TRANSIENCE

TRANSITIONING TOWARDS AN EFFICIENT, CARBON-NEUTRAL CIRCULAR EUROPEAN INDUSTRY

Date: 25/04/2025

D3.5 – Open database of policies & technologies

WP 3 – Characterising circularity and decarbonisation opportunities – generating model inputs

Disclaimer

Copyright Message

Grant Agreement Number	101137606	**Acronym**	TRANSIENCE
Full Title	TRANSItioning towards an Efficient, carbon-Neutral Circular European industry		
Topic	HORIZON-CL4-2023-TWIN-TRANSITION-01-36		
Funding scheme	HORIZON EUROPE, RIA – Research and Innovation Action		
Start Date	January 2024	**Duration**	48 Months
Project URL	https://www.transience.eu/		
EU Project Advisor	Fatima GONZALEZ GOMEZ		
Project Coordinator	Institute of Communication and Computer Systems (ICCS)		
Deliverable	D3.5 – Open database of policies & technologies		
Work Package	WP3 – Characterising circularity and decarbonisation opportunities – generating model inputs		
Date of Delivery	**Contractual** 30/04/2025	**Actual**	25/04/2025
Nature	DATA	**Dissemination Level**	Public
Lead Beneficiary	University College London (UCL)		
Responsible Author	Teresa Domenech	**Email**	t.domenech@ucl.ac.uk
	UCL	**Phone**	+44 7833376812
Contributors	Alvaro Calzadilla Rivera, Zijie Ma, Haoning Liu (UCL)		
Reviewer(s)	Miriam Ruß (WI); Edoardo Righetti (CEPS); Marius Neuwirth, Thurid Meta Lotz (Fraunhofer); Sonja Sechi (E3M); Panagiotis Kokkinakos (ICCS)		
Keywords	Circular economy policies, Circular Economy strategies, Circular Economy interventions		

EC Summary Requirements

1. Changes with respect to the DoA

No changes with respect to the work described in the DoA.

2. Dissemination and uptake

The target audience of the data underlying this report includes policymakers, academics, and industrial organisations looking for a systematic review of circular economy and decarbonisation opportunities for key industrial sectors. Importantly, it is intended to facilitate model development and use in the integrated assessment modelling community, by offering a dataset of CE measures, costs, and potentials that can be fed into modelling frameworks used to assess transition pathways for (European) industry.

3. Short summary of results (<250 words)

This report describes the methodology used for the generation of the open database of policies and technologies for industrial circularity performance and decarbonisation, which includes circular economy (CE) and decarbonisation interventions across the three core sectors of the project: steel, cement/concrete, and plastics. This database categorises key CE strategies and interventions based on two classificatory axes: the 9Rs framework (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle), and the approach of Narrowing, Slowing, Substituting, and Closing resource loops (NSSC). As most CE measures lead to or overlap with decarbonisation strategies, the database includes a list of technologies and associated costs that contribute to decarbonisation through increased circularity performance. This database complements the Policy Matrix, developed in D3.3., by considering parameters that can be used to transform policy interventions into modelling inputs, so that they can effectively be modelled in MIC3. The dataset also considers key technologies and their associated costs for circularity and decarbonisation. This supports the modelling efforts for the quantification of the costs of the circular and low-carbon transition as part of the model development undertaken in WP4 and, critically, the modelling exercises in WPs 7, 8, and 11.

4. Evidence of accomplishment

This report and the produced database, available via Zenodo (https://zenodo.org/records/15283670) as well as the IAM PARIS platform (https://iamparis.eu/datastories/CE_intervention).

Funded by the European Union

PROCESSES4PLANET

Preface

The need to approach climate action, resource efficiency, and circularity performance as integrated, economy-wide, cross-cutting issues is growingly gaining attention in the policy world, stimulating the development of new industrial policies in Europe and worldwide. Currently, however, there is little progress in conceptualising the circular economy and understanding its interactions with climate action. State-of-the-art modelling capacity to capture the interplay of the two agendas and their implications for energy-intensive sectors as well as to represent the European industry's transformation in line with the region's vision for climate neutrality is not yet fully developed. TRANSIENCE will undertake a comprehensive characterisation and assessment of circularity principles and measures vis-à-vis decarbonisation, by looking at the twin transition of European industries through the lenses of global competitiveness, innovation, and holistic sustainability. It will then produce MIC3, a consistent, fully open-source model ecosystem to assess industrial circularity, decarbonisation, and sustainability. A series of interoperable modules on the socioeconomic, service and product, material, industrial, energy-system, and environmental perspectives of the transformation of European industry will be developed and integrated, building on and opening the code of leading modelling tools. MIC3 will finally be used in extensive scenario modelling to produce diverse pathways toward a material-efficient, circular, climate-neutral, sustainable European industry. Transparency, openness, and knowledge sharing will be promoted, and technical capacities will be developed in four industrial agglomerations in the EU, moving beyond stakeholder consultation, onto model co-development, continuous validation of assumptions, co-creation of scenario modelling, evaluation of the desirability and usability of the developed model and insights, and eventually co-production of science and action.

ICCS – Institute of Communication and Computer Systems	EL
CEPS – Centre for European Policy Studies	BE
E3M – E3-Modelling AE	EL
Fraunhofer – Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.	DE
HOL – HOLISTIC IKE	EL
PIK – Potsdam Institut für Klimafolgenforschung e.V.	DE
PNTEC – Park Naukowo-Technologiczny Euro-Centrum Spolka Z Ograniczona Odpowiedzialnoscia	PL
TECNALIA – Fundacion Tecnalia Research & Innovation	ES
UU – Universiteit Utrecht	NL
WI – Wuppertal Institut für Klima, Umwelt, Energie gGmbH	DE
PSI – Paul Scherrer Institut	CH
UCL – University College London	UK

Executive Summary

The aim of Task 3.3 ('Characterising circularity and decarbonisation technologies, opportunities, and policies') in TRANSIENCE has been to identify and characterise circularity and decarbonisation measures, focusing on the selected materials/services/products that have been defined in Task 3.2 ('Open modelling framework definition/conceptualisation (scoping, interfaces, and integration)'). Following a review of the literature and current policies mapping circularity measures against phases of the life cycle and across sectors and areas of interventions (as documented in deliverable D3.3), the potential of interventions was identified in a database of CE measures, costs, and potentials that can be fed into the models (MS10).

This report documents the process followed to characterise selected measures individually and to describe potential synergistic and opposing interactions between them to allow them to be tested in applied modelling.

In particular, it describes the methodology used for the generation of the open database of policies and technologies for industrial circularity performance and decarbonisation, including CE and decarbonisation interventions across the three core sectors of the project (steel, cement/concrete, plastics). This database categorises key CE strategies and interventions based on two classificatory axes: the 9Rs framework (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle), and the approach of Narrowing, Slowing, Substituting and Closing resource loops (NSSC). As most CE measures lead to or overlap with decarbonisation strategies, the database includes a list of technologies and associated costs that contribute to decarbonisation through increased circularity performance. This database complements the Policy Matrix, developed in D3.3., by considering parameters that can be used to transform policy interventions into modelling inputs, so that they can effectively be modelled in MIC3. The dataset also considers key technologies and their associated costs for circularity and decarbonisation. This supports the modelling efforts for the quantification of the costs of the circular and low-carbon transition as part of the model development undertaken in WP4 and, critically, the modelling exercises in WPs 7, 8, and 11.

The main deliverable—i.e., the open database accompanied by this report—is freely available available via the TRANSIENCE project's Zenodo community (https://zenodo.org/records/15283670) and the IAM PARIS platform (https://iamparis.eu/datastories/CE_intervention).

Contents

Table of Figures

Table of Tables

1 Introduction

This report describes the methodology and structure of the Policies and Technologies dataset for Circular Economy and Decarbonisation. This dataset builds on MS10 and is connected to WP3 Task 3 (D3.3). The dataset identifies key interventions for Circular Economy (CE) and decarbonisation and the required technologies and costs. CE interventions are organised by two complementary frameworks: the 'narrow, slow, substitute, and close' approach and the '9Rs' approach (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose and recycle). Additionally, decarbonisation strategies have been included as circular interventions. where deemed complementary, or as transversal measures spanning across the 9Rs. The different types of strategies are briefly described, and a list of specific measures and interventions is provided in the rows of the matrix by core sectors, followed by ways of translating those measures as modelling inputs (as parameters).

The aim of the dataset is to provide inputs for modelling a wide range of interventions for decarbonisation and CE informing the modelling for MIC3. The dataset identifies key interventions and modelling parameters in the three core focus sectors selected in TRANSIENCE: cement/ concrete, steel and plastics. The dataset is complemented by a technology dataset which includes cost estimation by primary and secondary routes of production, a technology specific cost database and a technology trajectories dataset that incorporates potential impacts on GHG emissions based on technology roadmaps.

The matrix covers the full spectrum of CE interventions and the linkage to decarbonisation efforts, setting the basis for assessing the integrated impact of both decarbonisation and CE pathways. The report is structured in the following way: section 2 will briefly introduce the two approaches used as classificatory axis for CE interventions; section 3 explains the structure of the dataset; section 4 discusses the methodology undertaken to create the dataset and section 5 includes the bibliographic references in this document. References pertaining to different aspects of the dataset are included in the dataset itself to increase traceability.

Funded by
the European Union

PROCESSES4PLANET

2 Description of classification approaches of CE initiatives

Following the Policy Matrix, CE interventions are classified according to two alternative approaches, the narrow, slow, regenerate and close the loop (Bocken et al., 2016) and the 9Rs approach, which have been developed in D3.3. The dataset uses these approaches to enable filtering through different types of policies and associated technologies. In some cases, there may be overlaps or complementarities across strategies. For example, reuse of steel can be classified as reuse (e.g. direct reuse of structural steel) or, in some cases, repurposing (e.g. repurposing of metal pipelines as a substitute of a structural component.

A brief description of the classification approaches is provided in the sections below.

2.1 The 9Rs approach

The **9Rs approach** (Potting et al., 2017) is a hierarchical structure of CE strategies for advancing circularity across material and product life cycles. Expanding on the earlier "3Rs" (Reduce, Reuse, Recycle), already introduced as part of the Waste Hierarchy, the 9Rs model presents a **graduated scale of circular strategies**, from the most preferred (refuse) to least (recover), based on their potential to reduce resource use and environmental impact. This framework supports both qualitative and quantitative assessments of circular strategies along the value chain including design, production, consumption, and waste management systems.

The 9Rs, in descending order of circular value, are:

1. Refuse (R0)

Avoid the use of products or materials altogether—e.g., refusing single-use plastics or unnecessary packaging. This represents the most preventive form of resource conservation.

2. Rethink (R1)

Reconsider product use or function, to identify ways to fulfil the function with a lower environmental impact. An example would be changes in the design of building that reduce the need for structural elements.

3. Reduce (R2)

Minimise resource use through efficient design and consumption. This may include strategies such as lightweighting packaging or lightweighting steel structures.

4. Reuse (R3)

Direct reuse of products without significant reprocessing. An example would be reusable plastic bottles or the reuse of concrete slabs in a building after refurbishment or demolition.

5. Repair (R4)

Restore a product to its original function by fixing specific faults and problems. This may imply adopting strategies of planned maintenance of buildings, repairing of car or car components or household appliances.

6. Refurbish (R5)

Update or improve a product to meet current standards without complete remanufacture.

Examples may include refurbished smartphones and other personal electronics, but also refurbishment of buildings as an alternative to demolition, where structural components are maintained.

7. Remanufacture (R6)

Rebuild a product using a combination of reused, repaired, and new components, typically returning it to a "like-new" condition. This practice is common in the area of industrial equipment and machinery.

8. Repurpose (R7)

Use a product or its components in a new way or for a different purpose without significant processing. Using crashed concrete as secondary aggregates could be included under this R.

9. Recycle (R8)

Convert waste materials into new raw materials through physical or chemical transformation. Though widespread, it is generally more energy-intensive compared to higher-tier strategies. There are multiple examples of recycling across the core sectors such as the recycling of PET plastic bottles into plastic recyclates or the recycling of steel scrap.

10. Recover (R9)

Extract energy or materials from waste through incineration, digestion, or gasification. This is the least preferred option within circular economy principles, as it does not maintain the material integrity or value. Examples of this would be Refused Derived Fuel from construction waste or energy to waste plants using pyrolysis or gasification.

2.2 Narrow, slow, substitute and close the loop approaches

The CE transition requires moving away from end of pipe solutions to pollution and waste to adopt strategies that proactively reduce material and energy flows across the whole life cycle of products and services. Bocken et al. (2016) proposed a classification of CE strategies—Narrow, Slow, Substitute, and Close the Loop—(NSSC) to guide business model innovation towards circularity. These strategies focus on optimising resource use, extending product lifespans, replacing unsustainable materials, and closing material cycles, thereby supporting systemic decoupling of economic growth from environmental impact. The key strategies under this approach are briefly described below.

Narrow the Loop

This approach focuses on minimising the input of resources by rethinking product design, reducing material use, and preventing unnecessary consumption. By designing products with efficiency and sustainability in mind, this strategy aims to limit resource extraction and waste generation at the source.

Slow the Loop

"Slow" strategies extend the lifecycle of products by emphasising reuse, repair, refurbishing, remanufacturing, and repurposing. These actions help maintain products, components, and materials at their highest utility for as long as possible, delaying the need for replacement or disposal.

Substitute

This strategy involves replacing materials or processes with more sustainable alternatives. By substituting finite or harmful resources with renewable, biodegradable, or less environmentally damaging options,

Funded by the European Union PROCESSES4PLANET

businesses can create products that are more eco-friendly.

Close the Loop

Closing the loop refers to ensuring that materials are recovered and reused at the end of their lifecycle. This includes recycling materials back into production processes and recovering energy from waste, creating a circular flow of resources rather than a linear one.

2.3 Correspondences between the NSSC and 9Rs

While there is not a full correspondence between the 9Rs and NSSC approaches the table below provides an indication of the correspondences between strategies.

Table 1. Correspondences between CE NSSC and 9Rs

CE NSSC	9Rs
Narrow	Refuse, Rethink, Reduce
Slow	Reuse, Repair, Refurbish, Remanufacture, Repurpose
Substitute	Substitute materials or processes
Close	Recycle, (Energy) Recovery

3 Structure of the dataset

The Policy and Technologies dataset provides a comprehensive set of circular and decarbonisation interventions, covering all the life-cycle stages and the full spectrum of CE interventions, with an indication of parameters (or ways to translate policy interventions into modelling inputs), technologies and their associated costs.

The dataset builds on the Policy Matrix (D3.3) but incorporates many additional features, including parametrisation of the interventions, list of technologies and costs.

This is a comprehensive dataset which considers all possible interventions across the selected circularity approaches and provides specific guidance by core sectors. This matrix now incorporates the **parameters**, which provide guidelines into possible options for translating interventions into modelling inputs. While the parameters are defined in general terms (e.g. z% reduction in primary steel), the detailed material-specific matrices provide options for quantifying the parameters.

The second main element of the dataset is the datasets of **CE and decarbonisation technologies and associated costs**. This is split into different tabs, to deliver different options in which to incorporate and consider technology choices across the models. In the sector-specific tabs, the dataset includes specific technologies applicable across different types of CE strategies and a more general dataset that reflect main technology routes across the core sectors with detail of associated costs.

The Policy and Technologies dataset for plastics is structured into four principal components:

1. **Intervention Framework and Parameterisation:** This section consists of the following elements: 1) it outlines key intervention strategies for circular economy organised by the NSSR and the 9Rs frameworks; 2) it suggests ways to parametrise the interventions to serve as inputs for the different models and MIC3; 3) It provides, where possible, possible parameter values across four core scenarios: a) those informed by current policies under the baseline scenario; b) those informed by non-binding policy-driven policies such as roadmaps; c) parameter values informed by ambitious decarbonisation pathways generally building on modelling approaches and d) parameters derived from sectoral best practices. Finally, the material/ sector specific matrixes provide an indication of the measures that may have an opposing or synergistic effects in the interlinked circularity and decarbonisation transition. This is estimated based on expert understanding and previous modelling impacts but will be revised in the light of MIC3 outputs. This part is organised in the following way:

    - **Summary matrix** that summarises interventions across the three core sectors and parameters

    - **Individual matrixes for plastics, cement and steel**, which coded interventions, parameters, alternative parameter values, synergistic and opposing effects and references

2. **Macroeconomic Cost Structure of primary and secondary Production across core sectors:** Based on the GTAP-CE database, this dataset provides high-level cost estimates for both primary (virgin) and secondary (recycled) plastic production routes across all Member States (MSs) in monetary terms. This includes a breakdown of cost components (e.g., feedstock, energy, processing) to enable cross-comparative analysis of production pathways. This part contains two datasets:

    - **GTAP-**CE cost. This dataset build on IO data, provides a detailed account of all inputs required for production, included imported goods, domestic goods and other endowment factors such as labour, capital, land and natural resources. It also includes different taxes. The data is disaggregated by type of input and available for EU27+UK and for each MS.

- **GTAP-**CE cost_Summary. This dataset is a summarised version of the previous dataset where inputs have been aggregated by categories (Imports, Domestic input, land, unskilled labour, skilled labour, capital and Natural Resources). The data has been combined with physical production quantities for the core sectors, to derive **unit prices per tonne ($/kg) for primary and secondary production routes** for EU27+UK and by MSs.

3. **Technology-Specific Cost Dataset:** This dataset offers a detailed catalogue of plastic, steel, cement/concrete related technologies categorised by type of technology and R strategy. For each technology, cost estimations are derived from published literature, typically at a global or sectoral level, without specific geographic resolution. This dataset complements the macroeconomic dataset by allowing more granular understanding of different technologies and for benchmarking and comparative evaluation of emerging vs. incumbent technologies. This dataset is made up of three datasets:
   - **Plastic Technologies**. This covers main circular and decarbonisation technologies for plastics with detail of the TRL, range of costs, and applications.
   - **Cement/ concrete Technologies**. This covers main circular and decarbonisation technologies for cement/concrete with detail of the TRL, range of costs, and applications.
   - **Steel Technologies**. This covers main circular and decarbonisation technologies for steel with detail of the TRL, range of costs, and applications.

4. **Prospective Modelling of Technological Trajectories:** This component of the dataset explores potential future developments through scenario-based modelling of various 'technology mixes'. It aims to quantify the decarbonisation potential of different combinations of technologies, identifying their contributions to net-zero pathways and system-level transformations.

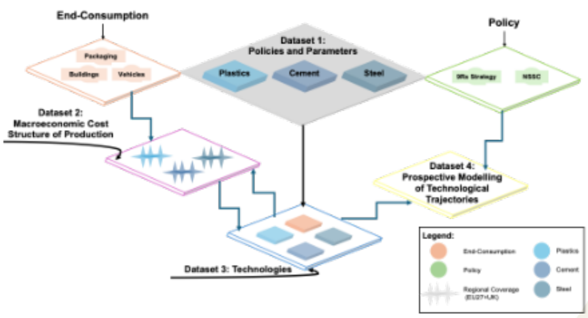

Figure 1. The TRANSIENCE internal data management platform

Funded by
the European Union

PROCESSES4PLANET

Table 2. Policies and Technologies Dataset components

Component	Description
POLICY MATRIX	Dataset with interventions organised by the 9Rs framework and the 'narrow, slow, and close' framework. Provides examples of intervention types and specific applications across the three core sectors. Includes ideas on how to parameterise interventions in MIC3 models and links to relevant policies.
Matrix_Plastics	Detailed dataset for plastics, covering all aspects as in the Policy Matrix.
Matrix_Cement	Detailed dataset for cement, covering all aspects as in the Policy Matrix.
Matrix_Steel	Detailed dataset for steel, covering all aspects as in the Policy Matrix.
Technologies and Cost	Detailed list of technologies by sector, with qualitative assessment of costs.
Technologies_Plastics	Detailed dataset for plastics, covering all aspects as in the Technologies dataset.
Technologies_Cement	Detailed dataset for cement, covering all aspects as in the Technologies dataset.
Technologies_Steel	Detailed dataset for steel, covering all aspects as in the Technologies dataset.
GTAP-CE Cost	Key technologies across focus sectors estimated from the GTAP-CE dataset, with detailed costs of imported and domestic inputs.
GTAP-CE Cost_Summary	Grouped summary of key technologies from the GTAP-CE dataset under a limited number of categories.
Prospective Modelling of Technology Trajectories	Summary of targets for key sectors based on roadmaps related to decarbonisation and circular production routes.

The dataset is freely available available via the Zenodo (https://zenodo.org/records/15283670) and the IAM PARIS platform (https://iamparis.eu/datastories/CE_intervention).

Funded by the European Union

PROCESSES4PLANET

4 Research methodology: dataset creation for policies and technologies for circularity and decarbonisation

The development of the dataset followed a structured multi-step approach combining systematic literature review, policy mapping, modellers' validation, and data standardisation. The aim was to compile a comprehensive, multi-sector dataset that links policies for the circular economy and decarbonisation with key technologies and their costs.

4.1 Scope definition and framework of the dataset

The initial steps built on the extension of the Policy Matrix, which provided an overview of key interventions for CE across the 9Rs and NSSC frameworks which set the boundaries and informed the scope of the dataset. Key elements considered for the Policies and Technologies dataset included:

- Identification of policies supporting circularity and/or decarbonisation, including regulatory, economic, voluntary, and information-based instruments, as well as roadmaps and other non-binding policies or interventions which incentivise a more efficient and circular use of resources and promote decarbonisation
- Definition of parameters that enable the consideration of CE policies in modelling.
- Identification of values or value ranges for the parameters defined.
- Identification of technologies enabling material circularity (e.g. reuse, remanufacturing, recycling, material substitution, digitalisation) and technologies for decarbonisation.
- Definition of costs structures and cost ranges by circularity and decarbonisation technologies at different levels of granularity.
- Overall cost structure of primary and secondary production routes for the three core sectors.

The sectoral focus of the dataset was put on high energy- and material-intensive sectors such as steel, cement/ concrete and plastics. The temporal scope was recent or emerging policies and technologies as well as other planned future interventions (e.g. roadmaps). Future objectives generally were considered up to 2050.

4.2 Systematic data collection, organisation, and analysis

The data collection strategy designed was based on a distinct approach for the Policy and Technology dataset which is briefly detailed below.

The Policy Dataset: EU, national and regional policy documents were reviewed building on the work undertaken in Task 3.3. The main documents were the EC Circular Economy Action Plan and strategy documents. These were complemented with product and sector specific policies and roadmaps for steel, cement and plastics. Relevant policies adopted at the national and regional levels were identified through review of best practices for the selected sectors. To ensure comprehensive representation of policies, where gaps were identified, keyword-based searches were conducted using chains such as "circular economy strategy," "low-carbon policies" "resource efficiency". Many of the key policy documents were located in EU databases (e.g., Eur-Lex, EEA policy database, OECD indicator dataset), but the search was also extended to national government websites, and international organisations (e.g., UN Environment, OECD, IEA). For the

Funded by
the European Union

parametrisation a literature review was undertaken to look at examples of how different policies have been represented across different modelling approaches. This was complemented with expert input and feedback from TRANSIENCE modellers and discussion-based sessions to identify different options to model circular interventions.

The Technology Dataset: For the technology dataset we followed two complementary approaches. The first approach was to collect specific mature and emerging technologies across each of the NSSC and 9Rs classification of CE interventions and other key decarbonisation technologies. The identification of key technology pathways and associated costs was done using GTAP-CE database v11. 2017. The GTAP database (Global Trade Analysis Projects) is a comprehensive, global dataset developed mainly used in CGE models that analyse international trade, economic policies, and their effects. GTAP is a multi-country, multi-sector dataset that covers over 140 regions and 65+ sectors in the latest versions. It is based in Input-Output tables which detail each region's production and consumption structures as well as bilateral trade flows. The dataset includes production, consumption, intermediate demand, final demand, investment, government spending. The dataset has recently been extended to consider aspects related to climate and energy policy analysis and circular economy. GTAP-CE enhances the conventional GTAP by incorporating energy use, emissions data and secondary routes of production, as well as scrap and critical raw materials.

In here, each column corresponds to a specific production route across the core sectors (such as primary plastic, secondary plastic etc.), while each row represents a source of inputs required for the production, including imported goods, domestic goods, and various endowment factors such as labour, capital, land, and natural resources, for the different pathways. The data is available for each Member State (MSs) plus the UK for 2017 and calculated based on monetary terms, expressed $1Mill. An estimation of the cost/tonne was calculated using data on physical production for the three core sectors by MSs and for the EU 27+UK. The dataset also provides shares of each input source in the total **cost of production** across each production route and sector by each MS.

The second approach was to collect data on specific technologies both established but also emerging, across the different 9Rs strategies for the core sectors. Relevant technologies were identified from peer-reviewed literature, technology catalogues (e.g., International Energy Agency, European Parliamentary Research), and technical reports from different institutions such as the Ellen MacArthur Foundation, OECD, WBCSD, and JRC. The specific references have been included in the dataset. Priority was given to technologies with reported environmental or resource efficiency benefits, with data including maturity level or Technology Readiness Level (TRL), application area, and circularity/ carbon mitigation potential. The work also builds on the outputs from Task 3.3. and, in particular, Deliverable D3.3., which describes core technologies across the main three sectors. In this case, estimation of costs did not have geographical granularity as is generally based on cost ranges, at the EU or global level. This represents key gaps in the assessment of transition costs which may be able to be further refined later by the MIC3 model results.

Finally, the dataset includes a section on '**Prospective Modelling of Technology Trajectories'** which include estimation towards the future in terms of decarbonisation and circularity based on technology mixes. In here, the data specifies key targets from sector-specific roadmaps and matches hem against key technology routes. The Technology Trajectories dataset was extracted from official EU policies and leading industry reports (e.g. Plastics Europe, CEMBUREAU, EUROFER). In the dataset share of primary and secondary production targets for 2030 and 2050 are identified and matched against corresponding technologies, e.g. mechanical recycling, H_2-based steelmaking, clinker substitution. Baseline data from the 2017 GTAP-CE dataset was utilised to benchmark the current shares of primary and secondary production against the 2030

Funded by the European Union

and 2050 targets and assess costs and transition requirements to align with those trajectories. This data helps define transition needs and track progress towards circularity and decarbonisation goals, with indication of potential for decarbonisation for each of the routes. The approach ensures that technological adoption trajectories align with policy objectives. Detailed descriptions of key decarbonisation and circular economy technologies were compiled, focusing on their implementation readiness and impact potential. Some examples of the technology routes include: 1) mechanical recycling for plastics as a way of enhancing polymer recovery rates to reduce virgin material demand; 2) Hydrogen-based Direct Reduction as a low-carbon alternative to traditional steel production; and 3) Clinker Substitution as a way to reduce CO_2 emissions by replacing clinker with alternative materials in cement manufacturing.

Impact Estimations of technology routes and interventions. Where available, impact estimations of GHG reductions (in Mt CO_2/year) were integrated from industry roadmaps, (e.g. EUROFER, CEMBUREAU, Plastics Europe) and decarbonisation pathways lied down by the IEA.

4.3 Experts' and modellers' validation

Preliminary entries for parametrisation and definition of modelling inputs were reviewed and validated through experts' and modellers' workshops within TRANSIENCE to ensure that they were adequate to be translated into suitable modelling inputs and to identify potential prioritisation of measures. The feedback from the modellers informed refinements in classification structure and, as well as parameters.

4.4 Data harmonisation and access

The dataset has been created in Excel and can be transferred to a relational database to ease its integration into modelling workflows or other templates which work across modelling suites. Where needed, we ensured that there was consistency in the way the interventions and technologies were organised and used standard units for the technology costs dataset. To provide data traceability we included references and links to main sources within the dataset.

Funded by
the European Union
PROCESSES4PLANET

5 References

Bocken, N.M.P., Bakker, C., Pauw, I. De, 2016. Product design and business model strategies for acircular economy. J. Ind. Prod. Eng. 1015, 20. https://doi.org/10.1080/21681015.2016.1172124 *(PDF) Circular Ecosystem Innovation: An Initial Set Of Principles*. Available from: https://www.researchgate.net/publication/338286462_Circular_Ecosystem_Innovation_An_Initial_Set_Of_Principles [accessed Apr 03 2025].

Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2017). *Circular Economy: Measuring innovation in the product chain* (Policy Report). PBL Netherlands Environmental Assessment Agency.

Funded by
the European Union

PROCESSES4PLANET