaves some room for interpretation of what should be included from the statistical perspective. For example, it is unclear whether flows of water or energy are within the measurement scope of what is called 'materials` and to what extent these flows should be covered.

50. The nomenclature used in statistics is much older than the concept of the circular economy. It is therefore important to interpret it with this new concept in mind, to agree on common principles and build consensus on a common language. Doing so will reduce terminological ambiguities (due to different expert communities using different definitions for similar terms) and help produce information that is more comparable.

51. Two groups of terms are discussed. They can also be found in the glossary, together with other related terms:

1. Terms used to define a circular economy (headline definition and its explanatory notes)
2. Additional terms used in material flow analysis and accounting

52. For each group of terms, pragmatic definitions that can be used for measuring the circular economy and for specifying the headline definition are proposed. Terms and definitions already used in the SNA, the SEEA, the FDES and the CES Waste Statistics Framework, and used by Eurostat, ISO, OECD, PACE, UNECE and UNEP are considered. Some of the terms discussed are semantically linked (e.g., hierarchically related, or mutually exclusive).

4.1.1 Key-terms used in the headline definition of a circular economy

4.1.1.1 ´Materials`

53. The CE headline definition uses the term ´materials` in a broad sense. It understands ´materials` to include natural resources, and the materials and products derived therefrom, i.e. materials at all points throughout their life-cycles. This definition includes three different (partially overlapping, non-mutually exclusive) categories:

- Natural resources (see section 4.1.1.1.1)
- Materials within a life-cycle, including waste (see section 4.1.1.1.2)
- Products within a product-cycle, including end-of-life products (see section 4.1.1.1.3)

54. These three terms can also be found in some circular economy definitions. See for example definitions in Annex 1: Examples of selected definitions of a circular economy.

55. In the SEEA-CF (para. 3.224) flows of ´materials` (i.e. physical flows) encompass flows of natural inputs (except energy and water), products and residuals, where ´products` are understood to be ´goods` as defined in the SNA (see below). The SEEA-CF doesn't define the term ´material`. Flows of materials are – along with flows of energy and water – a subsystem of physical flow accounting. The SEEA definition of physical flows (SEEA-CF, para. 3.20), i.e. natural inputs, products and residuals, is comparable to what these guidelines intend for the term ´material`.

56. In the context of EW-MFA, the functioning of a national economy, which is based and dependent on external exchanges of materials and energy, is compared with the metabolism of an organism. EW-MFA describe the material throughput of an economy, both at the input side as well as at the output side. They are physical flow accounts and record the movement of materials measured in physical mass (e.g., tonnes). The *Eurostat-Handbook of EW-MFA* (Eurostat, 2018) specifies that "***materials are physical bodies that have mass and volume***"*.*

57. In the *OECD guide on measuring material flows and resource productivity* (OECD, 2008a) the term ´materials` is used in a very broad sense so as to record all material-related flows at all relevant stages of the material cycle. It designates materials from renewable and non-renewable natural resource stocks that are used as material inputs into human activities and the products that embody them, as well as the residuals arising from their extraction, production and use (such as waste or pollutant emissions to air, land, water) and the ecosystem inputs required for their extraction, production and use (such as nutrients, carbon dioxide required by plants and animals for growth and the oxygen necessary for combustion).

58. **For the purpose of measuring the circular economy, it is recommended to use the EW-MFA definition of materials with the understanding that it includes materials at all relevant stages of the material life cycle**.

59. Materials are usually analysed by type and often grouped by category (e.g. biomass, metal ores, non-metallic minerals, fossil energy carriers). They can be analysed by specific groups or sub-groups of materials (e.g. flows of solid waste, carbon emissions) or for individual materials or substances (e.g. certain metals or hazardous substances).

60. Materials can be qualified with respect to the status of their natural stocks, the stage of their life-cycle or their processing, or their importance for the economy or the environment. The following terms have been defined in various other frameworks (such as Ellen MacArthur, CES Waste Statistics Framework, SEEA-CF, international conventions, etc.):

- **Renewable materials:** Materials whose stocks are continually replenished at a rate equal to or greater than the rate of depletion. Examples include: cotton, hemp, maize, wood, wool, leather, agricultural by-products, nitrogen, carbon dioxide, and sea salt. To fit in a circular economy such materials (where relevant) must be produced using regenerative production practices. (Ellen MacArthur Foundation, 2021)

- **Non-renewable or finite materials:** Materials whose stocks are non-renewable on timescales relevant to the economy, i.e. not geological timescales. Examples include: Metals and minerals; fossil forms of carbon such as oil, coal, and natural gas; and sand, rocks, and stones. (Ellen MacArthur Foundation, 2021)
- **Non-virgin materials**: Materials that have been previously used. This includes: Materials in products that have been reused, refurbished or repaired; components that have been remanufactured; materials that have been recycled. Also referred to as **secondary materials**. (Ellen MacArthur Foundation, 2021)
- **Virgin materials:** Materials that have not yet been used in the economy. These include both finite materials (e.g. iron ore mined from the ground) and renewable materials (e.g. newly produced cotton). (Ellen MacArthur Foundation, 2021). A synonym for virgin materials is "**primary raw materials**" (in contrast so "secondary raw materials", see below).
- **Waste (materials):** Any material which the holder discards or intends or is required to discard. (UNECE, 2021)**.**
- **Secondary raw materials:**
  - Based on the legislation on the extractive industry (published in the *Extractive Waste Directive (2006/21/EC)* and the legal definitions of waste and waste management hierarchy regulated by the *Waste Framework Directive (2008/98/EC)*, secondary raw materials can be defined as materials and products which can be used as raw materials by simple re-use, or via recycling and recovery. (European Commission 2022)
  - Recycled materials/substances that meet end-of-waste criteria as defined in the *Directive 2008/98/E on Waste* (European Commission, 2020)
- **Secondary materials:**
  - A secondary material has already been used and recycled (= recycled material). It refers to the amount of the outflow which can be recovered to be re-used or refined to re-enter the production stream. One aim of dematerialization is to increase the amount of secondary material used in production and consumption to create a more circular economy. (IRP, 2022)
  - Secondary material also referred to as recycled material, refers to any material that has been used at least once before, is not the primary product of a manufacturing or commercial process, and can include post-consumer material, post-industrial material, and scrap. (IRP, 2018)
- **Critical raw materials:** Those raw materials that are most important economically and have a high supply risk are called critical raw materials. (European Commission 2020a)

4.1.1.1.1 ´Natural resources`

61. Both the System of National Accounts (SNA) and the System of Environmental-Economic Accounting (SEEA) include definitions for natural resources. Although these definitions are quite similar, they differ as regards the asset boundary. The SEEA uses an extended asset boundary, meaning that (physical) assets must not necessarily have an economic value as defined in the SNA. One example is the way land and soil resources are considered.

SNA: "*Natural resources consist of naturally occurring resources such as land, water resources, uncultivated forests and deposits of minerals that have an economic value.*"

> **SEEA:** "*Natural resources include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources.*"

62. For the purposes of measuring a circular economy, **the definition of the SEEA is recommended**, since it has a broader perspective. It is also to be noted that the SNA is currently being updated with greater attention being paid to environmental aspects.

63. In the SEEA Central Framework, different types of natural resources are specified as follows:

- **Natural biological resources** consist of animals, birds, fish and plants that yield both once-only and repeat products for which natural growth and/or regeneration is not under the direct control, responsibility and management of institutional units.
  - **Timber resources** are defined, within the relevant areas, by the volume of trees, living or dead, and include all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground that can still be used for timber or fuel.
  - **Aquatic resources** comprise fish, crustaceans, molluscs, shellfish, aquatic mammals and other aquatic organisms that are considered to live within the boundaries of the exclusive economic zone (EEZ) of a country throughout their life cycles, including both coastal and inland fisheries. Migrating and straddling fish stocks are considered to belong to a given country during the period when those stocks inhabit its EEZ.
- **Mineral and energy resources** comprise known deposits of oil resources, natural gas resources, coal and peat resources, non-metallic minerals and metallic minerals.
- **Soil resources** comprise the top layers (horizons) of soil that form a biological system.
- **Water resources** consist of fresh and brackish water in inland water bodies, including groundwater and soil water.

64. It needs to be noted, that the SEEA-definition of natural resources excludes cultivated biological resources, which is slightly different from the approach in EW-MFA. However, **using the ´domestic extraction` as defined in EW-MFA for quantifying the input of materials from natural resources is recommended** in the context of measuring the circular economy. This is discussed in more detail in section 4.4.1.

4.1.1.1.2 'Materials within a life-cycle`

65. The ´life-cycle of materials` is understood to include all phases of the material cycle such as extraction, transportation, product design, manufacture, final consumption/use, reuse, end-of-life, recovery and final disposal, as well as the associated waste management activities and R strategies.

66. By referring to the life-cycle of materials,

- Waste prevention at all stages of the life-cycle is reflected and the importance of higher level Rs is highlighted.
- All associated environmental impacts are reflected, including impacts on climate, on air, water and soil quality, on biodiversity, on natural assets, as well as underlying pressures in terms of emissions or discharges of pollutants, greenhouse gases, wastewater, and other residuals from production and consumption processes, including natural resource residuals (e.g. unused extraction).

67. Waste minimisation and waste prevention entail a quantitative and a qualitative dimension. They encompass activities that reduce both the quantity and the hazardous character of wastes. The scope of waste minimisation is broader than that of waste prevention in that it includes recycling and (if considered appropriate) incineration with energy recovery.

68. **Waste minimisation** is understood to mean: "*preventing and/or reducing the generation of waste at the source; improving the quality of waste generated, such as reducing the hazard, and encouraging re-use, recycling, and recovery.*" (OECD Definition)

69. **Waste prevention** are all measures taken before a substance, material or product has become waste, that reduce (a) the quantity of waste, including through the re-use of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products. (UNECE, 2021). It is understood to encompass (a) Strict avoidance, (b) Reduction at source and (c) Product re-use. It occurs before products/materials are identified or recognised as waste.

a) **Strict avoidance** involves the complete prevention of waste generation by virtual elimination of hazardous substances or by reducing material or energy intensity in production, consumption, and distribution.

b) **Reduction at source** involves minimising use of toxic or harmful substances and/or minimising material or energy consumption.

70. As discussed in section 4.1.4 the term ´waste prevention` from the environmental impacts point of view should be understood as prevention of any kind of residuals, also including emissions to air and to water.

4.1.1.1.3 ´Products` and the ´product cycle`

71. Most CE definitions use the term ´products` to designate a physical item, which has a value. In the SNA products are both goods and services that are the result of production. They are exchanged and used for various purposes: as inputs in the production of other goods and services, as final consumption or for investment.

72. According to the SNA:

- "**G*oods*** *are physical objects for which a demand exists, over which ownership rights can be established and whose* ownership *can be transferred from one institutional unit to another by engaging in transactions on markets; they are in demand because they may be used to satisfy the needs or wants of households or the community or used to produce other goods or services*.
- ***Services*** *are the result of a production activity that changes the condition of the consuming units, or facilitates the exchange of products or financial assets*." (See SNA 6.17).

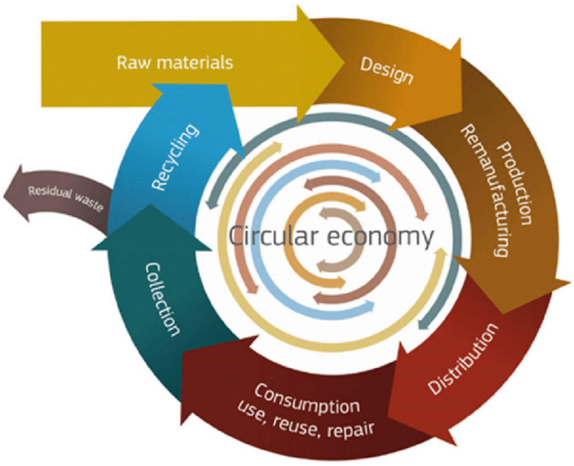
73. Key in the context of a circular economy is that the term **´goods` refers to physical objects**, which at the end of their lifecycle may become waste or result in releases of other residuals (air emissions, chemical substances, wastewater) to the environment. The term "product" as used in the annotations of the headline definition is thus understood to refer to physical goods.

74. In contrast to goods, **´services` are understood as outputs which are non-physical**, even if they require the presence of certain goods. Services therefore cannot be circular from a material point of view. However, services can serve as means to facilitate the circulation of material goods or to substitute them (for example, using the services of car sharing companies or public transportation can substitute for buying a car).

75. There are cases where a ´good` is classified as ´waste` at the same time. This is the case when the holder of the good (which is made of materials) discards or intends to discard it (definition of ´waste`), but the good (or material in the good) actually has value to someone else. The original holder may or may not receive a payment in exchange (definition of a ´product`). In SEEA-CF this is called ´waste products`. This includes items that are considered as waste by the original holder but have their original full or partial value ("One man's trash is another man's treasure"). See also section 4.1.5.2 which discusses this issue in detail.

76. A **product cycle** in a circular economy consists of the following life cycle phases: 1) (intake of) raw materials, 2) design, 3) production, manufacturing, 4) distribution, 5) consumption, use, reuse, repair, 6) collection and 7) recycling. Residual wastes leaving the cycle are wastes for final disposal. See Figure 4.

Figure 4: Life cycle phases in a circular economy as illustrated in a simplified way. (Source: EU Directorate General for Environment (https://www.oecd.org/env/outreach/EC-Circular-econonomy.pdf))



77. In its own CE concept, the Ellen MacArthur Foundation (2021) uses the term ´value circle` instead of ´product cycle` and divides the circular economy into biological and technical cycles. The biological cycle is a natural cycle, whereas the technical cycle represents the manufacturing side, where the materials are processed:

- ***Biological cycle**: The processes – such as composting and anaerobic digestion – that together help to regenerate natural capital. The only materials suitable for these processes are those that can be safely returned to the biosphere.*
- ***Technical cycle**: The processes that products and materials flow through in order to maintain their highest possible value at all times. Materials suitable for these processes are those that are not consumed during use – such as metals, plastics and wood. In the technical cycle the opportunities to maintain and generate value come through retaining the greatest proportion of the energy and labour embedded in the product. This is achieved, in order of value, by: maintaining, prolonging, sharing; reusing and redistributing; refurbishing and remanufacturing; and recycling.*

78. The term ´**end of use**` is often used for the end of the lifecycle phase "consumption, use, reuse, repair". At this stage, a product or material is not used for its original purpose anymore. End of use is a crucial phase of product cycle, since the management activities related to it determine if the cycle will be closed or not. Through the activities at the end of use phase, components or products can be remanufactured, materials can be recycled or their residual value recovered.

4.1.2 ´Value of materials`

79. The headline definition of a CE states that "*the value of materials in the economy is maximised and maintained for as long as possible*", with the ´value of materials` being understood to encompass the value for society as a whole, taking into account economic efficiency, environmental effectiveness and social equity.

80. The phrase "*maintaining the value for as long as possible*" links to the circularity concept and to the higher-level R-strategies (see section 3.1) that help close or slow material loops in the economy, such as reuse, repair or remanufacturing.

81. As discussed above the ´value of materials` can be specified as ´value of materials and goods` (everything of matter) from the statistical point of view. The terms ´goods` and ´materials` are not mutually exclusive. It is a major objective of a circular economy to maintain the value of any given good as long as possible by extending its life cycle. However, in addition, all other materials (e.g. from end-of-life goods or objects without a market value) should be kept for as long as possible in the economy resulting in less intake of natural resources and in less generation of residuals.

82. **Even if it is mainly the economic value which is usually measured, ´value` in the context of a circular economy has a broader meaning**, thus leading to an indicator set and underlying statistics that cover all pillars of sustainability.

83. Examples of different types of values covered are revenues, savings, productivity, sustainability, satisfaction, empowerment, engagement, experience and trust.

4.1.3 ´Minimising the input of materials and their consumption`

84. The phrase "*minimising the input of materials and their consumption*" of the CE headline definition is understood to contain both:

a) a **quantitative dimension**, e.g. reducing the quantity of materials extracted from natural resources (virgin materials/primary raw materials, unused extraction) and the quantity of materials used whether from domestic origin or from imports;

b) a **qualitative dimension**, e.g. reducing the use of materials that are potentially damaging to the environment or whose production and consumption processes have negative environmental impacts, and improving the productivity of materials use at all stages of their life-cycle.

85. It links to the preservation, restoration and regeneration of natural assets. Improved productivity will also reduce demand pressure on natural resources more generally, and thereby contribute to more secure supplies of natural resources for everyone.

86. In statistics the term ´extraction of virgin materials` does not exist. **The 'input of materials' is understood as 'extraction of materials from natural resources' from the statistical point of view.**

4.1.4 ´The generation of waste is prevented and negative environmental impacts reduced throughout the life-cycle of materials`

87. As explained earlier, the ´life-cycle of materials` is understood to include all phases of the material cycle such as extraction, transportation, product design, manufacture, final consumption/use, reuse, end-of-life, recovery and final disposal, as well as the associated waste management activities and R strategies.

88. The annotations of the headline definition specify that "*by referring to the life-cycle of materials,*

a) Waste prevention at all stages of the life-cycle is reflected and the importance of higher level Rs is highlighted.

b) *All associated environmental impacts are reflected, including impacts on climate, on air, water and soil quality, on biodiversity, on natural assets, as well as underlying pressures in terms of emissions or discharges of pollutants, greenhouse gases, wastewater, and other residuals from production and consumption processes, including natural resource residuals (e.g. unused extraction).*"

89. Many definitions of a circular economy refer to the "*minimization of generation of waste*" (or like the headline definition "*generation of waste is prevented*") as one of the main objectives of a circular

economy. However, since the CE aims to "*maximise the value of materials in the economy*" this already implies the minimization of waste generation. **What needs to be measured in addition is the loss of materials in the economy and the potential impact on the environment by generation of waste for final disposal as well as releases of other residuals to the environment.**

90. From the statistical point of view therefore the phrase "*generation of waste is prevented and negative environmental impacts reduced*" can be understood to include all types of residuals.

91. According to SEEA-CF, residuals are flows of solid, liquid and gaseous materials, and energy that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation. Groups of residuals are **solid waste**, **wastewater**, **emissions** (to air, water, to soil), **dissipative uses** of products, **dissipative losses** and **natural resource residuals**.

92. Generation of residuals occurs in both production and consumption activities. Residuals may be returned to the economy, e.g. as secondary raw materials, re-used wastewater, etc. Residuals may also be for final disposal (e.g. waste on a managed landfill or CO_2 disposed in carbon capture and storage systems) or may be released to the environment which usually results in negative effects on environmental quality and health.

93. According to the *CES Waste Statistics Framework* (UNECE, 2021), "*waste is any material which the holder discards or intends to or is required to discard"*. However, this actually refers to materials from the holder's point of view. Therefore, material that is considered to be waste for the holder could be at the same time be a good (with a market value) for the receiver of that material. This is discussed in section 4.1.5.2.

94. In some CE definitions the term ´residual waste` is used. For the purpose of measuring CE this is understood as a synonym for the term ´waste for final disposal`.

4.1.5 Important additional terms for describing the material point of view

4.1.5.1 "By-products"

95. By-products are defined slightly differently in SNA and the EU Waste Framework Directive (European Commission, 2008). See Table 3.

Table 3: By-product definitions

Source	**Operational definition**	**Comments**
System of National Accounts (SNA)	Product that is produced simultaneously with another product but which can be regarded as secondary to that product, for example gas produced by blast furnaces (§ 28.46).	• Includes both goods and services • Has a market value
Waste Framework Directive 2008/98/EC	A substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as being a by-product only if further use of the substance or object is certain and the substance or object can be used directly without any further processing other than normal industrial practice and the substance or object is produced as an integral part of a production process and further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.	• Refers to substances and objects, but not services • For practical purposes of measuring CE "Substance or object" could be understood as 'materials and goods` • Falls into the SEEA-CF category 'solid waste product`

96. The definition used in the EU Waste Framework Directive (WFD) differs from the broader one used in SNA in two main ways:

1. It uses the terminology “substances and objects” instead of the SNA term “goods”: and
2. It excludes services.

97. **For the purpose of measuring the circular economy it is recommended to use the EU WFD definition**.

4.1.5.2 Some thoughts about ´waste` versus ´product`

98. Depending on the underlying framework the terms ´waste` and ´product` may or may not be mutually exclusive. It also needs to be noted that in this discussion the term product actually refers to the SNA term ´good` which is a physical object with a market value, whereas the SNA term ‘product` also includes services.

99. In the context of waste management ‘product status` is usually used as the opposite of ‘waste status`. However, the definition of waste is based on the desire or act of discarding of any material, rather than on its value.

100. For example, in the *Communication from the Commission to the Council and the European Parliament on the Interpretative Communication on Waste and By-products* (European Commission, 2007), which deals with the distinction between waste and non-waste in a production process context, the term product and related terms are used in the following sense:

- Product: All material that is deliberately created in a production process. In many cases it is possible to identify one (or more) “primary” products, which is the principal material produced.
- Production residue: A material that is not deliberately produced in a production process but may or may not be a waste.
- By-product: A production residue that is not a waste (see section 4.1.5.1).

101. **End-of-waste** criteria, laid down in Article 6 of the Waste Framework Directive, specify when certain waste ceases to be waste and becomes a product, or a secondary raw material (see para. 104).

102. SEEA-CF (para. 3-269) distinguishes between

a) Flows of **solid waste residuals**: Where the unit discarding the materials receives no payment for the materials; and

b) Flows of **solid waste products**: Where the unit discarding the materials receives a payment but the actual residual value of the material is small—for example, in the case of scrap metal sold to a recycling firm.

103. Thus, in the SEEA-CF the terms waste and product are not mutually exclusive. The reason why the SEEA makes this distinction is that it enables a link between physical waste flows and monetary data on payments received or provided when discarding waste. Applying SEEA-CF as the underlying measurement framework for a circular economy means that a distinction needs to be made between “waste residuals” (which usually are treated in recovery and disposal operations against payment) and “waste products”, which have a market value and are usually reused, recycled or used for energy recovery. Because waste products have value, they can be returned to the economy.

104. According to the Report *Secondary Raw Materials and Waste Accounting* (Eurostat, 2021) the SEEA-CF term ´solid waste products` is a subset of ´secondary raw materials` (usually after some processing). The latter term comprises both ‘solid waste products` and ‘by-products`, i.e. excess materials from production processes which are usually not covered by waste statistics.

4.1.5.3 ´Waste management` and related terms

105. In a circular economy, waste is first and foremost to be prevented but when waste generation is unavoidable, waste management activities play a crucial role – these activities enable waste materials to be returned to the products cycle after the use and consumption phase of products.

106. **Waste management** can be defined as a "*Set of lawful activities carried out by economic units of the formal sector, both public and private for the purpose of the collection, transportation and treatment of waste, including final disposal and after-care of disposal sites*." (UNECE, 2021)

107. Although controlled and legal waste management activities obviously are the preferable option, **waste-handling carried out by informal economic units (e.g. informal waste picking) or illegal waste-handling may provide an important contribution towards circularity** in some countries. Integrating these existing recycling systems into the formal waste management sector may often be a recommendable strategy when developing a circular economy.

108. The waste hierarchy is a conceptual framework designed to rank waste management options from most to least environmentally preferred. It has become a guiding principle for the further development of waste management both EU-wide and globally.

109. In the European Union, the *Waste Framework Directive* (European Commission, 2008) establishes a five-step **waste hierarchy** "*as a priority order in waste prevention and management legislation and policy*". In this hierarchy, waste prevention is the most preferred option, followed by re-use (of waste), recycling and other forms of material and energy recovery. Waste disposal is seen as the last option, which should be avoided as far as possible.

110. **Circular economy and the waste hierarchy are highly related concepts**, which share the same principles aiming reduce to waste generation and environmental impacts as well as improving resource efficiency. The waste hierarchy can be seen as a guide map for circular economy which is also related to the cascading discussed in Box 1. However, circular economy has a wider perspective, with a strong additional emphasis on the minimisation of the intake of natural resources.

111. Although waste prevention is an important factor in waste management strategies and it is also mentioned as the most preferred option in the waste hierarchy, it is excluded from the definition of "waste management".

112. **Waste prevention** takes place before a substance, material or product has become waste. Following the definition of the European Waste Framework Directive, waste prevention refers to measures that reduce a) the quantity of waste, b) adverse impacts of the generated waste on the environment and human health or c) the content of harmful substances in materials and products. It can be achieved through more intelligent use and design of products (refuse, rethink, reduce) or through the extension of the life span of products and parts (re-use, repair, refurbish, remanufacture or repurpose). See also R-strategies in section 3.1.

113. Conference of European Statisticians Framework on Waste Statistics (UNECE, 2021) furthermore defines different **waste management activities**:

- **Waste collection:** Waste collection means the gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport
- **Exports and imports of waste** (transboundary movements): Movements of waste from a country to or through another country (the "rest of the world" in SNA terms). Waste can be exported or imported before or after treatment at their place of origin; they can be exported or imported for further treatment, for recovery or for disposal.
- **Sorting operations:** Sorting operations can take place at any stage of the waste management process, e.g. sorting by households for separate collection of their waste; sorting of recoverable materials before recycling, sorting of bulky waste collected before refurbishing.

- **Pre-treatment and preparatory activities**: Physical, thermal, chemical or biological processes applied prior to any recovery or disposal operation, and that change the characteristics of the waste to reduce its volume or hazardous nature, enhance recovery, and facilitate its handling or further treatment or disposal. It may also include temporary storage.
- **Recovery operations**: Any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy.
- **Waste disposal**: Any operation which main purpose is not the recovery of materials or energy even if the operation has as a secondary consequence the reclamation of substances or energy It includes incineration without energy recovery, deposit into or onto land (e.g. landfilling), deep injection, surface impoundment, release into water bodies and permanent storage.

4.2 The scope of the statistical measurement

114. The scope of statistics for measuring the CE depends on the purpose for which the data are to be used, their level of application, the scope of the CE policies in place, the stage of transition a country is in, and the perspective taken. Hence alternative measurement boundaries are relevant for different uses and users (policy makers, businesses, citizens, statisticians, researchers, academia). It is to be noted that determining what counts in a CE determines who and what actions are viewed as contributing to a CE.

115. The measurement scope should be conceptually embodied in the conceptual framework (section 3.4), be aligned with the headline definition of a CE (see section 3.3), and draw on international statistical frameworks, standards and classifications so as to guide countries in developing CE statistics in an internationally comparable way. It should further be delimited in a way that enables the calculation of major CE indicators (see section 5 on proposed indicators).

116. This section describes what should ideally be measured considering the various dimensions of the CE.

4.2.1 Measurement dimensions and levels of application

117. The statistical measurement needs to take into account the economic, environmental and social dimensions of a CE and its levels of application, including the macro, meso and micro levels (Figure 5), as well as the way materials flow through the economy, and between the economy and the environment (Figure 7). It is furthermore important that the statistics produced for different dimensions and levels complement each other and are coherent with each other. Figure 5 illustrates how the different analytical levels are interrelated.

4.2.1.1 The macro, meso and micro levels

118. The circular economy operates at different inter-related levels:

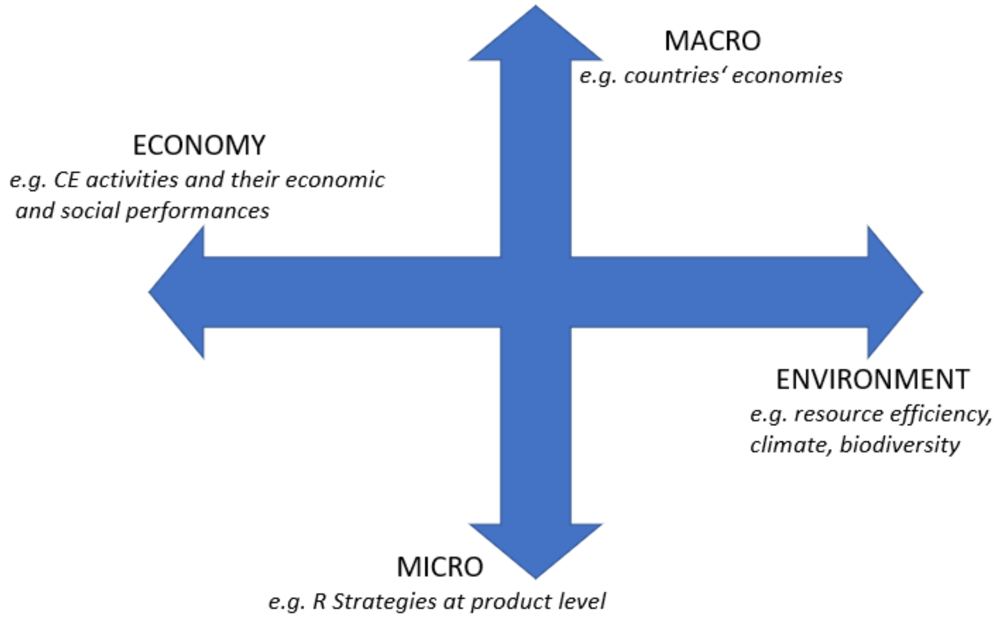
a) The **micro level**, for example products, companies, consumers;

b) The **meso level**, for example economic activity sectors, industries, cities, sub-national governments. This level also includes eco-industrial parks, networks and clusters;

c) The **macro level**, i.e. national or supranational economies.

The statistical framework needs to lend itself to being applied to all these levels.

Figure 5: Different perspectives of a circular economy (source: UNECE Task Force)



4.2.1.2 The social, economic and environmental dimensions

119. The three pillars of sustainable development (social, economic and environmental) are explicitly covered by the main building blocks of the conceptual framework (see section 3.4.2) and should be reflected in the statistical framework:

a) Material life-cycle and value chain (production and consumption)

b) Interactions with the environment (environmental effectiveness)

c) Responses and actions (policies, measures, framework conditions)

d) Socio-economic opportunities (economic efficiency and social equity).

4.2.2 Foundation and scope of the statistical framework

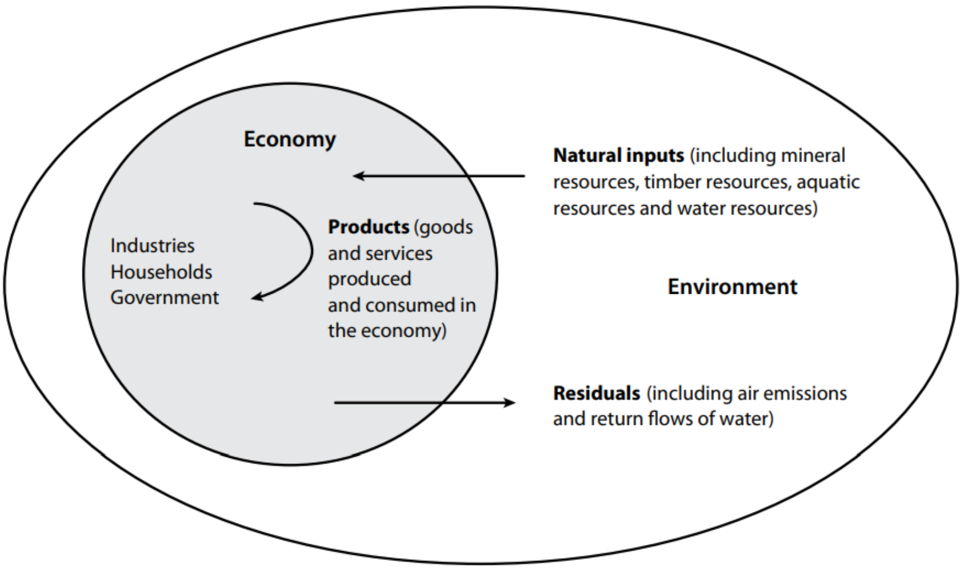
120. The **statistical framework is grounded in the Central Framework of the System of Environmental-Economic Accounting (SEEA-CF)**, which sees the economy as being inside the environment and measures flows as presented in Figure 6:

a) Flows from the environment to the economy;

b) Flows within the economy or between economies; and

c) Flows from the economy to the environment.

Figure 6: The conceptual foundation of the statistical framework: the SEEA-CF (Source: SEEA-CF, Figure 2.1)



121. **In addition to the SEEA-CF the presented statistical framework builds on the headline definition of a circular economy and the conceptual framework** (chapter 3). It further embeds the three main levels of application (micro, meso and macro), so as to ensure a coherent measurement across all CE dimensions and levels.

122. Its scope is thus broader and more detailed than the one of the SEEA-CF:

a) The SEEA-CF is designed for analysis at the macro- and meso-levels; the measurement of the CE also considers the micro level.

b) The SEEA-CF is designed to measure the interactions between the environment and the economy and to produce statistics that can easily be combined and inter-related. However, it does not fully cover aspects related to socio-economic opportunities and other aspects that are important for the transition to a CE, such as innovation and technology development, education, training and skills development, consumer behaviour.

123. See 4.5 for a more detailed discussion of the role of SEEA, its strengths and limitations.

4.2.2.1 Overview of the statistical framework

124. Figure 7 gives a simple overview of the measurement scope and shows how flows of materials interact with the domestic economy and environment and with the rest of the world. It builds on the principle of mass balancing and links the concepts of system analysis and of integrated environmental-economic accounting as described in the SEEA (see section 4.5).

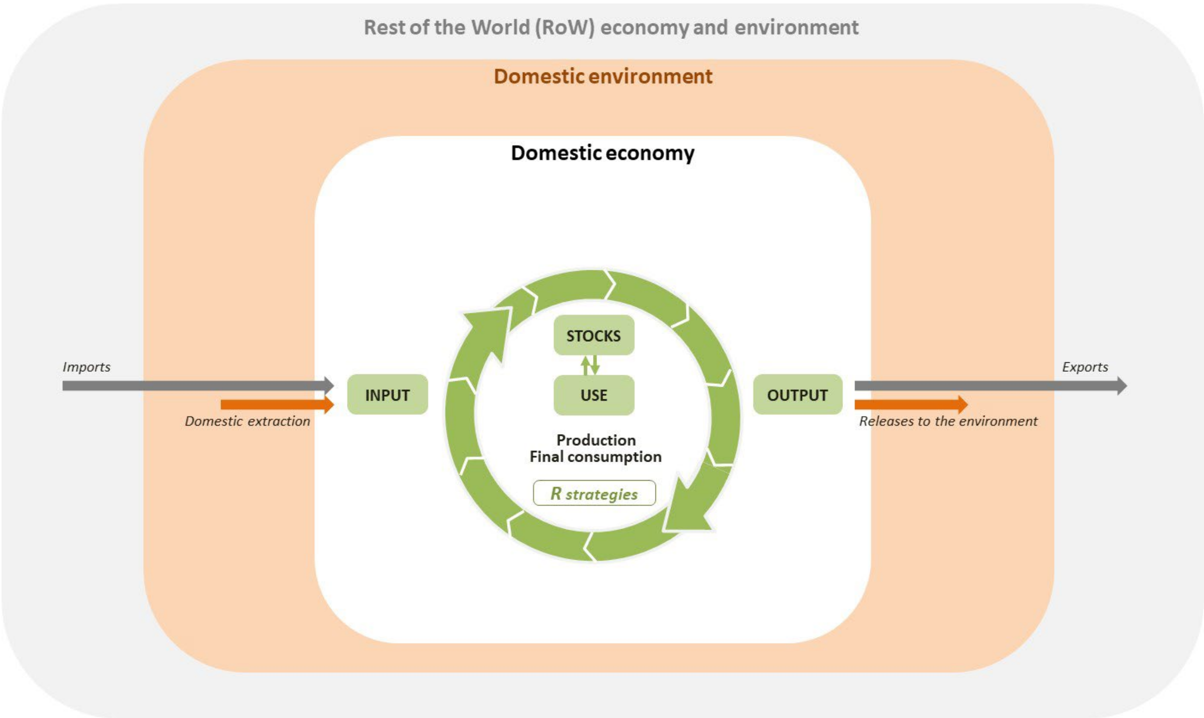
125. Figure 8 shows the links with the building blocks of the conceptual framework framework (see section 3.4.2) and its indicators (section 5). It shows how the framework fits into the broader picture of material flows, and how it could be used to develop a coherent narrative of a circular economy across all levels.

126. The overview diagram shows flows from the environment to the economy (input flows), flows within the economy, and flows from the economy to the environment (output flows) as well as flows between the domestic economy and the rest of the world (RoW, imports and exports). Flows within the economy refer to production and consumption activities, and to the ´R strategies` that aim at keeping the value of materials at their highest level for as long as possible. The diagram also refers to anthropogenic stocks of materials in the economy (i.e. fixed assets in SNA terms). Some materials accumulate in the economy where they are stored in the form of buildings, transport infrastructure

or durable and semidurable goods, such as cars, industrial machinery or household appliances. The materials stored in such goods are sooner or later removed from the stocks in the form of end-of life products and waste (e.g. construction and demolition waste) and may be released back to the environment. Anthropogenic stocks also represent important mines for future use (the so-called ´urban mines`).

127. The overview diagram was designed to apply to the macro-level, but it can equally be used to characterise CE data at the meso-level. The arrows in the diagram represent the direction of physical material flows, but can equally be applied to monetary flows. Data on both monetary and physical flows can be obtained from SEEA-CF use and supply tables.

Figure 7: Overview of the statistical framework of the circular economy



128. Description of the main components of the overview diagram (Figure 7):

- **Rest of the World (RoW) economy and environment**: These are actually two layers, which for simplification reasons are presented as one.
    a. Following the SNA and the SEEA-CF, the RoW economy refers to all **non-resident institutional units** that enter into transactions with resident units, or have other economic links with resident units. Flows between the RoW economy and the domestic economy are imports and exports.
    b. The RoW ´Environment` refers to the **non-domestic environment**. It is an important layer to be considered for example when calculating footprints or embedded emissions. It refers to the extraction of materials from natural resources in the RoW for imports to the domestic economy, as well as to related residuals released to the environment in the RoW, for example during production and transport activities.
- **Domestic environment:** This refers to the environment in which the domestic economy takes place. Following the SNA and the SEEA-CF, this also includes the environment outside the national territory when extraction of natural resources or releases of residuals to the environment are caused by an activity residing in the given country (the residence principle). This is particularly important for example in the case of international transport. For

measurement purposes, the domestic environment is defined as the sum of the environmental assets and ecosystems that may be impacted by the use of natural resources and the release of residuals to the environment (flows between the economy and the environment). Flows between the domestic environment and the domestic economy are:

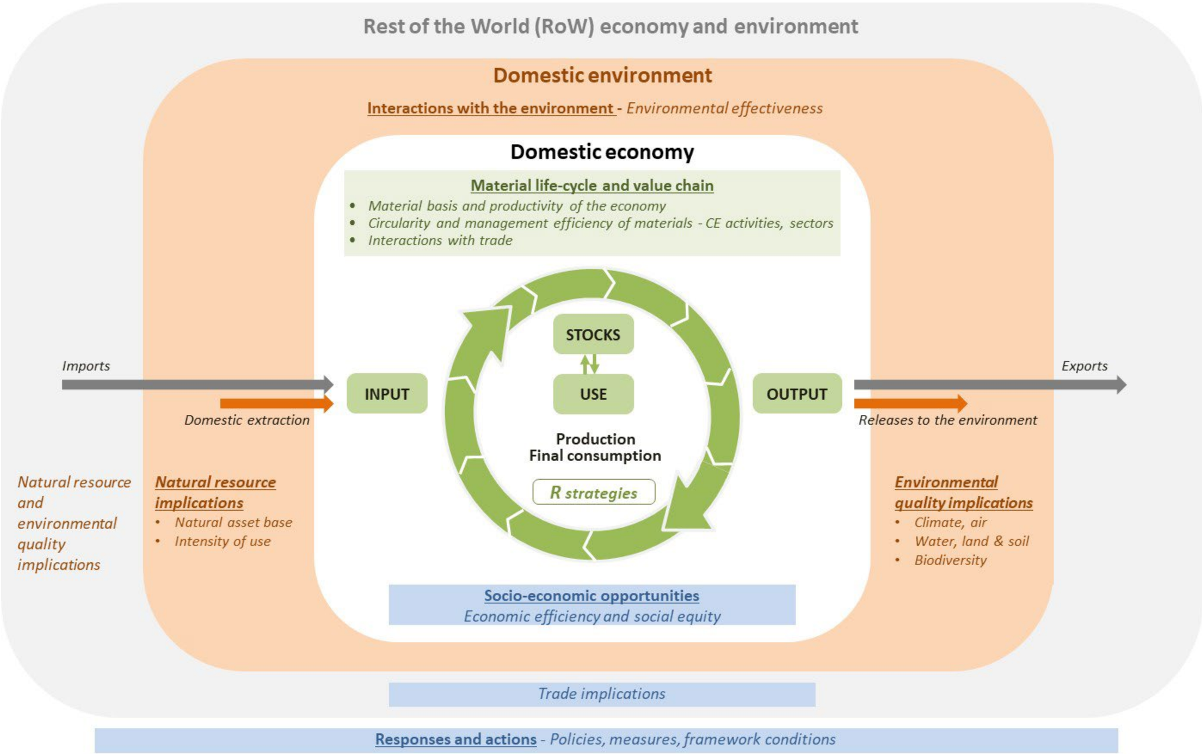
   a. Extraction of materials from natural resources (flows from the environment to the economy)
   b. Releases of residuals to the environment (flows from the economy to the environment).

- **Domestic economy:** Following the SNA and the SEEA-CF, the domestic economy is defined as the sum of all the institutional units that are resident in the economic territory of a country (the SNA uses the term ´total economy`). For measurement purposes, the following elements are relevant:
  - **Inputs to the domestic economy:**
    - Flows from the domestic environment to the economy (material extraction)
    - Flows from the RoW the to the domestic economy (imports)
  - **Outputs of the domestic economy:**
    - Flows from the domestic economy to the domestic environment (releases of residuals)
    - Flows from the domestic economy to the RoW (exports)
  - **Flows within the domestic economy (production and final consumption flows; life-cycle of materials; R-strategies)**
  - **Stocks within the domestic economy (anthropogenic stocks or fixed assets) and net additions to these stocks.**

129. Most of these flows and elements can be measured by applying the SEEA-CF, with some limitations though (see section 4.5). To ensure coherence with the SNA and the SEEA-CF, the **residence principle** should be applied. It should be noted though that in EW-MFA the boundary between the ‘environment` and the ‘economy` slightly deviates from the SNA definition of the boundary of the economy in the case of extraction of cultivated biological resources (agricultural plants and forests). See section 4.4.1.

130. Figure 8 links the statistical framework with the conceptual framework and its indicators.

Figure 8: Overview of the statistical framework with links to the conceptual framework and its indicators



131. The following gives a summary of the building blocks of the conceptual framework and how they relate to the statistical framework. These building blocks are described in detail in section 3.4.2.

- Building block ´**material life-cycle and value chain**`: As this building block is at the heart of measuring a circular economy it is presented in the centre of the diagram (see also 4.2.2.2). Relevant for its measurement are the themes:
    - **Material basis and productivity of the economy:** Indicators and statistics include for example, share of renewable or recyclable materials;
    - **Management efficiency of materials and waste, and the circularity of material flows, with reference to R-strategies and CE mechanisms when possible:** Indicators and statistics include for example, waste generation or products diverted from the waste stream through repair, remanufacture, reuse;
    - **CE activities and sectors:** Indicators and statistics include for example, share of products sold via second-hand shops or the share of waste recycled by specialised companies;
    - **Interactions with trade:** Indicators and statistics include for example the physical and monetary trade balance.
- Building block ´**interactions with the environment**`: This block concerns both layers – the domestic and the RoW environment. It covers:
    - **Natural resource implications:** This refers to the physical evolution of natural assets through material extraction (input flows). Indicators and statistics are for example on natural resource residuals or changes in natural resource stocks;
    - **Environmental quality implications**: These are the result of both the use of natural resources (input) and the release of residuals to the environment (output). Indicators

and statistics measure for example the impacts on climate, air, water and soil quality. They also include carbon footprint measures of priority materials and other measures of embedded emissions.

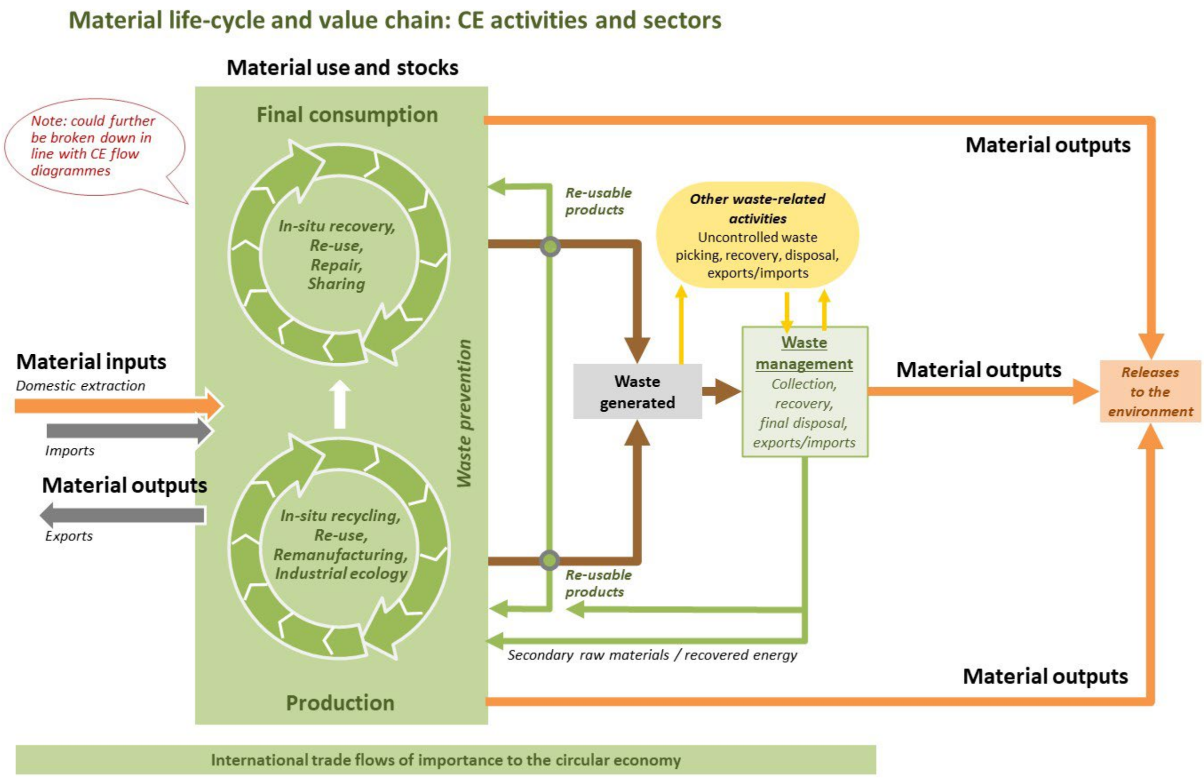
- Building block ´**responses and actions**`: This block describes the policy responses and other societal responses and actions to establish a circular economy. As they provide the framework conditions for the entire system to work, they are presented outside of the environment-economy layers. Indicators and statistics for measurement include for example taxes on materials raising environmental concerns, investments in waste management, CE R&D budgets, CE-related ODA etc.
- Building block ´**socio-economic opportunities**`: This block describes the social and economic outcomes of a circular economy. They are usually measured on the level of the domestic economy, and include indicators and statistics on market developments (e.g. jobs), skills, awareness and behaviour as well as the inclusiveness of the transition. Furthermore, it includes trade implications, for example development of flows between the domestic economy and RoW, but also addresses supply security of certain materials and goods.

4.2.2.2 Building block ´material life-cycle and value chain`

132. This is the central building block of the conceptual framework. It describes the various stages of the material life-cycle and value chain and the related CE activities and R-strategies.

133. Figure 9 gives a schematic presentation of the circular flows of materials, which are to be considered in the measurement themes, and the related R-strategies. It links to the *CES Waste Statistics Framework* (UNECE, 2021), which in its expanded scope, describes the inter-relationship between waste managements and the production and consumption cycles.

Figure 9: Schematic view of the material life-cycle and value chain and its links to waste management.



Orange boxes and arrows	• Flows of materials from the environment to the economy, i.e. material extraction (inputs). • Flows of residuals (releases) from the economy to the environment (pollutant emissions from production and consumption and from waste management and related activities, waste dumped, …).
Grey arrows	• Flows of materials from the RoW to the economy, i.e. material imports (inputs) in the form of raw materials, processed materials, materials embodied in goods. • Flows of materials from the economy to the RoW, i.e. material exports (outputs) in the form of raw materials, processed materials, materials embodied in goods.
Green boxes and arrows	• Flows of materials through production and consumption activities, and related trade flows; the flows of used and end-of-life products diverted from the waste stream for re-use, remanufacturing, repair or trade; and the flows of secondary raw materials and energy recovered from waste and that are used as inputs into the economy or traded. • Waste management activities and related flows, i.e. controlled activities, including waste collection, transport, treatment and disposal, and related transboundary movements
Brown arrows	• Flows of primary waste generated by production and consumption activities and to be managed.
Yellow boxes and arrows	• Other waste-related activities, i.e. uncontrolled (informal and illegal) activities, and related flows. In countries with waste-related activities that are difficult to monitor or not monitored, such as uncontrolled (informal and illegal) waste picking and recovery, these activities and related flows need to be considered in the measurement scope (see UNECE 2022, CES, Framework on Waste Statistics).

4.3 The role of international statistical frameworks and classifications

4.3.1 The role of statistical frameworks and standards

134. The most relevant statistical frameworks for measuring the circular economy include the System of National Accounts (SNA), the System of Environmental-Economic Accounts (SEEA-CF and SEEA-EA) as well as the United Nations Framework for Development of Environment Statistics (FDES). The SNA and the SEEA-CF are international statistical standards and are closely interlinked. The FDES plays an important role for producing the underlying environmental statistics.

135. National accounts are macroeconomic statistics that describe the structure and development of economies. The System of National Accounts (SNA) is the internationally agreed standard set of recommendations on how to compile such accounts. The recommendations are expressed in terms of a set of concepts, definitions, classifications and accounting rules. The latest version, SNA 2008, was jointly published by the United Nations, the International Monetary Fund, the World Bank, the OECD and Eurostat.

136. The SNA provides information about production, consumption and the accumulation of assets in recording the exchange of goods, services and assets between institutional units in the form of transactions. Gross domestic product (GDP) and its main components (gross value added, final consumption, gross fixed capital formation, exports and imports of goods and services, income accounts, etc.) provide an overview about key economic developments. Further details are provided for example by data on employment broken down by industries or by data on institutional sectors and government finances. In addition, the SNA contains supply and use tables, which are matrices by product and industry showing how domestic production and imports of goods and services in an economy are used by industries for intermediate consumption and final use.

137. The SNA and its headline indicator GDP have been criticised for not taking into account environmental impacts and not being able to represent developments towards wellbeing and sustainability. It is obvious that it is not possible to summarize in one single indicator, how well an economy is doing as a whole since valuable information is always lost when aggregates are formed. Satellite accounts of the National Accounts have been developed to meet specific data needs by providing more detailed or supplementary data. Satellite accounts are closely linked to the main system and use the same concepts, definitions and classifications, which allows the linkage of the data.

138. The System of Environmental-Economic Accounting (SEEA) is the international standard framework for environmental satellite accounts in line with the SNA, including monetary and physical accounts. It is designed to facilitate the integration of environment and economic statistics and support the analysis of the economy-environment nexus. The SEEA is thus a key tool for structuring and combining the data needed to measure the circular economy (see section 4.5).

139. Due to its complexity, the measurement of the circular economy requires a mix of environmental and socio-economic data from various sources. When aligned with the SNA and its satellite accounts (i.e. the SEEA), these data can easily be integrated and combined in a coherent way. Combining physical and monetary data provides a more complete picture of the economy and its interactions with the environment. Combining environmental accounts and national accounts data enables assessing the circular economy in relation to the total economy. By using well-established and internationally agreed upon concepts, classifications and frameworks, these data can further be used for cross-country comparisons.

4.3.2 The role of statistical classifications

140. A statistical classification or nomenclature is an exhaustive and structured set of mutually exclusive and well-described categories, often presented in a hierarchy that is reflected by the numeric or alphabetical codes assigned to them, and used to standardise concepts and compile statistical data. International statistical classifications provide a framework for data and information management and facilitate the production of reliable, methodologically sound statistics that are comparable worldwide.

141. **The circular economy is a subset of the total economy**, and activities related to the circular economy can be found in most economic sectors. When existing (official) statistics are used for measuring the circular economy and calculating related indicators, numerous challenges arise. The statistical classifications used for the compilation of the basic statistics determine the possibilities to identify activities, products or processes related to the circular economy and to aggregate/disaggregate these statistics. However, **commonly used statistical classifications do not allow for a straightforward and unambiguous identification of circular economy**.

4.3.2.1 Classifications relevant for measuring the circular economy

142. Internationally standardised economic nomenclatures exist for the classification of 1) economic activities, 2) products (including goods and services) and 3) traded goods. As an example, **ISIC and NACE** describe the economic activities. The **Central Product Classification (CPC)** and the **Classification of Products by Activity (CPA)** are used to describe which products and services an industry produces. **Prodcom** is a product classification, which is fully consistent with the CPA, while further detailing the product categories. The **Harmonized System (HS)** and the **Combined Nomenclature (CN)** are used for the classification of tradable goods. Table 4 gives an overview of selected economic nomenclatures that are relevant for measuring the circular economy. More details about these classifications, including on their structure, maintenance, interrelation with other classifications and their revision status can be found in Annex 2: Selected economic nomenclatures that are relevant for measuring the circular economy.

143. Environmental statistics and accounts use the internationally standardized economic nomenclatures introduced above. For the purposes of environmental statistics, specific classifications have been developed inter alia for the classification of material flows and environmental activities. The following Table 5 presents examples of relevant environmental classifications. More details about these classifications, including on their structure, maintenance, interrelation with other classifications and their revision status can be found in Annex 3: Selected nomenclatures from the domain of environmental statistics that have a high relevance for measuring the circular economy.

Table 4: Selected economic nomenclatures that are relevant for measuring the circular economy.

Classification	Usage and main statistical applications	Coverage of application
ISIC Rev.4: International Standard Industrial Classifications of All Economic Activities	ISIC provides a set of activity categories that can be utilized for the collection and reporting of statistics in the fields of economic and social statistics, such as for statistics on national accounts, demography of enterprises, employment and others.	Worldwide
NACE Rev. 2: Statistical Classification of Economic Activities in the European Community since 2008	Provides the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) but also in other statistical domains.	EU
CPC Version 2.1: The United Nations' Central Product Classification	CPC serves as an international standard for assembling and tabulating all kinds of data requiring product detail, including industrial production, national accounts, service industries, domestic and foreign commodity trade, international trade in services, balance of payments, consumption and price statistics. It can also be used as a basis for developing lists of goods and services for specific purposes, such as price statistics surveys, tourism statistics surveys or ICT-related surveys	Worldwide
CPA Ver. 2.1: Statistical classification of products by activity in the European Community	The CPA is classification designed to categorize products (goods and services) that have common characteristics. It provides the basis for compiling statistics on the production, distributive trade, consumption, international trade and transport of products.	EU
PRODCOM: Classification of goods used for statistics on industrial production in the EU	PRODCOM is used for an annual survey for the collection and dissemination of statistics on the production of industrial goods and services.	EU
HS 2022: The Harmonized Commodity Description and Coding System	HS is used as a reference for classifications of trade statistics and for customs tariffs. HS basically covers goods but also electricity and the physical "manifestations" of services (e.g. architects' plans, diskettes with software etc.).	Worldwide
CN 2022: The Combined Nomenclature, a European classification of goods used for foreign trade statistics	CN is used as a reference for classifications of trade statistics and for customs tariffs.	EU

Table 5: Selected nomenclatures from the domain of environmental statistics that have a high relevance for the compilation of indicators for circular economy:

Classification	Usage and main statistical applications	Coverage of application
EW-MFA: Classification of the materials for the economy-wide material flow accounts.	The classification is used for the economy wide material flow accounting.	EU
CEPA 2000: Classification of Environmental Protection Activities and Expenditure	CEPA is a functional classification used to classify activities, products, expenditure and other transactions whose primary purpose is environmental protection. Main applications include Environmental Protection Expenditure Accounts (EPEA) and Environmental Goods and Services Sector (EGSS) Accounts.	EU / Worldwide
CReMA 2008: Classification of Resource Management Activities	CReMA a functional classification used to classify activities, products, expenditure and other transactions that aim to preserve and enhance the stock of natural resources.	EU / Worldwide
EWC-Stat Version 4: European Waste Classification for Statistics	The European Waste Classification is a mainly substance-oriented classification of waste for the purposes of waste statistics.	EU

144. Besides statistical classifications, green/sustainability taxonomies may facilitate the identification of activities, products and processes related to circular economy. Green taxonomies typically provide technical criteria, terminologies and thresholds to identify sustainable activities, products or processes. The **EU Taxonomy** is an example of a taxonomy that might facilitate the identification of activities, products or processes relevant for the circular economy. It is a classification system for environmentally sustainable economic activities, created to help the EU scale up sustainable investment and implement the European green deal. An economic activity has to meet four overarching conditions in order to qualify as environmentally sustainable. These conditions are: 1) substantial contribution to environmental objectives, 2) no significant harm to any of the environmental objectives, 3) compliance with minimum social safeguards and 4) compliance with the technical screening criteria. Different means can be required for an activity to make a substantial contribution to each of the six environmental objectives, one of which is the transition to a circular economy.

4.3.2.2 Addressing the topics of circular economy in existing statistical classifications

145. International classifications are regularly revised in order to guarantee that they reflect the changing reality (changes in the economic structures, technological developments…) but also the changing data needs. Since environmental aspects and circular economy have gained importance, issues related to them have increasingly been taken into account in revision processes of statistical classifications.

146. The discussions in the frame of the current revision process of the ISIC/NACE classification have concluded that currently it is much easier to address the topics of circular economy by means of product classifications like CPA than by means of activity classifications like ISIC/NACE. Clear rules exist for the creation of activity classifications and these rules need to be respected. Neither ISIC nor NACE make a difference between manufacturing of goods made from primary or secondary raw materials. Neither do they differentiate between the manufacture of energy saving or long lasting and conventional goods (e.g. production of traditional and energy-saving light bulbs are classified in the same activity class). Such differentiations are possible in the CPA, at products level.

147. Eurostat is currently running a project[3] which aims at analysing ‘circular economy`, ‘bioeconomy`, ‘climate change mitigation` and ‘climate change adaptation` as economic sectors. See Box 2.

[3] The project is implemented through a contract with an external consortium of companies (Prognos and Devstat). The project started in June 2020 and will run until June 2023.

Box 2: Eurostat example of analysing circular economy as an economic sector. See Prognos & DevStat (2022)

The project is implemented by Eurostat through a contract with an external consortium of companies. It started in June 2020 and will run until June 2023.

The final objective is to compile key economic indicators (output, exports, imports, gross value added, employment, investment – gross investment in tangible goods) for the four considered sectors 'circular economy', 'bioeconomy', 'climate change mitigation' and 'climate change adaptation' sectors based on Eurostat's Structural Business Statistics (SBS), Prodcom statistics and on National Accounts (NA).

As the underlying classifications NACE and Prodcom do not explicitly distinguish these four sectors, the analysis relies on additional information and modelling. Only in a few cases even the most detailed codes of NACE and Prodcom classifications fully reflect the specific activity or product that is intended to be measured. In most cases, a share of the identified statistical entries has to be derived. Therefore, compilation of economic data needs to build on additional information that is used to estimate the shares of the relevant activities within the considered NACE divisions.

The objective of the methodology is to estimate the part of a product, activity or employment that is related to the production of the policy framework in focus. The estimation is based on the list of sector activities mapped to the NACE and Prodcom classification and builds on various approaches that can be considered in a hierarchy from more robust to more uncertain approaches:

- Fully considered NACE codes
- Fully considered Prodcom codes
- Based on secondary statistics from Eurostat, allowing for dynamic adjustments by year and Member State (e.g. waste statistics or energy statistics)
- Based on Use Tables, building on the supply relations to estimate the share of intermediate goods and services supplying core sector functions
- Based on other secondary data sources, including other secondary statistics available for a few countries or few years only, findings in literature, proportionality assumptions, expert interviews, among other. In practice, this approach usually leads to a fixed share that is applied to all years and Member States.

Two categories of circular economy goods and services are included: 1) primarily circular economy purposes (e.g. waste collection, treatment, equipment for recycling activities, secondary raw materials), 2) primarily a non-circular economy purpose but serve a secondary circular economy purpose because they are specifically designed to be more resource efficient than normal products of equivalent use (e.g. leasing and renting). Circular economy activities can be performed as principal, secondary or ancillary activities of a producer.

The specifications of activities draws upon the definition of terminology, and the scoping and delineation criteria detailed in the "Environmental goods and services sector accounts — Handbook 2016 edition" (Eurostat, 2016). The technical potential of a good or service forms the basis in determining the circular economy purpose. The delineation of circular economy focuses on goods and services related to (raw) materials but excludes economic activities from renewable resource for energy production and bio-based products and services. Upstream activities, goods or services used as an input in the production of a circular economy product, and downstream activities, the production of a good or service that uses a circular economy product as an input in further production activities, are included.

The resulting longlist of identified economic activities and products related to circular economy includes 190 items. This long list was narrowed down to a shortlist, which includes 126 items related to circular economy. For the shortlist of activities and products, relevant shares have been estimated and preliminary results for key variables compiled.

4.4 Measuring flows of a circular economy

148. Providing a comprehensive picture of a circular economy, in line with the measurement scope above (4.2.2), requires economic, social and environmental statistics. In particular, statistics are needed on the flows of materials, goods and residuals, as well as on monetary flows and social aspects (e.g. employment in CE-related activities or sectors). In alignment with SEEA-CF the measurement of the flows of materials and goods covers both physical measurement (e.g. in tonnes per year) and related transactions in monetary terms.

149. It is to be noted that not all aspects of a circular economy can currently be measured statistically. Data on higher level ´R-strategies`, including ´eco-design`, on consumer behaviour or on intra-industry flows are for example not yet available or of insufficient quality.

150. As the statistical framework builds on the SEEA-CF it also applies the boundaries of the System of National Accounts (SNA). The national (domestic) economy of a country is described as the transactions related to a very large number of activities – e.g. production, consumption, accumulation – carried out by resident units and the related stock of produced assets whose economic owner is a resident (SNA 2008, § 3.19).

151. Statistics on the following physical flows and stocks are needed:

- Input of natural resources from the environment into the national economy, i.e. extraction of natural resources;
- Imports and exports of goods from and to the Rest of the World (RoW);
- Consumption of goods as final demand;
- Flows of materials and goods within the economy, e.g. goods by CPA/Prodcom, waste products, primary and secondary raw materials;
- Products' and residual´s material components such as plastics, metals and wood;
- Material stocks within the economy, such as buildings and infrastructure, to show how stocks and flows are interlinked;
- Residuals to national and RoW environment, such as air emissions, water emissions and waste;
- Both direct domestic flows as and indirect flows in the RoW that result from domestic consumption.

152. The most important statistical classifications (see also section 4.3.2) to be taken into account are

- EW-MFA material categories
- ISIC/NACE
- CPA/PRODCOM
- European Waste Classification for statistical purposes (EWC-Stat.)
- Eurostat International trade in goods statistics (ITGS) and its Combined Nomenclature (CN, building on the Harmonised Commodity Description and Coding System (HS)

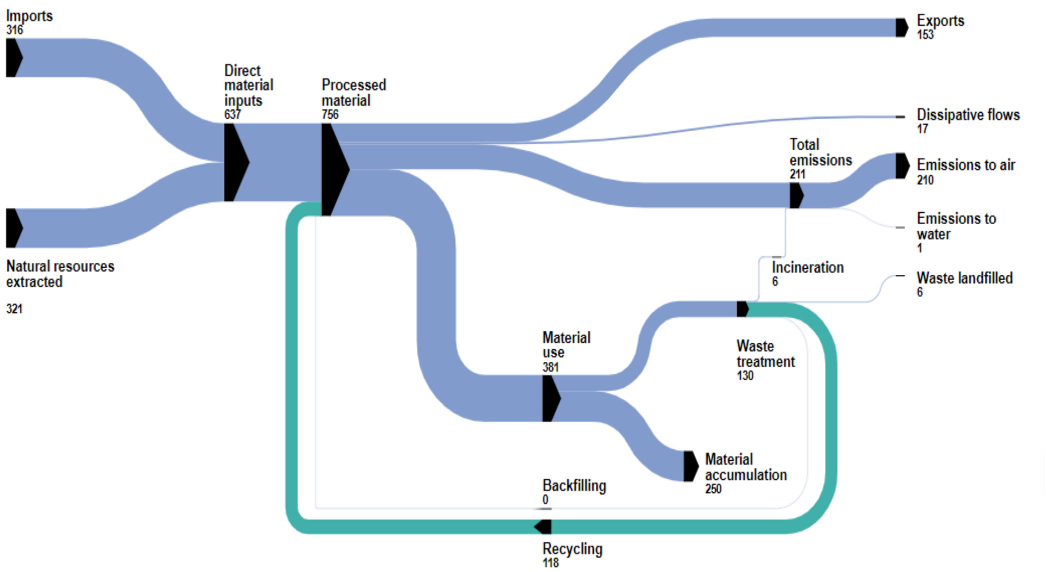
153. An important non-official statistical classification to be considered is the 9R framework which is used when defining the CE activities (see section 3.1).

154. As outlined in detail in section 4.2.2 the physical flows comprise of flows from the environment to the economy, flows within the economy, and flows from the economy to the environment. With these statistics important themes of the main framework components "material life-cycle and value chain" and "interactions with the environment" can be addressed.

155. The integration of all relevant statistics can be achieved by **compiling physical supply and use tables (PSUTs)** according to the principles of the System of Environmental Economic Accounting. PSUTs are counterpart of the monetary supply and use tables of the National Accounts. The PSUT captures national resource extraction, product imports and exports, product flows between economic sectors, as well as emissions and waste streams resulting from economic activities. For more detail see the SEEA-CF, and more recently, Delahaye et al (2022).

156. The underlying framework for measuring physical flows is the SEEA-CF. However, for presenting and checking the balance and completeness of the flows, the use of Sankey Diagrams is recommended, even if there are some limitations. For example, the following Figure 10 presents the physical material flows of the Italian economy in 2019.

Figure 10: Physical flows in Eurostat's Sankey diagram (Material flows of the Italian economy, 2019, Mt; source: Eurostat)



157. The Sankey diagram developed by Eurostat within the first EU CE monitoring framework currently employs three existing statistical data sources: waste statistics, economy-wide material flow accounts (EW-MFA) and emission accounts.

158. The main challenge of developing Sankey diagrams is to combine all available data in one clear and easy way to a comprehensible diagram. This is essential to exploit the rich data sources and to make policy relevant information easily accessible and understandable for users.

159. A study of CBS Netherlands (Delahaye et al., 2022) discusses both physical supply and use tables (in the Netherlands referred to as the Material Flow Monitor (MFM)) can be used to compile all sorts of policy-relevant Sankey diagrams.

160. In the mid-long-term the **development of physical supply and use tables for measuring material flows in the context of a circular economy is recommended**. The most relevant physical accounts for that purpose are:

a) EW-MFA

b) Energy accounts

c) Air emission accounts

d) Waste accounts

161. In addition, the monetary supply and use tables of National Accounts are needed to estimate production and use of good through the conversion of monetary flows into physical units.

4.4.1 Input of natural resources from the environment into national economies

162. This flow represents the **extraction of material from natural resources**.

163. In EW-MFA it is called 'domestic extraction`. The EW-MFA classification of materials (MF.1 to MF.4) is used for material inputs. Its main material categories are: biomass, metal ores, non-metallic minerals, fossil energy materials/carriers. Note that this excludes water.

164. According to the SEEA-CF (3.2.2) natural resource inputs comprise physical inputs to the economy from mineral and energy resources, soil resources (excavated), natural timber resources, natural aquatic resources, other natural biological resources, water resources and natural resource residuals. Natural resource inputs exclude flows from cultivated biological resources. Cultivated biological

resources are considered to be produced within the economy (i.e. their growth falls within the production boundary of the economy) and hence are not accounted for as flows from the environment.

165. Due to given conventions the domestic extraction in EW-MFA slightly differs from the definition of natural resources inputs as defined by SEEA-CF. For example, it includes cultivated biological resources, because the so-called ’harvest approach’[4] is applied. It excludes water resources because of their significant weight. Inputs from water resources are reported in separate accounts that can be used in parallel when relevant.

166. **As the circular economy conceptually mainly focuses on maintaining the value of materials (including goods) it is recommended for measuring the extraction of material from natural resources using the conventions defined in EW-MFA**. This is called ’**domestic extraction’** and refers to the “*extraction or movement of natural materials on purpose and by humans or human-controlled means of technology (i.e. involving labour)”.*

167. Recording of memorandum items make it possible to bridge between the SNA and SEEA concepts. For more details see Eurostat (2018). [5]

168. Not all CE frameworks treat flows of energy products and water similarly. In this statistical framework they are considered as follows:

- **Energy products:** Materials used for energy provision are an important part of economies' material inputs, and reducing their consumption through the transition from fossil to renewable (non-biomass) energy sources is important for moving towards a greater circularity of economic systems. Therefore, **‘energy’ is included in the statistical framework**.
- **Water:** In EW-MFA bulk water flows (e.g. water abstractions from natural water bodies) are excluded because of their high quantities[6]. However, even if bulk water flows are excluded from the EW-MFA measurement, sustainable use of freshwater resources is conceptually part of a circular economy. Therefore, **the framework includes indicators and statistics that are useful for measuring water use efficiency and impacts on natural water resources** but excludes measurements of all water flows. The necessary statistics can be taken from water statistics and SEEA Water Accounts. Guidance on flows of water can also be found in Eurostat (2018). [7]

4.4.2 Residuals (outputs) from national economies to the environment

169. According to SEEA-CF (3.73) “*residuals are flows of solid, liquid and gaseous materials, and energy that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation.*”

170. The main groups of residuals according to SEEA-CF are:

a) **Solid waste:** covers discarded materials that are no longer required by the owner or user.

---

[4] SNA and SEEA-CF consider cultivated biological resources as produced assets within the boundary of the economy. The grown biomass is considered to be the production output. Material inputs, i.e. natural inputs, into this process would be soil nutrients, water and carbon dioxide according to SEEA-CF. EW-MFA accounting rules deviate in this particular case from the SEEA-CF and introduced a simplified recording: the ‘harvest approach’. Applying the harvest-approach implies that cultivated forests and agricultural plants are treated as if they were part of the environment. EW-MFA recognise the flow from environment to economy, i.e. domestic extraction, at the point of harvest rather than as growth occur. See Eurostat (2018).

[5] See Eurostat (2018) § 34, and SEEA-CF, section 3.6.6 on the specific EW-MFA recording conventions.

[6] Including water in EW-MFA would dominate the accounts and dilute the flow patterns of other materials. EW-MFA take into account the water content of other materials (moisture), such as e.g. biomass material. Also, goods imported and exported as recorded in EW-MFA may have some water content.

[7] See Eurostat (2018) §§ 59-63.

b) **Wastewater:** covers discarded water that is no longer required by the owner or user.

c) **Emissions:** Substances released to the environment by establishments and households as a result of production, consumption and accumulation processes

   a. Emissions to air: Gaseous and particulate substances released to the atmosphere by establishments and households as a result of production, consumption and accumulation processes.

   b. Emissions to water: Substances released to water resources by establishments and households as a result of production, consumption and accumulation processes.

   c. Emissions to soil: Substances released to the soil by establishments and households as a result of production, consumption and accumulation processes.

d) **Dissipative use of products:** Covers products that are deliberately released to the environment as part of production processes, for example, fertilizers and pesticides.

e) **Dissipative losses:** Material residues that are an indirect result of production and consumption activity. Examples include particulate abrasion from road surfaces, abrasion residues from car brakes and tyres, and zinc from rain collection systems.

f) **Natural resource residuals:** Natural resource inputs that do not subsequently become incorporated into production processes and, instead, immediately return to the environment.

171. **For the purpose of measuring CE it is recommended to focus on the following releases of residuals, which are covered by the EW-MFA indicator 'domestic processed output`** (see Eurostat, 2018):

- MF.7.1 Emissions to air
- MF.7.2 Waste disposal to the environment
- MF.7.3 Emissions to water
- MF.7.4 Dissipative use of products
- MF.7.5 Dissipative losses

172. More detailed analysis can be carried out using SEEA-based accounts such air emission accounts, waste accounts and water accounts. Alternatively, emission inventories, waste statistics etc. can be used.

4.4.3 Flows of materials within the economy

173. These flows cover:

- Product flows;
- Waste flows;
- Secondary raw material flows; and
- Additions to the stock of fixed assets.

4.4.3.1 Product flows

174. EW-MFA do not account for flows within the economy, although they are very important in the CE context. Those are relevant for CE policy as they track changes in resource efficiency by industry and consumer behaviour.

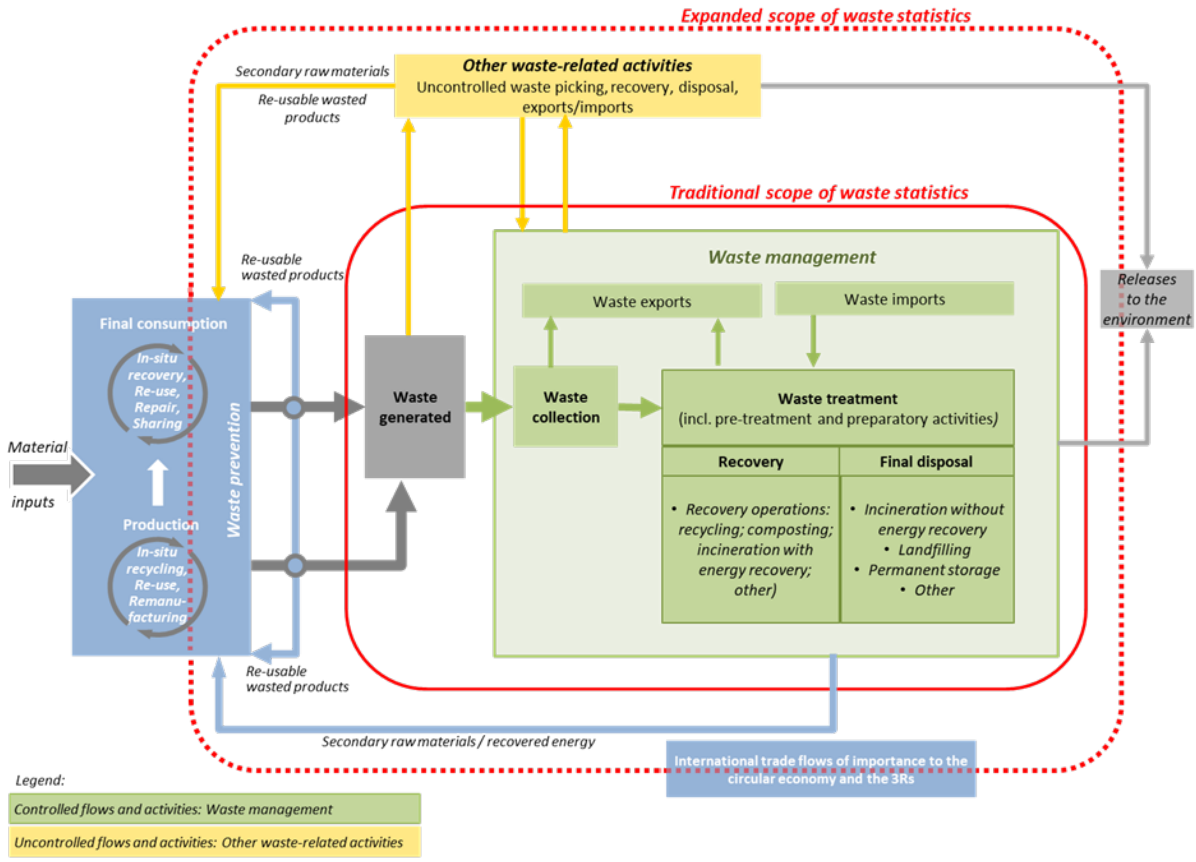
175. Measuring physical flows of materials within the economy is generally not yet supported by statistics. However, **as shown by the development of Dutch and Danish complete physical supply**

and use tables, it is possible – based on existing data, and in accordance with SEEA principles – to present a comprehensive picture of all material flows, also those within the economy.

4.4.3.2 Flows of waste and secondary raw materials

176. Waste flows and flows of secondary raw materials are an important part of the material flows within the economy. In the CE context the *Conference of European Statisticians (CES) Framework on Waste Statistics* (UNECE, 2021, see Figure 11) plays a pivotal role. This framework links to the structure of the CE statistical framework and provides an important foundation for the production of SEEA waste accounts. Amongst other issues, the CES Waste Statistics Framework suggests to broaden the scope of ´traditional` waste statistics and to integrate them with other material-related statistics to make them more useful for measuring circular economy.

Figure 11: CES Framework for Waste Statistics, embedded in a broader context (UNECE-CES, 2021)



177. Waste-related policies have undergone a paradigm shift. Their initial focus was on the protection of the environment and human health, resulting in municipal, sectoral and national waste management plans. In the traditional view of the economy, waste is seen as the inevitable result of a linear chain of production and consumption activities. Due to emerging policy needs, waste policies are currently being improved to meet the broader CE objectives such as resource efficiency and dematerialization of the economy, with the long-term aim of reducing the generation of waste and its final disposal. Therefore, **the circular economy approach considers waste as an integral part of the production and consumption cycle.** It also increases the demand for reliable statistics on waste generation, treatment and disposal and on the life-cycle of materials and products.

178. In this more complex policy environment, better and more detailed waste statistics than those currently available are required. Waste statistics can no longer stand alone but must be seen as an integral part of statistics on flows of materials and goods. Furthermore, integration with social and economic statistics as well as with other environmental statistics (for example, climate change-related statistics) are needed. Only when the conceptual and measurement links of these statistics are

considered, coherent statistics and indicators for all the main components of a circular economy (see section 3.4.2) can be produced.

179. **Informing circular economy policies with waste statistics requires clarity on what is a product and what is waste.** Applying the ´end-of-waste criteria` of EU (Article 6 of the EU WFD) is useful in that regard. According to the EU WFD, certain specified waste ceases to be waste when it has undergone a recovery operation (including recycling) and complies with specific criteria, in particular when

- the substance or object is commonly used for specific purposes;
- there is an existing market or demand for the substance or object;
- the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products); and
- the use will not lead to overall adverse environmental or human health impacts.

180. From the waste hierarchy perspective (see Figure 12), the boundary between waste and products is at the stage of re-use. See also Box 3.

Figure 12: Waste hierarchy (source: Webpage of the EU Commission[8])

Box 3: Eurostat's Pilot Study on Secondary raw materials and waste accounting (Eurostat, 2021).

> This pilot study introduces a waste flow model developed to determine material flows according to the requirements of SEEA waste accounting. It distinguishes between the classification of waste in the context of waste statistics and the classification of materials in the context of waste accounting and extends the SEEA 'physical supply and use tables' framework.
>
> The results are based on waste statistics and on the modelling of treatment processes.
>
> It provides an example for detailing waste statistics' categories (European Waste Classification for statistical purposes – EWC-Stat) – i.e. waste residuals and waste products – according to EW-MFA material categories (biomass, metal ores, non-metallic mineral, fossil energy materials/carriers) and by material components such as paper, plastics and metals.
>
> The results are compatible with material flow accounts and follow the logic of the Eurostat Sankey diagram on material flows and distinguish between primary and secondary wastes.

181. **The production of waste accounts is recommended**, because they comprise:

[8] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en (accessed on 9 December 2022)

- Primary waste generation flows;
- Waste treatment flows;
- Secondary raw material flows; and
- Additions to the stock of fixed assets.

182. Using waste statistics, **primary waste generation**[9] can be estimated from 'total waste generation' by

- deducting secondary raw material flows – i.e. waste generated in NACE E38 and G46.77, and secondary wastes categories (EWC-Stat) W033, W103, W128_13 from the other economic activities, and by
- adding by-products not covered by waste statistics and imports of primary waste.

183. The treatment steps of **waste treatment flows** are broken down by the following treatment categories. They are allocated to:

- ISIC/NACE 38 (waste collection, treatment and disposal activities; materials recovery):
  - Pre-treatment, sub-divided into mechanical treatment, biological treatment and physico-chemical treatment;
  - Energy recovery;
  - Incineration.
- Accumulation:
  - Backfilling;
  - Landfilling;
  - Other disposal.

184. **Secondary raw material flows** include:

- **Secondary waste materials**, which can be taken from waste statistics (waste generated in industries E38 and G46.77, and secondary wastes categories W033, W103, W128_13 from other economic activities); and
- **By-products**: which are materials from production processes that can be used directly by other companies without any further processing other than normal industrial practice (see section 4.1.5.1). By-products are partially covered by waste statistics. Therefore, they can be estimated via data research on the total use of secondary raw materials, irrespective of their legal status as waste or non-waste.

4.4.3.3 Additions to the stock of fixed assets

185. As discussed earlier, activities of the economic system are fed by flows of materials from the natural environment (input). These flows of materials are then processed by industries, and either are accumulated in physical stocks (additions to the stock of fixed assets) or transformed and released back to the natural environment as residuals. Materials stockpiled in buildings, infrastructure, and durable goods in the economy (gross additions) and old materials that are removed from stock as buildings are demolished, and durable goods disposed of (removals) are described by the EW-MFA derived indicator '**net additions to stock (NAS)**'. NAS measures the physical growth of the economy.

[9] Primary waste means waste that is originally generated by industries and households outside the waste management industry, whereas the term secondary waste is used for waste that arises in the waste management industry as output from waste treatment.

4.4.4 Flows from and to the Rest of the World

186. Physical imports originating from other economies (RoW) comprise all imported goods, including import of secondary raw materials (secondary waste) and import of waste residuals (primary waste).

187. Physical exports to other economies (RoW) comprise all exported goods, exports of secondary raw materials (secondary waste) and export of waste residuals (primary waste).

188. The relevant classifications (see also section 4.3.2) are:

- In the European Union the **Classification of Products by Activity (CPA)** and the **Combined Nomenclature (CN) for International trade in goods statistics**.
- For other countries the **Central Product Classification (CPC)** and the World Customs Organization's **Harmonized System nomenclature (HS Codes)** apply.
- Furthermore, the **EW-MFA material classification** (biomass, metal ores, non-metallic mineral, fossil energy materials/carriers, other products, waste for final treatment and disposal) as well as the **European Waste Classification** (there is no global waste classification available) are relevant in this context.

189. The *CES Waste Statistics Framework* (UNECE, 2021) discusses the problem of measuring imports and exports of waste in detail. Wastes that are imported or exported are often not classified as such in trade statistics. Customs officers consider the "objective characteristics" of the materials, which are sometimes inconsistent with the definition of waste in environmental policies and statistics. A customs officer cannot judge, for example, whether a used refrigerator is a second-hand refrigerator intended for continued use or a waste refrigerator intended for disposal.

190. The material resources associated to imported and exported goods are explicitly excluded from EW-MFA indicators on international trade. For the full picture, and for the calculation of material footprints, it is therefore necessary to measure raw materials extracted abroad for imported products.

191. Indicators expressed in terms of 'Raw Material Equivalents (RME)' measure imports and exports in terms of the natural resources which are necessary to extract from the natural environment and to produce the traded goods and services. A products' RME indicates the raw materials needed throughout that product's entire production chain. The materials required are included in the RME irrespective of whether they were extracted from the domestic environment or from the rest of the world environment. Also, it does not matter where the materials used to realise an imported product reach their final state: whether they become waste or emissions abroad or are incorporated into the product, they belong to the product and follow it as it passes from one economy to another. The RME approach allows measuring the potential environmental pressures associated to a country's final purchases because it includes all waste and emission generated anywhere in the world.

4.4.5 Flows related to the circular economy sector

192. These flows comprise information on the transactions carried out by the 'circular economy sector', for which currently no common conceptual framework exists. The statistical information usually available as the 'circular economy sector' – i.e. the recycling, repair and reuse sectors – only represents a subset of a much wider economic impact of the circular economy. Indeed, in only few cases (e.g., NACE/ISIC 38.3 'Materials recovery') codes of the statistical classifications of economic activities fully reflect goods and services identified by the circular economy definition and scope. Subsequently, methodologies are being developed to estimate also the shares of CE activities within relevant activities identified, e.g. those industries that carry out circular economy activities as secondary or ancillary activities only.

193. Eurostat is currently working to define the CE activities(see Box 2 in 4.3.2.2). This work draws on the methodology for the definition of the environmental sector used within the Environmental Goods

and Services Sector accounts; therefore, Eurostat's project is grounded in the SEEA. According to this approach, CE activities can then be categorised by their purpose, e.g. using the R framework:

a) either **serve a circular economy purpose directly** (e.g. waste collection, treatment, equipment for recycling activities, secondary raw materials),

b) or serve primarily a non-circular economy purpose, **but serve a secondary circular economy purpose**. This is the case when they produce goods and services that are specifically designed to be more resource efficient than normal products of equivalent use (e.g. leasing and renting).

194. The following presents the broad purpose types of CE activities, which are aligned with the 9R-Framework (see section 3.1):

- **Use and create product more intelligently (R0-R2):**
  - **R0 Refuse:** This category includes producing of products that make another product redundant by abandoning its prior function, or by offering the same function by a radically different product or service. Examples are the provision of online news, and e-magazines, because they make prints and their shipping obsolete and unnecessary packaging can be avoided.
  - **R1 Rethink:** This category includes activities with the focus to intensify product use (for example by sharing products, or multifunctional products). Examples are providing product-as-a-service, reuse and sharing models or by putting multi-functional products on the market.
  - **R2 Reduce:** Producing a product more efficiently by using less (raw) materials in its production, or requiring less during its use. Examples are instruments to achieve greater material efficient production or machinery which result in less wastes as by-products.
- **Lifetime extension of product and parts (R3-R7):**
  - **R3 Reuse:** Reuse of a product which is still in good condition and fulfils its original function (and is not waste) for the same purpose for which it was conceived. An example is the re-use of laptops by being sold in second-hand shops.
  - **R4 Repair:** Repair and maintenance of a broken product for use in its old function. For Examples are the repair of vehicles or washing machines to prolong their lifetime.
  - **R5 Refurbish:** Refurbish or modernize an old product and bring it up to date (to specified quality level). The boundary to R4 Repair in the economic classification is fuzzy. Examples are the refurbishment of electrical equipment, such as mobile phones and the re-treading of tyres.
  - **R6 Remanufacture:** Use parts of discarded product in a new product with the same function.
  - **R7 Repurpose:** Use discarded product or parts of it in a new product with a different function.
- **Useful application of materials (R08-R09):**
  - **R8 Recycle:** Process materials to the same (high-quality) or lower (low-quality) quality.
  - **R9 Recover:** Materials recovered from wastes to serve a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function. Incineration is excluded, although constituting recovery for energy generation, as this would be the end-use in the material cycle.

4.5 Role of the System of Environmental-Economic Accounting (SEEA)

195. Given its strength on measuring the interactions between the environment and the economy SEEA-CF provides the foundation for the CE measurement framework. Section 4.2.2 discusses this in detail.

196. However, there are certain areas and levels of analysis that cannot be addressed with SEEA, therefore it needs to be complemented with additional information. This includes for example measuring consumer behavior, innovative economic activities or product design.

4.5.1 What is the SEEA and how does it link to the CE?

197. The System of Environmental-Economic Accounting (SEEA) is an international statistical standard and a multi-purpose framework for compiling integrated economic and environmental statistics. (UN et al, 2012). The SEEA is based on internationally agreed standard concepts, definitions and classifications allowing for internationally comparable accounts. The SEEA framework follows similar accounting rules as the System of National Accounts (SNA). It is a flexible system that can be adapted to meet CE policy needs.

198. The System of Environmental Economic Accounting – Central Framework (SEEA-CF) covers measurement in three main areas:

1. Physical flows. The flows of natural inputs, products and residuals between the environment and the economy, and within the economy, measured both in physical and monetary terms.
2. Environmental assets. The stocks of individual assets, such as water or mineral and energy assets, and how they change over an accounting period due to economic activity and natural processes, both in physical and monetary terms. Also includes ecosystem accounting, which considers the capacity of living components within their non-living environment to work together to generate flows known as ecosystem services.
3. Economic activity related to the environment. Monetary flows associated with economic activities related to the environment, including spending on environmental protection and resource management, and the production of ‘environmental goods and services’.

199. All three areas of the SEEA CF may provide useful information on the circular economy and its policy goals. For example, the physical flows provide useful information on the input of (secondary) materials into the economy, and waste and other residual flows from the economy back into the environment. Stocks of environmental assets, in combination with information on international trade (measured also in physical terms), provide information on a country’s material dependency. Finally, the potential of the circular economy in terms of employment and value added is covered in the third area on ‘economic activity related to the environment’.

4.5.2 Strengths

200. The strength of the SEEA lies in its coherence with the accounting structure, concepts and classifications of the System for National Accounts (SNA) that facilitates the integration of physical and monetary statistics, and that supports environmental-economic analyses at the macro and meso level. Its modules can easily be combined with each other and with NA economic information and other statistics in the SNA family. By extending the standard SEEA modules with complete or specific physical supply and use tables, it provides powerful tools for analyzing material flows, including CE-relevant flows within the economy. By enabling the integration of environmental and economic information (e.g. from NA – National Accounts) it provides unique, CE relevant, insights that are not available when individual statistics are considered. Being an international standard with internationally agreed concepts, definitions and classifications, it enables the production of internationally comparable statistics, which can be used to develop CE indicators.

201. According to the 2022 Global Assessment on Environmental-Economic Accounting and Supporting Statistics, 92 countries have already adopted and implemented the SEEA CF and 69% of them publish at least one account on regular basis.

202. Compilation of the SEEA requires the compilation of consistent time series. This is an important feature for monitoring the transition towards a circular economy, which is likely going to take several decades. For many countries there are already time series of one or more SEEA accounts available. For European countries six environmental accounts modules, among which the material flow accounts, are mandatory under Regulation (EU) 691/2011 (amended in Regulation (EU) 538/2014). Furthermore, SEEA accounts are often compiled using macro statistics from pre-existing data. If source data/statistics have been gathered previously for other purposes, time series can also be extended backwards.

4.5.3 Limitations

203. One limitation of the SEEA is that it is designed as a macro-economic framework to measure the interactions between the environment and the economy at the macro- and meso-levels This makes it less suitable for the measurement of processes related to the transition towards a CE. Transition indicators deal with, for example, consumer behavior, skills development, innovative economic activities or product design. Other CE relevant information, like product lifespan or material composition of products, also cannot be derived from the SEEA.

204. The level of detail in the recommended international classifications to be used in SEEA is limited due to its macro-economic approach. The SEEA is not very suitable for obtaining information on specific products or production processes. This does not, however, mean that micro data cannot be incorporated into SEEA modules. Classifications in official statistics, including those used in the SEEA, often lack CE relevant distinctions such as the specification of second-hand or bio-based commodities. These CE relevant specifications are often not very important from a monetary perspective. Because criteria for distinguishing commodities are often based on the monetary value of a product, classifications lack CE relevant distinctions.

205. Another limitation is that source data for SEEA modules often come from other statistics. As a consequence, SEEA modules are at the end of a line and often last to be published. This could be mediated by compiling early estimates for the statistics most important for CE monitoring (such as quarterly air emission accounts).

206. Production by households is, due to NA concepts, not allocated to households but to the industry producing the product as a main activity, e.g., the production of electricity generated by privately owned solar panels is recorded under ISIC D. Transactions between households, e.g., supply and use of secondary goods, are not part of the NA because these transactions take place within a single economic entity.

4.5.4 Aspects of the circular economy transition which can be measured with SEEA

207. Figure 13 shows the different aspects in the CE transition, building on the conceptual understanding of a CE (see chapter 3). At the bottom are the environmental effects that CE, as a means, tries to achieve. These effects can be achieved by setting circularity targets. These targets can be set on meso- or macro level, but also can be translated to the level of product or economic activity. These micro targets are important for industrial sectors who contribute to the CE transition. There are different kinds of drivers (ordered according to the R-ladder discussed in section 3.1) that can contribute to the CE transition, which are also referred to as circular strategies. A shift in drivers from bottom (energy recovery) to top (refuse) shows the stage of CE in a country. CE drivers are influenced by policy, technology or behavior. Ultimately a link between the applied lever instruments and the environmental effects is expected.

208. As explained earlier, the SEEA is most suited to measure aspects at the macro- and meso-levels. The terms in bold depicted in Figure 13 present areas and levels that can be monitored with SEEA. ´EU` is added for terms that comply with the *Circular Economy Action Plan of the European Union* (European Commission, 2020b).

209. The **levers** contain policy instruments, but also new technology or consumer behavior and they can be used to make it possible to achieve the set goals. The different kinds of levers are hard to monitor by using SEEA, apart from maybe taxes and subsidies for which data is available from SEEA module environmental subsidies and similar transfers.

210. SEEA can be used best to monitor **drivers** (circular or R-strategies with the highest numbers). For instance, recovery, recycling and substitution can be measured both in physical and monetary terms by using data from SEEA modules like physical energy flow accounts (PEFA), waste accounts, EW-MFA and EGSS. Drivers like reuse, remanufacture, repair, and recovery can be monitored in monetary terms by using national accounts data. This way national accounts data can be used to supplement EGSS data on recovery, recycling and substitution to get a more complete picture of the circular economy. Also, combining data on waste (waste accounts) and the input of natural resources (EW-MFA) provides information on secondary versus primary use of resources (Circular Material Use Rate, CMUR), and also on resource efficiency (amount of primary resources that end up in a product or that end up as waste with respect to total material input). Another resource efficiency indicator, Gross Domestic Product in relation to Domestic Material Consumption (GDP/DMC), can be measured by combining MFA and NA data. Improvements made in resource efficiency over time is an indication of the level of progress towards a circular economy. In order to monitor reduce, rethink and re-design additional data sources are needed.

211. The **goals at micro-level** apply to specific products and industrial processes that can be achieved by economic sectors. Products and industrial processes need to be selected that have the highest impact on the overall goals and their related effect. The EU Action Plan also focusses on key products and their value chain. SEEA can only be of limited use here because mostly detailed information is needed on specific products. But, for example, input-output analysis could be used as a tool to analyze environmental impacts of supply chains. Also, SEEA can be used to determine if micro goals eventually attribute to goals at a macro level.

212. To achieve these effects overall **goals on macro level** are set as general targets to work to. These goals could be to reduce waste and material input and consumption in the economy, but also to create economic opportunities and jobs. SEEA is suitable for monitoring targets such as the reduction in the use of abiotic resources. The Material Flow Accounts (EW-MFA) provides information on a country's material use, the waste accounts provide information on the generation of different types of waste, and the Environmental Goods and Services Sector (EGSS) is a good starting point to measure the size of the circular economy, in terms of employment and value added.

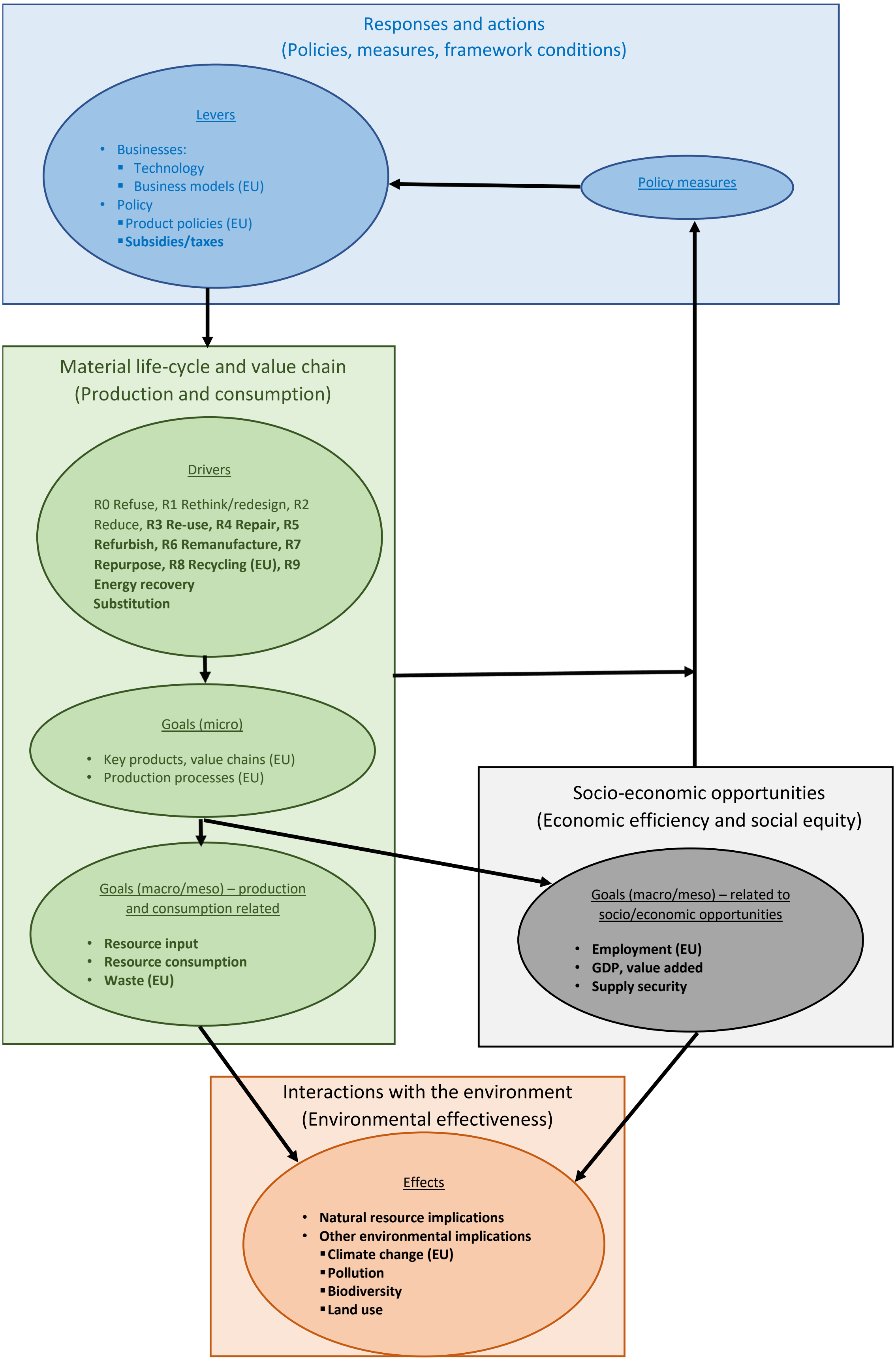
213. **Effects** refers to the effects that a CE would like to achieve. The transition towards a CE should support the sustainable use of natural resources (in quantitative terms) and reduce pressure on the environment. SEEA CF provides useful information to measure these direct effects at the national level. For instance, the air emission accounts provide information on the emission of greenhouse gases, water accounts provide information the use of water resources, and so on. At the micro level an LCA (Life Cycle Assessment) approach might be more suitable.

214. The SEEA framework makes it possible to link GHG emissions (Air Emissions Accounts, AEA), energy use (Physical Energy Flow Accounts, PEFA) and ecosystem services (Ecosystem accounts) to resource use and show how CE can contribute to mitigating climate change and biodiversity loss. The effects of the transition towards a CE do not only occur within the national economy, but may also affect the production chain and thereby affect other countries. The effects on the total production chain can be estimated by calculating environmental footprints by using input-output analysis, a tool that takes a combination of SEEA modules and national accounts as input.

215. In some countries, for example the Netherlands, security of the supply of certain critical resources for the economy are also part of the national CE program. The more these resources can be kept in the own economy the less the economy depends on other countries. Therefore, the recycling rates of these critical materials and the quantities that the urban mine can potentially provide in the future are monitored. Scientific research on critical materials in products combined with SEEA MFA and NA provides information on the economic sectors that depend on these critical materials.

216. The combination of the SEEA modules with the supply and use tables of the national accounts gives information on the use of materials per economic sector. This, for example, provides information on substitution between renewable and non-renewable resources. This is relevant for estimating the bio-based economy.

Figure 13: CE transition, from levers to environmental impacts. The terms in bold present areas and levels that can be monitored with SEEA. ´EU` is added for terms that comply with the Circular Economy Action Plan of the European Union.



5 Indicators for measuring CE

217. The main objective of this chapter is to present a relatively small set of core indicators for measuring circular economy which are relevant in the entire region, internationally comparable, and which are recommended to be produced regularly by National Statistical Systems.

218. The indicators that best reflect major trends related to the transition towards a CE are to be carefully selected. The number of potentially useful indicators can be large. It is therefore necessary to apply commonly agreed upon criteria that guide and validate their choice and keep the selection at a manageable level, building on earlier OECD work on environmental and green growth indicators (Box 4).

Box 4: Key principles in selecting indicators to monitor progress towards a circular economy

Policy relevance and utility for users	The indicator set should have a clear policy relevance, and in particular: • provide a balanced coverage of the key features of a circular economy with a focus on those that are of common interest to member countries • be easy to interpret and transparent, *i.e.* users should be able to assess the significance of the values associated with the indicators and their changes over time • provide a basis for comparisons across countries • lend itself to being adapted to different national contexts, and analysed at different levels of detail or aggregation.
Analytical soundness	The indicators should be analytically sound and benefit from a consensus about their validity. They should further lend themselves to being linked to economic and environmental modelling and forecasting.
Measurability	The indicators should be based on data that are available or that can be made available at a reasonable cost, and that are of known quality and regularly updated.

** These principles and criteria describe the "ideal" indicator; not all of them will be met in practice.*

Source: Adapted from OECD (2011), Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Green Growth Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264111356-en, and from OECD (1993), OECD Core Set of indicators for environmental performance reviews, Environment Monograph N.83, https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=OCDE/GD(93)179&docLanguage=En

219. As the circular economy is a cross-cutting concept based on systemic approaches, it is important that the indicators selected under the different building blocks and themes:

- Are aligned and can be interconnected to inform the assessment of policy outcomes and progress made. Indicators listed under "material life-cycle" could have a counterpart under "responses and actions", as well as under "socio-economic opportunities". This would help linking responses to results obtained.
- Fit into an overall narrative framework while supporting more granular analysis.

220. As information on a circular economy is not yet available for all dimensions and aspects to be considered, the proposed indicator set encompasses both operational and aspirational indicators.

- Operational indicators are indicators that are available or could be made available at a reasonable cost in the short to medium term, and that build on recognised definitions and methodologies.
- Aspirational indicators are new or improved indicators that while relevant and desirable to fill gaps require important statistical and methodological efforts. Such indicators could become part of an international measurement agenda.

5.1 A 3-tier structure of indicator types

221. As for other OECD environmental indicators, it is proposed to use a 3-tier structure of core, complementary and contextual indicators, based on their relevance, measurability and usefulness to track key features of the circular economy transition.

- **Core indicators** (or their proxy when the core indicator is currently not measurable) are indicators that capture key elements of a CE, respond to main CE policy questions and point at developments or changes that require further analysis and possible action. Core indicators are designed to provide the big picture of the transition to a CE. They represent a common minimum set of indicators for use in CES and OECD member states, and other international work and that countries would be encouraged to produce or adapt to their own circumstances. The number of core indicators should be limited so as to facilitate the monitoring and communication of major trends; it should not exceed 20-25.

  Both operational and aspirational core indicators are proposed. Operational core indicators are indicators that are highly relevant from a CE point of view, already measurable in a representative number of CES and OECD member countries or that countries would be willing and able to report to in the short term or the medium term (e.g., within the next few years). Operational indicators mainly cover basic waste management, material flow and resource efficiency aspects. Aspirational core indicators are indicators that are highly relevant from a CE point of view, but not yet measurable, and that require further methodological and statistical developments. Most indicators needed to reflect the circularity of materials flows are aspirational. They are included as an incentive for countries to develop underlying methodologies and/or to produce the required data. They are also proposed to become part of an international measurement agenda and roadmap.

  A shortlist of core indicators could further be identified as headline indicators to inform high-level decision-makers and civil society and to support wider communication with the public.

- **Complementary indicators:** Indicators that accompany or complement the message conveyed by “core” indicators, by providing additional detail (sub-national detail, sectoral detail) or focus (particular materials or activities), or by covering additional aspects. For country application of the framework, other country-specific indicators can be added. For application in international work, complementary indicators that describe country-specific features are particularly useful for country projects and peer reviews. Complementary indicators also include new and innovative indicators that are yet to be defined and developed, and that could become core indicators in future.

- **Contextual indicators:** indicators that provide background information on socio-economic and environmental variables to facilitate interpretation in the appropriate country context and to inform about drivers of material use. They include general indicators on the characteristics of economic growth (GDP, income) and changes in countries’ industrial structure.

222. The indicators are further to be accompanied with references to additional information needed to guide interpretation, and with cross-references to other indicators.

5.2 Proposed indicator set

223. A list of proposed indicators has been established drawing on indicators available from UNECE’s and OECD’s own work and work by other international organisations, including:

- The OECD Core Set of Environmental Indicators, OECD sectoral sets of environmental indicators, the set of Green Growth indicators, and OECD indicators to monitor material flows and resource productivity (OECD, 2011).

- The EU CE monitoring framework and indicators.
- The list of indicators reviewed by the UNECE Task Force on Measuring Circular Economy in its Work Package 3 (WP3).

224. The list also considers indicators listed in national work, the OECD Inventory of Circular Economy Indicators, the work by PACE Circular Indicators for Governments, and work by ISO 59004 WD2 on Circularity Measurement Taxonomy. Coherence with the global list of SDG indicators and with the Bellagio principles (EEA & ISPRA, 2020) is ensured.

225. Table 6 gives an overview of the proposed core indicators, structured in line with the conceptual framework. The list is not final and will be refined based on further consultations with countries.

Table 6: Overview of framework themes and proposed core indicators

Framework	Themes	Proposed core indicators [a]
Material life-cycle and value chain	The material basis of the economy	▸ **Material consumption & productivity** (DMC, RMC): trends and mix
	The circularity of material flows and the management efficiency of materials & waste *(with reference to R strategies and CE mechanisms)*	▸ **Waste generation:** total, municipal, specific waste streams ▸ **Circular use rate** ▸ **National recycling rate** ▸ **Waste going to final disposal**
	Interactions with trade	**none**
Interactions with the environment	Natural resource implications *(physical evolution of natural assets)*	▸ **Natural resource index/ depletion ratios:** energy & mineral resources ▸ **Intensity of use of renewable freshwater resources**
	Environmental quality implications *(effects of materials extraction, processing, use and end of life management on environmental conditions and human health)*	▸ **GHG emissions from production activities** ▸ **Pollutant discharges from production activities to water bodies and share safely treated**
	Impacts on human health	**Placeholder**
Responses and actions	Support circular use of materials, promote recycling markets and optimise design	▸ **Taxes and government support for circular business models**
	Improve the efficiency of waste management and close leakage pathways	▸ **Investments in waste management** infrastructure, waste collection and sorting (government, businesses) ▸ **Tax rate/tonne landfilled or incinerated**
	Boost innovation & orient technological change for more circular material lifecycles	▸ **R&D expenditure on CE technologies**: budget allocations (government, businesses)
	Target setting and planning	**Placeholder:** distance to targets
	Strengthen financial flows for a circular economy and reduced leakage	▸ **Business investments in CE activities**
	Inform, educate, train	**Placeholder**
Socio-economic opportunities for a just transition (economic efficiency and social equity)	Market developments and new business models	▸ **Gross value added of CE sectors** ▸ **Share of jobs in CE sectors**
	Trade developments	**none**
	Skills, awareness and behaviour	**Placeholder**
	Distributional aspects of CE policies	**Placeholder**

Note: (a) The proposed core indicators include both operational core indicators that are measurable for most OECD countries, and aspirational core indicators that require further work and that countries are encouraged to produce. Placeholders refer to indicators that are yet to be identified and defined. Other indicators that could become core indicators in future can be found in Table 7.

226. Table 7 presents the framework themes with a detailed list of proposed indicators. However, relevance and measurability are to be further reviewed. New and innovative data sources are to be identified for highly relevant indicators that are not yet measurable. Indicators that should be given priority for further research and development to be identified.

227. Notes concerning Table 7:

(a) All indicators are expected to reflect change over time.

(b) **Indicator types**: A 3-tier structure of core, complementary and contextual indicators, based on their relevance, measurability and usefulness to track aspects of the circular economy transition is proposed. Acronyms used in the table: Core indicator (Core); Complementary indicator (Compl); Contextual indicator (Cont)

(c) **Relevance** indicates the level of relevance/usefulness of the proposed indicator for the given topic: High (H); Medium (M); Low (L). Relevance is assessed with respect to the following criteria:

- ability to provide a representative picture of the material life-cycle, its interactions with the environment, and society's responses.
- simplicity, ease of interpretation
- ability to show trends over time, and responsiveness to changes
- ability to provide a basis for international comparisons;
- existence of a threshold or reference value against which to compare it, so that users can assess the significance of the values associated with it.

(d) **Measurability** indicates the current availability of data and agreed methodologies.

High (H) = measurable in the short term; basic data available for a majority of OECD members and a few non-members; indicator methodology well defined with consensus about validity.

Medium (M) = measurable in the medium term; the indicator is being developed and should be available in the near future; basic data partially available; goes with further efforts to improve the quality of underlying data (consistency, comparability, timeliness) and their geographical coverage (number of countries covered).

Low (L) = measurable in the longer term; major methodological or data gaps, calling for sustained data collection & conceptual efforts.

(e) **Related indicator sets:** international indicator set that includes the same or a similar indicator. OECD: set of material flow and resource productivity indicators (MFRP), core set of environmental indicators (CEI), green growth indicators (GGI); EU monitoring framework (EU-MF) (European Commission 2018); SDG global indicator set (SDG); UNECE Working Package 3 (WP3) list (Sept.2022).

Table 7: Framework themes and proposed indicators: Detailed list

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
Material life-cycle and value chain						
1. The material basis of the economy - Production, consumption, accumulation						
1.1 Material inputs	○ Direct material inputs (trends; intensities; mix) a. Production-based domestic material inputs (DMI) b. Demand-based raw material inputs (RMI)	Compl	H	H/M	OECD MFRP; WP3 Core	Double-headed indicator DMI & RMI, with complementary but related messages. Reflects the (raw) material basis of the economy accounting for domestic extraction and imports. To be read with information on the materials mix. DMI and RMI cannot be aggregated at international level without double counting (e.g., EU, OECD regions). Could be a core indicator for use by countries.
	○ Share of materials from renewable natural stocks in DMI	Compl	H	H	OECD MFRP	Links to biological material cycles. Could equally be related to RMI.
1.2 Material consumption	**Material consumption and productivity** (trends; mix) a. Production-based domestic material consumption (DMC) b. Demand-based raw material consumption (RMC) (material footprint) c. Production-based material productivity (GDP/DMC) d. Demand-based raw material productivity (net disposable income/RMC)	**Core**	H H	H H/M	SDG 8.4.2/12.2.2 SDG 8.4.1/12 2.1 OECD MFRP, GGI, CEI; WP3 Core: footprint	Double-headed indicators: DMC & RMC, with complementary but related messages. DMC can be related to future waste, recognising that there is a time lag between material consumption and waste generation. To be read with information on the materials mix. To be complemented with information on unused material flows (see "natural resource implications"). DMC and RMC can be aggregated at international level without double counting (e.g., EU, OECD regions). N.B. work on international method for demand-based measures is ongoing. Material productivity could be the main core indicator, with DMI/RMI and DMC/RMC being complementary indicators. It characterises the environmental and economic efficiency with which natural resources and materials are used in production and consumption, and informs about the results of policies and measures that promote resource productivity and sustainable materials management in all sectors. Complemented with information on the share of recycled (secondary raw) materials, it informs about the results of policies that promote a circular use of materials. See "circular use rate" below. In the absence of reliable data on net or gross national income, GDP can be used as a proxy for calculating the demand-based indicator.
	○ Share of materials from renewable natural stocks in DMC	Compl	H	H	OECD MFRP	Links to biological material cycles. Could equally be related to RMC.
	○ Share of recyclable materials in DMC	Compl	M	L	OECD MFRP	Links to circular design. Requires a common definition of "recyclable" materials. "Recyclability" is challenging to define. Technical and economic factors play a role.
1.3 Material accumulation	○ Net addition to stocks	Compl	H	L	OECD MFRP	Links to potential future waste and to potential future "urban" mines of raw materials. Requires the further development of material flow accounts.
	○ Changes in man-made stocks of mineral resources	Compl	M	L		
2. The circularity of material flows and the management efficiency of materials and waste *(economy-wide; in activity sectors)*						
2.1 Waste generation (materials ending up as waste)	**Total waste generation** (trends; intensity per GDP, per capita) – Municipal waste generation	**Core**	H M	M H/M	OECD CEI; EU MF, SDG 11.6.1; WP3 Core	Waste generation should ideally cover all primary waste generated so as to be relevant from a marco-economic CE point of view. If not available, municipal waste could be used as a proxy to get started. Municipal waste is also a good indicator to reflect efforts or the lack of efforts by citizens and households. Idem for other waste-related indicators proposed here. Waste generation should ideally distinguish between mineral waste and other waste.
	○ Waste generation trends by source, and by waste or material type (% share in total; trends) e.g. – Hazardous waste – Construction & demolition waste; mining and quarrying waste – Waste electrical and electronic equipment, packaging waste, plastics	Compl	H	M		Complements the core indicator with a breakdown by source sector (ISIC/NACE) and by type of waste or material. Particular attention could also be given to waste streams that raise particular concerns such as hazardous waste, WEEE, plastics, packaging waste, C&D waste, mining and quarrying waste. To be related to indicators on targets and distance to targets below to monitor policy outcomes.

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
	○ Total primary waste supply by sector (% share in total, intensities per value added) *(from waste accounts)*	Compl	H	M/L		Indicator derived from waste accounts building on the SEEA with a breakdown by sector (ISIC/NACE) aligned with national accounts, which opens up additional analyses. Requires the elaboration and maintenance of waste accounts in countries.
	○ Waste generation compared to DMC (or DMI) (total, by type of material)	Compl	M	M	OECD MFRP, EU MF	Relates total primary waste generation to the amount of material consumed or used in the economy. Could be applied to product groups. Interpretation: Should take into account stocks, recognising that there is a time lag between material consumption and waste generation.
	Food waste generated – Food loss index (production and supply levels) – Food waste index (retail and consumption levels)	Compl	H	L	SDG 12.3.1, EU MF; WP3 Core	Reducing food waste and food loss has an enormous potential for saving the resources used to produce food. Links to environmental implications. Most relevant indicator to be selected. Methodological guidance exists from Eurostat/EU and from SDG indicator metadata (FAO, UNEP).
	○ Hazardous waste generated & % treated, by type of treatment	Compl	M	M	SDG 12.4.2	Hazardous waste raises particular management and environmental issues.
2.2 Circularity of material flows	**Circular material use rate** – Share of recycled materials (secondary raw materials) in material consumption (all materials, material groups, selected materials)	**Core**	H	H/M	EU MF; OECD MFR;P WP3 Core	Reflects the extent to which recycled materials contribute to satisfying a country's demand for materials without adding pressure on natural resources. Reflects a country's recycling efforts, whether the amounts are sent to recycling in the country or sent to recycling abroad. Links data from waste statistics to data from material flow accounts. Is calculated as: recycled amounts (waste recycled in domestic recovery plants minus imported waste destined for recycling plus exported waste destined for recycling abroad) over (DMC+recycled amounts). The use of DMC avoids double counting when aggregating at international level (EU, OECD regions). Should ideally be calculated using amounts of materials coming out of recycling processes, net of losses during the recycling process (cf. Japan). Can also be calculated using the amounts of waste being sent to recycled including losses during the recycling process (cf. Eurostat). At national level, countries may wish to calculate this indicator by relating the amounts recycled to DMI (see the circular input use rate used in Japan)[10]. Could be expanded to account for reused materials if data availability permits.
	○ Intermediate consumption of secondary raw materials in production processes	Compl	H	L?	EU MF	Complements the circular use rate. Level of application tbd: by sector, material type, product groups or company. Could focus on "strategic" raw materials (see also "supply security" below). Feasibility of a harmonised measurement at international level to be explored.
	Renewable content of material inputs into production processes (average %)	Compl	H	L	ISO WD2 59020; WP3 Core	Relates to material substitution. and to biological material cycles. Reflects the share of virgin renewable materials in material inputs; to be complemented with indicators on the share of recycled and reused content in material inputs. Level of application tbd: By sector, product groups or company. Feasibility of a harmonised measurement at international level to be explored. Data disclosure by companies to be explored. Interpretation to consider the overall environmental footprint of renewable materials vs. non-renewable materials and the sustainability of the management of the natural resource.
2.3 Products diverted from the waste stream *(repair, remanufacture, reuse)*	○ Ratio of products repaired or reused to new products sold, by product type	Compl	H	M/L	WP3 Core	Can be related to product design and manufacture. Data availability and alternative data sources to be explored. Feasibility of a harmonised measurement at international level to be explored.
	○ <u>Placeholder</u>: Remanufacturing by sector or by branch	Compl	H	L		
2.4 Materials diverted from final disposal through recycling or recovery	**National recycling rate**: share recycled in total waste generated (or collected)	**Core**	H	M	SDG 12.5.1/OECD MFRP, CEI, GGI/ EU MF; WP3 Core	Refers to all waste materials recycled in the country plus quantities exported for recycling out of total waste generated in the country, minus material imported for recycling. Recycling includes material recycling, codigestion/anaerobic digestion and composting/aerobic process; does not include controlled combustion (incineration) or land application. Requires a consolidation and strengthening of waste statistics. Municipal waste recycling could be used as proxy and to reflect efforts by citizens and households. To be read together with information on other recovery types and on waste going to final disposal.

[10] Circular input use rate (Japan): Share of recycled materials (secondary raw materials) in material inputs, for selected materials or material groups, i.e. recycled amounts/(DMI+recycled amounts).

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
	○ Recycling or recovery rates for selected waste or material types	Compl	H	M	OECD MFRP ; EU MF	Complements the national recycling rate. Can be related to indicators on targets and distance to targets below to monitor policy outcomes. Should distinguish between recycling and other recovery operations. Examples of waste types include bio-waste, WEEE, plastics; packaging, construction and demolition waste.
	○ Incineration rates with energy recovery	Compl	M	H		Complements the national recycling rate.
	○ Capacity of waste recovery infrastructure, by type (recycling, incineration with energy recovery, other recovery)	Compl	M	M		Interpretation: Capacity does not reveal whether waste is effectively recycled. To be read with information on actual recovery rates and on related infrastructure investments. Could be a contextual indicator.
2.5 Materials leaving the economic cycle	**Waste going to final disposal** (landfill or incineration w/o energy recovery): total; by type of materials	**Core**	H	H/L	OECD MFRP; WP3 Core	Accounts for domestic waste going to final disposal in the country and abroad. Examples of material types include plastics, organic materials. Requires an appropriate breakdown in waste statistics or accounts.
3. Interactions with trade *(see also "opportunities" below)*						
3.1 Trade in materials	○ Material exports, material imports (incl. in RMe) ○ Physical trade balance (incl. in RMe)	Compl	M	H	OECD MFRP	
	○ Material intensity of trade flows (trade value indicator)	Compl	M	H	OECD MFRP	Material intensity= net weight/value of goods traded; Trade value indicator = value/net weight of goods traded; (aggregated indicator or per product type or material).
3.2 Trade in CE related materials and products	○ Trade in secondary raw materials: share in imports, in exports ○ Trade in second-hand goods, EoL products ○ Trade in waste and scrap	Compl	M	H	OECD MFRP	Equally relevant for "opportunities".
Interactions with the environment						To be supplemented with other environmental indicators as appropriate.
1. Natural resource implications *(of material extraction and processing)*						
1.1 Changes in natural resource stocks	○ Domestic extraction from natural stocks (renewable & non-renewable) (trends; mix)	Compl	M	H	OECD MFRP	To be expanded with information on unused extraction (see below).
	Placeholder: Natural resource index (aggregate and by type of material; non-renewable assets) / **Depletion ratios**, extraction over existing reserves	**Core**	M	M/L	OECD MFRP, GGI	Most relevant indicator to be identified. Level of application tbd. (national, global). Data available for mineral and energy sub-soil resources (accounts) for selected "resource rich" countries by type of stock. See http://dotstat.oecd.org/Index.aspx?DataSetCode=NAT_RES
	○ Changes in natural stocks (global) of mineral resources	Cont	M	M		Provides global context.
	Intensity of use of renewable freshwater resources (abstraction over available renewable stocks) (water stress)	**Core**	H	M	OECD CEI, GGI; SDG 6.4.2; WP3 Core	Reflects the (potential) pressure on renewable freshwater resources from abstraction during material extraction, processing and use (total freshwater abstraction),
	○ Intensity of use of forest resources (removals over growth)	Compl	H	M	OECD CEI	
1.2 Other natural resource impacts	○ Water abstracted for material extraction and processing	Compl	M	M		To be read with (i) water stress reflecting total freshwater abstraction from material extraction, processing and use, and (ii) water discharges and safe treatment. Sector scope to be confirmed.
	○ Water footprint of selected products or sectors	Compl	M	M		Link to WP3 complementary indicators.
	○ Natural resource residuals: Unused extraction (by material group)	Compl	M	L		Refers to unused domestic extraction. Complements domestic extraction used. Could be related to information on potential impacts on habitats and ecoystems.
2. Environmental quality implications *(of material extraction, processing, use, and end-of-life management management)*						
2.1 Impacts on climate	**GHG emissions from production activities** (trends, intensities) – Total GHG emissions (proxy)	**Core**	H	M H	WP3 Core	To be derived from air emission accounts (SEEA). Refers to emissions from the production of goods and services. Total emissions from GHG inventories could be used as a proxy
	○ Share of emissions from waste management or waste sector	Compl	H	M	WP3	Complements the core indicator by showing the contribution of waste management to GHG emissions. Could further be complemented with "share of emissions from resource intensive sector".

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
	○ Carbon footprint (CO_2)	Compl	H	M	WP3 Core	Complements the indicators on GHG emissions. To be read together with the material footprint indicator. Sector scope to be confirmed (all or focus on the production of good and services as for GHG emissions above).
	○ Carbon footprint of priority materials or products, of selected sectors	Compl	M	L	OECD MFRP	Complements the C footprint indicator. The materials, products, sectors to be covered need to be selected.
2.2 Impacts on air quality	○ Air pollutant emissions from production activities (trends, intensities)	Compl	M	M		To be derived from air emission accounts (SEEA). Refers to emissions from the production of goods and services. The pollutants to be covered need to be selected (e.g. PM2.5).
	○					
2.3 Impacts on water and soil quality	**Pollutant discharges from material extraction and processing to water bodies & share safely treated** – Total discharges to water bodies & % safely treated (proxy)	**Core**	M	M	OECD CEI; WP3 Core: safe treatm.	Discharges from material extraction and processing and their safe treatment. The pollutants to be covered need to be identified (e.g. heavy metals, nutrients). Sector scope to be confirmed. Link to SDG 6.3.1
	○ Share of waste improperly managed (proxy for waste leakage) ○ Number of uncontrolled open landfills	Compl	H	M		Important indicators for countries confronted with basic waste management issues.
	Placeholder: Soil contamination	Compl	M	M		
2.4 Impacts on biodiversity	Placeholder: Impacts from material extraction, processing, use and end-of-life management on land, habitats and species	Compl	H	M		Possible indicators: land cover change with focus on the spatial occupation of the built environment; land footprint. Indicator reflecting the impacts of marine plastics.would also be relevant. Developing and measuring such indicators would require a consensus on the methodologies to use (e.g. life cycle based assessments).
2.5 Impacts on human health	Population exposure to air pollution; related premature deaths and welfare costs	Compl	M	M		To be derived from EO sources. See the OECD datasets on environmental health and risks.
	Placeholder: Water-related health impacts	Compl	M	M		See WHO Global Burden of Disease project. Most relevant indicator to be identified.
	Placeholder: population groups living in the vicinity of waste management sites and production sites	Compl	M	L		Most relevant indicator and calculation method to be identified. Links to well-being and environmental justice.

Responses and actions

1. Support circular use of materials, promote recycling markets and optimise design

1.1 Measures supporting circular business models and encouraging reuse, repair, remanufacturing *(incl. industrial ecology/ symbiosis & sharing models)*	**Taxes and government support for CE business models**	**Core**	H	M	OECD, Eurostat, WP3 Core	Most relevant indicator and calculation method to be identified. Requires a definition of CE business models in the context of tax systems. CE relevant subsidies and other government support (including tax reliefs and exemptions) to be identified. Measurement boundaries to be specified. Could be derived from accounts on 'Environmental subsidies and similar transfers' building on the SEEA (Eurostat).
	○ VAT relief and tax credits for refurbished/repaired items	Compl	H	M		
	○ Tax benefits for businesses for the purchase/use of repaired, refurbished, remanufactured items	Compl	H	M		
	○ Trade tariffs: Import and export taxes for re-used and refurbished equipment compared to taxes on new equipment	Compl	H	M		
	○ Circular Public Procurement (CPP) or Green Public procurement (GPP): share of CPP (GPP) in total public procurement (total; by type of good)	Compl	H	L	EU MF, WP3 Core	CPP could be a core indicator. GPP to be considered as a proxy. Links to SDG 12.7.1: Degree of sustainable public procurement policies and action plan implementation. PP accounts for a large share of consumption and can drive the circular economy and innovation.
1.2 Measures encouraging optimised design or eco-design	Design for extending lifespans (i.e. durability, repairability, upgradeability) ○ Requirements for minimum lifespan, warranties, software upgrades ○ Requirements for accessibility to spare parts	Compl	H	M		Most relevant indicator and calculation methods to be identified. Could become part of “other relevant information to be considered”.

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
	Design for recycling, dismantling & material circularity ○ Bans/Guidelines on hazardous substances ○ Taxes on difficult-to-recycle items ○ Availability of guidance documents on design for recycling	Compl	H	M		Most relevant indicator and calculation methods to be identified. Could become part of "other relevant information to be considered".
1.2 Measures encouraging efficient use of materials and economically efficient waste recovery	○ Reform of subsidies encouraging unsustainable use or extraction of materials, e.g., taxes on virgin materials	Compl	H	M		Could be expanded to economic instruments encouraging linearity.
	Extended Producer Responsibility (EPR) schemes Availability of EPR schemes in different product sectors: distance between reported performance and set target	Compl	M	M		Product sectors could include: automobiles, batteries, tyres, packaging, pharmaceuticals, textiles, etc. Distance could be zero if legally binding performance target is not available. Could be a core indicator for countries.
	Deposit-refund systems (DRS) & Pay-as-you-throw (PAYT) schemes ○ Availability of DRS in different product sectors (scope of beverage containers, for reuse & recycling) ○ Availability of PAYT schemes	Compl	M	H/M		Best way to calculate and present these indicators to be identified. To be complemented with stringency indicators e.g. the disposal cost difference between different waste types. Could become part of "other relevant information to be considered".
2. Improve the efficiency of waste management and close leakage pathways						
2.1 Measures to improve waste management	**Investments in waste management infrastructure, waste collection and sorting** (government, businesses)	**Core**	H	M	EU MF; WP3 Core	To be derived from environmental expenditure accounts (SEEA). If data availability permits, could be expanded with information on investments in (i) repair, reuse and waste prevention infrastructure; (ii) energy recovery of waste; (iii) sound disposal of waste
2.2. Measures to encourage waste reduction	○ Bans, taxes on frequently littered items or single-use items (e.g. plastics)	Compl	H	H		
	○ Tax rate/tonne landfilled or incinerated	Compl	H	H		Could be derived from the OECD PINE database. Important indicator for countries with waste management challenges.
	○ Landfill bans	Compl	H	H		Important indicator for countries with waste management challenges.
3. Boost innovation and orient technological change						
3.1 Measures supporting R&D	**Government and business R&D expenditure on CE technologies** (recycling, secondary raw materials, …): budget allocations	**Core**	H	M/L		Allocating data on R&D budgets to circular projects/topics is not easy. The measurement boundaries need to be specified.
3.2 Technology development and international diffusion	○ Patented inventions related to (1) recycling and secondary raw materials; and (2) reuse and repair models as: – % of total technologies, by inventor's residence	Compl	M	M/L	OECD; EU MF; WP3 Core	Innovative technologies related to the CE can boost countries' global competitiveness. Patents however only give only a limited view on what is being invented. Little data are available on patents for repair and reuse models. Indicators equally relevant for "opportunities".
	– % of foreign inventors, by patent office	Compl	M	M/L		
4. Target setting and planning						
4.1 Targets & distance to targets	Placeholder: Distance to targets	Compl				Should revealing how distance to targets changes over time. Most relevant indicator to be identified. To be related to material life cycle indicators ("waste generation" and "recycling" indicators). Interpretation needs to take into account that targets vary across countries and depend on national circumstances and levels of ambition. Could be core indicators for countries. N.B. Monitoring recycled content targets and reuse targets is challenging. To be applied to selected products (plastics, food, packaging, …).
	– Resource productivity targets	Compl	H	H	WP3 Core (Placeholder)	
	– Recycled content targets, by type of product	Compl	H	M/L		
	– Recycling targets, by type of waste	Compl	H	H		
	– Reuse targets, by type of product	Compl	H	L		
	– Waste reduction and prevention targets, by type of waste	Compl	H	H		
	– Landfill targets, distance to targets by type of waste	Compl	M	H		Important indicator for countries with waste management challenges.
4.2 CE strategies & plans	tbd	Compl	M	?		Most relevant indicator and calculation method to be identified. Could become part of "other relevant information to be considered".

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
5. Strengthen financial flows						
5.1 Domestic financial flows	**Business investment on CE activities**	**Core**	H	M	EU MF. WP3 Core	To be derived from environmental expenditure accounts (SEEA). Could be related to jobs and value added in the CE sector (cf EU MF) and to subsidies and other transfers supporting CE sectors. Data availability is best for reuse and recycling activities and in EU countries. Other activities such as renting and leasing could be added in future; current statistics are not granular enough to provide a means of distinguishing activities that clearly contribute to a circular economy from those that do not.
	○ Revenue from CE related taxes	Compl	H	H/M		Could be derived from the OECD PINE database or from environmentally related tax revenue accounts building on the SEEA. Requires a consensus on the measurement boundaries.
	○ Government budgets allocated to CE objectives	Compl	H	M		Country-specific indicator. Could be derived from green budgeting initiatives in countries.
5.2 International financial flows	○ CE related Official Development Assistance (ODA)	Compl	M	L		Data on financial flows related to waste management exist. CE related flows are more difficult to identify. The measurement boundaries need to be specified.
	○ CE related Foreign Direct Investment (FDI)	Compl	M	L		
6. Inform, educate and train						
− Information instruments	Placeholder ○ Eco-labelling; product labelling & certificates ○ Requirement to provide repair guidelines ○ Requirement to provide: − information on expected lifespan − dismantling guidelines & material content lists for recyclers	Compl	M	M/L		Most relevant indicators and calculation methods to be defined; data sources to be identified. Could become part of "other relevant information to be considered".
− Education and training	Placeholder ○ Integration of CE issues in school curricula and professional training	Compl	H	M		

Socio-economic opportunities for a just transition (economic efficiency and social equity)

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
1. Market developments and new business models						
− CE entrepreneurship, goods & services incl. uptake of new circular business models, industrial ecology/symbiosis initiatives	**Gross value added related to circular economy sectors:** share in GDP and change over time	**Core**	M	H/L	EU MF; WP3 Core	Reflects the contribution of the circular economy to the creation of growth. To be derived from national accounts or SEEA-related EGSS accounts. Trend in indicator value is more important than absolute values. CE sectors delineated as waste and recycling. Should be expanded to include repair services and second-hand markets as data availability progresses. Could be complemented with information on power production from renewable sources (cf SDG 7.b.1/12.a.1 and WP3 Core)
	○ CE start-ups and trademarks ○ CE certification of companies	Compl	M	L		Indicators to be defined. Data sources to be identified.
− Employment markets and jobs	**Jobs in CE sectors**: share in total employment and change over time	**Core**	H	H/L	EU MF, WP3 Core	Reflects the contribution of the circular economy to the creation of jobs. To be derived from accounts on the environmental goods and services sector (EGSS) available in EU countries. CE sectors delineated as waste and recycling. To be expanded as data availability progresses to include other CE activities, including repair services, second-hand markets and sharing economy. (cf also the EU taxonomy of sustainable activities). Trend in indicator value is more important than absolute values.
	○ Jobs in sharing economy, reuse and repair activities: number and change over time	Compl	H	L		Complements the core indicator by providing additional detail on the sharing economy, repair and reuse activities. Trend in indicator value is more important than absolute values. Data on repair activities may be more available than data on jobs in the sharing economy or in reuse services. Alternative data sources are needed.

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
− Recycling markets	○ Markets for recycled materials	Compl	H	L		Indicator to be defined. To focus on materials of particular importance from an environmental and economic point of view (e.g. construction, plastics, metals)
2. Trade developments						
− Trade in CE related goods and services	○ Trade in recycled (secondary raw) materials (share in imports & exports)	Compl	M	M/L	OECD MFRP EU MF	Trade in recycled and recyclable materials reflects the importance of the domestic market and global participation in the circular economy. Requires a common definition of "recyclable" materials. "Recyclability" is challenging to define. Technical and economic factors play a role. To be read with "interactions with trade" under "material life cycle" above.
	○ Trade in recyclable materials (share in imports & exports)	Compl	M	L		
− Supply security/ autonomy	Domestic material autonomy (aggregate, by material group) a. share of domestic extraction in DMI or DMC b. share of domestic extraction in RMI or RMC	Compl	H	H	OECD MFRP, EU MF, WP3 Core	Double-headed indicator. To be read with "interactions with trade" under "material life cycle" above. Material autonomy is an important driver for moving towards a CE.
	○ Supply security of "strategic" raw materials, by material or material group	Compl	H	M	OECD MFRP, EU MF	A circular economy helps address the supply risks for raw materials, in particular "strategic" materials. May vary across countries and regions. Could be a core indicator if common strategic raw materials are identified. Tbd what to classify as "strategic" materials. Needs to consider economic & environmental factors. Different methodologies exist to assess material criticality (e.g. Coulomb et al. 2015; Graedel et al. 2011). See also EU critical raw materials.
	○ Food security ○ Energy security	Compl	H	M		Could be considered as indicators on the supply security of strategic materials (raw and processed or semi-processed).
3. Skills and awareness						
− Skills	○ CE literacy ○ CE skills : indicator tbd	Compl	M	L		Most relevant indicators to be identified.
− Awareness	○ Public opinion on CE issues and actions	Compl	M	L		
− Behavioural changes	Placeholder: Households, consumer, firm behaviour	Compl	M	L		
4. Inclusiveness of the transition						
	Placeholder: Distributional aspects & socio-economic inequality of CE policies	tbd	M	L		Would reflect how different territories and population groups are affected or benefit from CE policies and actions (young people, women, vulnerable communities, etc.). To be complemented with more general inequality indicators (see socio-economic context below).
1. Factors that drive demand for materials						
− Socio-demographic factors	○ Population growth and structure ○ Household size	Cont	M	H		
− Economic factors	○ GDP growth and structure (trends, value added by sector)	Cont	M	H		
	○ Income levels: GDP per capita	Cont	M	H		Could further be supplemented with debt to income ratio, poverty index, energy poverty, employment rates, etc.
	○ Income inequality (Gini index); wealth inequality	Cont	M	H/M		
	○ Human development index (HDI)	Cont	M	H		
	○ Final consumption expenditure: government, household	Cont	M	H		
− Sectoral drivers	○ Construction: tbd, e.g., floor space per capita, value added of construction sector	Cont	H	M/L		
−	○ Other (tbd)					

Framework themes and indicator topics	Possible indicators (a)	Type (b)	Rel. (c)	Meas. (d)	Related indicator sets (e)	Comments
2. Factors that influence the environmental implications of material use						
− Environmental drivers	○ Energy supply and consumption: trends and intensities	Cont				
	○ Water use efficiency	Cont				
	○ Protected areas	Cont				
	○ Other					

6 List of issues for further work

6.1 Review of international classifications

228. Circular economy is present in all stages of the product life cycle. When measuring circular economy, all activities leading to circularity should be taken into account, including for example, sustainable design and efforts to lengthen product life cycle. It might not be possible to capture all these activities directly with the help of activity or product classifications also due to the fact, that they are often integral parts of other activities. However, **existing activity and product classifications should be optimized** for the capturing of circular economy to facilitate the measurement endeavours.

229. **There is currently no globally accepted classification of wastes**. The CES Task Force on Waste Statistics (UNECE, 2021) recommended that a classification be proposed for global use based on the European Waste Classification for Statistics for both hazardous and non-hazardous waste. This would improve international comparability and indicator development, thus improving monitoring of sustainable production and consumption. Also worth discussing is the need for a classification of waste-related products (such as secondary raw materials) by type of material (paper, aluminium, etc.). This would help inform policies on manufacturing and mineral extraction in a circular economy.

230. **Better alignment of Harmonized Commodity Description and Coding System (HS)** for monitoring the transboundary movements of waste: Wastes are not reflected consistently throughout the HS nomenclature. Solutions need to be found to better adapt HS for monitoring of transboundary movements of waste.

6.2 Major measurement issues and data gaps

231. The assessment of the measurability of the indicators proposed in section 5.2 reveals important gaps in the data required for calculating these indicators, including core indicators, and a number of measurement challenges that will need to be addressed. These challenges can be grouped into three categories:

- **Indicator definition:** challenges related to indicator definitions, classifications, measurement boundaries and calculation methods.
- **Data accessibility**: challenges that arise when data are available, but access is hindered by legal or financial constraints (e.g. business confidentiality).
- **Data mobilisation and collection**: challenges related to data availability and production, i.e. data are not or hardly available or available in formats or levels of detail that are not appropriate.

232. For many core indicators, more than one challenge is experienced. The feasibility for solutions to overcome these challenges also varies among the indicators.

233. In terms of data availability, indicators on material flows, waste, recycling and emissions are measurable and in reach for any country given dedicated investments. Hence waste management information (e.g., waste generation rates, recovery and recycling rates, disposal rates) can be used as a starting point, in particular data on municipal waste whose availability is often best and that still mirrors trends in household consumption expenditure. This can be complemented with information on specific waste streams (e.g., construction and demolition waste, food waste, hazardous waste) and with material flow data from national or international sources.

234. However, it should be borne in mind that although all OECD countries and most CES member countries produce **data on waste**, data quality has been an issue and many gaps remain.

- Gaps exist in particular as regards (i) non-hazardous industrial waste, (ii) amounts of particular waste streams and related recovery and recycling efforts, (iii) categories of hazardous waste.

- Gaps are also notable as regards metadata and the documentation of the data (e.g. information on definitions and surveying methods, breaks in time series, waste collection methods, waste prevention measures, national laws and regulations).
- In many countries official data on waste and materials management in the business sector remain scarce, and little information exists on waste prevention measures and the use of secondary raw materials in production processes.
- Not all countries have established material flow accounts. In countries where such accounts are produced, the data on material flows cannot easily be combined with data on waste.
- In most countries data quality is affected by frequent changes in definitions and methodologies that reduce the length and the coherence of the time series available and make it difficult to monitor the effects of earlier policy measures.

235. Indicators describing particular mechanisms or features of a CE, like **higher R-strategies**, CE activities, **employment** in circular economy sectors and **behavior**, are more difficult to measure and may require longer-term efforts. Aspects that cannot easily be measured in statistical terms may need to be monitored by using other more qualitative types of information.

236. Important gaps identified in the *2021 Report on the Implementation of the OECD Recommendation on Resource Productivity* (OECD, 2021b) include:

- Information on flows of materials that are important to a CE, distinguishing between primary and secondary raw materials. This is important for assessing resource productivity and decoupling trends, and for understanding the economic benefits of a circular economy.
- Information on key materials and substances, including critical raw materials, environmentally harmful substances, substances that play a role in global biogeochemical cycles and materials that raise global concerns as to their production, use and end-of-life management (e.g. plastics; food; materials in electric and electronic goods; packaging materials).
- Information on the different processing levels of materials (raw materials, semi-finished products, finished products) that is needed to identify opportunities for improved performance and efficiency gains in production and consumption processes, and along the supply chain.
- Information on the size and value of the material stocks locked in the economy, i.e. future urban mines, which is needed to understand the potential of urban mines to contribute to future supply and how they relate to virgin stocks.
- Information on the actual environmental impacts and costs of material resource use throughout their life-cycle, and on the availability of natural resource stocks.
- Information on economic and fiscal instruments in use to improve resource productivity, including subsidies for resource extraction and use, beyond those for fossil fuels, and other market-based instruments.

6.3 Indicators research agenda

237. The shift to a circular economy entails having a new perspective to measure the different components of the economy. Although indicators are proposed to provide an in-depth assessment of circular economy, other indicators require additional research and elaboration. These research areas include for example:

- **Avoided components**: including for example avoided food waste, expenditure, etc. Currently, such indicators or methodologies are not available and entail the development of models to estimate the avoided portion;

- **Reduction in GHG emissions** as a result of reduced use of resources: although the EEA is working on a similar approach, this is not yet available. However, other existing indicators can be used to interpret similar conclusions;
- **Average life span of products**: this refers to the extended life span of products that result in reduced product purchasing and less waste;
- **Intensity of products used**;
- **Products' values across its life cycle**;
- **Recycling quality**: this refers to measuring the quality of recycled materials that are re-introduced to the manufacturing industry; and
- **Value of substitute products (or services):** this refers to the new development and technologies that replace products or services available in the market, I.e., the increased use of e-books.

7 Glossary of terms

Term	*Definition*	*Source*	*Comments*
Biological cycle	The processes - such as composting and anaerobic digestion - that together help to regenerate natural capital. The only materials suitable for these processes are those that can be safely returned to the biosphere.	Ellen Mac Arthur Foundation Glossary	
Biological materials	Biological materials can, after use, safely flow back to the environment, where they will biodegrade.	Ellen Mac Arthur Foundation	See also technical materials
By-products	Product that is produced simultaneously with another product but which can be regarded as secondary to that product, for example gas produced by blast furnaces.	SNA	
Circular economy	A circular economy is an economy where the value of materials in the economy is maximised and maintained for as long as possible; the input of materials and their consumption is minimised; and the generation of waste is prevented and negative environmental impacts reduced throughout the life-cycle of materials.	OECD expert group and UNECE Task Force	Headline definition as defined in this report
Critical raw materials	Those raw materials that are most important economically and have a high supply risk.	European Commission (2020a)	
Finite materials	Materials whose stocks are non-renewable on timescales relevant to the economy, i.e. not geological timescales.	Ellen MacArthur Foundation Glossary	Examples include: Metals and minerals; fossil forms of carbon such as oil, coal, and natural gas; and sand, rocks, and stones
Goods	Physical objects for which a demand exists, over which ownership rights can be established and whose ownership can be transferred from one institutional unit to another by engaging in transactions on markets; they are in demand because they may be used to satisfy the needs or wants of households or the community or used to produce other goods or services.	SNA	
Material	Materials are physical bodies that have mass and volume.	EW-MFA	For the purpose of measuring the circular economy, it is recommended to use the EW-MFA definition of materials with the understanding that it includes materials at all relevant stages of the material life cycle.
Natural resources	Natural resources include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources.	SEEA-CF	

Term	*Definition*	*Source*	*Comments*
Natural resource inputs	Physical inputs to the economy from mineral and energy resources, soil resources (excavated), natural timber resources, natural aquatic resources, other natural biological resources, water resources and natural resource residuals. Natural resource inputs exclude flows from cultivated biological resources.	SEEA-CF	Cultivated biological resources are considered to be produced within the economy (i.e. their growth falls within the production boundary of the economy) and hence are not accounted for as flows from the environment.
Non-virgin material	Materials that have been previously used.		This includes: Materials in products that have been reused, refurbished or repaired; components that have been remanufactured; materials that have been recycled. Also referred to as secondary materials.
Primary raw materials	Basic natural materials that are extracted from the ground or harvested and processed into new materials or products.		For example, bauxite is the raw material that is processed into aluminium, petroleum for plastics manufacture, iron ore for steel manufacture and wood pulp for paper manufacture Synonym: Virgin materials
Primary waste	Primary waste means waste that is originally generated by industries and households outside the waste management industry, whereas the term secondary waste is used for waste that arises in the waste management industry as output from waste treatment.		
Products	Goods and services (including knowledge-capturing products) that result from a process of production.	SNA	Most CE definitions use the term "products" to designate a physical item, which has a value. The proper SNA term in this context would be "goods"
Raw materials	Natural resources which are converted into useful primary materials. Examples are ores (for metals), minerals (e.g. chalk, gravel, sand, stones), air and water, but also oil, natural gas, coal and biomass if they are used as matter (e.g. construction materials, lubricants)	OECD MFA Guide (https://www.oecd.org/environment/indicators-modelling-outlooks/MFA-Guide.pdf)	Examples are ores (for metals), minerals (e.g. chalk, gravel, sand, stones), air and water, but also oil, natural gas, coal and biomass if they are used as matter (e.g. construction materials, lubricants) A distinction can be made between primary raw materials and secondary raw materials
Recovery	Any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy	EU Waste Framework Directive	A sub-category of "waste management"
Recycling	Any activity by which materials are recovered from a waste stream for the purpose of providing material inputs for use in another production process (other than processes designed for energy recovery, the		A sub-category of "waste management" The conceptual definition uses a slightly different wording than the EU Waste Framework Directive

Term	*Definition*	*Source*	*Comments*
	reprocessing into fuels or material for backfilling)		
Renewable material	Materials whose stocks are continually replenished at a rate equal to or greater than the rate of depletion.	Ellen MacArthur Foundation Glossary	Examples include: cotton, hemp, maize, wood, wool, leather, agricultural by-products, nitrogen, carbon dioxide, and sea salt. To fit in a circular economy such materials (where relevant) must be produced using regenerative production practices.
Residuals	Flows of solid, liquid and gaseous materials, and energy that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation.	SEEA-CF	The term "waste" as used in the headline definition of a circular economy can be understood as referring to any kind of residuals.
Re-use	Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived	EU Waste Framework Directive	
Re-usable products	Used and end-of-life goods (including second-hand goods) diverted from the waste stream for re-use, remanufacturing, repair or trade (e.g. electrical and electronic equipment or its components that can be used for the same purpose for which they were conceived).		Re-usable products can be diverted from the waste stream after waste collection (thus ceasing to be waste), or before the products become waste.
Secondary materials	Materials recovered from recycling	International Resource Panel and CES Waste Statistics Framework	Ellen MacArthur foundation uses the term non-virgin materials which could be understood as a synonym.
Secondary raw materials	Materials and products which can be used as raw materials by simple re-use, or via recycling and recovery	European Commission (2022)	
Secondary wastes	Residual materials left over after treatment of waste	Eurostat Glossary and CES Waste Statistics Framework	
Technical cycle	The processes that products and materials flow through in order to maintain their highest possible value at all times. Materials suitable for these processes are those that are not consumed during use - such as metals, plastics and wood.	Ellen MacArthur Foundation Glossary	
Technical materials	Technical materials such as metals, plastics, and synthetic chemicals, cannot flow back to the environment without negative impacts. These materials must be kept in the economic cycle and value chain as long as possible	Ellen MacArthur Foundation	See also biological materials

Term	*Definition*	*Source*	*Comments*
Virgin materials	Materials that have not yet been used in the economy.	Ellen MacArthur Foundation Glossary	These include both finite materials (e.g. iron ore mined from the ground) and renewable materials (e.g. newly produced cotton). Synonym: Primary raw materials
Waste	Any material which the holder discards or intends or is required to discard.	CES Waste Statistics Framework	Note that in the context of the headline definition of a circular economy the term waste is understood to encompass all types of residuals.
Waste collection	The gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport	EU Waste Framework Directive and CES Waste Statistics Framework	
Waste disposal	Any operation which main purpose is not the recovery of materials or energy even if the operation has as a secondary consequence the reclamation of substances or energy. It includes incineration without energy recovery, deposit into or onto land (e.g. landfilling), deep injection, surface impoundment, release into water bodies and permanent storage.	CES Waste Statistics Framework	
Waste management	Set of lawful activities carried out by economic units of the formal sector, both public and private for the purpose of the collection, transportation, and treatment of waste, including final disposal and after-care of disposal sites.	CES Waste Statistics Framework	The conceptual definition clarifies that it refers to legal activities carried out by economic units of the formal sector
Waste minimisation	Preventing and/or reducing the generation of waste at the source; improving the quality of waste generated, such as reducing the hazard, and encouraging re-use, recycling, and recovery	OECD	
Waste prevention	Measures taken before a substance, material or product has become waste, that reduce (a) the quantity of waste, including through the re-use of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products.	EU Waste Framework Directive and CES Waste Statistics Framework	In the context of the headline definition of a circular economy “waste prevention” should be understood as prevention of any kind of residuals, also including emissions to air and to water.
Waste treatment	Recovery or disposal operations, including preparation prior to recovery or disposal	EU Waste Framework Directive	A sub-category of "waste management"

8 References

CES (Conference of European Statisticians) (2021): In-depth Review of Measuring Circular Economy, https://unece.org/sites/default/files/2021-05/08_Measuring_Circular_Economy_full_version_ENG.pdf

Delahaye, R., Bogaart, P., Couzy, P. & Schoenaker, N. (2020): Analyzing and Visualizing Material Flows within the Circular Economy

Delahaye, R., Tunn, V. S. C., & Tukker, A. (2022): Developing a material flow monitor for the Netherlands from national statistical data. Journal of Industrial Ecology, 1–15. https://doi.org/10.1111/jiec.13365.

Ellen MacArthur Foundation (2021): Circular Economy Glossary. https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/glossary

European Commission (2007): Communication from the Commission to the Council and the European Parliament on the Interpretative Communication on waste and by-products. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52007DC0059&from=EN

European Commission (2008): Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. https://eurlex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098

European Commission (2018): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a monitoring framework for the circular economy, COM(2018)029 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A29%3AFIN

European Commission (2020): Categorisation System for the Circular Economy, A sector-agnostic approach for activities contributing to the circular economy, https://op.europa.eu/en/publication-detail/-/publication/ca9846a8-6289-11ea-b735-01aa75ed71a1

European Commission (2020a): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability, COM/2020/474 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0474

European Commission (2020b): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2020)98 final, A new Circular Economy Action Plan, For a cleaner and more competitive Europe, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:98:FIN

European Commission (2022): Raw Materials Information System (RMIS), Circular economy, secondary raw materials & waste, Policies and definitions, https://rmis.jrc.ec.europa.eu/?page=policies-and-definitions-2d5b5e

EEA (European Environment Agency) & ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) (2020): Bellagio Declaration. Circular Economy Monitoring Principles. https://epanet.eea.europa.eu/reports-letters/monitoring-progress-in-europes-circular-economy

Eurostat (2016): Environmental goods and services sector accounts — Handbook 2016 edition, https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ks-gq-16-008

Eurostat (2018): Economy-wide material flow accounts Handbook, 2018 edition, https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ks-gq-18-006

Hanemaaijer, A., Kishna, M., Koch, J., Lucas, P.,Rood, R., Schoten, K., en van Sluisveld, M.,. (2023), Integrale Circulaire Economie Rapportage 2023, Den Haag: PBL, https://www.pbl.nl/sites/default/files/downloads/pbl-2023-icer-2023-4882.pdf

International Resource Panel, United Nations Environment Programme (IRP) (2018). Re-defining Value – The Manufacturing Revolution. Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy. Nabil Nasr, Jennifer Russell, Stefan Bringezu, Stefanie Hellweg, Brian Hilton, Cory Kreiss, and Nadia von Gries. https://wedocs.unep.org/handle/20.500.11822/31612

International Resource Panel, United Nations Environment Programme (IRP) (2022): Glossary. https://www.resourcepanel.org/glossary

McCarthy, A., R. Dellink and R. Bibas (2018), "The Macroeconomics of the Circular Economy Transition: A Critical Review of Modelling Approaches", *OECD Environment Working Papers, No. 130*, OECD Publishing, Paris, https://doi.org/10.1787/af983f9a-en.

OECD (2008a): Measuring Material Flows and Resource Productivity. https://www.oecd.org/environment/indicators-modelling-outlooks/MFA-Guide.pdf

OECD (2008b): Recommendation of the Council on Resource Productivity. OECD/LEGAL/0358. https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0358

OECD (2011): Working Party on Environmental Information, Material Flow and Resource Productivity Indicators, ENV/EPOC/WPEI(2011)4/REV, https://one.oecd.org/document/ENV/EPOC/WPEI(2011)4/REV/en/pdf

OECD (2020): The Circular Economy in Cities and Regions: Synthesis Report, OECD Urban Studies, OECD Publishing, Paris, https://doi.org/10.1787/10ac6ae4-en

OECD (2021): The OECD Inventory of Circular Economy indicators, https://www.oecd.org/cfe/cities/InventoryCircularEconomyIndicators.pdf

OECD (2021b): Report on the Implementation of the OECD Recommendation on Resource Productivity, C(2021)62/REV1, https://one.oecd.org/document/C(2021)62/REV1/en/pdf

Potting, J., Hekkert, M., Worrel, E. & Hanemaaijer, A. (2017): Circular Economy: Measuring innovation in the product chain, Policy Report, https://www.pbl.nl/sites/default/files/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf

Potting, J., Hanemaaijer, A., Delahaye, R., Ganzevles, J., Hoekstra, R. & Lijzen, J. (2018): Circular Economy: What We Want to Know And Can Measure. Framework and Baseline Assessment for Monitoring The Progress of the Circular Economy in the Netherlands. The Hague: PBL Netherlands Environmental Assessment Agency. https://circulareconomy.europa.eu/platform/sites/default/files/pbl-2018-circular-economy-what-we-want-to-know-and-can-measure-3216.pdf

Prognos & DevStat (2022): Eurostat funded project. Lot 6: Economic aspects of the circular economy. Task 2 – Data compilation and dissemination. Data Note: Methods to compile data (Phase I version). https://circabc.europa.eu/ui/group/b01d2930-990e-44fb-9121-a9a6b00a1283/library/e686bdcf-5869-4e12-9f2d-6c8112bb3952/details

UNECE (2021): Conference of European Statisticians Framework on Waste Statistics. https://unece.org/statistics/publications/conference-european-statisticians-framework-waste-statistics

UNECE & FAO (Food and Agriculture Organization of the United Nations) (2021): Circularity concepts in forest-based industries, https://unece.org/forests/publications/circularity-concepts-forest-based-industries

United Nations (2013): Framework for the Development of Environment Statistics, https://unstats.un.org/unsd/environment/FDES/FDES-2015-supporting-tools/FDES.pdf

United Nations, European Commission, IMF, OECD & The World Bank (2009): System of National Accounts 2008, https://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf

United Nations, European Commission, FAO, IMF, OECD & The World Bank (2012): System of Environmental-Economic Accounting 2012 – Central Framework, https://seea.un.org/content/seea-central-framework

Yamaguchi, S. (2021), "International trade and circular economy - Policy alignment", *OECD Trade and Environment Working Papers*, No. 2021/02, OECD Publishing, Paris, https://doi.org/10.1787/ae4a2176-en

Annex 1: Examples of selected definitions of a circular economy

There are numerous definitions of the CE in existence among international organizations, many of which share commonalities with each other. The following section highlights a selection of these definitions, which were all taken into consideration in the development of the headline definition.

<u>Bellagio declaration, Circular economy monitoring principles (EEA; EPA Network; ISPRA; SNPA), final (Dec. 2020)</u>
A circular economy is an economy where the value of products, materials and resources is maintained in the economy for as long as possible. All outputs from one process is input for another. Thus, a move towards a circular economy entails reducing the intake of virgin materials and reducing the generation of waste.

<u>Ellen MacArthur Foundation (website glossary; accessed Oct. 2020)</u>
The circular economy [is] a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution. It is based on three principles, driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature. It is underpinned by a transition to renewable energy and materials. Transitioning to a circular economy entails decoupling economic activity from the consumption of finite resources. This represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits.

<u>EU Action Plan for a Circular Economy, COM(2015) 614 final</u>
A more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy.

<u>EU Taxonomy Regulation, Regulation 852 (2020)</u>
Circular economy means an economic system whereby the value of products, materials and other resources in the economy is maintained for as long as possible, enhancing their efficient use in production and consumption, thereby reducing the environmental impact of their use, minimising waste and the release of hazardous substances at all stages of their life cycle, including through the application of the waste hierarchy.

<u>International Organization for Standards (ISO), draft[11]:</u>
[The circular economy *is an] economic system that uses a systemic approach to maintain a circular flow of resources, by recovering, retaining or adding to their value, while contributing to sustainable development.*

<u>UN Environment Programme (UNEP) Resolution Innovative pathways to achieve sustainable consumption and production, UNEP/EA.4/Res.1, Nairobi, 11–15 March 2019</u>
A more circular economy, one of the current sustainable economic models, in which products and materials are designed in such a way that they can be reused, remanufactured recycled or recovered and thus maintained in the economy for as long as possible, along with the resources of which they are made, and the generation of waste, especially hazardous waste, is avoided or minimized, and

[11] https://www.wcoomd.org/-/media/wco/public/global/pdf/events/2022/greener-hs/session-3/iso-tc-323-iso_international-standardization-activities-in-the-circular-economy.pdf?la=en

greenhouse gas emissions are prevented or reduced, can contribute significantly to sustainable consumption and production.

UNEP, buildingcircularity.org (Accessed Oct. 5, 2021)
In a more recent document from the ENEP, the UNEP expands on the circular processes, which it has grouped into 4 categories, from the most impactful to the least:
1. Reduce by design (reducing the amount of material used, particularly raw material, should be applied as an overall guiding principle from the earliest stages of design of products and services;
2. From a user to user perspective: Refuse, Reduce and Re-use;
3. From a user-to-business intermediary perspective: Repair, Refurbish and Remanufacture;
4. From business-to-business: Repurpose and Recycle.

An analysis of 114 definitions of the CE by Kirchherr et al. (2017)
The interest in defining the circular economy goes well beyond the selected international organizations whose definitions of the CE are listed above. Many national and subnational governments, industry organizations, and academics are also interested in harnessing various aspects of the circular economy for a variety of reasons, and have come up with definitions along the way.

In 2017, Kirchherr et al. published a paper that analysed 114 different definitions of the circular economy from 148 articles from peer-reviewed journals, policy papers, and reports. Their paper concludes with a proposed definition to serve as a conceptual foundation for future work:
"A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation, and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations."

The definition in Kirchherr et al. specifically includes both a hierarchical 4R framework (reduce, reuse, recycle, recover) and a systems perspective (micro, meso, macro processes), which their research illuminated to be two core principles of the CE.

Annex 2: Selected economic nomenclatures that are relevant for measuring the circular economy

Classification	Description
ISIC Rev.4: International Standard Industrial Classifications of All Economic Activities	**Structure**: ISIC is a four-digit classification that has four hierarchical levels (21 sections, 88 divisions, 238 groups, 419 classes). **Usage and main statistical applications**: ISIC provides a set of activity categories that can be utilized for the collection and reporting of statistics in the fields of economic and social statistics, such as for statistics on national accounts, demography of enterprises, employment and others. **Coverage of application**: Worldwide **Maintenance**: United Nations Statistics Division **Interrelation with other classifications**: **NACE** is largely consistent with ISIC and the revisions of NACE and ISIC take place simultaneously. Each **CPC** subclass has a reference to the ISIC industry or industries in which most of the goods or services in question are generally produced. **Revision status**: ISIC Rev. 4 was published in 2008. The revision of ISIC is currently ongoing.
NACE[12] Rev. 2: Statistical Classification of Economic Activities in the European Community since 2008	**Structure**: NACE is a four-digit classification that has four hierarchical levels (21 sections, 88 divisions, 272 groups, 615 classes). National implementations may introduce additional levels. **Usage and main statistical applications**: Provides the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) but also in other statistical domains. **Coverage of application**: European Union **Governed by**: United Nations (the first two levels), Eurostat (third and fourth level), individual Member States (additional levels) **Interrelation with other classifications**: NACE is largely consistent with **ISIC** and the revisions of NACE and ISIC take place simultaneously. ISIC and NACE have exactly the same items at the highest levels, but NACE is more detailed at lower levels. Each **CPA** product is assigned to one single NACE activity. The first four digits of the **PRODCOM** codes are taken directly from the NACE classification. **Revision status**: NACE Rev. 2 was established by Regulation (EC) No 1893/2006 and has been used for statistics referring to economic activities performed as from 1 January 2008 onwards. The classification is currently being revised and the new revision is expected come into force in 2024.
CPC Version 2.1: The United Nations' Central Product Classification	**Structure**: CPC is subdivided into a hierarchical, five-level structure (10 sections, 71 divisions, 329 groups, 1.299 classes, 2.887 subclasses). **Usage and main statistical applications**: CPC serves as an international standard for assembling and tabulating all kinds of data requiring product detail, including industrial production, national accounts, service industries, domestic and foreign commodity trade, international trade in services, balance of payments, consumption and price statistics. It can also be used as a basis for developing lists of goods and services for specific purposes, such as price statistics surveys, tourism statistics surveys or ICT-related surveys **Coverage of application**: Worldwide **Maintenance**: United Nations **Interrelation with other classifications**: Each CPC subclass has a reference to the ISIC industry or industries in which most of the goods or services in question are generally produced. CPC subclasses for transportable goods (sections 0 to 4) are defined in such a way that each consists of one or more six-digit subheadings of the Harmonized System.

[12] **N**omenclature statistique des **a**ctivités économiques dans la **C**ommunauté **e**uropéenne.

Classification	Description
	Revision status: CPC Version 2.1 was published in 2015. The classification is currently being revised.
CPA Ver. 2.1: Statistical classification of products by activity in the European Community	**Structure**: CPA has a hierarchical structure with six levels (21 sections, 88 divisions, 261 groups, 575 classes, 1.342 categories, 3.218 subcategories). The structure of CPA is consistent with the structure of NACE. **Usage and main statistical applications**: The CPA is classification designed to categorize products (goods and services) that have common characteristics. It provides the basis for compiling statistics on the production, distributive trade, consumption, international trade and transport of products. **Coverage of application**: European Union **Maintenance**: Eurostat **Interrelation with other classifications**: CPA is largely aligned to the UN Central Product Classification **CPC**. Each CPA product is assigned to one single **NACE** activity. **Revision status**: Commission Regulation (EC) No 1209/2014 establishing CPA version 2.1 was adopted in 2014 and entered into force 1 January 2015. The classification is currently being revised.
PRODCOM[13]: Classification of goods used for statistics on industrial production in the European Union.	**Structure**: PRODCOM is an eight-digit list and its structure is consistent with the structure of NACE and CEPA. **Usage and main statistical applications**: PRODCOM is used for an annual survey for the collection and dissemination of statistics on the production of industrial goods and services. **Coverage of application**: European Union **Interrelation with other classifications**: The first four digits refer to **NACE**-classes and the next two digits refer to **CPA** subcategories. The last two digits are PRODCOM-specific but most of them have a reference to the **CN**. Most PRODCOM headings correspond to one or more CN codes. **Revision status**: PRODCOM is widely based on the NACE, CPA and CN classifications and will thus follow revisions of these classifications.
HS 2022: The Harmonized Commodity Description and Coding System	**Structure**: About 7,500 headings organized in four hierarchical levels (sections, chapters, headings, subheadings) **Usage and main statistical applications:** HS is used as a reference for classifications of trade statistics and for customs tariffs. HS basically covers goods but also electricity and the physical "manifestations" of services (e.g. architects' plans, diskettes with software etc.). **Coverage of application**: Worldwide **Maintenance**: The World Customs Organisation **Interrelation with other classifications**: The HS is at the heart of the whole process of harmonisation of international economic classifications and its items and sub-items are the fundamental terms on which industrial goods are identified in product classifications. **Revision status**: The latest version was implemented on 1 January 2022. Revisions take place every five years.
CN 2022: The Combined Nomenclature, a European classification of	**Structure**: 8-digit classification with a hierarchical structure (sections, chapters, headings, subheadings) **Usage and main statistical applications:** CN is used as a reference for classifications of trade statistics and for customs tariffs.

[13] **Prod**uction **Com**munautaire

Classification	Description
goods used for foreign trade statistics.	**Coverage of application**: European Union **Maintenance**: Eurostat and the EU Directorate General for Taxation and Customs Union **Interrelation with other classifications**: CN is directly derived from HS. Where necessary CN subdivides categories of HS for purposes of external trade, agricultural regulation and customs duties. The first 6 digits of the CN-codes correspond to the Harmonized System nomenclature and the 7^{th} and 8^{th} digits are EU-specific. The CN codes are generally taken as a reference for the PRODCOM codes. **Revision status:** The Combined Nomenclature is revised annually.

Annex 3: Selected nomenclatures from the domain of environmental statistics that have a high relevance for measuring the circular economy

Classification	Description
EW-MFA: Classification of the materials for the economy-wide material flow accounts.	**Structure**: The EW-MFA classification of materials is hierarchical with a break down maximal down to 4-digit-level (category, class, group, sub-group). Material categories (1-digit level) have correspondence to certain types of material flows (domestic extraction, imports and exports, domestic processed output, balancing items). **Usage and main statistical applications:** The classification is used for the economy wide material flow accounting. **Coverage of application**: European Union **Maintenance**: Eurostat **Interrelation with other classifications**: The first four material categories MF.1 to MF.4 initially designed for characterising domestic extraction of materials are pragmatically based on the statistical data sources employed to compile domestic extraction (e.g. agriculture, forestry, fishery, and energy statistics). Correspondence tables between EW-MFA classification and various Eurostat statistics are provided. For the presentation of traded products by type of material each CN code is assigned to one and only one MF class. For raw products (e.g. output from mining) this assignment to one and only one MF class is straightforward. However, the further processed the goods are the more they are composed of more than one material and the material-wise assignment of these goods is ambiguous. **Revision status**: The latest revision of the classification established by the Regulation (EU) 691/2011 came into force in the beginning of 2022.
CEPA 2000: Classification of Environmental Protection Activities and Expenditure	**Structure**: The classification has three levels (9 items at level 1, 46 items at level 2, 20 items ate level 3) **Usage and main statistical applications:** CEPA is a functional classification used to classify activities, products, expenditure and other transactions whose primary purpose is environmental protection. Main applications include Environmental Protection Expenditure Accounts (EPEA) and Environmental Goods and Services Sector (EGSS) Accounts. **Coverage of application**: European Union/ Worldwide **Maintenance**: Eurostat & SEEA Central Framework Technical Committee **Interrelation with other classifications**: CEPA classes 2 and 3 have a direct relation to ISIC and NACE. **Revision status**: Explanatory notes were published by Eurostat in 2021. Eurostat prepared a new classification of environmental functions (CEF), which integrates the CEPA and CREMA classifications. The CEF is currently undergoing a global consultation (text to be updated in final version).
CreMA 2008: Classification of Resource Management Activities	**Structure**: The classification has two levels (7 items at level 1, 5 items at level 2) **Usage and main statistical applications:** CreMA a functional classification used to classify activities, products, expenditure and other transactions that aim to preserve and enhance the stock of natural resources. **Coverage of application**: European Union/ Worldwide **Maintenance**: Eurostat & SEEA Central Framework Technical Committee **Interrelation with other classifications**: **Revision status**: Explanatory notes were published by Eurostat in 2021. Eurostat prepared a new classification of environmental functions (CEF), which integrated the CEPA and CREMA

Classification	Description
	classifications. The CEF is currently undergoing a global consultation (text to be updated in final version).
EWC-Stat Version 4: European Waste Classification for Statistics	**Structure**: For statistical purposes the administrative classification on waste (LoW) is aggregated into 51 mainly substance orientated waste categories. The classification has four levels (13 items at level 1, 44 items at level 2, 83 items at level 3, 117 items at level 4) **Usage and main statistical applications:** The European Waste Classification is a mainly substance-oriented classification of waste for the purposes of waste statistics. **Coverage of application**: European Union **Maintenance**: Eurostat **Interrelation with other classifications**: The European Waste Classification for Statistics is based on the European list of waste (LoW) established by Commission Decision 2000/532/EC. **Revision status**: The Version 4 was established in 2010 by Commission Regulation (EU) No 849/2010 amending Regulation (EC) No 2150/2002 on waste statistics

Annex 4: National and Regional Case Examples

Belgium (Region of Flanders): Monitoring framework

The Flanders Region in Belgium has developed a monitoring tool that focuses on the outputs and outcomes of a circular economy, with indicators on environmental outcomes (e.g. climate impacts), economic outcomes (e.g. access to materials), societal outcomes (e.g. jobs). The tool includes indicators on product chains, footprint indicators (material and carbon), and indicators that link the circular economy to planetary boundaries, as well as indicators on societal and economic drivers (e.g. mobility, housing, food habits, consumption goods).

Flanders' monitor was published in 2021 as a result of a five-year academic research project dedicated to provide the Flemish government of Belgium with a tool to monitor its transition towards a more circular economy (Circular Flanders, 2022). Since 2017 the Flemish government maintains a long-term policy agenda called Vision 2050 in which circular economy is one of the seven societal transition themes and in which a dedicated public-private cooperation has been installed named Circular Flanders. The process of building the monitor included academic research combined with elaborate stakeholder discussions (Alaerts, et al., 2019).

The framework displays a total of about 140 indicators.

- About 25 indicators constitute a top layer of macro indicators that represent the circular economy as a means to reach broader sustainability goals. It includes a separate section for 'circularity' comprising inflows, R-strategies and outflows, and broader environmental and socio-economic effects. The indicators cover among others Direct and Raw Material Input, Domestic and Raw Material Consumption, water consumption, waste generation, recycling, cyclical material use, an in-house developed reuse indicator, residence-based and indirect emissions, spatial occupation, employment in circular economy and employment in reuse shops. Indicators about the transition process are almost absent.
- More specific indicators on four systems that fulfil societal needs, including (i) mobility, (ii) buildings and housing, (iii) nutrition, and (iv) consumer goods are available down to the product group level with the aim to provide a more direct feedback to policy. A few of these indicators refer to the transition process, e.g. the amount of car sharing memberships or the number of renovations.

The overall indicator set is available online and will be further maintained and developed in the coming years by the research consortium. In 2019, the Flemish government announced several headline targets for the circular economy transition, notably on household waste reduction, recycling and a 30% reduction of the material footprint. These targets link to the respective indicators in the monitoring framework.

Canada: Measuring circular economy and Zero Plastic Waste Initiative

With the view of developing relevant indicators and data products to measure Canada's transition to a more circular economy, Statistics Canada has been meeting with other federal departments on a regular basis to discuss current and upcoming policy priorities and how to potentially measure various aspects of circularity to assess the effectiveness of these policies and to develop a roadmap for Canada on circular economy.

In response to *Canada's Zero Plastic Waste Initiative*[14], Statistics Canada conducted a pilot project with Environment and Climate Change Canada to develop relevant indicators as well as a Physical Flow Account for Plastic Material (PFAPM) in the Canadian economy on national and sub-national levels. This work included identifying existing data sources, adding plastics-specific modules to several surveys to fill data gaps, and the development of the PFAPM. This pilot project is now complete and PFAPM data for 2012-2018 was released on March 23, 2022[15]. Recently the project was given further funding and work is now underway to publish the PFAPM annually, as well as expanding its coverage and updating its methodology. This new funding runs from 2022-2027.

Statistics Canada and the UNECE organized a joint online seminar on measuring circular economy in December 2021. The seminar included governments, businesses and individuals around the world discussing the role of circularity for a more sustainable future. Information on the results of the seminar can be found on the UNECE website https://unece.org/media/Statistics/press/363586.

Over the past two years, Statistics Canada has also been working to improve data on business expenditures related to environmental protection, including measures aimed at increasing circularity (e.g., materials recycling and water recirculation). The improvements include more comprehensive coverage of the economy as well as more detailed information on goods and services purchased for water reuse and recirculation.

China: Monitoring framework

Since 2008 the Circular Economy Promotion Law drives the transition towards a more circular economy in China. The associated monitoring comprises two separate indicator sets: one that helps to monitor progress on national and regional levels, and one that applies to industrial parks. The indicator sets provide guidance to circular economy development planning (Geng, Fu, Sarkis, & Xue, 2012).

The indicator set for national and regional analysis contains 22 indicators, categorised into four main themes. The theme "resource output rate" tracks outputs of main mineral resources and of energy. The theme "resource consumption rate" focuses on energy and water consumption divided by three denominators: Gross Domestic Product, added value and the amount of produced materials. Indicators in the theme "resource utilisation" largely focus on recycling of different material streams including metals, paper, plastics and wastewater. The theme "waste disposal and pollutant emissions", includes indicators on waste sent to landfill, wastewater discharges and emissions air (Geng, Fu, Sarkis, & Xue, 2012).

The indicator set for industrial parks contains 12 indicators, categorised into the same four main themes. The indicators are similar to the ones for national and regional analysis, but also provide information of water and energy consumption per unit of key product. It aims to monitor environmental implications of China's expanding economy.

Whilst the two indicator sets cover a variety of aspects of the circular economy, the monitoring framework has some limitations, notably (Geng, Fu, Sarkis, & Xue, 2012):

- Consumption indicators are only included as efficiency indicators (divided by GDP or per unit of output produced). This reflects progress to a more resource efficient economy, but it hides overall material consumption.

[14] Website "Zero plastic waste: Canada's actions": https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/zero-plastic-waste/canada-action.html
[15] https://www150.statcan.gc.ca/n1/daily-quotidien/220323/dq220323f-eng.htm

- Waste indicators only indicate the amount of waste destined for disposal, but not the overall amount of waste generated. Similarly, recycling rates are only available for specific waste streams, but no overall recycling rate.
- The indicator set focuses largely on environmental impacts but is lacking indicators on social implications. It also lacks indicators on business activities, circular business models and the higher Rs more generally.
- There is no consideration of value chains outside the country territory and impacts embedded in imports or exports.
- Indicators on environmental implications refer to wastewater discharges emissions of SO_2 and chemical oxygen demand. Greenhouse gas emissions are not included but appear to be retrievable beyond this indicator set at the Department for Climate Change Response. Several other ecological indicators appear to be available at the Ministry of Environmental Protection with a city focus, which could also complement this framework.
- No information is available on targets associated with the indicators, nor on follow-up progress assessments or revisions of the indicator set.

Colombia: Monitoring framework

Recognizing the relevance and impact of the circular economy, Colombia has made a commitment to advance in this area within the framework of the green growth policy regulated by CONPES 3934 of 2018, which aims to boost the country's productivity and economic competitiveness by 2030, while ensuring the sustainable use of natural wealth and social inclusion, in balance with climate security. Thus, the transition to the circular economy model must be accelerated through the reduction, reuse, recycling of waste and materials, and the efficient use of resources. To implement this transition, the Ministry of Environment and Sustainable Development (MADS, by its acronym in Spanish), with the support of other entities, formulated the National Strategy for the Circular Economy (ENEC), which defines instruments to achieve the country's short and medium-term goals in this area.

The ENEC aims to create a new economic development model that includes the continuous valorization of resources, the closing of material, water and energy cycles, the creation of new business models, the promotion of industrial symbiosis and the consolidation of sustainable cities, with the objective, among others, of optimizing efficiency in the production and consumption of materials, and reducing the water and carbon footprint[16].

With the purpose of articulating the entities of the National Statistical System (SEN), for the identification, strengthening and generation of relevant and timely information required in decision-making, as well as for the evaluation of public policy associated with the circular economy, in 2019 the Circular Economy Statistics Roundtable (MEEC) was created, which is composed of six subgroups which have as a purpose to identify, organize, produce and strengthen the statistical information for each of the thematic areas of the ENEC's priority lines[17].

Colombia’s National Statistical Office (DANE, by its acronym in Spanish), through Resolution 1598 of 2021, created the Internal Working Committee of the Circular Economy whose purpose is to identify, analyze, verify and guarantee the quality of the statistical information produced by the National

[16] https://economiacircular.minambiente.gov.co/wp-content/uploads/2021/05/Estrategia-Nacional-de-Economia-Circular-Gobierno-de-Colombia.pdf. Page 11.
[17] Subgroups of the Circular Economy Statistics Roundtable: a) Flow of industrial materials and mass consumption products; b) Material Flow of containers and packages; c) Biomass Flow; d) Energy sources and flows; e) Water Flows; and f) Flow of construction materials.

Statistical System, associated with Circular Economy, as well as to promote the methodological research processes developed for the measurement of the circular economy. The objectives of this committee are: a) to contribute to the design, construction and implementation of the Circular Economy Information System (SIEC), b) to identify, analyze and verify the information of the entities that provide statistical information to the SIEC, and c) to develop the critique, validation and endorsement of the information to be published in the circular economy report.

Through DANE's leadership, the Circular Economy Information System (SIEC) has been developed, which is an application that will be available on the DANE website as of October 2022 and will present the progress of the circular economy in the country in an interactive way to users. The SIEC will have an indicator consultation tool that will allow annual comparisons, the direct download of information, as well as presenting the progress of the different subgroups of the MEEC.

Every six months, DANE presents Circular Economy, which isintended to provide information for decision making and the strengthening of public policy on Circular Economy. The sources of information used for the elaboration of these report include: primary statistical operations such as the Quality of Life Survey (LCS), the Environmental Industrial Survey (EAI), the Building Census (CEED), among others, statistics derived from the Environmental Satellite Account (ESA), as well as information from different institutions of the national level, for example, the Institute of Hydrology, Meteorology and Environmental Studies (Ideam) and the Institute of Marine and Coastal Research (INVEMAR). To date, five (5) circular economy reports have been published, which group the indicators into four components: i) Demand for environmental assets and ecosystem services; ii) Conservation or loss of value of materials in the production system; iii) Pressure on ecosystems due to waste disposal; and iv) Factors that facilitate the circular economy.

Additionally, it is worth nothing that the reports include Sankey diagrams to represent the supply and use of energy flows, forest, water, air emissions, solid waste and waste products, as well as the financing of public environmental spending. For the fifth report, the first calculation of the Environmentally Extended Input-Output Matrix (MIP-EA) was presented. The information associated with the reports can be consulted at the following link: https://www.dane.gov.co/index.php/estadisticas-por-tema/ambientales/economia-circular

The Environmentally Extended Input-Output Matrix (MIP-EA) consists of an environmental extension of the Input-Output Matrix for atmospheric emissions, allowing to relate the impacts of greenhouse gas (GHG) emissions with economic activities within the framework of the System of National Accounts, showing the state of backward and forward linkages of the country's economic activities. This exercise is a tool that not only contributes to the country's green growth, climate change, air quality and circular economy policies, but also to the decision-making processes of the productive sector in areas associated with sustainable development. The MIP-EA information can be consulted in the fifth circular economy report, through the following link: https://www.dane.gov.co/index.php/estadisticas-por-tema/ambientales/economia-circular

DANE is currently developing the design and construction of the Circular Economy Satellite Account (CSECI), in accordance with the parameters of the Generic Statistical Process Model (GSBPM) as a guideline and standard for the production of official statistics. The main objective of the CSECI is to measure the circular economy in an expanded analytical framework of concepts, classifications and accounting treatments complementary or alternative to the System of National Accounts (SNA, 2008) and under the Central Framework of the System of Environmental and Economic Accounting (SEEA, 2012), as well as to identify and characterize the material flows associated with circularity, implement the use of the Input-Output Matrix (IPM) in expanded or extended environmental concepts, and calculate indicators derived from this measurement.

Moreover, it is important to highlight that currently DANE is advancing in the design of the Economy Wide Material Flow Account (EW-MFA), based on the Central Framework of the System of Environmental and Economic Accounting (SEEA, 2012), the Generic Statistical Process Model (GSBPM) and Eurostat's Economic Wide Material Flow Accounts - Handbook, as part of the commitments made in the circular economy framework, set out in the country's green growth policy.

Regarding the use of information from the framework of the System of Environmental and Economic Accounting (SEEA, 2012), a set of indicators derived from the environmental and economic accounts have been incorporated in the circular economy reports, providing information about: material productivity (water, energy and forest), extraction and use of resources, renewable energies, solid waste and residual products, air emissions, among others.

Additionally, the Environmental Satellite Account (CSA, by its acronym in Spanish) develops tools for the graphic representation of information through Sankey diagrams, which allow visualizing the supply and use of energy, water, solid waste, air emissions and environmental expenditure flows, enhancing the integration and analysis of statistics generated as a result of the implementation of the SEEA.

Denmark: Using physical supply-use tables for measuring plastic flows

Pursuing strategies for reducing plastics waste and moving towards circular economies require information systems and monitoring frameworks, which enables policy makers and others to monitor and analyse flows of plastics.

Statistics Denmark has developed detailed physical-supply use tables, which accounts for all Danish flows of natural resources, products, and residuals in the form of air emissions, solid waste, etc. Part of the physical supply use tables concerns products of plastics. By extending the framework with information on the content of plastics in all types of products and waste, e.g. household appliances and mixed municipal waste, it has been possible to draw a complete picture of plastic flows through the Danish economy from imports and production, through use by industries and households towards exports of plastic products, recycling, depositing and incineration of plastics waste. The account for plastics serves as an example of the usefulness of establishing physical supply-use tables and highlights how they can be used to focus on specific product/material types, thereby providing information, which otherwise is difficult to obtain.

The detailed Danish physical supply-use tables mirror the Danish monetary supply-use table from the Danish national accounts, but instead of using the Danish currency, DKK, the flows are measured using weight units, i.e. tonnes. The level of detail includes imports, exports, production and intermediate consumption of 117 industries. Consumption by households and government and capital formation, etc. are also included. In addition, the physical tables include information on the flows of natural resources from the environment to the economy (i.e. extraction of minerals, harvest, etc.) as well as the flows of residuals from the economy (i.e. air emissions, solid waste, dissipative flows, and waste discarded through the sewer, etc.). At the most detailed level the classification of products include 1800 products of all material types. Natural resources are broken down by 26 types of natural resources and residuals by 130 types. However, the tables are disseminated at a much less detailed level due to the large uncertainties involved.

The sub-tables for plastics are made from the full tables by first identifying 39 product groups and 3 waste fractions consisting entirely by plastics. Secondly, based on research reports, etc., plastic percentages were allocated to all other product and waste categories, and these percentages were then used to estimate the plastic content in those products and waste fractions.

Figure 14 and Figure 15 below illustrate some of the information that can be derived from the tables. Figure 1 is a Sankey diagram presenting the overall flows of plastics, while figure 2 shows a breakdown of the Danish use of plastics by households and industries and according to the appearance of the plastics, i.e. whether it is raw plastics for further processing, products made by 100 per cent plastics or plastics embedded in composite products together with other material types.

The tables and figures show that the rest of the world is the dominating source of plastics. Imports to Denmark in 2016 included approximately 2.2 million tonnes of plastics, of which 4 per cent was embedded in waste (mainly waste imported for incineration). There was a tiny Danish production of raw plastics based on the use of chemical products and, in addition, some recycling of plastics, which reduced the need for imports and Danish production of plastics. Recycled plastics amounted to 99 000 tonnes.

A little more than 1.1 million tonnes of plastics left Denmark in connection with the exports of goods, and to a lesser extent as part of the waste exports.

A large part, approximately 506 000 tonnes, of plastics in waste (collected in Denmark or imported) was incinerated in energy producing facilities. Thereby, an amount corresponding to one fourth of the imports of plastics ended up in the atmosphere as part of air emissions from incineration plants.

A similar net amount of plastics was accumulated in the Danish economy in connection with the purchases by households and companies of durable consumption goods, textiles, vehicles, machineries and appliances, etc. Not the least, plastics in building materials contributed to the accumulation of plastics.

Goods used for intermediate consumption by industries had a total content of plastics of approximately 1.7 million tonnes. This includes a substantial use of raw plastics for manufacturing of plastic products. Another large user of plastic products is the wholesale and retail industry, which mainly used processed products in the form of packaging materials. In general, packaging materials explains quite a lot of the use of plastics. The use of products by households included 350 000 tonnes of plastics, of which a little more than half came in the form of pure plastic products, to a large extent consisting of plastic packaging.

The supply and use tables for plastics include much more information than presented here, including a detailed assessment of the plastics included in different types of waste. The tables' consolidation of information on plastics retrieved from different sources makes it possible to obtain a quite complete picture of the plastic flows through the economy. The assessment involves, of course, very large uncertainties and a lot of assessments and guesstimates. However, the inclusion of the different statistics and assessment within a coherent supply-use framework helps keeping the assessments on the right track, while at the same making it possible to estimate missing data and to see where data conflicts with each other.

The methodology used for establishing the plastic accounts can be applied to most other material types: wood, metals, glass, textiles, energy, etc. Statistics Denmark is currently using the methodology to establish physical supply-use tables for filled and empty packaging materials.

The construction of physical supply-use tables is a time-consuming process that requires availability of good basic data on the main physical flows and also the existence of monetary supply-use tables from the national accounts. However, the costs of producing physical-supply use tables have to be seen in the context of the urgent need to move economies towards circularity and the need for monitoring and analyzing material flows at a quite detailed level. For that, physical supply-use tables are important tools, which statistical agencies can bring to the table in order to help policy makers, analysts and researchers understand the physical dimension of our economies.

Figure 14: Danish plastic flows 2016, 1000 tonnes

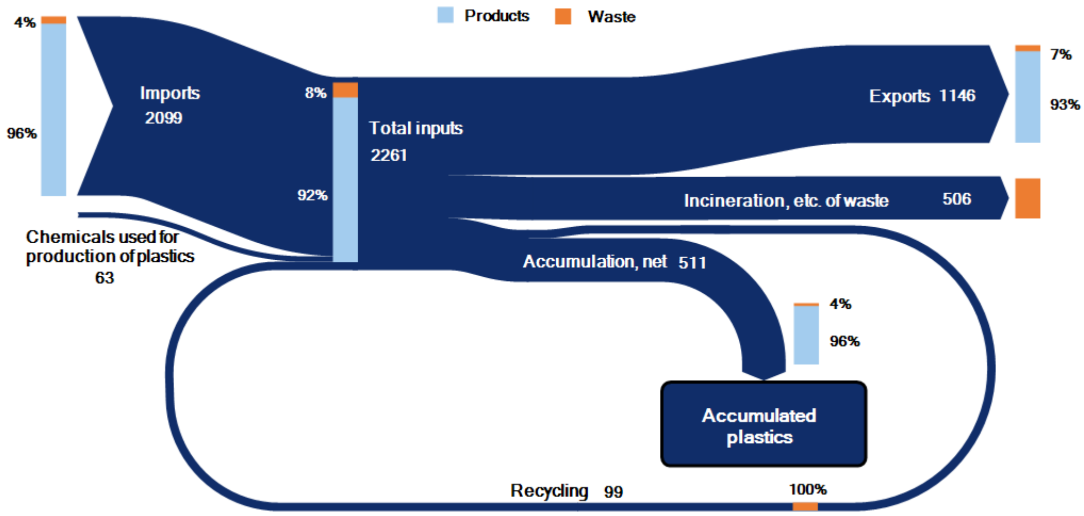
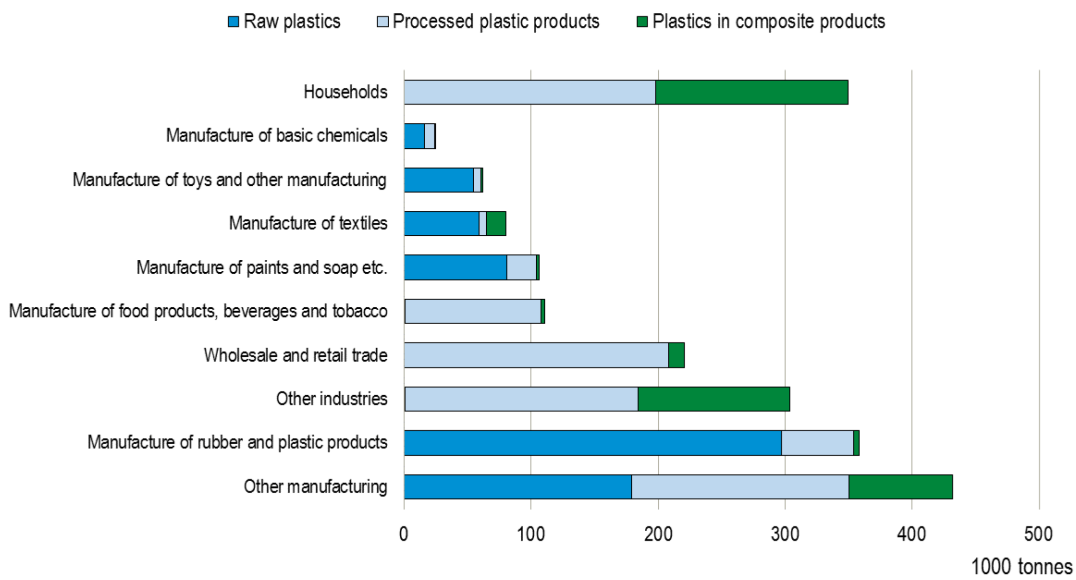


Figure 15: Danish domestic use of plastic products



More information can be found at:

- Power point presentation: https://unece.org/statistics/documents/2022/03/presentations/using-physical-supply-use-tables-measuring-plastic-flows
- The report "Accounts and indicators for Danish Plastic flows" (https://www.dst.dk/Site/Dst/SingleFiles/GetArchiveFile.aspx?fi=87942105799&fo=0&ext=n

ational) describes the methodology and presents results. However, observe that the physical supply-use tables have been updated since the report was prepared. Thus, data presented in this note may not exactly match data in the report.

- Full Danish physical supply-use tables: www.statbank.dk (select: Environment and Energy -> Environmental-Economic Accounts -> Material Flow and waste accounts -> Detailed material flow accounts (physical supply-use tables).

European Union

The European Commission started to develop a CE monitoring framework as part of its 2015 EU Circular Economy Action Plan. It is maintained by Eurostat and available online since 2018 (Mayer, et al., 2018). Most of the indicators were retrieved from existing EU monitoring frameworks, including the Resource Efficiency Scoreboard, the Raw Materials Scoreboard and the Waste Framework Directive (Moraga, et al., 2019).

The framework contains ten indicator themes and 24 indicators in the categories production and consumption (including self-sufficiency for raw materials, Green Public Procurement, Waste generation and Food waste), waste management (featuring a range of recycling indicators), secondary materials (End-of-life recycling input rates, Cyclical material use rate, imports, exports and trade of recyclable raw materials) and competitiveness and innovation (investments, employment, value added and patents). The monitor also includes an interactive Sankey diagram for the European Union as a whole. The indicators are available at the level of the European Union, as well as for individual member states and updated annually. A revision of the monitoring framework is currently in progress.

The framework has a strong focus on material circularity and waste and recycling aspects. The aim was to focus on circularity, whilst other aspects of the circular economy, such as the link with climate is already covered in other monitoring frameworks. Another motivation to keep it concise was also to minimise additional burden on national administrations for providing data. As such, the framework does not include indicators on environmental impacts, nor on indirect material use. Material footprint indicators, whilst widely recognised as highly relevant for the circular economy, do not yet feature in the EU monitoring framework due to insufficient data availability and certain controversy about the input-output modelling methodology (UNECE, 2021). Domestic Material Consumption appears indirectly as part of the Circular Material Use Rate indicator, while it is prominent in the 2015 Resource Efficiency Scoreboard (European Commission, 2015). In this way an absolute representation of the overall material consumption is absent. The framework has also included a number of indicators for which data gathering is still in progress (i.e. for Food Waste), still needs to be developed (Green Public Procurement) or experiences bottlenecks (indicators in the competitiveness and innovation category). With respect to the latter, the documentation mentions the issue that economic statistics are based on industrial sectors, impairing a proper definition of the circular economy in terms of employment (NACE codes) or innovation (patent statistics). Patent statistics have the limitation that it does not cover all innovation taking place, but only certain types.

Finland: National strategies for a transition to a circular economy and measurement mechanisms

Finland has adopted a **resolution on promoting circular economy** in April 2021 (https://ym.fi/en/-/circular-economy-programme-sets-targets-to-curb-overconsumption-of-natural-resources).
According to the resolution, both the productivity of resources and circular material use rate must be doubled by 2035 from 2015. In order to achieve the targets, a **strategic programme** (https://ym.fi/en/strategic-programme-to-promote-a-circular-economy) to promote a circular economy has been prepared. The programme includes several measures to promote circular economy

and included appoints ministries and other actors in charge of each measure. The following set of indicators[18] have been selected to monitor the success of the programme:

- Domestic material consumption DMC
- Material input required for domestic end-use material-specifically RMC
- Resource profitability (GDP/RMC)
- Circular material use rate (CMU)
- Turnover of circular economy sectors and number of enterprises
- Eco-innovations
- Innovative public procurements
- Municipal, packaging and construction waste and recycling rate
- Circular Economy Barometer: A survey and interview-based study for companies and consumers on attitudes and operating models that support the circular economy.

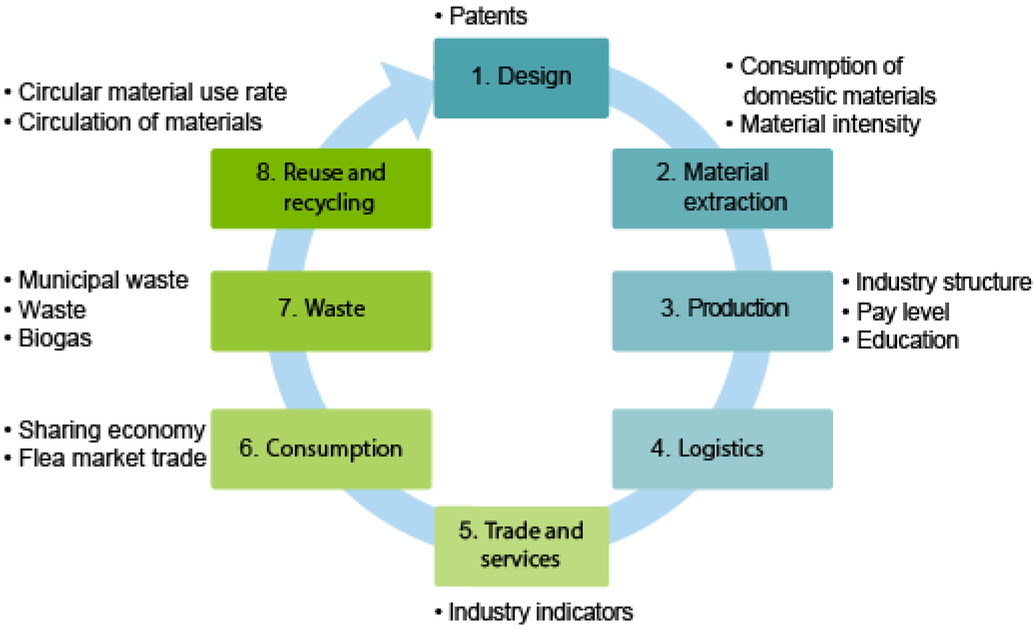
Circular Economy Roadmap for Finland (https://www.sitra.fi/en/projects/leading-the-cycle-finnish-road-map-to-a-circular-economy-2016-2025/) by The Finnish Innovation Fund Sitra was published in 2015 and updated to version 2.0 in 2019. The Roadmap includes policy actions, key projects and pilots to facilitate transformation from linear to circular economy and has also been a driver behind many measurement initiatives. One action included the Roadmap is to 'Develop a comprehensive set of indicators that describe the development of Finland's circular economy'.

CIRCWASTE (https://www.materiaalitkiertoon.fi/en-US) is a seven-year (2016-2023) LIFE IP project that promotes efficient use of material flows, waste prevention and new waste and resource management concepts. All actions contribute to implementing the national waste management plan and directing Finland towards a circular economy. The project is coordinated by the Finnish Environment Institute. As part of the CIRCWASTE project, the Finnish Environment Institute is compiling **circular economy indicators** (https://www.materiaalitkiertoon.fi/en-US/Monitoring) with a special focus on the regional and municipal scale data.

Statistics Finland contributed to CIRCWASTE project by compiling **indicators for Circular Economy Business** (https://www.stat.fi/tup/kiertotalous/kiertotalousliiketoiminnan-indikaattorit_en.html). This indicator set consists of 15 indicators that have been categorized into eight activities (see Figure 16). The indicators have been compiled from existing statistical data and registries making the data production relatively resource efficient. The focus of the indicators is on national level, but some of the indicators have also been produced regionally, for example the number of circular economy establishments, turnover and personnel, and flea market trade. Indicators were published for the first time in end-2020 for years 2013 – 2018 and an update has been commissioned for 2022.

[18] the indicator selection at this stage. However, the programme states that the indicators require further development.

Figure 16: indicators for Circular Economy Business



Finland has also adopted a Bioeconomy Strategy (https://www.bioeconomy.fi/) in 2022, which has a strong emphasis in circularity. Natural Resource Institute Finland has a research programme on Circular bioeconomy and produces as set a statistics to monitor this strategy in cooperation with Statistics Finland. In addition, the Natural Resource Institute is working on recycling and other circular issues in agriculture and in food production chains. Finnish Environment Institute has assessed nutrient cycles within a project Nutrients, energy and livelihood for the countryside from a biogas plant (BioRaEE). Also, they have studied water and harmful substances in circular economy context. In VTT Technical Research Centre of Finland, the circular economy related research include circular plastics and redesigning mineral and metal loops

France: Monitoring framework

The French monitoring framework for the circular economy was first published in 2017, comprising 11 indicators (Magnier, 2017). It was updated and revised in 2021 (Scribe, Calatayud, Gauche, & Nauroy, 2021). It was inspired by the emerging publications on circular economy of the European Commission and is designed to benchmark France's performance against other European countries and many indicators are available on EU28 level.

France uses a measurement framework and indicators that cover the following dimensions of a circular economy: the supply side (sustainable extraction and manufacturing, eco-design, industrial ecology, employment), the demand side (consumer behaviour, sharing economy initiatives), product management aspects (second-hand, repair, reuse) and waste management aspects (waste prevention, recycling). Eleven indicators within seven pillars are used to report on the circularity of the French economy (Table 8).

Table 8. Indicators of the French monitoring framework (Source: (Scribe et al., 2021[11])

Pillar	Indicator
Extraction / manufacturing and sustainable supply chain	Domestic material consumption per capita
	Resource productivity
	Material footprint *(new since 2021)*
Eco-design (products and processes)	European ecolabel

Pillar	Indicator
Industrial symbiosis	Number of industrial symbiosis initiatives
Functional economy	Number of companies and local authorities that have benefited from government support mechanisms on the functional economy
Responsible consumption	Food waste
Extension of product lifespan	Household spending on product maintenance and repair (excluding vehicle maintenance)
Recycling (material and organic)	Landfill tonnage trend
	Use of secondary raw materials in production processes
	Jobs in the repair of goods and recycling of materials

The indicator scoreboard marks individual indicators in colours, depending on the extent to which the indicator score evolves in the desirable direction. Two of the indicators are connected to national circular economy targets (i.e. resource productivity and waste sent to landfill) (Scribe, Calatayud, Gauche, & Nauroy, 2021).

Overall, the indicator set has a strong focus on the material consumption aspect. Indicators on environmental implications are not considered. With regards to recycling, the use of secondary raw materials is monitored, but not the recycling rate in itself. The indicator list includes several indicators on the higher Rs, such as jobs in repair and household spending on repair and maintenance services. Also eco-design aspects are considered. Whilst the monitoring framework covers a diverse set of indicators, the diversity of individual indicators makes it challenging to compare progress and trends of individual indicators. Also, several data limitations are acknowledged for some of the chosen indicators, which have been partially improved in the 2021 revision (Scribe, Calatayud, Gauche, & Nauroy, 2021).

Japan: Monitoring framework

In Japan, policies related to implementing the circular economy are centred around the concept of a "Sound Material-Cycle Society", first enacted by the Basic Act for Establishing a Sound-Material Cycle Society in 2000. In 2003 the Japanese government adopted its Fundamental Plan for Establishing a Sound Material-Cycle Society, which is reviewed and revised every five years by the Ministry of Environment Japan (MOEJ). The Fundamental Plan and its targets were last revised in 2018 (MOEJ, 2018[3]; Bangert, 2020[4]).

The development of the Plan was motivated by Japan’s high rate of waste generation, limited availability of land space for waste disposal, increasing public demand for recycling, supply security concerns of raw materials and Japan’s heavy import reliance. The plan is aligned with Japan’s waste and recycling policies, and aims to provide comprehensive measures for materials management, including upstream consumption and downstream waste management and recycling measures (Geng et al., 2012[5]).

The Plan for Establishing a Sound Material-Cycle Society is supported with quantitative time-bound targets and performance indicators. Stakeholders are asked to contribute to their achievement. The targets and the associated indicators are used to monitor progress, assess each stakeholder’s efforts and encourage further action. The Plan includes targets on resource productivity, cyclical use rate (defined at the level of resources and of waste), and on landfilled waste (MOEJ, 2018[6]). The targets are monitored by a framework consisting of a set of 151 indicators, with four headline indicators. The FY2025 targets set in the 4th Plan for the four headline indicators are:

- Resource Productivity [GDP/Input of natural resources]: 490,000 JPY / ton (approximately double from FY2000)
- Cyclical use rate [amount of cyclical use/(amount of cyclical use + input of natural resources)]: 18% (approximately 80% increase from FY2000)
- Cyclical use rate (waste base) [amount of cyclical use / generation of waste]: 47% (approximately 30% increase from FY2000)
- Final disposal [amount of waste destined for landfills]: 13 million tonnes: 77% decrease from FY2000)

Supplementary indicators refer to different elements of the transition process and societal efforts towards realising a circular economy and track various elements of material input (material consumption), circularity (recycling rates), material output (waste generation), efforts on regional level, household behaviour, consumer awareness (e.g. through survey results), business operations (e.g. market size of circular business models) and actions in the public sector (e.g. public procurement) (MOEJ, 2018[6]; EASAC, 2016[7]). (Box 5). Indicator scores are updated yearly and available starting from 2000. The indicators are published in the Annual report on the Environment, the Sound Material-Cycle Society and Biodiversity in Japan (White Paper)[19], and progress reports are being emitted regularly (MOEJ, 2010[8]; MOEJ, 2013[9]; MOEJ, 2018[3])

Box 5: Material flow and resource productivity indicators in Japan

Overview indicators and associated targets for FY 2025

238. Indicators	*239. Targets for FY 2025*
1. Resource Productivity	490 000JPY/tonne, i.e. approx. a doubling of FY 2000
2. Cyclical Use Rate (resource based)	18%, i.e. ~ 80% increase from FY 2000
3. Cyclical Use Rate (waste based)	47%, i.e. ~ 30% increase from FY 2000
4. Final Disposal Amount of waste	13 million tonnes, i.e. a 77% cut from FY 2000

II. Thematic material flow indicators (some associated with targets)

1. Resource productivity by industry
2. Generation of household food waste
3. Generation of commercial food waste
4. Emission of greenhouse gas from the waste sector
5. Reduction of GHG emissions from other sectors through using waste as raw materials and fuel for power generation
6. Ratio of domestically-produced biomass resources to total natural resource inputs
7. Per-capita waste generation per day
8. Per-capita household waste generation per day
9. Business waste generation
10. Amount of illegal dumping
11. Amount of waste treated improperly

II. Thematic management indicators (some associated with targets)

1. Market size of sound material-cycle society business
2. Average power generation efficiency of waste incineration facilities constructed/improved during the period
3. Area of forests with specific forest management plans
4. Number of local governments working on Regional circular and ecological sphere
5. Size of reuse market
6. Size of sharing economy market
7. Guidelines for product assessment by industries (design for environment)
8. Implementation rate of recycling of cyclical food resources
9. Establishment rate of life extension plans for individual facilities (individual facility plan)
10. Number of illegal dumping cases
11. Number of improper waste treatment cases
12. Diffusion rate of electronic manifests
13. Remaining sustainable years of final disposal sites for municipal waste
14. Remaining sustainable years of final disposal sites for industrial waste
15. Share of local governments having a disaster waste management plan
16. Number of nations with which a memorandum of understanding/agreement on environmental cooperation (including for resource recycling) is signed
17. Number of recycling businesses promoting overseas expansion
18. Share of research projects on sound material cycles
19. Waste reduction and awareness for cyclical use and green purchase
20. Implementation rate of specific 3R actions

Source: Country contribution to the annual Round Table on Environmental Information (WPEI) and http://www.env.go.jp/en/wpaper/

[19] http://www.env.go.jp/en/wpaper/

The focus of the Fundamental Plan appears to be predominantly on domestic environmental and economic issues related to materials. With the circular use rate as one of the headline targets, the circular economy is also partially framed as a goal in itself. The transition process and the broader effects on the environment, economy and society are less visible within the framework and only covered to some extent in the supplementary indicators. For instance, emissions are only covered to the extent that these occur from waste management. There is also little consideration of transboundary issues related to material consumption and impacts, but the development of such indicators has been announced (MOEJ, 2018[6]). The lead indicator on resource productivity is based on Direct Material Inputs, not subtracting exports. Data on Domestic Material Consumption and absolute material flows are however available in the background of the monitoring framework and there are discussions to compute the material footprint indicator, once a methodology has been established (MOEJ, 2018[6]).

The Netherlands: Monitoring framework

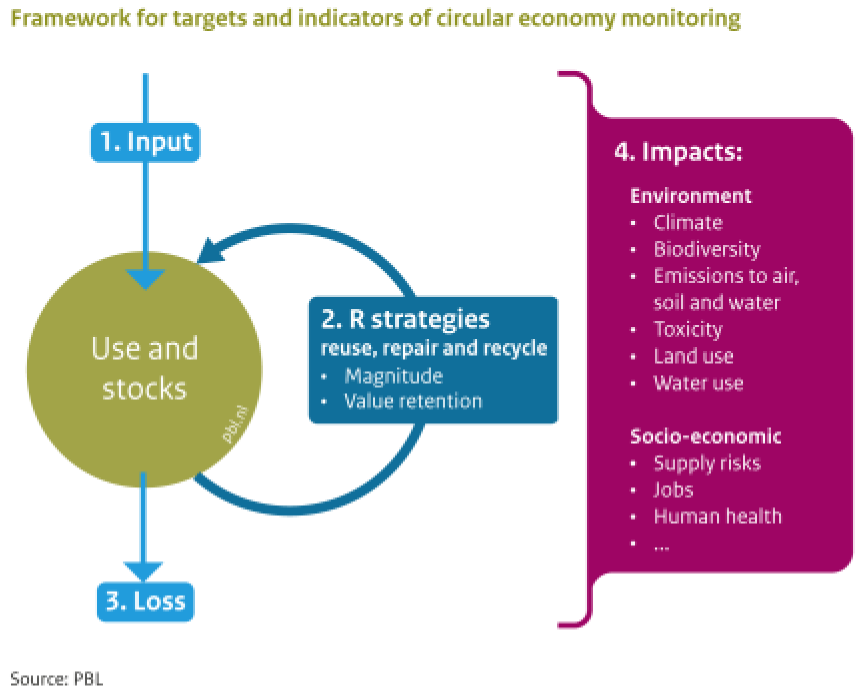
The Dutch government has set a goal for the Dutch economy to be completely circular by 2050, with an intermediate goal aiming at a 50 percent reduction in the amount of primary abiotic material use by 2030. To achieve this, the Government-wide Programme for a Circular Dutch Economy by 2050 was developed. This programme outlines how the Dutch economy can be transformed into a sustainable, fully circular economy by 2050. It describes what needs to be done to ensure the use of raw materials, products and services in a smarter and more efficient way. The Dutch government set a climate target of 2-Mton CO2 reduction due to circular economy policy in order to strengthen the relation between circular economy and climate change. This reduction considers greenhouse gas emission in the complete production chain and as a result of product life extension. As a result of globalization of supply chains indirect (supply chain) effects may be outsourced and lead to an underestimation of environmental and socio-economic effects when only domestic production processes are considered. To get better insights in the environmental effects, also abroad, footprint calculations have an important role in measuring all kind of environmental and socio-economic effects.

The central government's approach is to work closely together with other public authorities, knowledge institutions and environmental organisations, industry, trade unions, financial institutions and other civil-society organisations. An example is the National Raw Materials Agreement, a document that contains agreements on having the Dutch economy operate on the basis of reusable raw materials. It was signed by more than 400 parties. Key to this approach is also the establishment of five transition teams which include, among others, members of companies, environmental agencies and consumer organizations. Each team focuses on the development of a transition agenda for one of the five priorities set by the government. The priorities set are sectors and value chains of economic importance and high environmental burden, which are 1) biomass and food, 2) plastics, 3) manufacturing industry, 4) construction and 5) consumer goods. The transition agendas suggested product groups that have CE potential with regard to resource reduction and related environmental impacts. To make products more circular collaboration is needed within the whole supply chain, from product design to waste management. To achieve this a product approach focusing on a whole product supply chain is more suiting than an industry approach focusing only on a specific task within a production chain. In the National Programme Circular Economy (NPCE) 2023-2030 national targets are developed that will be translated in targets for relevant product groups.

A monitoring system is required to determine whether the transition is progressing as planned, a first proposal was published in 2018 (PBL, 2018). The report presents a framework and baseline assessment for monitoring the progress of the circular economy in the Netherlands. In 2019 the Circular Economy Implementation Programme was presented by the government, which translates the five transition agendas in concrete actions and projects to be put into effect. To monitor and evaluate both the progress towards and the effects of a circular economy the Work Programme Monitoring and Control Circular Economy was developed. The monitoring is done by a consortium of eight knowledge institutions , among which are Statistics Netherlands (CBS) and the Environmental Assessment Agency (PBL).

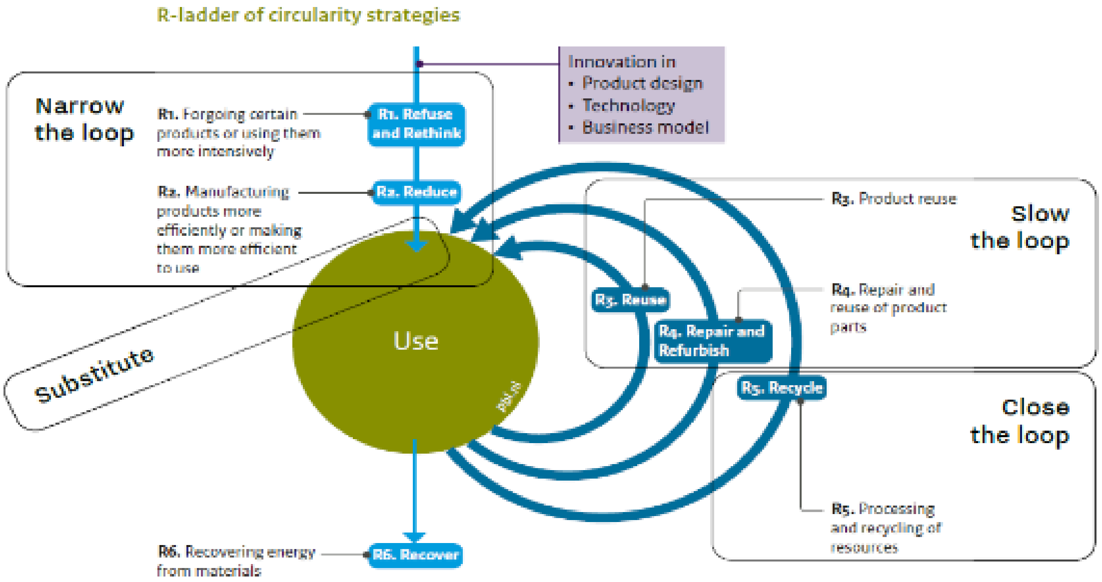
One of the main outputs of the work programme is a biennial Integrated Circular Economy Report (Hanemaaijer et al., 2021) The main goal of this report is to measure the progress of the transition, for which a monitoring framework has been developed (see Figure 17). The framework distinguishes three phases of material use in the economy, the input of resources into the economy, resources within the economy and losses from the economy to the environment. Together these three phases show the level of circularity of the economy and impact environmental and socio-economic effects of material use. The negative effects of material use can be reduced by making a more circular economy.

Figure 17: Dutch monitoring framework



There are different ways to make more efficient use of material resources and thereby reducing any negative effects. These circularity strategies (R-strategies) can be presented by the R-ladder where the rule of thumb applies that in general strategies higher on the ladder contribute more to reducing material use and environmental pressures. The R-strategies can be summarized in three main strategies, i.e. narrowing (refuse, rethink, reduce), slowing (re-use, repair) and closing (recycling) the loop. Additionally, substitution of non-renewable resources by sustainable alternatives like bio-based materials is another strategy to make resource use more circular. See Figure 18.

Figure 18: R-ladder of circularity strategies



Source: Potting, J. and Hanemaaijer, A., 2018. Circular economy: what we want to know and can measure. [online] PBL Netherlands Environmental Assessment Agency. Available at: https://www.pbl.nl/sites/default/files/downloads/pbl-2018-circular-economy-what-we-want-to-know-and-can-measure-3217.pdf [Accessed 26 December 2021] - Edited by the Ministry of Infrastructure and Water Management

Statistics Netherlands is contributing to the Integrated Circular Economy Report as knowledge partner and by compiling several kinds of indicators. The required data is obtained from various sources, mainly the Environmental Accounts (SEEA) and Environmental Statistics, but also other (external) data sources are used. Particularly, the Material Flow Monitor (MFM) (Delahaye et al, 2022) provides useful insights into the physical material flows (in kilos) to, from and within the Dutch economy. More specifically, the MFM comprises of the supply and use of natural resources, goods and residuals specified per sector and for households (around 400 types of goods and 130 sectors). The MFM is set up in accordance with monetary supply and use tables of the National accounts. Monetary figures of goods in the National accounts are converted to physical quantities. In addition, physical environmental accounts modules, like MFA, PEFA, waste and air emissions, are integrated in the MFM. The MFM is for instance used to compile indicators on material input, consumption, resource dependencies and use of secondary materials (Circular Material Use Rate). In addition to physical indicators also socio-economic indicators such as employment and value added of the circular economy and compiled by taking a subsection of the EGSS module. Finally, footprint indicators like the material and carbon footprint are compiled based on Input-Output analyses and the Eurostat RME tool. Footprint indicators give a better understanding of the environmental effects throughout the whole supply chain, including effects abroad.

Currently, based on the MFM, a Bio-Monitor is being developed that focuses on the biotic flows within the economy in order to monitor the transition towards a bio-based economy (Delahaye and Tunn, 2022). In the same line, the integration of the MFM with the carbon accounts of SEEA-EA provides insights in the relationship between policy on circular economy, climate change, eco-system services and natural resource dependency (Lof et al., 2017).