ZEvRA

Zero Emission electric Vehicles enabled by haRmonised circulArity

Design for Circularity and Circularity Assessment

ZEvRA at TransensusLCA Final Event

Violeta Vargas

June 25th, Brussels

eurecat

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101138034 and UKRI under Grant Agreement No. 10105316.

Funded by the European Union

UKRI

The Urgency for Sustainable Mobility

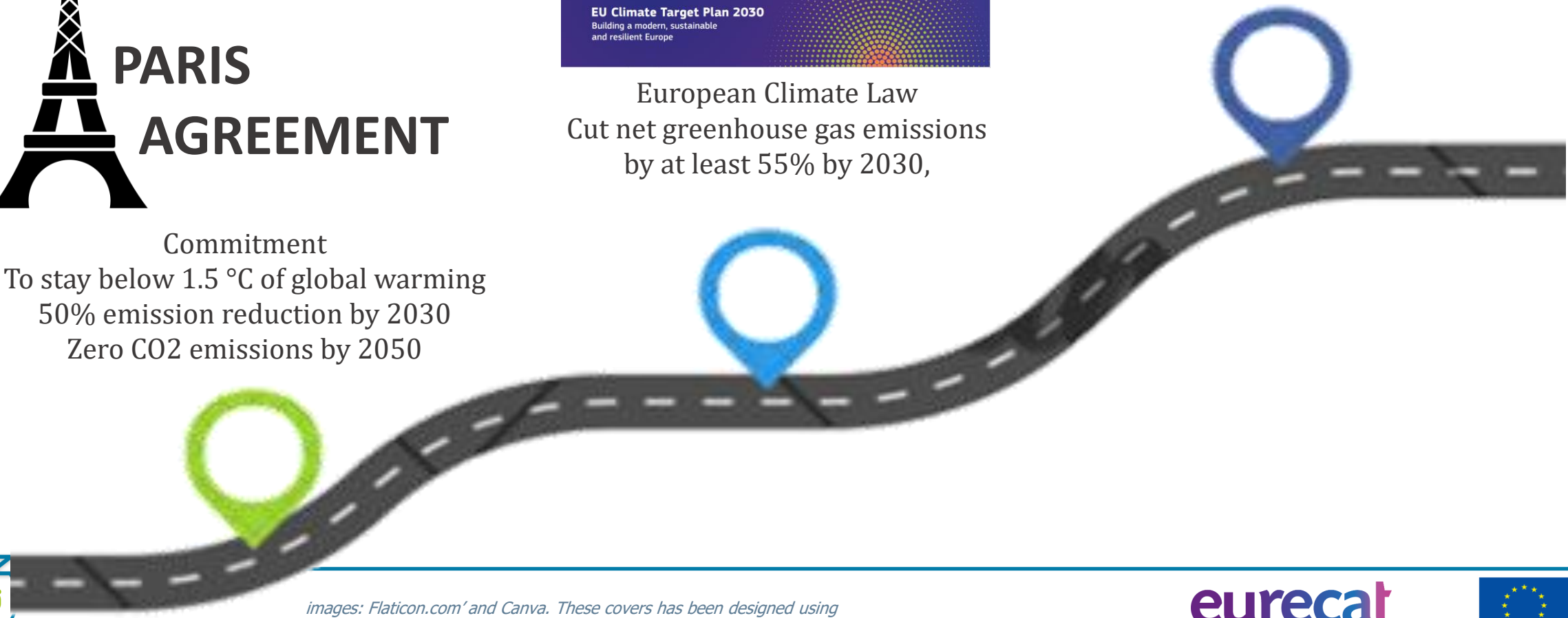
The European Green Deal

Strategy
Climate neutrality by 2050

PARIS AGREEMENT

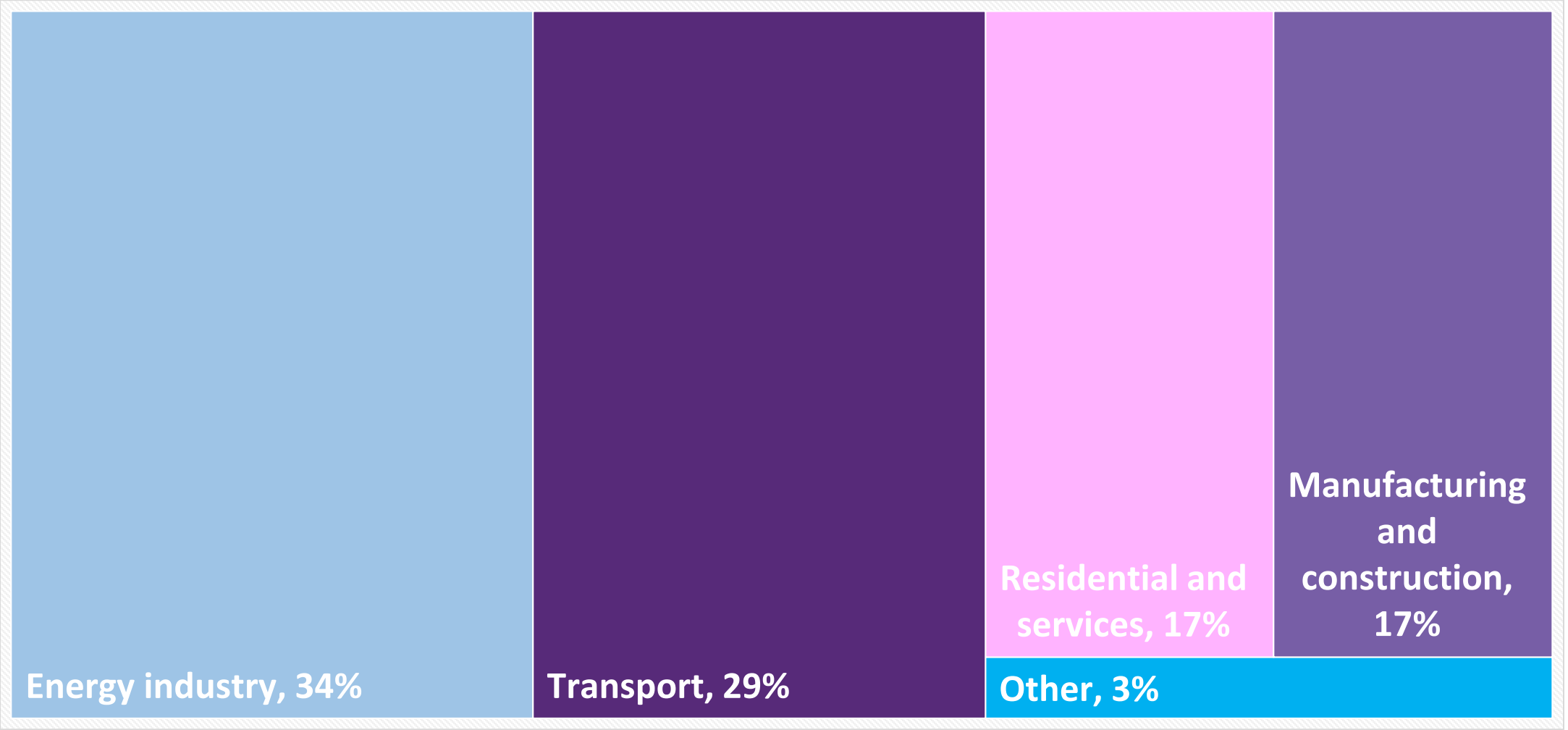
Commitment
To stay below 1.5 °C of global warming
50% emission reduction by 2030
Zero CO2 emissions by 2050

European Climate Law
Cut net greenhouse gas emissions
by at least 55% by 2030,



images: Flaticon.com' and Canva. These covers has been designed using resources from Flaticon.com and canva.com

The Urgency for Sustainable Mobility



Breakdown by source of GHG emissions in the EU-27 between 1990 and 2021
Source: UNFCCC

ZEvRA – Zero Emission electic vehicles enabled by harmonised circularity

Key Figures

- Grant Authority: EUROPEAN CLIMATE, INFRASTRUCTURE AND ENVIRONMENT EXECUTIVE AGENCY (CINEA) (**G.A. no. 101138034**)
- Call Topic: Circular economy approaches for zero emission vehicles (RIA) – D5-01-04
- Grant: **€ 11.4 million** from the EU **+ UNN share** from the UK
- Duration **3 years** from **1st January 2024** to **31th December 2026**
- **28 partners** from **13 countries and over 1150 person months work**

- **Main objective:** improve the circularity of light-duty electric vehicles throughout their value chain, from material sourcing to manufacturing and end-of-life processes

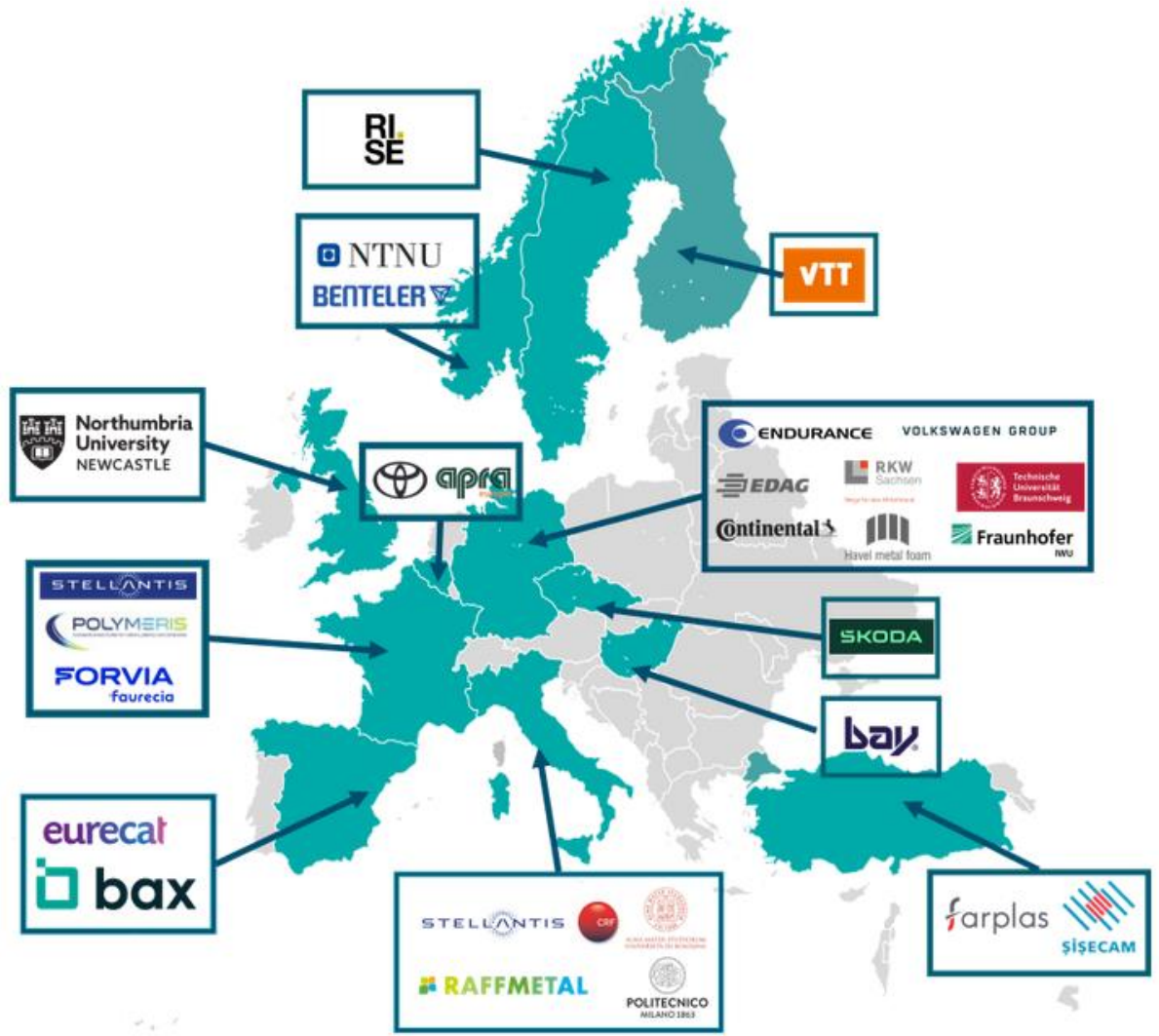
ZEvRA – Zero Emission electic vehicles enabled by harmonised circularity

Ambition and overall objectives

- **Main objective:** improve the circularity of light-duty electric vehicles throughout their value chain, from material sourcing to manufacturing and end-of-life processes
- **Obj. 1.** Developing Design for Circularity methodology and a holistic circularity assessment
- **Obj. 2.** Validate Obj. 1. by developing zero-emission solutions for 8 use cases
- **Obj. 3.** Circular Car Concept based on the Skoda Enyac which integrates Obj. 2.
- **Obj. 4.** Awareness and acceptability of the circularity strategy by demonstrating key aspects and advantages
- **Obj. 5.** Virtual learning and educational platform for training and upskilling of the industrial workforce
- **Obj. 6.** Adopt circular business models (CBMs) to the project's zero emission solutions

ZEvRA – Zero Emission electic vehicles enabled by harmonised circularity

Consortium



Iterative Design for Circularity methodology

The methodology involves 4 steps.

Iterative design for Circularity methodology

Step 1: Identification of Hotspots and Life Cycle Stages

STEP 1: Identification of Hotspots and Life Cycle Stages

STEP 2: Establishment of the most properly Design for Circularity strategies based on STEP 1

STEP 3: Definition of concrete actions and alignment to the strategies & technological procedures

STEP 4: Selection of concrete Design for Circularity actions and Conceptualized Design

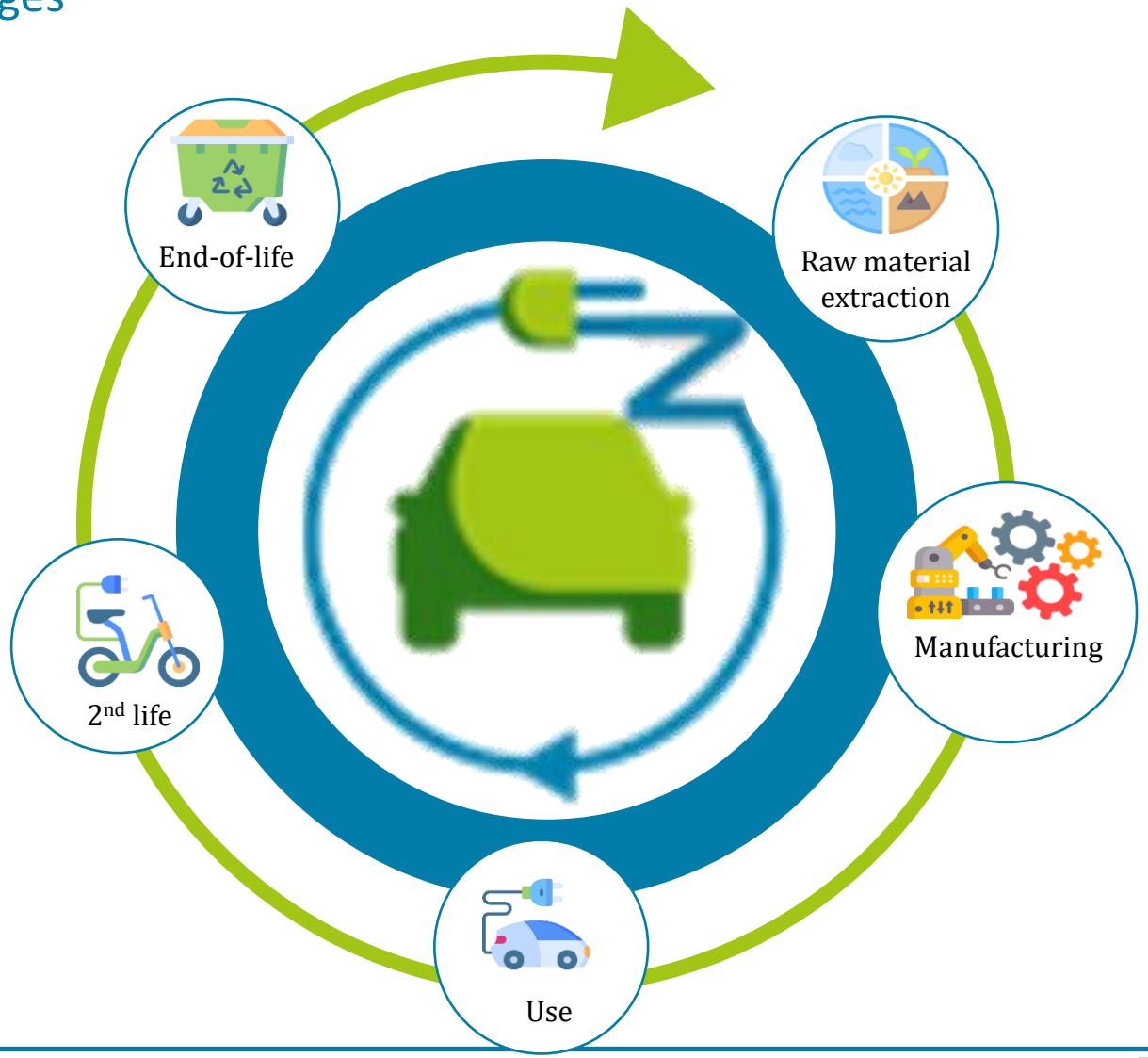
Based on a benchmark analysis for conventional products/stages/materials

Iterative design for Circularity methodology

Step 1: Identification of Hotspots and Life Cycle Stages

Use Cases

- Steel
- Wrought Aluminium
- Casting Aluminium
- Foam Aluminium
- Plastics
- Composites
- Glass
- Tyres
- Rare Earth Elements (REE)



Iterative design for Circularity methodology

Step 2: DfC Strategies Definition and Setup

STEP 1: Identification of Hotspots and Life Cycle Stages

STEP 2: Establishment of the most properly Design for Circularity strategies based on STEP 1

STEP 3: Definition of concrete actions and alignment to the strategies & technological procedures

STEP 4: Selection of concrete Design for Circularity actions and Conceptualized Design

Focused and aligned with the objectives of the study and coupled to technical actions

Iterative design for Circularity methodology

Step 2: DfC Strategies Definition and Setup

Smarter product use and manufacture	***R0***	***Refuse***	*Make product redundant by abandoning its function or by offering the same function by a radically different (e.g. digital) product or service*
	R1	***Rethink***	*Make product use more intensive (e.g. through product-as-a-service, reuse and sharing models 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*
Extend lifespan	***R3***	***Reuse***	*Re-use 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*
	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 (to specified quality level)*
	R6	***Remanufacture***	*Use parts of a discarded product in a new product with the same function (and as-new-condition)*
	R7	***Repurpose***	*Use a redundant product or its parts in a new product with different function*
Useful application of materials	***R8***	***Recycle***	*Recover materials from waste to be reprocessed into new products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations*
	R9	***Recover***	*Recovery of (embodied) energy from wastes and residue*

Iterative design for Circularity methodology

Step 3. Re-adapting technological aspects and strategies

STEP 1: Identification of Hotspots and Life Cycle Stages

STEP 2: Establishment of the most properly Design for Circularity strategies based on STEP 1

STEP 3: Definition of concrete actions and alignment to the strategies & technological procedures

STEP 4: Selection of concrete Design for Circularity actions and Conceptualized Design

Technical procedures must be defined from the environmental perspective from the beginning.

HOW? Workshop where all parties involved provide circular-design concepts and possibilities

Participants shared their expert view on the viability of implementing the 9Rs across different materials and components of EVs.

Iterative design for Circularity methodology

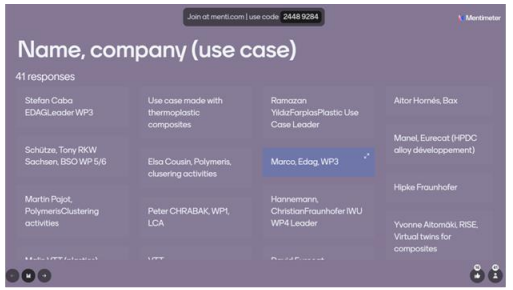
Step 3. Re-adapting technological aspects and strategies

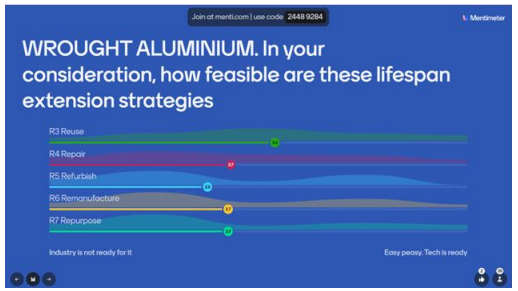
R8 Recycling most feasible strategy across nearly all materials.

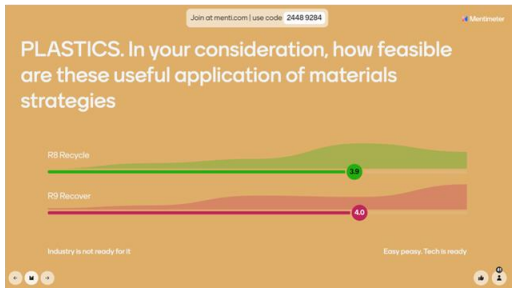
R2 Reduce has been voted as highly feasible for many materials, supported specially by innovative design.

Contrarily, lifespan extension strategies (R4 Repair, R5 Refurbish and R6 Remanufacture) have been considered less viable.

R0 Refuse has been consistently ranked low, as these materials (use cases) can be essential in various applications.







Steel	Wrought Aluminium	Casting Aluminium	Foam Aluminium	Plastics	Composites	Glass	Tyres	REE
R8 Recycle	R8 Recycle	R8 Recycle	R8 Recycle	R9 Recover	R2 Reduce	R8 Recycle	R9 Recover	R8 Recycle
R2 Reduce	R2 Reduce	R2 Reduce	R2 Reduce	R8 Recycle	R1 Rethink	R2 Reduce	R8 Recycle	R2 Reduce
R1 Rethink	R1 Rethink	R1 Rethink	R1 Rethink	R2 Reduce	R8 Recycle	R1 Rethink	R2 Reduce	R1 Rethink
R3 Reuse	R3 Reuse	R3 Reuse	R0 Refuse	R1 Rethink	R0 Refuse	R0 Refuse	R1 Rethink	R0 Refuse
R4 Repair	R4 Repair	R4 Repair	R3 Reuse	R3 Reuse	R4 Repair	R3 Reuse	R3 Reuse	R3 Reuse
R5 Refurbish	R5 Refurbish	R5 Refurbish	R4 Repair	R4 Repair	R3 Reuse	R4 Repair	R4 Repair	R7 Repurpose
R6 Remanufacture	R6 Remanufacture	R6 Remanufacture	R5 Refurbish	R5 Refurbish	R7 Repurpose	R7 Repurpose	R5 Refurbish	R6 Remanufacture
R7 Repurpose	R7 Repurpose	R7 Repurpose	R6 Remanufacture	R7 Repurpose	R9 Recover	R9 Recover	R6 Remanufacture	R5 Refurbish
R9 Recover	R9 Recover	R9 Recover	R7 Repurpose	R6 Remanufacture	R5 Refurbish	R6 Remanufacture	R7 Repurpose	R4 Repair
R0 Refuse	R0 Refuse	R0 Refuse		R0 Refuse	R6 Remanufacture	R5 Refurbish	R0 Refuse	R9 Recover

Iterative design for Circularity methodology

Step 4. Actions definition

STEP 1: Identification of Hotspots and Life Cycle Stages

STEP 2: Establishment of the most properly Design for Circularity strategies based on STEP 1

STEP 3: Definition of concrete actions and alignment to the strategies & technological procedures

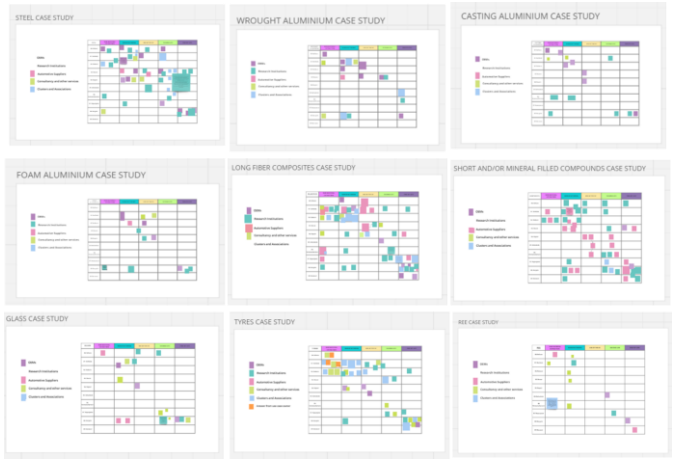
STEP 4: Selection of concrete Design for Circularity actions and Conceptualized Design

More specific actions should be defined in alignment with technical possibilities.

HOW? Brainstorming session

Iterative design for Circularity methodology

Step 4. Actions definition



Steel. More secondary materials and modular design for a better reuse and recycling alternatives. Community engagement along the value chain has been also considered relevant.

Aluminium. Use of fewer different alloys to enhance recycling sorting and impurities. Enhancing Material consumption reduction through lightweight design and new advanced technologies. Second life applications have been also considered.

Plastics and composites. Compostable plastics and a reduction in the complexity in material classes. Standardize designs and improved recycling technologies while also considering new business models for reuse and remanufacture involving community engagement.

Glass. Replacing glass with thermoplastics and AI for a more efficient design. Repurposing glass for other industries has also been proposed.

Tyres. Biobased materials, repairability and improved recycling techniques. Repurposing tyres for building insulation or fillers on roads.

REE. Explore carbon-based materials and standardize REE materials and solutions.

AI to reach better levels of efficiency in use of materials, and also for more circular designs and end-of-life solutions.

Standardization in design and material class to increase reuse and recycling.

Increase secondary material content to reduce reliance on primary raw materials.

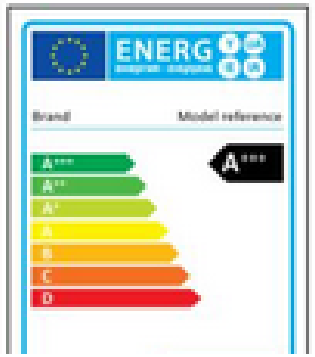
Modularity and design for disassembly at early design

Harmonised Circularity Assessment

THE ASSESSMENT

The HCA-tool aggregates circular, environmental, economic and social spheres' indicators, to obtain a final numerical value, single-indicator, which enables products' benchmarking in a holistic way.

Final numeric indicator which provides **only comparative** information and not absolute values.



Useful decision-tool for supporting performance-based strategies / policies / purchase.

Harmonised Circularity Assessment

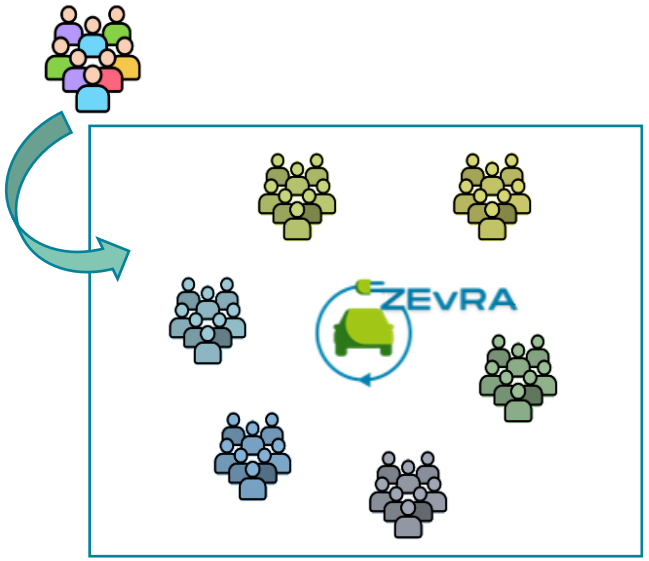
THE ASSESSMENT

Harmonised Circularity Assessment

Circular
Environmental
Economic
Social

Aim: to consider circular, environmental, economic and social product's performances to obtain holistic results allowing decision making processes and comparative assessments.

How: Stakeholders' consensus rating.



The **rating framework** of the four sustainability spheres considered for the assessment remains the key step which will determine the final ranking of the intermediates/vehicle assessed.

The main objective is to capture the different "sensitivities" of the rating consortium:

WEIGHT → rates sustainability spheres

IMPORTANCE → rates each of the indicators of the spheres

Harmonised Circularity Assessment

THE ASSESSMENT

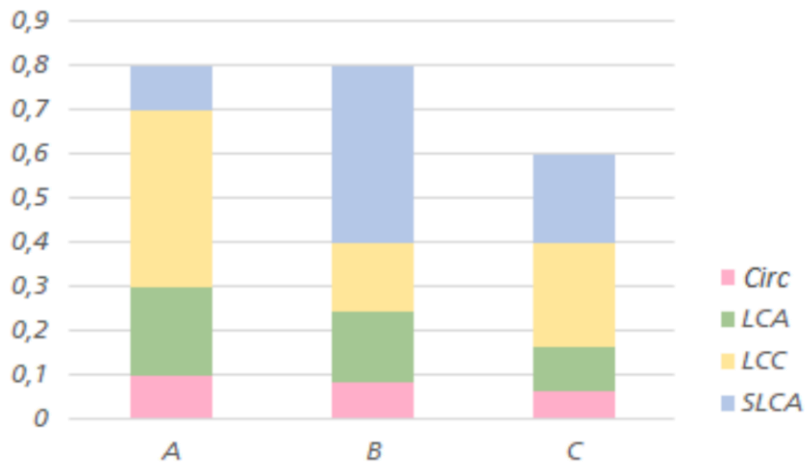
Harmonised Circularity Assessment
Circular
Environmental
Economic
Social

Single comparable result: As main "attractive" result, a single comparable value which considers all the indicators is achieved.

well received by some stakeholders because of its simplicity [the opposite also for the same reason]

In-depth analysis results:

Possibility to assess the **contribution** of each of the **sustainability spheres** to the final value.



Possibility to **disaggregate** project consensus results **into stakeholders' sub-groups**: engineers, producers, environmentalist, users…

Consensus

Engineers

Environmental researchers

Producers

Others

Harmonised Circularity Assessment

CEES – Rating methodology

CEES-indicators

Rated from 1 to 3

Low Importance (LI)
Medium Importance (MI)
High Importance (HI)

CEES-spheres

Rated from 0 to 100

(The score of the four categories must add up to 100)

Harmonised Circularity Assessment

CEES – INDICATORS

CIRCULAR

R9 framework	Indicators	
Refuse	Unnecessary feature reduction	**Measures the percentage reduction in non-essential features or elements/components in components/vehicle over time**[%/CorV]
Rethink	Suppliers sustainability	**% (mass-based) of component/vehicle with sustainability recognition (organizational or product level)** [%/CorV]
Reduce	Lightweighting	**% (mass-based) of weight reduction** [%/CorV]
Reuse	Reuse potential	**Nº of pieces/components designed to be incorporated** (without modifications) **into new/used component/vehicle production/repair** [Nº/CorV]
Repair	Disassembly complexity	**Disassembly depth** [Nº of steps to disassemble/CorV]
Refurbish	Refurbishment potential	**Nº of pieces/components (aimed to be) refurbished** (restore and update) **and reintroduced into the supply chain** [Nº/CorV]
Remanufacture	Remanufacturing potential	**Nº of pieces/components (aimed to be) remanufactured and reintroduced** (with the same function) **into the supply chain** [Nº/CorV]
Repurpose	Upcycled elements	**Nº of pieces/components created from or aimed to be redundant (such as surpluses not used for its original purpose)**[Nº/CorV]
Recycle	Cyclic recyclability	**% (mass balance) of recycled & recyclable material at component/vehicle** [%/CorV]
Recover	Waste-to-energy	**% (mass balance) production waste sent for energy recovery** [%/CorV]

Harmonised Circularity Assessment

CEES – INDICATORS

ENVIRONMENTAL

Product Environmental Footprint (PEF)

PEF impact category	unit	Definition
Climate Change	*kgCO2eq*	Assesses the potential global warming effect consequence of GHG emissions (CO2, CH4, NOx, CFCs, etc.)
Ozone Depletion	*KgCFC11eq*	Assesses the depletion of the stratospheric ozone layer (sun's ultraviolet radiation protection)
Human toxicity – Cancer effects	*CTUh*	Accounts for adverse health effects on humans related to cancer from toxic substance intake from air/water/soil
Human toxicity – Non-cancer effects	*CTUh*	Measures non-cancer health effects on humans from toxic substance intake from air/water/soil
Particulate Matter	*Disease incidence*	Evaluates the impact of fine particulate matter (2,5 microns) on human health (NOx and SO2 as precursors)
Ionising radiation	*kBq U235*	Assesses the health effects caused by manmade radioactive releases (nuclear energy, X-rays, etc.)
Photochemical Ozone Formation	*KgNMVOCeq*	Measures the formation of ground-level ozone, which can harm human health and vegetation (caused by VOCs, CO, Nox, etc.)
Acidification	*molH+eq*	Evaluates the increase in acidity of water and soil systems (harmful effects to ecosystems and heritage)
Eutrophication Potential - Freshwater	*KgPeq*	Assesses nutrient enrichment which could lead to overfertilization and biogeosystem inbalances in freshwater ecosystems
Eutrophication Potential - Marine	*KgNeq*	Assesses nutrient enrichment which could lead to overfertilization and biogeosystem imbalances in terrestrial ecosystems
Eutrophication Potential - Terrestrial	molNeq	Assesses nutrient enrichment which could lead to overfertilization and biogeosystem imbalances in marine ecosystems
Ecotoxicity freshwater	*CTUeq*	Assesses the toxic effects of chemicals on freshwater ecosystems (estimates the number of species affected over time and space, for each unit of chemical released)
Land use	*Pt Dimensionless*	Measures the impact of land occupation and transformation on soil quality and biodiversity considering: biotic production, erosion resistance, grounddwater regeneration and mechanical filtration.
Water Scarcity	m^3	Evaluates the consumption and scarcity of freshwater resources considering the availability or scarcity of water in the regions where the activity takes place
Resource Use - Minerals and Metals	*KgSBeq*	Assesses the depletion of mineral and metal resources (reflects the ratio between the annual production of the resource and the known global reserve that is considered)
Resource Use - Fossil	*Mj*	Measures the depletion of fossil fuel resources (MJ is an inherent energy in all fossil fuels, oil, gas, coal, etc.)

*For further information: European Platform on LCA | EPLCA

Harmonised Circularity Assessment

CEES – INDICATORS

ECONOMIC

Impact category	unit	Definition
Manufacturing cost	*€/CorV*	Reflects materials, components, manufacturing costs, costs related to sales, marketing, administration, and R&D, (cradle-to-gate stage) **[both components and full vehicle]**
Use costs	$€/V_{lifespan}$	Electricity cost during the use phase (200,000 Km) for SKODA Enyaq EV based on the average household electricity prices in the EU region (household electricity has been used since it represents between 70% and 75% of the total charging of the EVs in the EU region **[only applicable to full vehicle]**
Maintenance cost	*€/CorV*	Regular preventive maintenance costs for the entire life cycle (200,000 km ≈ 15 years). It considers tires, brakes (brake discs front, brake linings rear, and brake pads front), and wiper blade, and includes the labour cost and number of replacements per part over the lifespan **[not applicable to all components]**
End-of-life cost	*€/CorV*	encompass expenses related to decommissioning, disposal, and environmental remediation of an component/vehicle at the end of its use life **[both components and full vehicle]**
Environmental externalities	*€/CorV*	Costs not directly reflected in market price which represent the broader societal and ecological consequences component/vehicle life cycle on climate change. This is monetization of GHG emission [**both components and full vehicle]**

Harmonised Circularity Assessment

CEES – INDICATORS

SOCIAL

PSILCA

Psilca impact category	unit	Definition
Child labour total	*%*	Percentage of children aged 5-17 engaged in child labor (both formal and informal economy) in the reference year
Frequency of forced labour	*cases*yr/1k inhab.*	Number of reported forced labor incidents annually
Goods produced by forced labour	*Nº in sector*	Count of goods known to be produced using forced labor
Safety measures	*OSHA*yr//100k emp.*	Assessment of the presence and adequacy of workplace safety measures [Occupational Safety and Health Administration]
Fatal accidents	*cases*yr/100k emp.*	Rate of work-related fatalities per 100,000 workers
Non-fatal accidents	*Cases*yr/100k emp.*	Rate of non-fatal work-related injuries per 100,000 workers
Unemployment	*%*	Percentage of population ages 15-64 in reference year
Drinking water coverage	*% inhab.*	Proportion of population with access to safe drinking water
Pollution	*DALYs*yr/1k inhab.*	Disability-Adjusted Life Years due to indoor and outdoor air and water pollution
Net migration	*‰*	Difference between immigrants and emigrants in a reference year
Contribution of the sector to economic development	*% GDP*	Sector's share in the country's total Gross Domestic Product
Promoting social responsibilty	*Nº of companies/sector*	Assessment of a sector's efforts to promote social responsibility
Anti-competitive behaviour or violation of anti-trust and monopoly legislation	*cases*yr-frame(5)/100k empl.*	Number of reported incidents of anti-competitive practices annually

converted to

medium risk hours

*For further information: openLCA Nexus: The source for LCA data sets

ZEvRA

Zero Emission electric Vehicles enabled by haRmonised circulArity

Questions & Comments

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101138034 and UKRI under Grant Agreement No. 10105316.

Funded by the European Union