Zero Emission electric Vehicles enabled by haRmonised circularity

Deliverable 5.2

Awareness and Acceptability report

31 December 2025

Funded by the European Union

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

ZEvRA
Zero Emission electric Vehicles enabled by haRmonised circulArity

Project information

Project acronym	ZEvRA
Full name of the project	Zero Emission electric Vehicles enabled by haRmonised circulArity
Grant agreement	101138034
Coordinator	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV
Starting date	1st January 2024
Duration in month	36
Call identifier	HORIZON-CL5-2023-D5-01-04

ZEvRA
Zero Emission electric Vehicles enabled by haRmonised circulArity

Document information

Document title	Awareness and Acceptability report
Deliverable number	D5.2
Dissemination level	PU - Public
Deliverable type	R – Document, Report
Work package	WP 5 – Awareness, Acceptability and Training: Robust Education Platform
Work package leader	UNN
Partners involved	UNN (leader) APRA, RKW, POL, STL, SKO
Authors	Kirsten Lange [APRA], Jikai Zhang [UNN], Dr. Katharina Schöps [RKW]
Reviewers	FRA
Submission date	31.12.2025

Document history

Date	Version number	Summary of changes
17.12.2025	V0	Initial draft document]
23.12.2025	V0.1	Results compilation, structure and writing of the report
28.12.2025	V0.2	Polished after review
31.12.2025	V1	Final- / Submission version

ZEvRA project abstract

ZEvRA's main objective is to improve the circularity of light-duty EVs throughout their entire value chain, from materials supply and manufacturing to end-of-life (EoL) processes, which aligns with the European Union's goal of achieving zero CO2e emissions by 2035, particularly in the EV value chain. To do so, ZEvRA will develop a Design for Circularity (DfC) methodology and a holistic circularity assessment aimed at improving the production of electric vehicles (EVs) based on the 9Rs. This methodology will be validated by developing zero emission solutions for the most important automotive materials, covering > 84% material mix: steel, three versions of aluminium (wrought, casting, and foam), thermoplastics composites (long and continuous fibre-reinforced), unfiled/short fibre plastics, glass, tyres and Rare Earth Elements (REE). These solutions will be supported by a set of digital tools to support the manufacturing of the use cases, the assessment of circularity, traceability, and the virtual integration of components into a full replicable vehicle.

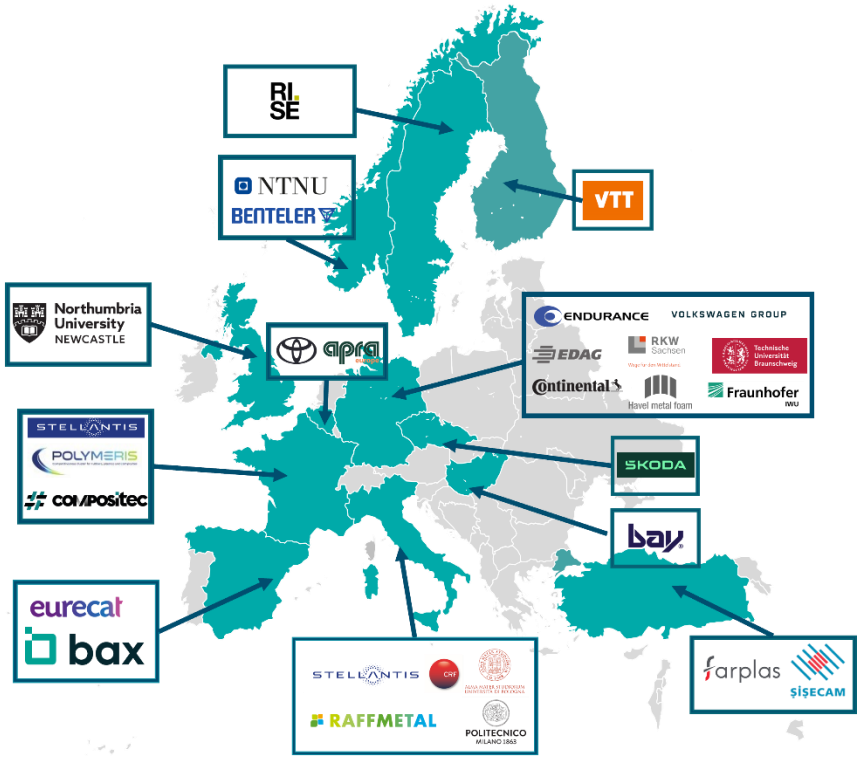

Figure 1: *ZEvRA Consortium*

To maximise the outreach of our methodology and zero emission solutions, ZEvRA will develop a dedicated training & upskilling programme for the automotive workforce and academia, together with activities aimed at increasing awareness & acceptability of the proposed zero emission solutions. Lastly, circular business models targeting EoL and logistics aimed at improving the economic feasibility of circularity in EVs are advanced. ZEvRA's innovations aim to improve zero emission approaches in the life cycle and value chain of at least 59% of European EVs by 2035 through the 5 OEMs and Tier 1's that are part of the consortium (Figure 1), which includes industry and academia covering the entire automotive value chain.

Table of Contents

Disclaimer

The content of this publication does not represent the official position of the European Commission and is entirely the responsibility of the authors. The information presented here has been thoroughly researched and evaluated and is believed to be accurate and correct. However, the authors cannot be held legally responsible for any errors. There are no warranties, expressed or implied, made with respect to the information provided. The authors will not be liable for any direct, indirect, special, incidental, or consequential damages arising out of the use or inability to use the content of this publication.

Copyright

Index of Figures

Index of Tables

Abbrevations and Acronyms

Table 1: *Abbrevations and Acronyms*

Abbr.	Full name
CE	Circular Economy
SOTA	State-of-the-Art analysis
EU	European Union
CEAP	Circular Economy Action Plan

Executive summary

This updated version of the Awareness and Acceptability Report presents the foundational work carried out under Task 5.1 to advance awareness and acceptability of circular economy (CE) principles and Life Cycle Assessment (LCA)-based design for zero-emission solutions in road transport. Despite the increasing relevance of circularity in sustainable manufacturing, significant knowledge gaps persist, particularly within the industrial workforce. ZEvRA addresses this challenge through a structured awareness and acceptability programme aimed at engaging key stakeholders, strengthening human capital in research and innovation, and supporting the adoption of circular economy practices in the automotive sector.

A structured methodology was applied to assess the current state of CE awareness and acceptance. The report presents a state-of-the-art analysis of relevant policies, training programmes, industry initiatives and best practices, followed by an in-depth identification of gaps and barriers affecting CE implementation. These barriers include stringent performance requirements for recycled materials, limited availability of high-quality secondary materials, economic constraints affecting cost competitiveness, and integration challenges within design and production processes. Broader systemic factors, such as consumer perceptions, aesthetic considerations and logistical constraints, further complicate the transition towards circularity.

Based on interviews with OEMs and OESs and supported by ongoing survey activities, the report develops concrete measures to address the identified barriers, focusing on regulatory alignment, technical integration, economic incentives and workforce upskilling. Particular emphasis is placed on tailored communication and awareness tools, including newsletters, events, presentations and the ZEvRA Annual Conference, to improve stakeholder engagement and acceptability. The results presented establish a solid, data-driven foundation for the next phases of Task 5.1 and contribute to advancing circular economy solutions and sustainable innovation in the automotive sector.

1 Introduction

The transition to a circular economy and the electrification of transport are critical to addressing the zero-emission transport challenge. Despite growing recognition of circularity as a key sustainability strategy, awareness and acceptability of circular economy principles remain limited, particularly within the industrial workforce, where only about one-fifth of employees are familiar with these concepts. ZEvRA aims to bridge this knowledge gap by developing a structured awareness and acceptability program that maximizes the impact of circular economy innovations in the automotive sector. By fostering a deeper understanding of circular design, sustainable manufacturing, and LCA-based decision-making, ZEvRA seeks to accelerate the adoption of circular practices and facilitate a large-scale transition towards sustainability in the industry.

The updated analysis confirms that awareness and acceptability challenges are closely linked to skills availability, organisational readiness, regulatory conditions and market dynamics, underlining the need for integrated and targeted awareness-raising approaches.

Work package 5 contributes directly to this objective by focusing on raising awareness and increasing acceptability of circularity among key stakeholders. It will develop a comprehensive virtual learning environment and a robust educational platform to provide specialized training for the industrial workforce. Additionally, it will promote innovation in automotive technology and circular economy strategies, facilitate collaboration between academia and industry, and assess the effectiveness of training activities in improving skills and job placement opportunities. Through targeted learning initiatives, work package 5 aims to strengthen human capital in research and innovation by equipping professionals with expertise in Design for Circularity (DfC) methodologies, advanced prototyping, and large-scale manufacturing of sustainable technologies.

Project-dedicated communication instruments such as the ZEvRA newsletter and ZEvRA annual conferences have been introduced to support stakeholder engagement, increase awareness and improve acceptability of circular economy solutions among industrial and non-industrial audiences.

Work package 5 is structured into three interconnected tasks that together support the overall project objectives. First, it aims to systematically increase awareness and acceptability of circularity by implementing a guided approach to engagement and demonstrating the key advantages of circular economy practices. Second, it strengthens research and innovation capabilities by providing specialized training in circular design methodologies and emerging technologies relevant to the use cases. Third, it establishes a virtual learning framework and an advanced educational platform to upskill the industrial workforce, ensuring that circular economy principles are embedded in technical training and professional development.

This Awareness and Acceptability Report outlines the foundational work to work package 5, prepared in Task 5.1 "Awareness and Acceptability", presenting an updated assessment of the state of awareness and acceptability of circular economy practices, identifying barriers to

implementation, and proposing strategies to overcome them. It describes the methodology for gathering data through stakeholder engagement, industry surveys, and expert interviews, ensuring that all findings are based on practical industry insights. The structure of the deliverable follows a logical progression, beginning with an analysis of the current landscape, identifying knowledge gaps and barriers, and culminating in the development of concrete measures to enhance awareness, improve skills, and support the widespread adoption of circular economy solutions in the automotive sector. As ZEvRA progresses, this work package will continue to evolve, incorporating new findings and refining its strategies to maximise impact and ensure long-term success.

2 State of the Art (SOTA) Review of Circular Economy and Circular Technologies

Together with the gap analysis, the State of the Art analysis (SOTA) forms the theoretical basis for the development of the plan to overcome barriers for acceptance of ZEvRA innovations.

The aim of the SOTA is to provide a comprehensive and systematic overview of existing research, practices and technological advances related to the promotion of the circular economy. The overview will highlight the current landscape, identify existing gaps and provide a basis for the investigation of barriers to ZEvRA innovations and market and social analysis within the project. Furthermore, it will serve as a foundation for developing targeted strategies to enhance awareness, improve workforce upskilling, and support the implementation of circular economy practices at a European level.

2.1 Purpose of the SOTA analysis

The purpose of the State-of-the-Art (SOTA) analysis on circular economy (CE) awareness and training is to provide a comprehensive overview of existing knowledge, initiatives, and best practices that support the transition to a circular economy across the automotive industry and other relevant sectors in Europe. This analysis aims to identify current educational and training programs, describe their effectiveness in promoting CE principles, and highlight gaps in awareness and skills development. By evaluating research papers, policies, industry-led initiatives, and academic curricula, the SOTA offers insights into the strengths and weaknesses of current CE training efforts. The SOTA aims to ensure alignment with EU policies and strategic frameworks related to CE and sustainable skills development.

Furthermore, it will serve as a foundation for creating targeted communication tools to enhance awareness, improve workforce upskilling, and support the implementation of circular economy practices at a European level. It also contributes to the plan to overcome barriers to the ZEvRA innovations..

With this update to the Awareness and Acceptability Report, the SOTA has been revised and refined, and supplemented with additional insights from automotive industry, stakeholders and emerging developments in CE education and training. This iterative approach is also planned for the latest edition of the report.

2.2 Scope of the SOTA analysis

The State-of-the-Art (SOTA) analysis was conducted to assess the current landscape of circular economy (CE) education, training, and awareness within the European Union (EU), with a particular focus on workforce development, industry engagement, and policy support. The primary objective was to identify existing initiatives, educational programs, and knowledge gaps

that impact the adoption and implementation of CE principles across various sectors, particularly within the automotive industry.

The analysis focused on the following key areas:

- EU policies, directives, and regulatory frameworks to understand policy-driven incentives, regulatory barriers, and the alignment between policy objectives and actual CE education implementation.
- Systematic literature review of peer-reviewed research papers and academic studies to map the evolution of CE education.
- Search for EU-funded research projects, Horizon Europe initiatives, and industry collaborations to understand how CE training is being implemented at both academic and professional levels. This included analysing ongoing projects in sustainable materials and green skills development.
- Providers of vocational education and workforce upskilling initiatives across different EU member states.
- A search for CE-related university curricula, degree programs, and online courses was conducted to assess the integration of CE concepts into engineering, business, environmental science, and interdisciplinary education. The analysis also evaluated the role of micro-learning, project-based learning, and digital education tools in CE training.

The methodological approach for the SOTA analysis combined quantitative and qualitative research techniques to provide a holistic view of CE education and training efforts in the EU. The following steps were undertaken:

- A structured review of scientific literature, policy papers, and industry reports was conducted in Google Scholar to map out existing knowledge and emerging trends in CE training.
- EU policy documents, directives, and action plans were studied to assess their impact on CE education and workforce transition measures.
- EU research project databases, such as CORDIS, were analyzed to identify past and ongoing initiatives related to CE education and workforce development.
- University websites and academic databases were reviewed to compile degree programs, vocational training, and specialized CE courses across the EU.

By integrating these sources, the SOTA analysis provides a comprehensive overview of the status and gaps in CE training and education. The findings serve as a foundation for the development of the plan to overcome barriers for acceptance of ZEvRA innovations.

2.3 Current Landscape of Circular Economy Education & Awareness

A systematic review of reports, policies, academic papers and industry publications revealed the following state of the art on the circular economy in the European Union.

2.3.1 Policy & Strategic Frameworks

The European Green Deal is the overarching strategy for a sustainable EU economy. Moving to a circular economy paradigm is at its core for achieving climate neutrality in the EU by 2050. [1] The second Circular Economy Action Plan (CEAP) for the circular economy is decisive for the promotion of the circular economy in the EU. The CEAP brings together a range of measures to accelerate the transformation to a sustainable economy. The measures are to be transposed into the national law of the EU member states. The first CEAP was launched in 2015, focusing on establishing circularity. The second CEAP was released in March 2020 focusing on mainstreaming circular economy with the key aspects fostering the competitiveness of the EU while protecting the environment and giving new rights to consumers for sustainable consumption. The Consumer Rights Directive (2024/825) [2] is mentioned here in particular. With the Consumer Rights Directive aspects of the circular economy such as durability, reparability or recyclability will be included in the list of a product's most important characteristics to enable consumers to make more informed choices and thus promote the demand for and supply of more sustainable goods. The directive will enter into application on 27 September 2026.

According to The European Centre for the Development of Vocational Training (Cedefop) it is a challenge to quickly change mindsets towards a preference for recyclable products and to convince organisations to adopt circular business models (especially in the energy sector and in some manufacturing sub-sectors). Cedefop's experts therefore see regulation as the most important lever to accelerate the transition to a circular economy. This includes the revision of EU directives and the mandatory introduction of product passports, supply chain traceability and the extension of product lifetimes, particularly in sectors where such regulatory measures make a significant difference to the organisation of production (e.g. energy, waste management, textiles, agri-food and remanufacturing). In addition to the introduction of measures, programmes to promote innovation and financial incentives (e.g. for repairs) also play an important role. [3]

Basic concepts and definitions related to waste management, including the definitions of waste, recycling and recovery, are set out in the Waste Framework Directive (EU) 2018/851. EU Directive 2018/851 concretises the measures set out in Directive 2008/98. While the EU Directive 2008/98 only mentions education as an exemplary measure for the promotion of reuse and/or repair, the amended EU Directive 2018/851 establishes education as a significant contribution to waste prevention. The directive calls on member states to take measures to raise awareness of waste prevention and littering among consumers through continuous communication and education initiatives. [4], [5]

Economic instruments are also planned to raise awareness of the circular economy. Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment, aims to sensitise participants in the financial market to the environmental impact of financial products by means of suitable labels. Greenwashing of financial products is also to be prevented. [6] The EU Commission aims to encourage EU Member States to extend the use of economic instruments such

as environmental taxes, including landfill and incineration taxes. Member States are to be given the option of using VAT rates to promote recycling activities aimed at end consumers, in particular repair services. [7]

The CEAP also recognises that the EU Commission's skills and job creation instruments will help accelerate the transition to a circular economy, including in the context of the update of its skills agenda, the launch of a skills pact with large-scale multi-stakeholder partnerships and the Social Economy Action Plan. Further investmens will be made under the European Social Fund Plus, the European Union (EU)'s main instrument for supporting investments in education and training systems, lifelong learning and social innovation. [7]

These measures are further reinforced by the EU Clean Industrial Deal, which aims to strengthen the competitiveness and resilience of European industry while accelerating the green transition. The Clean Industrial Deal was published on 26th February 2026 and highlights circularity, access to sustainable materials, and demand-side measures for low-carbon and circular products as strategic priorities. It emphasises the role of industrial ecosystems, including the automotive sector, in scaling circular solutions, improving material efficiency, and securing secondary raw material supply chains. By linking decarbonisation objectives with circular economy principles, the Clean Industrial Deal provides an enabling policy context for increasing awareness and acceptability of circular design, remanufacturing and recycled materials, in line with ZEvRA objectives. [7a]

The 'Right to repair' directive (EU) 2024/1799, an important directive for strengthening consumer rights, also contains measures to raise awareness. The directive emphasises sustainable consumption by promoting repair, reuse and refurbishment and aims to reduce waste and environmental impact while making repair services more accessible and cost-effective for consumers. A key initiative is the establishment of a European online repair platform that provides easy access to repair services, refurbished goods and community-led repair initiatives, making repair a viable and attractive option. To further raise consumer awareness, the Commission and Member States are encouraged to run information campaigns, including publicising the European online platform on national websites. Manufacturers also have a crucial role to play, as they are obliged to provide clear and easily accessible information about their repair obligations and the services available to ensure that consumers are well informed about their repair options. In addition, Member States must implement at least one measure to promote repair, which can take the form of financial incentives such as repair vouchers and funds or non-financial support such as training programmes to improve repair skills or the establishment of local repair initiatives. With these measures, the Directive aims to integrate repair more strongly into consumer habits and make it a practical and attractive alternative to disposal and replacement, thus promoting a more circular economy. [8]

In addition, the revised version of Directive 2000/53/EC on end-of-life vehicles (ELV Directive) remains a key regulatory framework for circularity in the automotive sector. The Directive establishes measures to prevent waste from vehicles and to promote reuse, recycling and other

forms of recovery of vehicle components and materials. It sets quantitative targets for reuse and recovery (95%) and for reuse and recycling (85%) by average weight per vehicle and year, and restricts the use of hazardous substances in vehicles. Ongoing policy discussions at EU level indicate further strengthening of ELV requirements, including enhanced traceability of materials, higher recycled content targets, and improved dismantling and information obligations, which are directly relevant to the objectives of ZEvRA. The revised version has not yet been adopted. [9a]

The Union of Skills framework, launched by the European Commission in 2025, provides a strategic policy umbrella to address persistent skills gaps and mismatches arising from the green and digital transitions. It places strong emphasis on industry involvement in skills development, calling for closer cooperation between enterprises, education and training providers, social partners and public authorities. The framework highlights the importance of work-based learning, lifelong upskilling and reskilling, skills portability across Member States, and targeted support for strategic industrial ecosystems. [9b]

2.3.2 Existing Training & Education Programs

University Programs and Courses on Circular Economy

Higher education institutions are recognised as strategic actors that need to support sustainability and the principles of CE through teaching and research activities. They play a crucial role in educating leaders and policy makers with appropriate CE skills, competences and awareness.

In Italy, a study of 49 higher education institutions for the academic year 2020-2021 identified master's degrees and postgraduate programmes with ‘Circular Economy’ in the title, suggesting that the circular economy is establishing itself as an academic discipline in its own right. Examples include a master's programme in ‘Sustainability and Circular Economy Management’ at the Polytechnic University of Marche, ‘Circular Economy’ at the University of Tuscia and ‘Sustainable Chemistry and Technology for CE’ at the University of Padua. Postgraduate courses include ‘Circular Economy’ at the Polytechnic University of Bari and ‘Environmental sustainability & circular economy’ at the Polytechnic University of Milan. The study also identified numerous CE modules offered by various universities, covering themes like circular processes, chemical-environmental plants, elements of circular economy, circular economy for energy storage, circular economy design and development, circular and sustainable waste management, economics for the circular economy, and material design for circular economy. [9]

Project-based learning is emphasised as a valuable tool in CE education, allowing students to apply theoretical concepts in real-life situations, interact with industry and develop both technical and transversal competencies such as teamwork and leadership. Case-based learning is also used to look at CE challenges from a systemic perspective and encourage critical thinking. [10]

In Europe, about 28 English-speaking bachelor's programmes and 174 master's programmes on the circular economy are currently listed. [11], [12] Both bachelor's and master's degree

programmes are mostly in the disciplines of engineering and technology, environmental studies and earth science, business and management, or social sciences. Since CE is a cross-disciplinary topic spanning a wide range of disciplines, there are fewer bachelor's programmes than master's programmes, and only a few bachelor's programmes whose titles explicitly refer to CE. Examples of universities offering bachelor-level programmes with explicit reference to circular economy include Maastricht University and Leoben University. In addition, universities such as LUT University (Lappeenranta) and Aston University (Birmingham) offer bachelor-level programmes that integrate circular economy-related specialisations. Among the more specialised master's programmes, universities with explicit reference to circular economy include the University of Graz, HAN University of Applied Sciences (Nijmegen) and ZHAW Zurich University of Applied Sciences. Some universities, such as Delft University of Technology in the Netherlands, Aalborg University, and the Royal Institute of Technology KTH, have also developed dedicated programmes that focus on principles related to the circular economy.

Vocational Education and Training (VET) Programs on Circular Economy

The TREE Project ('Micro- and project-based learning programme for Teaching Circular Economy and Ecological awareness in VET') was an Erasmus+ funded initiative aimed at integrating circular economy (CE) and sustainability education into vocational education and training (VET) schools. The project spans from December 2021 to November 2023 and involved partners from Lithuania, the Netherlands, Estonia, and Bulgaria. The project analysed education for sustainable development (ESD), EU sustainable development policy and the role of green skills in three key economic sectors: plastics, agri-food and wood. It introduced project-based learning (PBL) and micro-learning as innovative teaching methods to bridge the gap between theory and practice. The project results show that the demand for green skills is increasing but there is a lack of structured training, which led to the development of comprehensive teaching materials and training programmes. The outcomes from the TREE project aim to support the transition to a circular economy by providing students with relevant skills, strengthening links between VET and industry and promoting sustainability in education and employment. [13]

In its policy recommendations, Cedefop emphasises the importance of training teachers and trainers responsible for training in the circular economy at all levels and for the education and training of public sector workers. To meet emerging skills needs, opportunities for further education, on-the-job training and apprenticeships should be expanded. According to Cedefop, vocational education and training can promote learning through interdisciplinary and multidisciplinary approaches. VET needs to move away from a linear view of production and towards the paradigm of repair, recycling and reuse, with systems thinking and other core VET competences becoming part of the core curriculum. Harmonisation of basic VET courses at national and EU level is also proposed. The actors that govern and regulate VET should focus on developing new and updating existing training programmes to prepare people for emerging circular occupational profiles. Enriching curricula with CE skills in energy-intensive sectors and incorporating practical, work-based and problem-based learning will be crucial. A national or

regional directory of VET institutions specialising in different aspects of the circular economy would help to match the range of programmes to local and business skills needs. Increasing the attractiveness of vocational education and increasing the attractiveness of jobs in the circular economy should also be a priority. [3]

Cedefop further underlines that effective VET responses to the green and circular transition require stronger involvement of social partners and enterprises in curriculum design, delivery and assessment. Work-based learning, apprenticeships and continuous upskilling pathways are identified as key instruments to ensure that VET provision remains responsive to rapidly evolving skill needs and supports the acceptability of new circular practices among workers and employers. [13a]

In the energy sector, there are a number of training initiatives for the circular economy: The Energy Academy (CEA) is a key initiative that offers training seminars and exams for vocational qualifications in the circular economy, in addition to renewable energy, energy efficiency, sustainable tourism and financing. Another program is the Youth Employment Network for Energy Sustainability in Islands (CEA), which focuses on preparing young people (25-29 years) for green jobs in the fields of energy efficiency, renewable energy and sustainable mobility. This program includes e-learning courses and incorporates case studies of success stories to enhance learning. In addition, the Montenegro Summer School on Green Energy provides students with an overview of Montenegro's energy landscape, including solar and wind energy as well as energy storage systems. The program spans three days, with one day dedicated to presentations and two days of visits to hydropower and solar power plants to ensure a hands-on learning experience. These training initiatives integrate both theoretical knowledge and practical experience and aim to close the skills gap in the circular economy. [14]

Micro-learning is considered an effective method for teaching education for sustainable development (ESD) in vocational schools. Micro-learning is based on modular training that breaks down educational content into small, focused learning units that can be absorbed and applied quickly. It follows key principles such as brevity, flexibility and interactivity and allows students to engage with bite-sized lessons that suit their learning pace. Micro-learning is particularly suitable for vocational students as it provides practical, easily digestible knowledge that can be applied immediately in real-life scenarios. It supports active learning through videos, quizzes, case studies and digital tools, making sustainability education more engaging and accessible. Integrating micro-learning into VET curricula can improve knowledge retention, increase accessibility and better prepare students for green jobs in a circular economy. [13] Examples of micro-learning include the “Green skills for circular economy” course [15] and the course from Circulab academy [16].

This approach is consistent with Cedefop’s recommendation to modularise learning pathways and support flexible, short-cycle training formats that enable workers and learners to update skills throughout their careers, particularly in response to fast-evolving green and circular skill demands. [13a]

The BUILD UP Skills is a European Union initiative for the construction sector for skills uptake also aiming at decarbonization and circular economy. It was launched in 2011 and is currently funded under the LIFE Clean Energy Transition program and managed by the Climate, Infrastructure, and Environment Executive Agency (CINEA). It supports the EU Pact for Skills, particularly the construction sector pact, which aims to upskill and reskill at least 25% of the industry's workforce—equivalent to three million workers—over five years. The initiative targets professionals across the building value chain, including companies, public authorities, building owners, and tenants. Its key focus areas are skills intelligence for the green transition, skills development through new or upgraded training schemes, and skills uptake by promoting demand for skilled professionals. Supported projects have introduced various approaches to circular economy, such as circular construction and energy efficient construction. [19]

Industry-Led Upskilling and Workforce Development Initiatives

In general, training on the circular economy is crucial for people in management roles, as they need to know how to integrate the circular economy into their company and its business processes. It is crucial to encourage employers to offer training to their employees.

Recent industry-facing initiatives emphasise that effective upskilling for circular economy implementation must address both technical competences and organisational change capabilities, including leadership, decision-making and cross-functional collaboration. [19a]

Collaboration between universities and industry can help close the skills gap and ensure that the workforce is adequately prepared for the demands of the circular economy. Institutions such as Delft University of Technology in the Netherlands have developed specific programs that focus on the principles of the circular economy. Partnerships between universities and industry leaders can lead to internships and mentorships that give students hands-on experience in the circular economy. [17]

Similar approaches are observed in Horizon Europe projects DaCapo and RENÉE, where workforce development is directly linked to the industrial deployment of circular solutions. In the DaCapo project, workforce development focuses on webinar-based training, didactic factory activities and stakeholder-oriented learning formats addressing managers, professionals and operators, with the aim of enabling the practical uptake of digital tools and circular decision-support systems. [17a] In the RENÉE project, upskilling activities are embedded in human-centric training strategies for remanufacturing, combining technical training on AI-supported robotic systems with the development of transversal skills such as leadership, adaptability and job crafting, supported by an educational platform and iterative feedback from end-users. [17b]

An example for collaboration between universities and industry is the RenewChem initiative. The RenewChem initiative was established by the Green Chemistry Centre of Excellence (GCCE) at the University of York to enhance graduate training in green chemistry and sustainable manufacturing. Developed in collaboration with industry partners such as Merck KGaA, Croda,

GSK, and Brocklesby Ltd., RenewChem aims to equip doctoral students with the necessary skills, knowledge, and experience to address industry challenges related to sustainability and the circular economy. This initiative covers key areas identified by industry, including resource efficiency, regulation, life cycle thinking, commercialization, and environmental impact assessment. [18]

Open education programmes and choices

In addition to formal education courses, there are also numerous open education courses available that can be included in formal education programs.

- The RES4CITY project developed and implemented a micro-credential (MC) program focused on the green energy transition utilizing online modules, reading materials, and assessments. The project's aim is to promote sustainability and circularity in cities with focus on renewable energy systems. [20] Available at https://res4city.boostmyskills.eu/.
- The free online micro-learning courses focused on ESD (Education for Sustainable Development) mentioned above:
    - The Circular Skills open online course for young adults to raise their awareness about circular economy principles [15], available at https://circular-skills.org/online-course/.
    - The circular economy introduction course, a self-paced two hour online course to understand circular economy principles and apply them in businesses. [16] available at https://circulab.academy/courses/activate-circular-economy/
- The European Circular Economy Stakeholder Platform provides a free accessible knowledge hub with good practices, strategies and a collection of studies, reports, presentations and position papers on circular economy. [21] Available at https://circulareconomy.europa.eu/platform/en/knowledge-hub
- TU Delft offers a self-paced Massive Open Online Course (MOOC) in "Engineering Design for a Circular Economy". The course teaches sustainable design and engineering methods to improve the reuse, repair, remanufacturing, and recycling of products for a circular economy. [22] Available at https://online-learning.tudelft.nl/courses/engineering-design-for-a-circular-economy/
- TU Delft also offers a continuously running open course on the introduction to the circular economy as part of its Sustainable Engineering Design Professional Certificate Program. Topics are circular economy strategies and design for circular economy. [23] Available at https://www.edx.org/learn/circular-economy/delft-university-of-technology-circular-economy-an-introduction
- University of Leiden offers an open course for the circular economy of metals. [24] Available at https://www.coursera.org/learn/circular-economy-metals .
- The EIT Manufacturing community offers open courses, summer schools and online training modules addressing circular manufacturing, sustainable product design and resource efficiency, often combining technical content with innovation and entrepreneurship

perspectives. [24a] Available at https://www.eitmanufacturing.eu/what-we-do/education/education-programmes/manufacturing-innovation-webinars/

- The EU Academy platform hosts openly accessible learning resources and courses related to sustainability, climate action and circular economy topics, which can complement formal and non-formal education pathways and contribute to raising awareness and acceptability of circular solutions among a broad range of stakeholders. [24b] Available at https://academy.europa.eu/topics/energy-climate-change-environment/

2.3.3 Awareness and Communication Efforts

In the table below is a selection of communication tools for circular economy awareness with their type, organisers, description and target group.

Table 2: *Communication tools for circular economy awareness*

Type of tool	Organiser	Description	Target group
E-Learning catalogue	BUILD UP Skills NL	Access to developed training modules and assessments	Building and installation workers and experts [50]
App	BUILD UP Skills NL	Contains a database for construction trainings in Europe and some specific EU countries. It also contains a community-managed content repository.	Practitioners and craftsmen in the construction value chain [50]
Round table discussion	European Circular Economy Stakeholder Platform (ECESP)	Stakeholder Dialogue held on 10 April 2025 to discuss key EU initiatives shaping the circular economy community	businesses, public authorities and NGOs to knowledge communities and other civil society organisations [19a]
Round table	VDI Verein Deutscher Ingenieure	VDI-Roundtable Circular Economy for Plastics to discuss challenges, chances and inevitable measures to transform to a circular plastics economy	(German speaking) Experts from all over the plastics value chain, including policymakers, researchers and NGOs [25]
Round table	Circular Innovation Talks/Circular Economy Forum Austria	Regular roundtables with an international exchange of knowledge and experience to promote synergy effects through cross-sector,	Austrian decision-makers and multipliers at various administrative levels, including federal Austrian states, cities, regions and municipal

		interdisciplinary dialog. (in German)	institutions with different levels of expertise [26]
Conference	European Roundtable on Sustainable Consumption and Production 2025	Conference with focus on Multi-stakeholder cooperation on sustainability: Role of business, academia, public sector and civil society in Sustainable Consumption and Production.	academia, the private sector and public administration [27]
Conference	EU Green Week 2025: Circular solutions for a competitive EU/ European Circular Economy Stakeholder Platform (ECESP)	Environmental conference that enables knowledge sharing, building of alliances, and awareness raising about the potential of a circular economy	policymakers, businesses, leading environmentalists, and other interested parties from across Europe and the world [28]
Conference	EUIndTech2025 – Industrial Technologies and Materials for Sustainable Europe/ Mineral and Energy Economy Research Institute of the Polish Academy of Sciences	Focus on presenting solutions and best practices while developing written recommendations for new EU policies in four key areas: technology, materials, science and business, community in action;	stakeholders from research organisations, industry, industry associations, NGOs and policy makers [29]
Campaign	Single-use plastics: are you #ReadyToChange?/European Commission	public awareness-raising campaign to highlight citizens' role in combatting plastic pollution and marine litter	Public [30]
Campaign	Réparons, Réutilisons, Recyclons, Réduisons #RRRR	Digital campaign run by Refashion in France promoting 'Repair, Reuse, Recycle, and Reduce' among citizens	French public, online. [31]
Campaign	Race against waste/t-rex project	School children are educated about textile waste and empowered with practical ways to help prevent it, through less consumption, repair, reuse, and proper collection.	Pupils in different countries including Netherlands and France [32]

Project	CircularPSP – Public Service Platforms for Circular, Innovative and Resilient Municipalities through PCP	EU Horizon funded project to implement a circular mindset in cities	Municipalities, City dwellers [38]
Online Platform	European Circular Economy Stakeholder Platform (ECESP)	A joint initiative by the European Commission and the European Economic and Social Committee brings together stakeholders active in the broad field of the circular economy in Europe.	Businesses, oranisations [33]
Online Platform	TRANSIT - Transition to a Sustainable Future through Training and Education	The project website serves also as a platform for ecucational campaigns	Training and re-skilling for the transformation of the energy sector [34]
Online learning platform	CICLO/ European Circular Economy Stakeholder Platform (ECESP	e-learning platform for the development of basic circular economy skills	Scholars [35]
Webinar	Circular Economy webinar series/Association of chemical and process engineers IChemE	Webinar series tailored to chemical engineers to raise awareness and practices on the circular economy.	Chemical engineers [36]
Webinar	Plastic Pollution Coalition	Webinar series on latest information and resources to stop plastic pollution	Public [37]

2.4 Gaps and Barriers in CE Awareness & Training

2.4.1 Identified Gaps in CE Training & Education

The following gaps in Circular Economy training and education were identified as part of the state-of-the-art analysis.

Table 3: *Identified gaps in CE training and education*

Gaps in CE Curriculum and Educational Content	
Limited integration of CE principles across all disciplines	While CE is increasingly integrated into engineering, business, management, and chemistry curricula, there is a notable absence in areas like law, arts, and humanities, which are important for designing and implementing CE projects. [9], [53]
Insufficient attention to higher-level "R" strategies:	Current offerings in higher education often focus on conventional "R" strategies, with less

	attention devoted to refuse, repair, and reuse, despite their significance in the CE. [9]
Lack of focus on specific circular business models	Circular business models like product-as-a-service and sharing platforms receive limited attention in existing education programs. [9]
Missing social goals of the CE	While economic and environmental aspects are generally covered, knowledge concerning the social goals of the CE is often lacking. [9], [53]
Overlooking soft skills:	Training programs often neglect the development of essential soft skills such as communication, teamwork, problem-solving, and project management, which are crucial in the CE field. [14], [53]
Lack of clarity on CE application advantages	The advantages of CE application are often unclear. [39], [53]
Skills and industry readiness	
Mismatch between the offering and industry needs	The skills and competences provided by CE higher education (the offering point of view) do not always align with what firms require to implement a CE transition (the demand point of view). [9], [53]
Lack of standardised programs and certifications	The absence of globally recognized standards in CE training makes it difficult to assess and compare skills and knowledge. [14]
Skills gap between education and industry	A gap exists between the skills taught in educational institutions and those required by industries in the renewable energy and sustainability sectors, often due to limited interaction and communication between academia and industry. [14]
Need for specific skills for CE	CE demands specific skill sets that may not be adequately addressed in current education. [39], [53]
Varying required skillsets	Skill requirements for CE often differ based on specific project or industry challenges. [39], [53]
Insufficient upskilling opportunities	There's a need to secure upskilling opportunities for workers to implement circular principles. [40], [53]
Focus on productive industries	ECE has predominantly focused on productive industries, with European engineering education being dominant, potentially limiting understanding of CE in service industries. [10]
Limited interaction between stakeholders with different educational backgrounds	ECE mostly focusing on specific fields or industries might reduce interaction and accessibility among stakeholders with diverse educational backgrounds. [39]
Unclear relationship between CE practices and knowledge management orientation	The connection between implementing CE practices and a firm's knowledge management approach is not well-defined. [41]
Minimal advancement in studying orientation capabilities	Despite progress in circular economy and entrepreneurial innovation, research on

	orientation capabilities within this context is limited. [41]
Limited understanding of how capabilities facilitate CE transition	There is a limited understanding of how different firm-level capabilities can aid the transition to a CE. [41]
Challenges in educational delivery and accessibility	
Lack of consensus on the ideal CE expert or educational modality	There is a lack of agreement on the characteristics of an ideal CE expert and the most effective ways to deliver CE education. [39], [53]
Divergence in opinions on ECE delivery	Differences exist between CE experts and vocational institutions regarding the preferred forms of knowledge transfer, modularity, course length, and experience requirements. [39],
Time constraints for educators	Lecturers may face time limitations in preparing new CE-related topics and institutions in developing ECE courses. [39], [53]
Absence of key performance indicators	The lack of key performance indicators for ECE is also a limitation. [39], [53]
Barriers for non-degree holders	There's a need for consensus on educational processes and tools to provide efficient training opportunities for individuals without traditional degrees. [39], [53]
Potential absence of first-hand experience	Lack of practical experience in ECE can lead to limited understanding of CE strategy applicability. [39]
Lack of clarity in online course descriptions	Descriptions of specific ECE web pages are not always clear, except for those offered by universities which tend to be more standardised. [39]
Interdisciplinary requirements of CE	The interdisciplinary nature of CE poses a barrier to knowledge transfer. [39]
Inequality in access to education	Disparities in access to quality CE education and training exist, particularly in developing regions or marginalized communities. [14]
Insufficient professional development for educators	Educators may lack adequate training and professional development opportunities specifically focused on renewable technologies, sustainability, and CE concepts. [14]
Reduced accessibility due to cost	Expensive CE courses could reduce accessibility and negatively impact social equality and youth unemployment. [39], [53]
Awareness and engagement gaps	
General lack of awareness about the benefits of the CE	Collaboration between the private and public sectors is needed to provide educational opportunities and accessible study materials to increase awareness. [39], [53]
Need for more emphasis on innovation and entrepreneurship skills	Education should further focus on creating skills related to innovation and entrepreneurship within the context of the CE. [9]

Fragmented educational paths	Education for sustainable development (ESD), which shares similarities with ECE, often suffers from fragmented approaches and a lack of a comprehensive body of knowledge, with some focusing solely on social, economic, or environmental dimensions. Similarly, ECE can be fragmented, not focusing on all CE phases. [39], [53]
Need for public awareness	Institutions need to focus on public awareness programs to highlight future opportunities and required green jobs. [39]

2.4.2 Identified Gaps in Industry Adoption

Barriers to implementing CE practices in different industrial sectors. Skills mismatch between industry needs and available training programs.

Table 4: *Identified gaps in industry adoption*

Lack of understanding and knowledge about CE	Many in the industry, including teachers and potentially business leaders, do not fully understand what the circular economy really means and the related opportunities it presents. This lack of fundamental knowledge hinders the adoption of CE principles. [3], [39], [42], [54], [17a]
Underestimation of importance	Topical areas of CE, such as cooperation with stakeholders, are underestimated by SMEs, suggesting a lack of awareness regarding the potential benefits of collaborative circular economy approaches. [43] [54]]
Limited visibility of benefits:	There appears to be a general lack of awareness about the full spectrum of advantages offered by the CE, which includes not only environmental sustainability but also economic and social benefits. Highlighting these multifaceted advantages is crucial for increasing awareness. [39] [54]
Mismatch between the offering and industry needs	The skills and competences provided by CE higher education (the offering point of view) do not always align with what firms require to implement a CE transition (the demand point of view). [9] [53]
Lack of standardised programs, certifications and knowledge	The absence of globally recognized standards in CE training makes it difficult to assess and compare skills and knowledge. [14], [39], [54]
Skills gap between education and industry	A gap exists between the skills taught in educational institutions and those required by industries in the renewable energy and sustainability sectors, often due to limited interaction and communication between academia and industry. [14], [53]
Need for specific skills for CE	CE demands specific skill sets that may not be adequately addressed in current education. [39], [53]
Varying required skillsets	Skill requirements for CE often differ based on specific project or industry challenges. [39], [53], [54]
Insufficient upskilling opportunities	There's a need to secure upskilling opportunities for workers to implement circular principles. [40], [17a], [17b]
Focus on productive industries	ECE has predominantly focused on productive industries, with European engineering education being dominant, potentially limiting understanding of CE in service industries. [10], [54]

Limited interaction between stakeholders with different educational backgrounds	ECE mostly focusing on specific fields or industries might reduce interaction and accessibility among stakeholders with diverse educational backgrounds. [39], [54]
Unclear relationship between CE practices and knowledge management orientation	The connection between implementing CE practices and a firm's knowledge management approach is not well-defined. [41], [54]
Minimal advancement in studying orientation capabilities	Despite progress in circular economy and entrepreneurial innovation, research on orientation capabilities within this context is limited. [41], [54]
Limited understanding of how capabilities facilitate CE transition	There is a limited understanding of how different firm-level capabilities can aid the transition to a CE. [41], [54]
Focus on traditional models	Convincing organizations to shift from traditional linear business models to circular ones is challenging. There can be resistance to this transition due to a lack of perceived incentives to address sustainability comprehensively. [43], [54]
Lack of practical examples and best practices	There is a limited amount of readily available best-practice examples of circular economy implementation that industries can learn from. [39], [54]
Limited understanding of stakeholder roles	A vital issue is increasing the understanding among various stakeholders in industry about their roles in creating awareness regarding sustainable production and consumption through efficient resource management. [41], [54]

2.4.3 Identified Regulatory and Market Barriers

Following gaps in policy support and incentives for CE training. Market barriers limiting workforce upskilling and public awareness were identified (Tables 5, 6).

Table 5: *Identified Regulatory Barriers*

Regulatory Barriers	
Limitations of voluntary approaches	Voluntary EU initiatives as the EU Ecolabel or the EU green public procurement (GPP) criteria have had a reduced impact due to the limitations of voluntary approaches. [7]
Risk of frustrate the growth of upskilling for CE	Government policy can either frustrate or accelerate the growth of the sustainable built environment market. Frustration can complicate the labor market dynamics, for example, by creating a need to upskill large numbers of people in a short period. [44]
Limited potential of existing climate law	The European Climate Law's limited reference to the CEAP may signal its limited potential to contribute to the EU moving towards a circular economy. [45]
Lack of guidance and harmonisation	There is a need for further guidance and harmonisation of calculation models, methods, and reporting of progress related to resource consumption and the impact of policies at all levels (EU, Member-State, local, and regional). [45], [54], [7a]
Failure to involve local and regional authorities	Failing to involve LRAs in national decision-making processes on material resources reuse and climate mitigation and adaptation is hindering the circular economy transition. Examples include uncertainty around the categorisation of waste streams and regulatory barriers related to second-hand materials, land allocation, water reuse, demolition material reuse, and the use of sludge and reclaimed water. [45], [54], [7a]
Lack of reporting mechanisms	Reporting mechanisms on regulatory barriers are lacking at both national and European levels. [45], [54]
Inadequate funding for R&D	Current policies fail to adequately fund research and development initiatives about recycling technologies. [46], [7a]
Administrative and legal obstacles	There are administrative and legal obstacles to a circular sharing and service economy. [7], [54]
Need for a supportive regulatory environment	Creating the right regulatory environment is crucial for innovation in circular solutions, materials, and business models. [7], [54]
Policy and legal frameworks	Policy and legal frameworks can act as barriers to the successful development and implementation of circular product-service systems. [47], [54]
Need to understand laws and regulations	Understanding laws and regulations is essential to promote the circular economy. [48], [54]

Table 6: *Identified Market Barriers*

Market Barriers	
Labor shortage	A growing labor shortage, even for traditional work, can make companies less inclined to explore new kinds of business such as a sustainable built environment. [44], [55]
Perception of sustainability as cost	Sustainability is associated with costs rather than an investment. [43], [54]
High investment costs	High up-front investment costs for sustainable innovations act as a market barrier. [43], [54]
Low virgin material prices	Low virgin material prices can also hinder the competitiveness of circular alternatives. [43], [7a]
Lack of consumer demand	A lack of consumer demand to address environmental issues is an inhibiting factor. [43], [54],[58]
Non-competitive prices of secondary raw materials	Non-competitive prices of secondary raw materials: Non-competitive prices of secondary raw materials are a barrier to a circular economy. [7], [7a]
Lack of high-quality secondary raw materials and markets	The absence of high-quality secondary raw materials and well-functioning markets for them are significant barriers. [7], [7a]
Weak innovation activity	Weak innovation activity may limit the capability of businesses to make the shift towards a circular economy. [3], [54]

2.5 Best Practices & Lessons Learned

2.5.1 Successful CE Training & Upskilling Programs

Following successful training and upskilling programs on circular economy were identified.

The BUILD UP Skills NL project, a project from the BUILD UP Skills initiative of the European Union, was designed to address skill gaps in the construction sector, particularly related to sustainability and energy efficiency. The initiative sought to upskill craftsmen and professionals in the Netherlands to meet the demands of a circular economy, fostering energy-efficient and environmentally sustainable building practices. The BUILD UP Skills initiative serves as a successful model for upskilling professionals in circular economy practices within the construction sector. By combining digital tools, practical training, and stakeholder collaboration, the program has created a foundation for long-term sustainability and workforce development. [19][44][50]

- Project Period November 2011 to April 2013
- BUILD UP skills initiative by the European Commission
- Project reference number: Horizon 2020, grant agreement 649737
- Objectives
    - Facilitate large-scale upskilling in the construction sector.

    - Develop and implement effective training tools and resources.
    - Monitor and evaluate the impact of training on workforce competence.
    - Foster collaboration between training providers, vocational education institutions (VET), and industry stakeholders.
- Implementation and methodology
    - Development of Structured training resources, including
        - E-learning modules covering key topics such as energy efficiency, renewable energy systems (RES), and circular economy principles,
        - BUILD UP Skills Advisor App to guide professionals in selecting appropriate training courses,
        - Assessment tools to measure learning outcomes and identify skill gaps.
    - Regional pilot programs were conducted to test and refine training methods. These pilots:
        - Engaged local training providers, companies, and craftsmen.
        - Integrated training into on-the-job learning environments.
        - Encouraged collaboration between public and private stakeholders to ensure training aligned with industry needs.
    - Policy and Market Integration with
        - National and EU policies promoting sustainable construction.
        - Market trends, ensuring that trained professionals met the evolving needs of the industry.
        - Formal qualifications, incorporating course content into vocational education curricula.
- Key sectors addressed
    - Energy
    - Education and training
    - Building sector
- Stakeholder engagement
    - partnership with VET providers,
    - Building industry leaders in the Netherlands and,
    - Policymakers.
- Outcomes and impact
    - The initiative helped integrate circular economy principles into mainstream construction training.
    - Scalable upskilling framework combined of digital tools and on-site training.
    - Data-driven monitoring revealed steady engagement with training programs, highlighting the importance of structured learning pathways.

The TREE project, Micro and Project-based learning for Teaching ciRcular Economy and Ecological awareness in VET schools (TREE) was an Erasmus+ funded initiative aimed at integrating circular economy (CE) principles into vocational education and training (VET) schools. The project seeked

to enhance the employability of students by equipping them with green skills and fostering sustainable practices aligned with the transition from a linear to a circular economy. [13], [49]

- Project period December 2021 to November 2023
- Erasmus+ program: Cooperation partnerships in vocational education and training
- Project Reference No.: 2021-1-LT01-KA220-VET-000034724
- Partners
    - Public Institution "eMundus", Lithuania
    - Kėdainiai Vocational Educational Training Centre (Lithuania)
    - S.A.F.E. Projects (the Netherlands)
    - Zinev Art Technologies (Bulgaria)
    - Profesionalna gimnazia Asen Zlatarov (Bulgaria)
    - Valga County Vocational Training Centre (Estonia)
- Objectives
    - Incorporate circular economy education into VET curricula.
    - Strengthen links between VET institutions and businesses practicing sustainability.
    - Increase student employability by providing relevant green skills.
    - Promote eco-friendly habits and sustainability awareness among students.
    - Support industries in transitioning towards circular economy models.
- Implementation and methodology
    - Project-Based Learning (PBL): Encourages hands-on, real-world problem-solving activities where students engage with circular economy challenges through research and practical applications.
    - Micro-Learning: Offers modular, bite-sized training sessions on specific CE-related topics, making knowledge acquisition flexible and accessible.
- Key sectors addressed
    - Plastics: Strategies for reducing waste, promoting recycling, and fostering innovation in biodegradable materials.
    - Agri-Food: Sustainable farming practices, food waste reduction, and responsible resource management.
    - Wood: Sustainable forestry, eco-friendly construction, and efficient material reuse.
- Stakeholder engagement
    - VET schools and teachers, who receive training to incorporate CE into their curricula.
    - Businesses adopting sustainable practices, offering real-world case studies and internships.
    - Policy makers and NGOs, who contribute to shaping educational and industry standards.
- Outcomes and impact
    - Development of CE-oriented curricula and teaching materials for VET schools.
    - Creation of an online learning platform with interactive modules.

- Increased awareness and practical knowledge among students regarding sustainability and CE principles.
- Strengthened collaboration between educational institutions and industry leaders.
- Enhanced employability of VET graduates in green jobs such as sustainability consultants, ecodesigners, and environmental managers.

2.5.2 Effective Awareness-Raising Strategies

The following project has been identified as a successful awareness-raising project in the course of the project to date.

The TRANSIT project serves as a model for a successful circular economy awareness initiative, leveraging education, training, and stakeholder collaboration to drive sustainability. The TRANSIT project is designed to promote sustainability education and training across various sectors. [14] [34]

- Project period October 2022 to September 2025
- Funded by the European Union under the program Horizon Europe under the grant agreement 101075747
- Partners
  - FIR Foundation For Innovation And Research (Malta)
  - University of Cyprus (Cyprus)
  - Kolos Resarch and Innovation Center (Greece)
  - Univerzitet Crne Gore (Montenegro)
  - Universidad Politecnica De Madrid (Spain)
  - University of Zagreb, Faculty of Electrical Engineering and Computing (Serbia)
  - Faculty of Electronic Engineering, University of Nis (Serbia)
  - Faculty of Electrical Engineering and Information Technologies, "Ss Cyril and Methodius" University in Skopje (Macedonia)
  - Cyprus Energy Agency (Cyprus)
  - The University of Manchester (Great Britain)
  - Manchester Climate Change Agency (Great Britain)
- Objectives
  - Promote awareness and training in renewable energy, low-carbon technologies (LCTs), and circular economy principles
  - Bridge knowledge gaps in sustainable finance, energy efficiency, and environmental policies
  - Engage key stakeholders including universities, industry professionals, and the wider community in sustainability education
  - Support EU policies related to the transition to a low-carbon and circular economy
- Implementation and Methodology
  - The project follows a multi-layered approach to training and education, involving:

  - Interdisciplinary training modules covering renewable energy, circular economy, and sustainable finance
  - Hands-on learning experiences, including field visits, case studies, and laboratory sessions
  - Collaboration with industry experts to provide real-world applications and knowledge-sharing sessions
  - Online and hybrid learning platforms to ensure accessibility across different regions
  - Community engagement initiatives such as outreach events, public lectures, and networking sessions
- Key Sectors Addressed
  - Renewable Energy: Solar, wind, hydrogen, and energy storage technologies
  - Workforce training, upskilling and reskilling
  - Sustainable Finance: Green investments and policy-driven economic frameworks
  - Mobility & Transportation: Promotion of electric vehicles and smart transport systems
- Stakeholder Engagement
  - University students and researchers through specialized courses and workshops
  - Industry professionals via re-skilling and upskilling programs
  - Government and policymakers to align education with EU sustainability goals
  - Community members through surveys, awareness campaigns, and participation in sustainable initiatives
- Outcomes and Impact
  - Increased awareness of circular economy and sustainability concepts among diverse stakeholder groups
  - Identification of knowledge gaps, especially in: Circularity, Energy storage, Multi-energy systems
  - Improved understanding of barriers to sustainable behaviour and technology adoption
  - Accessible educational resources (interactive courses, interactive learning platform) via online platforms

2.6 Summary and Recommendations

The State-of-the-Art (SOTA) analysis was conducted to assess the current landscape of circular economy (CE) education, training, and awareness within the European Union. The goal of this analysis was to map existing policies, educational programs, industry initiatives, and awareness-raising efforts, while also identifying gaps and barriers that hinder the widespread adoption of CE principles in education and workforce development.

To ensure a comprehensive understanding of the topic, the SOTA analysis followed a structured approach. A systematic review was conducted, incorporating European policy frameworks, academic literature, industry reports, and training initiatives. Key EU strategies, such as the European Green Deal and the Circular Economy Action Plan (CEAP), were examined to determine

the policy environment supporting CE education. Furthermore, higher education and vocational training programs were analysed to assess the extent to which CE principles are embedded in curricula. The analysis also included a review of industry-led workforce development initiatives to evaluate how businesses are integrating CE training into professional environments. In addition, communication and awareness-raising tools were mapped to understand existing outreach efforts and their effectiveness in promoting CE adoption. Finally, identified gaps and barriers were categorized to provide a structured overview of current challenges in CE education and training.

Compared to D5.1, the SOTA has been updated to reflect recent policy developments, published academic literature, and additional insights from Horizon Europe projects addressing circular economy education, workforce upskilling and industry adoption. The analysis places stronger emphasis on awareness, acceptability and implementation barriers relevant to the automotive and manufacturing sectors addressed by ZEvRA.

Key Findings

The results of the SOTA analysis highlight both significant progress and critical gaps in CE education and training across Europe. Policy frameworks, such as the European Green Deal and CEAP, provide a strong regulatory foundation, aiming to integrate sustainability and circularity into economic and industrial practices. Directives such as the Consumer Rights Directive (2024/825) and the Right to Repair Directive (2024/1799) introduce consumer-focused CE measures, reinforcing awareness and regulatory alignment. However, implementation remains uneven, and industry adoption of CE education initiatives varies significantly across sectors.

Higher education institutions are increasingly offering CE-related degree programs and research initiatives, particularly in engineering, environmental sciences, and business management. However, interdisciplinary integration remains limited, with fields such as law, arts, and humanities often lacking dedicated CE components. The analysis also found that vocational education and workforce training are advancing, with EU-funded projects such as TREE, BUILD UP Skills, and TRANSIT providing specialised training programs. Yet, there is no standardised CE training framework across EU member states, leading to inconsistencies in skills development and certification recognition.

Industry engagement in CE upskilling efforts remains fragmented, with many companies lacking the financial incentives or structured pathways to implement workforce training. The mismatch between education and industry needs is a key barrier, as CE-related skills taught in academic settings do not always align with the competencies required for industrial application. Furthermore, awareness and communication strategies—while effective in some contexts—have not reached all stakeholders equally. Many businesses and policymakers still lack a clear understanding of CE benefits and practical implementation steps.

The SOTA also revealed regulatory and market barriers that hinder CE education and workforce transition. These include unclear policy guidelines, a lack of financial incentives for upskilling programs, and limited market competitiveness for secondary raw materials. Additionally, limited access to practical learning experiences poses a challenge, as hands-on training and real-world case studies are essential for bridging the gap between theory and practice.

The project is currently one-third of the way through, and these initial findings provide a foundation for further research and validation. As the project progresses, stakeholder engagement and additional data collection will refine these insights and support the development of targeted strategies for improving CE education and workforce readiness.

The updated analysis confirms that awareness and acceptability challenges are closely interlinked with skills availability, organisational readiness and market conditions, highlighting the need for integrated approaches that combine education, workforce development, regulatory support and communication.

Initial Recommendations

To address the identified gaps and accelerate the integration of CE principles into education and industry, the following initial recommendations are proposed:

- Enhancing interdisciplinary CE education:
    - Expand CE education beyond technical fields to include law, social sciences, and business strategy.
    - Strengthen curricula with advanced CE strategies such as product-as-a-service models, reuse, and repair economies.
    - Increase entrepreneurship and innovation training to enable new business models in CE.
- Aligning CE education with industry demands:
    - Establish standardized CE training certifications to ensure recognition across industries and EU member states.
    - Promote stronger collaboration between academia, vocational institutions, and businesses to develop practical skills-based learning.
    - Introduce modular learning and micro-credential programs to provide flexible lifelong learning opportunities.
    - Expanding Access to Practical Training & Demonstration Projects:
    - Develop more living labs, apprenticeships, and work-based training programs that integrate CE principles.
    - Strengthen industry partnerships to facilitate real-world applications and case-based learning.
- Strengthening policy & financial support for CE workforce development:
    - Advocate for harmonized regulatory frameworks that align CE education policies across EU member states.

  - Introduce economic incentives for CE upskilling programs, such as tax reductions for companies investing in employee training.
  - Improve validation of informal and non-degree training programs to increase accessibility and workforce transition into CE jobs.
- Raising Awareness & Stakeholder Engagement in CE Training:
  - Expand public and corporate awareness campaigns to promote the economic and social benefits of CE.
  - Utilize digital learning platforms to enhance access to CE training and open-source educational resources.
  - Increase cross-sector collaboration to encourage knowledge-sharing between policymakers, educators, and businesses.

Next Steps

The findings from this SOTA analysis serve as a basis for developing a strategies to create awareness for CE and for overcoming the barriers to the ZEvRA innovations.

3 Gap Analysis

Together with the SOTA analysis, the Gap Analysis forms the theoretical basis for the development of the Awareness and Acceptability plan.

The primary goal of this study is to support the advancement of the European Circular Economy (CE) strategy by identifying critical gaps, barriers, and opportunities in upskilling pathways across the automotive and related industrial sectors. Specifically, this study aims to:

- Evaluate the current state of knowledge and skills related to CE practices among industry stakeholders to design effective upskilling and training programs
- Provide actionable insights to policymakers and industry leaders to foster CE adoption through targeted interventions
- Identify measures that enable consumers to actively participate in CE by choosing circular products and understanding their benefits
- Address disparities in CE adoption by identifying region-specific and sector-specific challenges and solutions
- Evaluate the CE market

The scope of this study is framed around the responses to a comprehensive questionnaire targeting key stakeholders within the ZEvRA project. The study focuses on:

- The primary focus is on the automotive sector, with additional insights applicable to other industrial sectors involved in material use, recycling, and design for sustainability
- Analyse the areas where additional training and skill development are required, including lifecycle assessment (LCA), sustainable materials selection, and policy understanding.
- Investigate organizational, economic, regulatory, and consumer-related barriers that hinder the transition to CE practices
- Collect feedback from diverse stakeholders, including engineers, innovation managers, and policymakers, to ensure a holistic understanding of the current state of CE adoption
- Examine the role of consumer demand in driving CE adoption and the effectiveness of measures like financial incentives and product labelling
- The study encompasses EU member states, highlighting regional differences in CE readiness and adoption levels.

3.1 Purpose of the Gap Analysis

To show EVs with 0% virgin material are keeping up with the conventional ones, the scope of the study would be to first raise the awareness on the topic throughout the whole value chain (aligning with Objective 4). This will be followed up with having the EV community accept the circular model and further get trained on this topic. Through this, the human capital as well as uptake will be increased. This will be done via surveys to ZEvRA's Tier 1-2 suppliers and OEMs (SKO, STE, CRF,

TME, and VW) and beyond. Based on the gathered knowledge, the gaps and challenges will be identified and overcomed.

This report examines the gaps in adopting CE principles in the automotive sector within the EU, focusing on the improvement of circularity of light-duty electric vehicles (EVs) throughout their entire value chain, from materials supply and manufacturing to end-of-life processes. The goal is to align with the European Union's goal of achieving zero CO2 emissions by 2035, particularly in the EV value chain, and to also align findings with the EU Green Deal and EU's CEAP.

Addressing these gaps is crucial to achieving the EU's target of making sustainable products the norm in the EU, empowering consumers and public buyers, ensuring less waste, and make circularity work for people, regions, and cities. The European Green Deal launched a concerted strategy for a climate-neutral, resource-efficient and competitive economy. Scaling up the CE from front-runners to the mainstream economic players will make a decisive contribution to achieving climate neutrality by 2050 and decoupling economic growth from resource use, while ensuring the long-term competitiveness of the EU and leaving no one behind.

ZEvRA will enable the collaboration of five big OEMs, supported by top European universities and key players from all facets of the value chain (and three 2ZERO partnership members) to demonstrate a harmonised circularity methodology that allows for interchangeability and replicability. The methodology and manufacturing technologies will be supported by digital tools and validated on a full circular car, integrating 8 prototype components covering 84% of the total automotive material mix. ZEvRA's innovations aim to improve zero emission approaches in the life cycle and value chain of at least 59% of European EVs by 2035.

3.2 Methodology

3.2.1 Data Collection

Data were collected via survey responses from 18 industry partners in the executive/management, engineering/technical, production/operations and academia sectors, focusing on their knowledge about CE, creating awareness for CE, and EU's CEAP and its relevance to their work.

SWOT analysis constitutes a form of appraisal of the current position of an organisation at a particular time, and also the future potential. It is an analysis tool that is helpful to determine and evaluate the strengths, weaknesses, opportunities, and threats of an organisation, as it is represented by the initials of the word SWOT.

The following diagram (Figure 2) represents the general information for SWOT analysis:

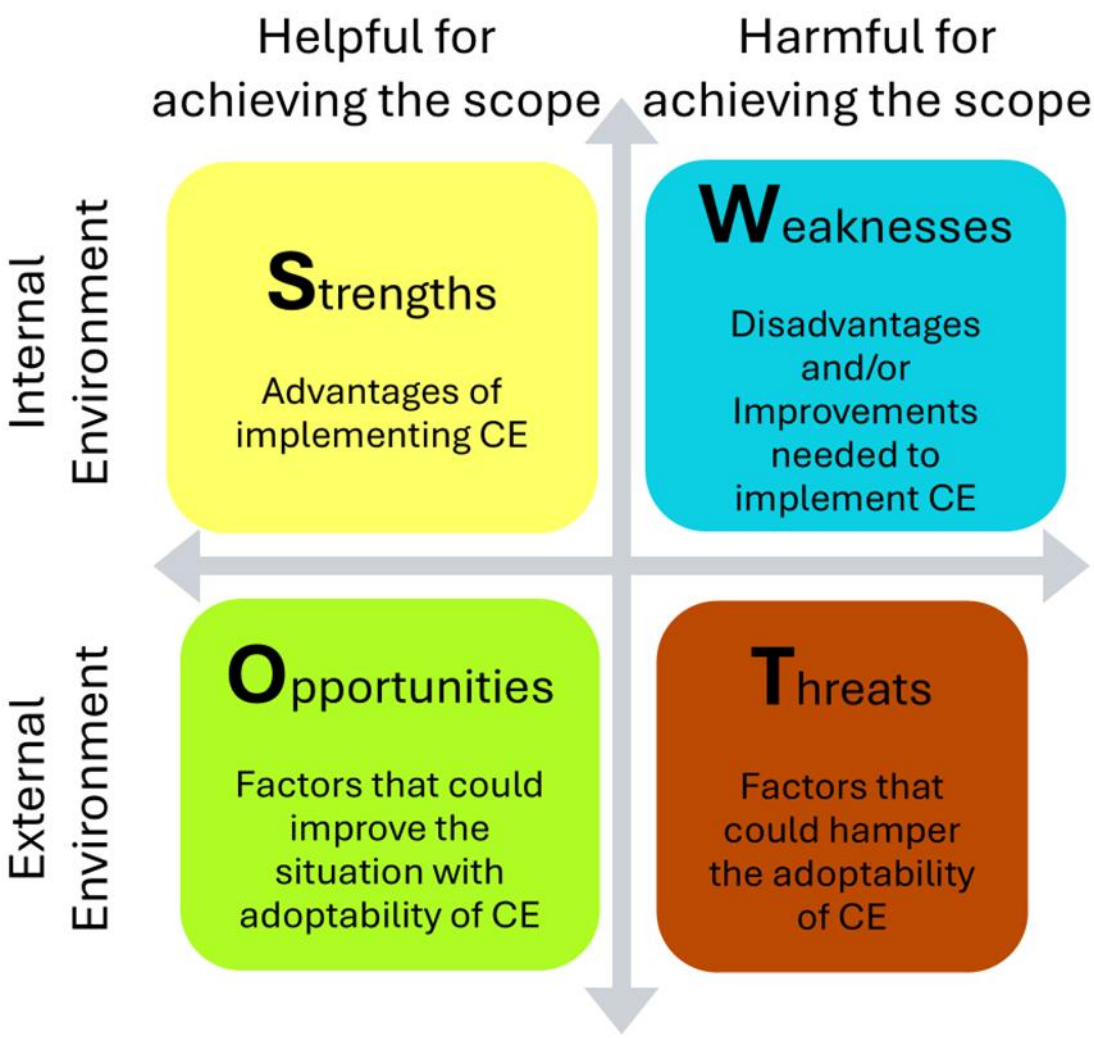

Figure 2: *Diagram of SWOT analysis*

3.2.2 Framework for Analysis

For the SWOT analysis, the examined factors have been analysed through the general aspects of the responses gathered from the survey, that provides data and information for the current state of knowledge for CE. The specific data provide helpful information, for both possible options for the implementation of CE to create acceptability and awareness to the industry partners and public. Furthermore, at the next level of analysis, factors that might be helpful emphasising on the adoption of CE to create acceptability and awareness, are also presented.

The referred procedures will provide the most important Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T), related to the current knowledge about CE. Moreover, this analysis will be helpful for the understanding of the framework conditions for creating acceptability and awareness about CE, and it provides an orientation for the next actions/planning, that could be held.

3.3 Gap Analysis Results and Discussions

3.3.1 Current State

The current state of the gap analysis survey is summarised below in terms of knowledge about CE, creating awareness for CE, and familiarity with the CE strategies and CE business models within the automotive industry with accordance with the responses received from 18 industry partners.

The following chart (Figure 3) represents about the knowledge of CE with accordance with the 18 industry partners. More than 50 % of the responses denotes a good knowledge of CE strategies available which include CE aiding in climate change and reducing environmental impacts, recycling and/or recovering materials, reducing waste to a minimum and using recovered materials to produce new products.

With the other indicators, less than 50 % of the responses denotes certain opportunities for the implementation of knowledge of CE. This involve recycling all waste that are produced, finding methods to extend the life cycle of products/materials, and implementing sustainable designs of materials/products according to CE principles.

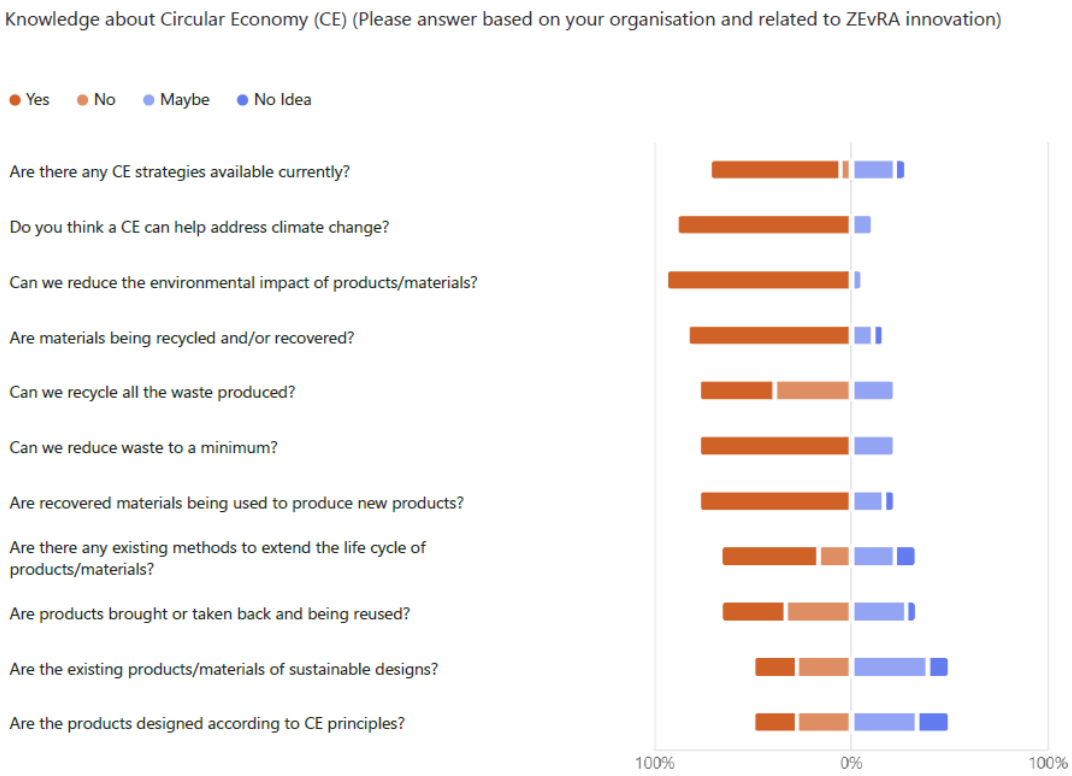

Figure 3: *Chart representation about knowledge of CE*

The following chart (Figure 4) represents about creating awareness for CE. A close 100% of the responses denote that both education and businesses play a role in raising awareness and promoting CE, and the respondents suggest that CE can create job opportunities.

With the other indicator, less than 50 % of the responses denotes a threat towards not willing to pay premium for products that are produced sustainably in a CE. This will be further explained and explored in Section 5.3 Economic Gap.

Figure 4: *Chart representation about creating awareness for CE*

The following chart (Figure 5) represents the CE strategies applied to the automotive industry. More than 80% of the responses have denoted strengths towards the familiarity of CE strategies in all of the indicators (e.g., reduce, repair, and recycle, and etc).

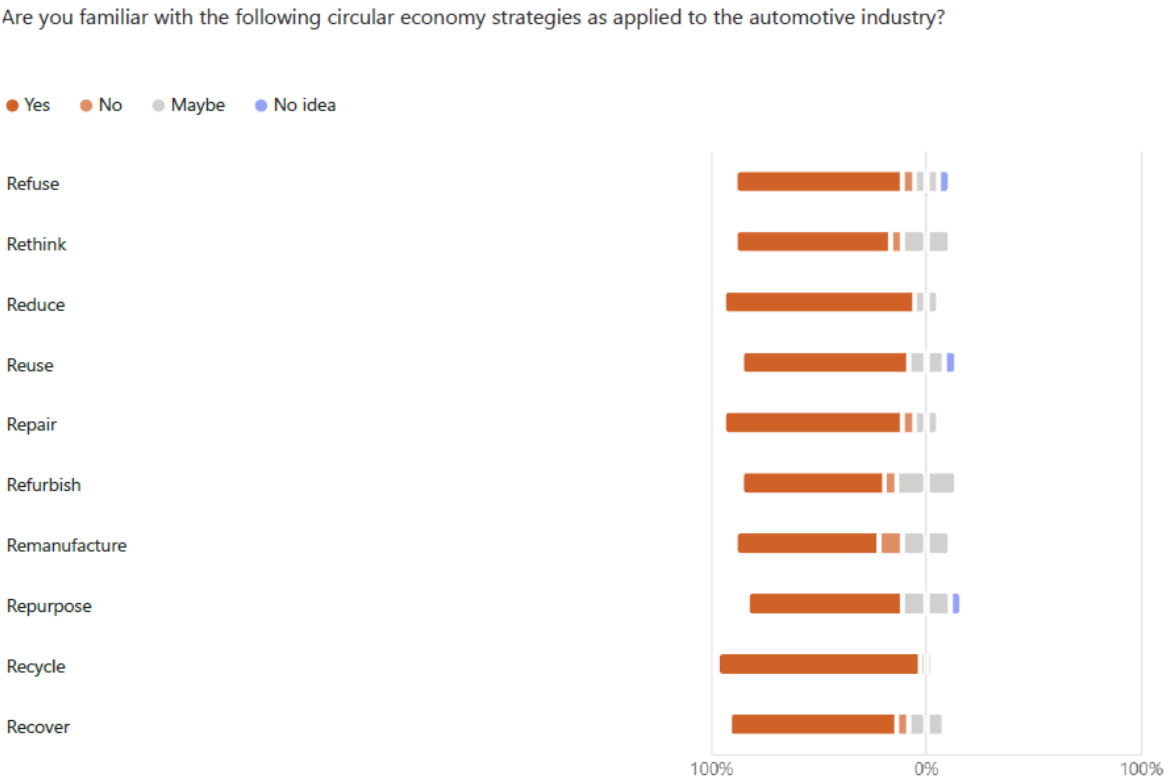

Figure 5: *Chart representation about CE strategies applied to automotive industry*

The following chart (Figure 6) represents the CE business models in the automotive industry. More than 50 % of the responses have denoted the implementation of product-as-a-service, take-back

schemes, repair and refurbishing services, sharing platforms, and closed-loop recycling, and these serves as strengths in the gap analysis.

In terms of other indicators, less than 50 % of the responses denotes weaknesses and/or opportunities. This involves extended producer responsibility (EPR) and product life extension.

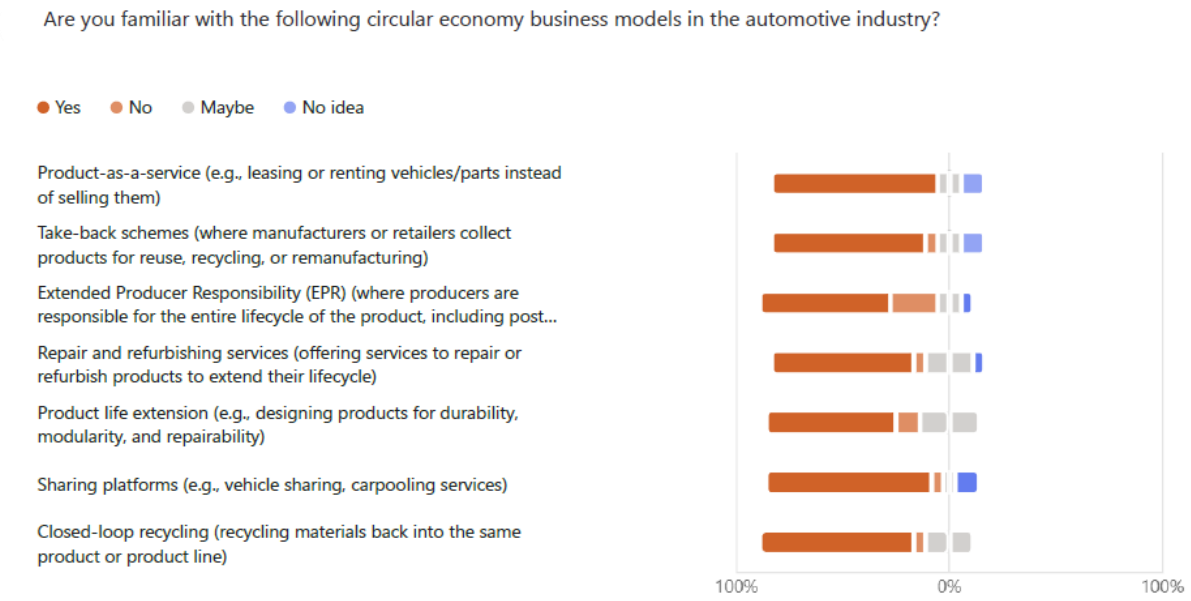

Figure 6: *Chart representation about CE business models in the automotive industry*

3.3.2 Desired state

The EU CEAP [7] mandates making sustainable products the norm in the EU, which focus on the sectors that use most resources and where the potential for circularity is high. For example, the CEAP targets key resource-intensive sectors, including electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, as well as food and water systems, where circular solutions can have the greatest impact. This would require a significant increase in investment to ensure material footprint and resource productivity, and consumption footprint. Notably, the CEAP aims to reduce the EU's overall consumption footprint and to double the circular material use rate by 2030, underscoring the level of investment and innovation needed to achieve these goals. It also empowers consumers and public buyers in ensuring less waste and making circularity work for people, regions, and cities. To empower consumers, measures like a "right to repair" and improved product transparency are being introduced, along with policies encouraging green public procurement, so that both individuals and institutions can more easily choose circular options. This requires a significant increase in education and creating awareness for the people (i.e., consumers, buyers, businesses, public, and etc) regarding CE strategies and its implementations. Indeed, transitioning to a circular economy will demand extensive upskilling and education at all levels, ensuring that consumers, employees, and decision-makers have the necessary knowledge and skills to implement CE strategies effectively.

The EU green deal [51] mandates in transforming the EU into a modern, resource-efficient and competitive economy by ensuring no net emissions of greenhouse gases by 2050 and economic growth decoupled from resource use. It also emphasizes that no person and no place should be left behind in this transition, stressing social fairness alongside sustainability. Moreover, EU leaders have explicitly recognized that achieving the 2050 climate-neutrality goal will require a fully circular economy, reinforcing the central role of circularity in the Green Deal's vision.

In addition, the EU Battery Regulation [6a] establishes a comprehensive legal framework to ensure that batteries placed on the EU market are sustainable, circular, and safe throughout their entire lifecycle. The Regulation introduces mandatory requirements on carbon footprint declaration, recycled content targets, durability and performance, traceability through battery passports, and extended producer responsibility, directly supporting the objectives of the Circular Economy Action Plan and the European Green Deal. By embedding circularity principles at the design, production, use, and end-of-life stages, the Battery Regulation aims to reduce environmental impacts, improve resource efficiency, and secure critical raw materials for the EU. Achieving this desired state requires not only technological and infrastructural investments, but also increased awareness, training, and capacity building across industry stakeholders, policymakers, and consumers to ensure effective implementation and compliance with the new regulatory requirements.

Beyond battery-specific legislation, the desired state for electric vehicle circularity is further reinforced by a broader set of EU regulatory initiatives addressing vehicle-level lifecycle impacts, industrial production, and waste management. In particular, the proposed End-of-Life Vehicles (ELV) Regulation [6b] strengthens requirements for dismantling, reuse, and material recovery at vehicle end-of-life, directly supporting circular design and recycling of electric vehicles and their components. In parallel, the Industrial Emissions Directive (IED 2.0) integrates circular economy principles into industrial best available techniques, influencing the manufacturing of electric vehicles, batteries, and associated components [6c]. Additionally, the revised Waste Shipment Regulation introduces stricter controls on the transboundary movement of waste, including end-of-life vehicle parts and batteries, aiming to ensure environmentally sound treatment and higher-quality recycling within the EU. Together, these regulatory measures complement the EU Battery Regulation by extending circularity requirements across the entire electric vehicle value chain, from production and use to end-of-life management, thereby defining a comprehensive regulatory framework for a circular electric mobility system.

While this policy and regulatory landscape clearly define an ambitious and comprehensive desired state for circular electric mobility in the EU, its effective realisation depends on the capacity of industry, institutions, and stakeholders to translate these regulatory requirements into practice.

3.3.3 Identified Gaps

The following table (Table 7) summarises the strengths, weaknesses, opportunities, and threats to enable the identification of gaps based on the survey conducted with 18 industry partners.

There are certain opportunities being identified which include creating awareness about CE in education and business to promote CE by giving clear training and dissemination on circular business models and implementation. Some factors have to be in consideration towards these, as there are fears of lack in consumer demand, perception that circular products are of lower quality or durability, and the need for time and resources versus business to receive necessary training and upskilling.

The gaps identified are being categorised in terms of technological, policy, and economic, and root cause analysis is utilised to explain each gap (Table 8).

Table 7: *Table representation of strengths, weaknesses, opportunities and threats*

Strengths	- Availability of CE strategies - Familiar with CE strategies as applied to automotive and materials used in this industry - Implement energy-saving techniques by using lesser materials, water, or energy as resources - CE can create more job opportunities. - Taking part in communication platforms and established networks
Weaknesses	- Insufficient skillset to effectively implement CE strategies - Materials not designed based on CE principles - Inadequate time and budget allocated for trainings, and lack of practical education - CE might be costly wise and not competitive mid team - Lack of skilled workforce and low customer demand to implement CE strategies.
Opportunities	- Creating awareness about CE in education and business should play a role to promote CE - Clear training and dissemination on circular business models and implementation - Benefiting from additional training and upskilling of CE - Fundings to develop products/concepts/platforms for industry - Networking with other stakeholders (materials suppliers, OEMs, recycling companies, etc)
Threats	- Not all waste produced are being recycled. - Perception that circular products are of lower quality or durability - Needing time and resources versus business to receive necessary training or upskilling - Fear of high implementation costs and uncertain return on investment to promote CE - Difficulties with recycling due to regulatory barriers

Table 8: *Table representation of technological, policy and economics gaps*

Technological Gap	• Description: Lack of infrastructure (e.g., for take-back schemes or recycling) • Root cause: High implemental costs and uncertain return on investment (ROI)
Policy Gap	• Description: Regulatory barriers • Root cause: Difficulty in integrating with current business operations
Economic Gap	• Description: Lack of consumer demand • Root Cause: High costs and limited funding for innovation, and limited internal expertise or skills

These findings underscore that achieving a circular automotive industry will require both innovation and collaboration across the value chain. In line with this, ZEvRA's outlook emphasizes the need to "rethink how vehicles are designed, produced, and reused" from the very beginning, directly addressing the weakness that current products are often not designed for circularity.

Encouragingly, steps are already being taken to close these gaps. For example, ZEvRA partners have shown that automotive components like battery covers and interior parts can be manufactured with up to 97% recycled plastics without performance loss, and even tires using ~40% recycled material can meet safety and durability standards , successes that help dispel the notion that circular products are of lower quality.

Furthermore, collaborative forums are bringing stakeholders together to tackle policy and infrastructure challenges; for instance, ZEvRA's first annual conference convenes industry leaders to discuss technical, regulatory, and economic solutions for establishing circular value chains in electric mobility.

In parallel, these gaps were explicitly addressed through the ZEvRA project newsletter, which serves as an ongoing communication tool as a key dissemination channel to translate these gaps into accessible messages for a broader audience, highlighting concrete examples, regulatory developments, and practical insights related to circular economy implementation in the electric vehicle value chain. By addressing misconceptions about circular products, showcasing policy-driven opportunities, and emphasising the need for skills development and collaboration, the newsletter contributes to narrowing the identified awareness and knowledge gaps among industry stakeholders, policymakers, and the wider public.

3.3.4 Implications of Gaps

Failure to address the awareness of CE to promote circularity could result in increased environmental degradation and loss of critical materials. This can also include missed opportunities, inefficiencies, and a lack of direction.

3.3.5 Challenges

The barriers and challenges on certain areas are being highlighted in this section. Many businesses and organisations are not rooted in industrial sectors, which means they might not even realize that circular business models are an option for them. In addition, there is a noticeable shortage of skilled workers, coupled with a tepid demand from customers for circular solutions, making it tougher for companies to take that leap. It is also concerning how many organisations are unaware about what the other organisations can offer to help them transition. There is also limited budgets and time for training, along with a lack of practical education, making implementing CE strategies feel daunting. The infrastructure for returning or recycling products is often inadequate, and navigating various regional regulations can feel like a maze - some partners are struggling with recycling simply because of regulatory hurdles, not to mention the issue of scrap materials being shipped out of Europe. There is also a general lack of awareness about the benefits of circular economy where businesses and consumers are concerned with the upfront costs of circular products. Additionally, there is a perception that these products might not hold up in terms of quality or durability, which can deter organisations from making the switch. It is clear and evident that these barriers need addressing to foster a better understanding and implementation of circular economy practices.

3.3.6 Recommendations

Policy Recommendations

Offering financial incentives, such as discounts, vouchers, or deposit-schemes, to encourage people to return used or broken products can aid to ensure consistent enforcement of recycling targets. Making it easier for consumers and/or buyers to return products by increasing the number of collection points and improving their visibility. This can be done by providing information on how to find the nearest collection point and ensure that personal data is properly managed and deleted.

Establishing partnerships between reuse organisations and take-back schemes can aid in the recycling and repurposing aspects of CE. This can be achieved through setting targets for reuse and preparation for reuse. Focusing on reducing production and consumption, rather than just increasing recycling rates can aid with reducing consumption. This can be achieved by ensuring that waste is prevented, and resources are kept in the economy for as long as possible.

Targeting on how products are designed can encourage CE processes and promote sustainable consumption of products that are being manufactured with accordance with CE strategies.

Industry Recommendations

Encourage the adoption of closed loop recycling technologies and using minimal packaging to reduce waste as part of CE initiatives. Designing products to be repairable and lasting longer can

be recommended to design for durability. Industries can learn to adopt reuse and sharing platforms, recycle and recover materials, optimise resource use and costs to reduce waste and pollution, and also to keep products and materials in use.

Complying with regulations and maintaining operating licenses can aid to promote the implementation of CE. This also include reducing the environmental footprint, diversify the energy mix and providing a sustainable alternative to landfill.

Financial Mechanisms

Allocating resources by encouraging banks, insurers, and investors to shift loans and investments towards making sustainable technologies and business models to support R&D in promoting CE. This can be achieved through making financing circularity the default option for mainstreaming financial instruments.

Providing governments with incentives and a supportive policy and legislative framework for the financial sector can aid in promoting CE. This can involve using existing financial products and services, as well as developing new financing solutions, to allocate capital to circular projects and companies.

4 Identification and analysis of barriers to ZEvRA innovations

The identification of barriers to the implementation of the project's innovations serves as a critical foundation for ensuring their successful adoption. Alongside the State-of-the-Art (SOTA) analysis and the gap analysis, this assessment forms the third pillar of the project's awareness and acceptability plan, aimed at fostering a supportive environment for the ZEvRA innovations. By proactively identifying potential barriers, targeted strategies can be developed to overcome barriers before they hinder implementation of the ZEvRA innovations.

4.1 Purpose of the barrier identification

The results of this barrier identification process form the development of measures to overcome obstacles, ensuring that the ZEvRA innovations can be effectively integrated into industry practices, policy frameworks, and education systems. This proactive strategy will enhance awareness, acceptability, and long-term sustainability of ZEvRA innovations while strengthening their adoption. As the project progresses, the identification and assessment of barriers will be continuously reviewed and refined, allowing for a dynamic and adaptive approach to addressing challenges.

According to the Task description, the project will rely on the expertise and perspectives of consortium partners and identified key stakeholders. Key stakeholders include industry and academia.

Following the identification of the barriers to ZEvRA innovations, a plan will be developed to overcome the barriers. The plan includes the creation of communication tools that support the implementation of ZEvRA innovations and raise awareness on ZEvRA and circular economy. Communication materials such as newsletters, pitches and presentation will be crated, along with workshops, symposiums, and industry events that encourage direct stakeholder interaction.

To assess the effectiveness of these barrier mitigation strategies, evaluations and feedback mechanisms will be implemented. These evaluations will track stakeholder engagement and the impact of policy and regulatory measures. The results will provide a basis for continuous improvement and adaptation of the strategies.

As the ZEvRA project progresses, the plan will be regularly reviewed and updated to incorporate new findings, stakeholder feedback, and evolving regulatory frameworks, ensuring that it remains effective and aligned with industry needs.

4.2 Identification of Barriers to Innovation Adoption

The identification of barriers to the implementation of ZEvRA's innovations follows a two-step approach. The goal is to proactively identify and address barriers that could hinder the adoption and acceptability of ZEvRA's innovations while fostering awareness for Circular Economy in

general within the industry. The first step involved direct engagement with key stakeholders, particularly Original Equipment Manufacturers (OEMs) and Original Equipment Suppliers (OESs) from within the project consortium. Through interviews, these stakeholders provide valuable insights into barriers to ZEvRA's innovations, including technical, regulatory, financial, and market-related barriers. The interviews also explore potential solutions that OEMs and OESs have already considered, as well as recommendations on communication and policy measures that could facilitate the transition to circular economy principles.

Following the analysis of the initial interviews, the findings will expanded through broader surveys targeting industry representatives, academia, and other relevant stakeholders. These surveys aim to validate and refine the key challenges identified in the interviews while also capturing a wider range of perspectives on the factors influencing the adoption of circular economy solutions.

4.2.1 Approach to interviewing ZEvRA OEM/OES

Questionnaire

The first section gathers background information on the consortium partner's role in the project, identifying in which specific use cases in which the organization is involved

The questions are conducted by ZEvRA's individual use cases with their assigned innovations. Table 9 shows ZEvRA´s use cases and innovations according to the Grant Agreement.

Table 9: *ZEvRA's use cases and innovations*

Use case	Innovation
Steel	The reProd® approach (reProd® - resource-autarkic production based on secondary semi-finished products) will be used to reshape an old steel component into a new component. Besides 100% recyclability, the process also entails a lower energy consumption by up to 16 GJ and CO2e emissions by 4.4 t/t of steel.
Wrought aluminium	Maximized recycling content with up to 100% scrap. The alloy development includes evaluating scrap, sorting, and tailoring to certain chemistry by monitoring the content of Mg, Si, Fe, Cu, Zn to maintain properties.
Cast aluminium	Maximized recycling content with 100% scrap (vs. 40% common practice26). Alloy development as in the wrought version. Adapting of HPDC for specimen and prototype. Introduction of ribs directly in the casting process for 20% improved lightweight design.
Aluminium foam	Mixed aluminium scrap is fully used for producing new foam at 100% recycling rate. The foaming process will be adapted prior simulation and production of prototype part.
Plastics	A series of interior automotive interior parts will be made with unfilled/short fibre plastics that are already under serial production using up to 70% recycled PCR.
FRP (Fibre-reinforced plastic)	Organo sheets with continuous fiber prepregs and GMT (chopped fiber prepregs) and pellets/flakes of long fiber TP (LFT) of PP and

	PET will be used. The manufacturing technology is thermocompression with either chopped fibres or chopped fibres in combination with continuous fibres. Feedstock of the TP will come from automotive industry or packaging. Feedstock of fibre will come from other industries (e.g., wind turbines, aeronautics).
Glass	Automotive glass will be processed using less chemicals and water in the manufacturing phase, and photovoltaic cells (output power ranging between 40-100W/m2) will be added to the glass to assist battery usage in the use phase. Digital printing methods will be applied to reduce paint usage with serigraphical printing traditionally.
Tyres	Tyres will be manufactured aiming at using 100% secondary material: For the recycling pyrolysis will be used to break down a carcass into separate materials. New tyre will be manufactured using bio-based and renewable feedstock.

The core of the questionnaire is divided into thematic sections that cover key areas where barriers to implementation may arise. The section on design and construction investigates whether the physical properties of the innovation impose limitations on product design and whether there are challenges in integrating the innovation into the design process. It also assesses communication barriers between design, production, and material teams that could hinder effective integration. The section on technical feasibility and quality examines whether the innovation can be seamlessly incorporated into current production processes and how it compares to conventional materials in terms of durability and performance. The economic considerations section evaluates cost competitiveness, potential adaptations needed in production lines, effects on production efficiency, and the existence of economic incentives or disincentives.

Supply chain and availability are analysed by assessing the stability and quality of material supply, as well as the availability of end-of-life feed for new innovation cycles. Regulatory and compliance issues are explored by identifying legal constraints and industry standards that may impact the adoption of the innovation. The section on employee training and acceptance investigates the level of expertise within the organization regarding circularity, the need for additional training, and any potential resistance among employees to working with the innovation.

Further sections focus on production technology and infrastructure, evaluating whether the current production setup can accommodate the innovation without major modifications and whether technological innovations or upgrades are required. The environmental impact and sustainability section assesses how the innovation influences the overall environmental footprint of electric vehicle production and whether it offers specific sustainability benefits or drawbacks. Collaboration and partnerships are explored by examining the role of relationships with recycling companies and material suppliers in the successful implementation of the ZEvRA innovations, as well as the effectiveness of existing partnerships.

Marketing and customer perception are assessed to understand whether consumers may perceive vehicles made with the innovation as lower in quality or less desirable in design. The questionnaire also includes a section on implementation and rollout timelines, determining

whether there are any concerns regarding ZEvRA's objective of improving zero-emission approaches across at least 59% of European EV production by 2035. Finally, the interviews explore which process steps from design to production or shipping require employee awareness of circular economy principles or deeper knowledge regarding the use case-specific innovations. The questionnaire can be found in Annex B.

Interviews

Each interview was conducted via web call with suitable representatives from the consortium partners. The responses were transcribed to capture detailed insights, after which the transcribed answers are sent back to the interviewees for review. The interviewees were then invited to provide written comments, clarifications, and any additional information to refine their responses. This process ensures that the collected data is both precise and representative of the partner's perspective on potential barriers and possible strategies to overcome them. The results of these interviews serve as a basis for further validation through surveys targeting a broader group of industry and academic stakeholders.

4.2.2 Summary of the Interviews

To date of this report five out of seven interviews are completed, two interviews are conducted and under review of the interviewees. Five interviews are fully analysed and incorporated into the project's assessment. The remaining interviews will be fully incorporated to revise the broader assessment framework, supporting the development of targeted measures to address the barriers and enhance the adoption of circular economy principles in the automotive sector.

The following table 8 shows a summary of the analysed interviews according to use cases.

Table 8: *Summary of the interviews*

ZEvRA use-case / Innovation	Barriers
Aluminium Foam	Implementation Barriers: - Interviewees consistently reported low awareness and limited internal expertise on aluminium foam applications. - The absence of proven cost–performance advantages was frequently cited as a reason for low prioritisation.
Wrought aluminium	Technical Barriers: - Changes in mechanical properties due to impurities in aluminium scrap, such as copper, iron, and manganese, can affect strength. This limits the quantity used in safety-relevant components. - Maintaining mechanical properties throughout the whole use cycle is a concern. - Variability in scrap composition was repeatedly cited as the most critical technical risk, leading to conservative material specifications and low acceptance in safety-relevant components.
	Economic Barriers:

	- Recycled material of the same quality is currently more expensive than virgin material due to high labour costs associated with manual disassembly. - The proportion of recycled material can only be increased in vehicles where additional costs can be passed on to the customer (e.g., luxury vehicles) unless there is regulatory pressure. - Cost uncertainty over long vehicle lifecycles was frequently mentioned as a barrier to committing to secondary aluminium in series production.
	Supply Chain Barriers: - A massive increase in scrap requirements across all material groups of a large OEM makes the availability of end-of-life feed "rather bad". - The logistics of handling material flows of individual parts for recycling appear too costly; using whole vehicles is preferred from the OEM's perspective. - Interviewees repeatedly stressed the absence of long-term contracts guaranteeing both volume and quality of recycled aluminium. - Fragmented recycling infrastructure across regions was cited as a barrier to scaling up supply.
	Regulatory and Standard-related Barriers: - Safety regulations, such as occupant safety in crashes, can conflict with the need for dismantlability (detachable connections). - Potential changes in competition between materials (e.g., steel and aluminium) if CO2 emissions are given greater consideration. - Interviewees highlighted a lack of harmonised standards for recycled aluminium quality across Europe as a recurring barrier.
	Implementation Barriers: - Defining a specific use case for wrought aluminium to meet ZEvRA's objectives is a challenge. - Design-for-circularity principles are not yet systematically embedded in early vehicle development phases, according to most interviewees.
Cast aluminum	Technical Limitations: - Adjusting/improving the design geometry to the manufacturing (casting) process, considering limitations in injection, is necessary. - Fully characterizing the casting process to improve pressing is a task. - Communication barriers between product design and manufacturing (casting) processes can arise. - The casting process could be extended with the use of recycled material, potentially increasing costs. - Interviewees frequently noted insufficient process knowledge when higher shares of recycled aluminium are introduced.
	Supply Chain Barriers: - Limited availability of casting-grade recycled aluminium was repeatedly identified as a bottleneck. - Not enough end-of-life feed is available for implementing innovation in series production.
	Implementation Barriers: - Capacity for adapting the features of secondary aluminium in product and process designing. - Interviewees stressed that innovations often remain at pilot level due to missing internal scaling strategies.
Steel	Technical Barriers: - Technical restrictions exist when using old steel components, e.g., due to sheet thicknesses.

	- Interviewees frequently mentioned that quality assurance requirements limit the use of recycled steel in OEM series production.
	Supply Chain Barriers: - Due to the quantities required, using old steel components in OEM applications is difficult, with suppliers or the aftermarket being more likely users due to the need to guarantee material availability over a long period.-
	Implementation Barriers: - Lack of clearly defined, high-value applications for recycled steel within modern vehicle architectures was repeatedly cited.
Plastics	Technical Barriers: - Internal specifications for vehicle interiors regarding fogging and odour can exclude some secondary materials or material sources.
	Regulatory Barriers: - Regulatory hurdles can arise if substances are banned while products containing those substances are still in circulation (e.g., PFAS) - Interviewees frequently expressed uncertainty about future chemical regulations, discouraging investment in recycled plastics.
	Supply Chain Barriers: - When developing new material streams, it is important not to cannibalize other industries (e.g., PET from bottles), making it better to rely on one's own products. - Limited traceability of recycled plastic streams was repeatedly mentioned as a barrier to OEM acceptance. - Insufficient volumes of automotive-grade recycled plastics were highlighted as a common constraint.

4.2.3 Analysis of the Interviews Strategies for Overcoming Barriers

According to the results of the interviews, the following barriers to ZEvRA innovations can be identified.

Necessity to meet technical specifications and performance standards

The interviewees repeatedly emphasize that parts made with recycled materials must meet the same technical specifications as those made from virgin materials, especially for safety-relevant components. For wrought aluminium, changes in mechanical properties due to impurities in scrap limit its use in these critical areas. Similarly, for cast aluminium, the target is to achieve the same properties as virgin material. Interviewees consistently highlighted that variability in scrap composition represents the most frequently mentioned technical risk, leading to conservative material specifications, extended validation cycles, and limited acceptance in series production. A lack of harmonised standards and reference values for recycled material quality across Europe further exacerbates uncertainty in material approval processes. This overarching requirement means that any limitations in the properties or performance of recycled materials pose a fundamental barrier to their broader application.

Securing a consistent and reliable supply of high-quality recycled materials

The availability of end-of-life feed for new material cycles is rated as "rather bad" due to the massive increase in scrap requirements if a large OEM were to widely adopt secondary materials. This supply challenge is echoed for cast aluminium, where there is "not enough" available for implementing innovation in series production. Interviewees repeatedly stressed that supply risks are not limited to volume alone but also include fluctuations in material quality, traceability, and regional availability. The absence of long-term contracts guaranteeing both quality and quantity of recycled material was identified as a major impediment to scaling ZEvRA innovations beyond pilot level. The need to build resilient supply chains and manage the logistics of material flows are critical issues. The potential for increasing demand to outstrip supply of high-quality recyclate is a significant impediment.

Economic factors and cost competitiveness

According to the current market situation, recycled material of the same quality can be more expensive than virgin material, primarily due to high labour costs associated with manual disassembly. While casting aluminium from secondary material is expected to be lower in cost due to energy savings, the casting process could also be extended, increasing costs. The interviewees suggest that increasing the proportion of recycled material is more feasible in luxury vehicles where additional costs can be passed on to the customer or if regulatory pressure exists. The cost sensitivity of employees also creates resistance to using more expensive recycled materials. Interviewees frequently noted that cost uncertainty over long vehicle lifecycles makes it difficult to establish robust business cases for secondary materials in mid-volume vehicle segments. The lack of clear economic incentives or regulatory mechanisms to offset higher upfront costs was repeatedly cited as a barrier to wider adoption.

Therefore, the economic viability and cost-competitiveness of recycled materials are crucial barriers.

Integration into the design and production processes

The sources indicate that the use of secondary materials is not clearly implemented in the design process at present. For cast aluminium, communication barriers between product design and manufacturing (casting) processes can hinder effective integration. Designers need a deeper understanding of the material properties of ZEvRA innovations to incorporate them effectively. Adapting the design geometry to the manufacturing process when using recycled materials is also a task that needs to be carefully considered. Interviewees consistently reported that design-for-circularity principles are not yet systematically embedded in early vehicle development phases, where the greatest influence on material selection exists. Internal prioritisation of performance, cost, and time-to-market objectives over circularity considerations remains a structural barrier within OEM development processes.

While existing production infrastructure might be capable of handling some recycled materials without significant modifications (e.g., wrought aluminium), ensuring seamless integration into both design and production workflows is essential for widespread adoption.

There are also general barriers applicable to multiple ZEvRA innovations:

- Aesthetic customer requirements: Visible plastic admixtures, joints, or hinges on the outside can be undesirable, hindering the use of recycled materials.
- Lack of systemic implementation: The use of secondary materials is currently limited to individual components and is not systematically implemented in the design process.
- Logistical Costs: The logistics of handling material flows of individual parts for recycling are currently too costly.
- Procurement of secondary aluminium: Securing sufficient quantities of secondary aluminium is a challenge.
- Low internal awareness and limited expertise regarding certain ZEvRA innovations (e.g. aluminium foam), resulting in low prioritisation compared to more mature material solutions.

Barriers in a state-of-the-art circular economy (cf. section 3 of this report) include technological limitations in recycling certain materials, complex supply chain coordination, lack of design for disassembly, quality concerns with recycled materials, high initial investment costs, consumer behaviour resistance to circular products, and regulatory frameworks that may not fully incentivize circular practices; all of which can hinder the smooth implementation of a fully circular economy across various industries.

4.2.4 Industry and Academia Surveys

To this date, following surveys of industry representatives, academia, and other relevant stakeholders were conducted.

ZEvRA Automotive Strategy & Innovation Forum: Setting the course for a growing Circular Materials Demand

RKW and APRA held the forum as a workshop-format at the Rematec 2025 fair in Amsterdam on April 8th 2025, as reported in WP6. 32 participants from industry, academia and policy attended the two-hour event, 28 participants online and 4 on site. The aim was to investigate the key barrier areas cost and economic barriers, supply chain and availability barriers, regulatory and compliance barriers, employers acceptance barriers, collaboration and partnership barriers and consumer acceptance barriers (Figure 6). To gather participants' opinions, live voting was conducted via Microsoft Forms, and the results were then discussed.

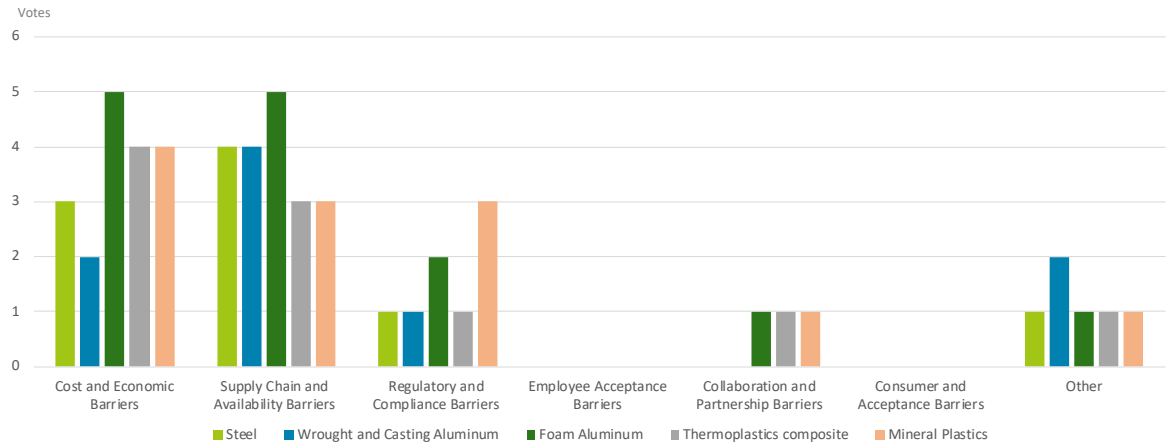

Figure 6: *What barriers do you see in increasing secondary materials demand?*

The results showed that among the most significant are economic and cost-related challenges, particularly for materials like foam aluminum, thermoplastics composites, and mineral plastics, where recycled alternatives can be more expensive than virgin materials due to labor-intensive processes or extended production times. Equally critical are supply chain and availability constraints. Participants expressed concern about the limited and inconsistent availability of high-quality secondary materials, especially as demand increases across the sector. The current reliance on existing recycling streams is insufficient to meet future volumes, and while some confidence was expressed—particularly for foam aluminum and thermoplastics—the overall assessment revealed considerable uncertainty. Scores reflecting confidence in the market's ability to supply secondary materials were largely moderate, suggesting that without strategic action, the supply gap may persist or widen.

With regard to the results, it should be noted that the participation rate in among participants was unfortunately low. Of the 32 participants, there were an average of 7–9 votes. [57]

Live polls at Automotive Circle Conference

During their presentation of WP3 results, EDAG also investigated challenges in advancing automotive circularity concepts. The participants at the Automotive Circle Conference were mainly from the automotive industry, including OEMs, Tier 1-3 suppliers, material suppliers and development service providers.

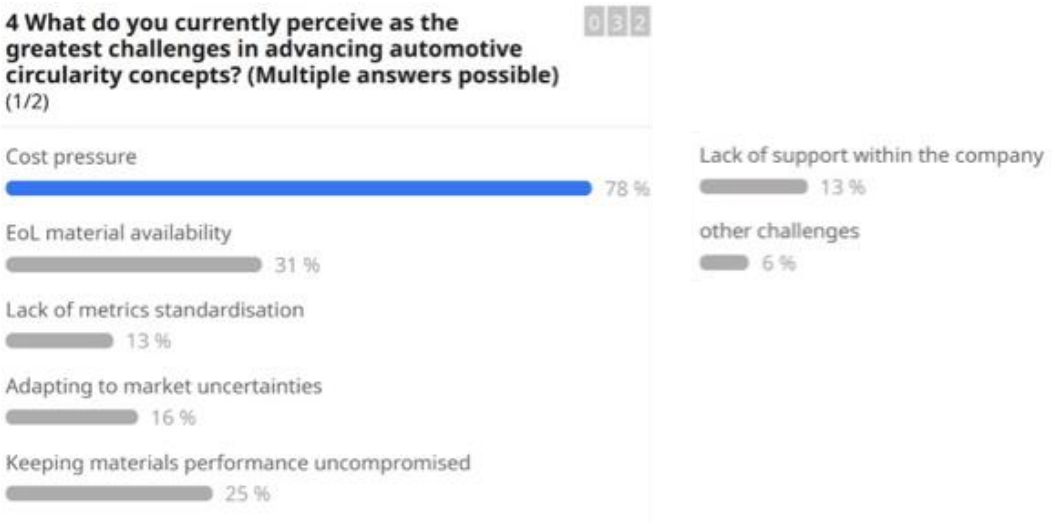

Figure 7: *Greatest challenge in advancing automotive circularity concepts*

Approximately 32 people took part in the voting. The most important barriers were cost pressure, EoL material availability and the material performance of secondary materials. (Figure 7). This voting confirms the statements made in the interviews.

4.3 Next steps

To deepen the knowledge gained from the interviews, further surveys will be conducted targeting industry representatives and academic institutions. These surveys help deepen the findings from the interviews while capturing additional perspectives from key stakeholders involved in ZEvRA innovation adoption. The identified barriers will be cross-checked with the findings from the social analysis conducted within the project to ensure that the assessment considers not only technical and economic challenges but also social and behavioural factors that may influence the acceptance and implementation of ZEvRA innovations.

Building on the deepened insights, the strategy and communication tools to address the identified barriers and facilitate the successful adoption of the ZEvRA's innovations will be modified. These tools include newsletters, workshops, webinars, and industry events designed to engage stakeholders and raise awareness about the CE and the ZEvRA innovations.

To assess the impact and effectiveness of these barrier mitigation strategies, evaluations and feedback mechanisms will be implemented. These evaluations will track stakeholder engagement and awareness of CE and ZEvRA's innovations. By continuously monitoring these factors, the project will be able to adjust and refine its approach to ensure that the proposed measures are both practical and effective.

All developed measures, communication strategies, and evaluation methodologies will be compiled into a comprehensive plan that will serve as a guiding document for stakeholders. This plan will outline clear actions, responsibilities, and timelines to support the successful implementation and widespread adoption of circular economy innovations. As the ZEvRA project

progresses, this plan will be reviewed and updated to incorporate new findings, stakeholder feedback, and evolving regulatory frameworks.

5 Initial Market and Social Analysis

The purpose of this section is to conduct analyses to understand market readiness and social factors affecting the adoption of the project's innovations.

ZEvRA's innovations aim to improve zero emission approaches in the life cycle and value chain of at least 59% of European EVs by 2035 through the 5 OEMs and Tier 1's that are part of the consortium, which includes industry and academia covering the entire automotive value chain. Eight prototype use cases, including the manufacturing technologies and digital tools that ZEvRA will work on for enabling a zero emission approach, will be the most important innovation under consideration and their contributions to ZEvRA's harmonized circularity methodology.

Contributing to Europe' s world leadership in automotive innovation, production, and services through increasing skills with CE techniques and accelerating the uptake of innovative CE-based solutions for EV, reducing the dependence on critical materials via the consistent recovery and use of secondary materials. ZEvRA will address this outcome by delivering innovations that aim to be adopted by five top OEMs which altogether cover 27 % of global market share. The harmonized circularity strategy will be replicable for all the European OEMs, since validation will enable brand-independency. ZEvRA will as well accelerate the uptake of CE-based solutions for EV by increasing the awareness and acceptability.

ZEvRA's innovations will also focus on improving the circularity of 84 % of the materials mix, by demonstrating the eight physical use cases. The extrapolation of results will allow replicating the targeted materials in other structures and components. ZEvRA will increase user acceptability through a dedicated programme that will raise awareness first, followed by targeting vehicle users and different stakeholders across the entire value chain, including workforce and academia working on materials, manufacturing, design, engineering, and EoL, among others.

The targeted market analysis is to have a clear identification of targeted users and main applications of the project results. It is also to serve a strong understanding of existing trends, opportunities, and barriers.

5.1 Market Readiness for CE Technologies

A methodology for assessing market readiness typically involves a multi-faceted approach, including [52] identifying the target market, conducting thorough market research, analyzing customer needs and pain points, evaluating competitive landscape, and assessing regulatory environment via utilizing the "Market & Technology Readiness Level" (MTRL) methodology to evaluate how close to the market project outputs/products are. A numerical combination of:

- Technological Readiness Level (TRL): Measuring the maturity of a technology being developed by a project, and considering factors like infrastructure, policy support, and financial incentives to gauge market receptivity

- Market Readiness Level (MRL): Measuring the commercial readiness of a technology for market, where incorporated alongside with TRL will allow a comprehensive view of both technical and commercial viability

MTRL methodology is useful to assess the current state of the project, helps with identifying the project weaknesses and next steps, and facilitates the interconnection between funded projects.

Recent research indicates that assessing the market readiness of circular economy innovations—particularly in electric vehicles has introduced more comprehensive and stringent requirements for market readiness assessment, such as the integration of societal acceptance, regulatory preparedness, and circularity performance alongside the traditional MTRL framework.

Emerging methodologies integrate additional readiness dimensions; for example, Societal Readiness Levels (SRL) gauge how prepared society and stakeholders are to accept an innovation, and some frameworks incorporate regulatory and market uptake factors to complement technical maturity (in effect extending MTRL to include policy and adoption considerations). New circularity metrics are also gaining prominence, for example, the Material Circularity Indicator (MCI) measures the extent to which a product's material flows shift from linear to circular usage, and other indices like the Circular Economy Performance Indicator or Recyclability Benefit Rate quantify the effectiveness of recycling processes. Moreover, innovation adoption models are being leveraged to complement readiness assessments, diffusion-of-innovation frameworks can help predict how quickly EV-related circular solutions (such as second-life battery use or recycled material uptake) will gain market acceptance. Digitalisation is also pivotal: tools such as IoT, AI, and blockchain are enhancing data transparency and traceability in circular supply chains, exemplified by the introduction of digital product passports for EV batteries (mandated by the EU Battery Regulation) to track lifecycle data and facilitate reuse/recycling. Concurrently, evolving policy frameworks like the EU Battery Regulation and the proposed Ecodesign for Sustainable Products Regulation are explicitly embedding CE criteria (e.g., minimum recycled material content and enhanced traceability requirements) into market entry conditions for new technologies, ensuring that CE innovations in EVs and materials recovery must meet higher sustainability and circularity standards to be deemed market ready.

5.1.1 Objectives of the market readiness assessment

The primary objective of a market readiness assessment is to evaluate whether a product or service is adequately prepared to enter a specific market, by analyzing factors like customer demand, competition, regulatory environment, and the company's own capabilities, to identify potential barriers and opportunities before launching, ultimately aiming to maximize the chances of successful market penetration and minimize risks. In other words, a market readiness assessment helps businesses make informed decisions about whether to launch a product or service in a specific market, and if so, how to best position it for success by proactively addressing potential challenges and capitalizing on opportunities.

Table 10: *Key objectives of a market readiness assessment*

Define the target market	The customer segments which are most likely to adopt the CE technology should be clearly identified, including their demographics, needs, and purchasing behaviours.
Identifying target market needs and desires	The specific needs, pain points, and preferences of the potential customer base should be understood to ensure the produce or service aligns with their expectations. Surveys, interviews and focus groups should be conducted to understand customer challenges and motivations related to adopting the technology.
Assessing market size and potential	The overall market size, growth rate, and potential market for the CE technology should be estimated and evaluated within the target market.
Analyzing competitive landscape	The existing CE solutions and key competitors in the market should be identified, and the strengths and weaknesses should be analysed, followed by accessing potential competitive advantages.
Evaluating regulatory environment/compliance	The relevant policies, standards, and incentives that may influence the adoption of the CE technology should be analyzed.

Table 11: *Technology assessment using TRL*

Evaluate technology maturity	The TRL scale should be applied to assess the development stage of the CE technology, ranging from basic research to commercialization.
Identify critical development milestones	The key steps needed to advance the technology to a higher TRL level should be determined.

Table 12: *Market readiness assessment (MRL)*

Customer acceptance	Customer awareness, perception, and willingness to adopt the technology should be evaluated
Infrastructure readiness	The availability of necessary infrastructure to support CE technology deployment should be assessed.
Financial viability	Potential cost-effectiveness, payback periods, and financing options for customers should be analyzed.

Table 13: *Market entry strategy*

Target entry strategy	The target market based on key customer segments should be further refined.
Marketing and communication plan	A strategy to effectively communicate the benefits of the CE technology to potential customers should be developed.
Pricing strategy	A competitive pricing model based on market factors and customer value proposition should be determined.

5.1.2 Define criteria

A market readiness assessment typically considers criteria like market size and potential, customer needs and pain points, competitive landscape, regulatory environment, product features and functionality, pricing strategy, distribution channels, marketing capabilities, and the company's readiness to enter the market; essentially evaluating whether a product or service is suitable for its intended market and has the necessary elements for successful launch and adoption.

Table 14: *Key criteria to assess in a market readiness assessment*

Market analysis	Market size: Total potential customer base and growth rate Target market segmentation: Identifying specific customer groups with relevant needs Market trends: Emerging trends and potential disruptions impacting the market.
Customer analysis	Customer needs and pain points: Understanding the problems a product aims to solve Customer buying behaviour: How customers make purchasing decisions and their preferred channels Customer willingness to pay: Price sensitivity and potential value perception
Competitive analysis	Major competitors: Identifying key players and their market share Competitive advantage: Unique selling proposition and differentiation Competitor strategies: Analysis of marketing tactics and product offerings
Product assessment	Product features and functionality: Alignment with customer needs and market requirements Product quality and reliability: Performance standards and customer expectations Product differentiation: What sets the product apart from competitors
Marketing and sales assessment	Marketing strategy: Target audience, messaging, and communication channels Sales channels: Distribution networks and sales force capabilities Pricing strategy: Pricing model and price competitiveness
Company readiness	Financial resources: Investment needed for market entry and operations Team capabilities: Expertise in product development, marketing, and sales Operational infrastructure: Necessary systems and processes to support market launch

5.1.3 Data collection

For a market readiness assessment, data collection typically involves methods like surveys, interviews, focus groups, observations, secondary research from market reports, and sometimes even product testing with potential customers to gauge customer awareness, interest, willingness to try, and overall perception of the product or service within the target market, allowing the identification of potential barriers to entry and assess the market's receptiveness to the offering.

Table 15: *Key data points to collect*

Customer demographics	Age, gender, income level, location
Awareness of the product/service	How familiar are potential customers with the offering?
Perception of need	Do customers see a need for the product/service?
Interest level	How interested are customers in trying the product/service?
Perceived benefits	What are the main benefits customers expect from the product/service?
Price sensitivity	How much are customers willing to pay for the product/service?

Competitive analysis	Who are the main competitors in the market and what are their strengths and weaknesses?
Barriers to entry	What factors might prevent customers from purchasing the products?
Trial and adoption intentions	How likely are customers willing to try the products and continue using it?

Table 16: *Data collection methods*

Surveys	Online, phone, or in-person questionnaires to gather quantitative data from a large sample of potential customers.
Interviews	In-depth conversations with key stakeholders, customers, or industry experts to gain qualitative insights
Focus groups	Facilitated discussions with a group of potential customers to explore their thoughts and opinions on the product
Observational research	Watching customer behaviour in relevant settings to understand their needs and pain points
Secondary research	Analysing market reports, industry data, and competitor information
Product testing	Providing a prototype or early version of the product to potential customers for feedback

Evaluation

Data evaluation for a market readiness assessment involves analysing various data points related to the product, target market, and competitive landscape to determine if the market is receptive to the offering, considering factors like customer needs, buying behaviours, market size, competitor activity, and overall industry trends, to gauge the potential for successful market entry and adoption.

A data evaluation scale to assess maturity level typically includes stages like “Initial”, “Managed”, “Defined”, “Measured”, and “Optimized”, where each stage represents a progressively higher level of data management capability, encompassing aspects like data governance, quality, accessibility, and utilization for informed decision making.

Table 17: *Key elements of a data maturity scale*

Level 1: Initial (Ad-hoc)	Characterized by inconsistent data collection, poor quality, limited data analysis, and primarily reactive data usage
Level 2: Managed (Basic)	Some data governance practices established, basic data cleansing, standardized reporting, and data used for operational decision-making.
Level 3: Defined (Proactive)	Well-defined data standards, data quality metrics, proactive data management, and data used to identify trends and patterns.
Level 4: Measured (Advanced)	Comprehensive data quality monitoring, data-driven performance metrics, advanced analytics, and data used to optimize business processes
Level 5: Optimized (Transformative)	Data integrated across systems, predictive modelling, continuous data improvement and data used to drive strategic decision-making.

On the other hand, there is a market maturity scale in consideration. Based on a scale of 1 to 9, where 1 represents very low market maturity and 9 indicates very high market maturity.

Table 18: *Market maturity scale*

1 – Concept Stage	The idea is just emerging, with minimal market awareness and no concrete product development yet.
2 – Early Research	Basic research and feasibility studies are underway, but no working prototype exist.
3 – Proof of Concept	A basic prototype is developed, demonstrating the core functionality and potential value proposition.
4 – Early Development	More refined prototypes are being tested, with initial market feedback being gathered.
5 – Beta Testing	A near-final product is tested by a larger user group, identifying key areas for improvement.
6 – Limited Launch	The product is released to a specific market segment, with controlled distribution marketing efforts.
7 – Market Expansion	The product is actively marketed and scaled to reach a wider customer base.
8 – Market Domination	The product becomes a significant player in the market, with high customer adoption and established brand recognition.
9 – Mature Market	The product is widely accepted as a standard, with continuous innovation and refinement focused on maintaining market leadership.

In terms of data maturity, several key factors come into play that can shape an organization's success. Firstly, data governance - it covers everything from who gets access to which data, to the security measures in place, and how quality is maintained. This also include how the data should be treated. Next would be the data quality which include having accurate and timely data can help navigate decisions confidently. In terms of data architecture, it is essentially the blueprint of how data is organised and accessed. It is also crucial to consider data literacy among employees whereby if everyone understands data concepts, they can better interpret and utilise the information at their disposal. Data analytics capabilities are another important factor where having the right tools and techniques can allow digging deeper into the data to uncover valuable insights. In terms of data integration, the ability to pull data together from various sources is important. By considering these factors, organizations can truly elevate their data maturity and harness its full potential.

Table 19: *Key aspects of data evaluation for market readiness assessment*

Market size and demographics	Population data: Analysing the total potential customer base within the target market. Segmentation: Identifying distinct customer segments based on demographics, needs, and buying habits Geographic distribution: Understanding where the target customers are located geographically
Customer needs and pain points	Market research surveys: Gathering feedback from potential customers about their current Focus group discussions: Conducting in-depth qualitative interviews to understand customer motivations and perceptions Social media analysis: Monitoring online conversations to identify customer pain points and emerging trends
Competitive analysis	Competitor identification: Identifying direct and indirect competitors in the market

	Competitor strengths and weaknesses: Analysing the features, pricing, and marketing strategies of competitors Market share analysis: Assessing the current market share held by existing competitors
Product-market fit	Customer validation: Testing product concept with potential customers to assess their interest and willingness to pay Feature priortisation: Identifying which product features are most valued by customers Value proposition analysis: Determining how the product uniquely addresses customer needs compared to competitors
Market trends and dynamics	Industry reports: Analysing market research reports to identify emerging trends and future growth potential Technological advancements: Evaluating the impact of new technologies on the market and product category Regulatory environment: Assessing any legal or regulatory factors that could impact market entry
Data evaluation methods	Quantitative analysis: Utilising statistical methods to analyse data sets like market size, customer demographics, and sales figures Qualitative analysis: Interpreting open-ended feedback from customer interviews and focus groups to understand customer motivations and perceptions Data visualization: Creating charts and graphs to visually represent insights and trends from data analysis

5.1.4 Interpretation

Data interpretation for a market readiness assessment involves analysing collected market research data to understand the potential receptiveness of a target market towards a new product or service, identifying key trends, customer needs, competitor landscape, and overall market conditions to determine whether the market is ready for introduction, and to inform strategic decisions regarding product development, marketing, and launch timing.

Table 20: *Key aspects of data interpretation in a market readiness assessment*

Market size and potential	Evaluating the overall market size, growth rate, and potential customer base to assess the commercial viability of entering the market
Customer segmentation	Identifying different customer segments within the market, analysing their needs, pain points, buying behaviour, and preferences to tailor product offerings accordingly.
Competitive analysis	Assessing the current competition landscape, including major players, their market share, product features, pricing strategies, and strengths/weaknesses to identify opportunities for differentiation
Technology adoption rate	Analyzing the level of technology adoption within the target market, including awareness of similar products or services and potential barriers to adoption
Consumer sentiment	Understanding customer attitudes and perceptions towards the product concept through surveys, focus groups, or social media analysis to gauge potential acceptance and willingness to to purchase
Market trends	Identifying emerging trends, regulatory changes, and technological advancements that could impact the market readiness of the product

Table 21: *Key metrics to consider in data interpretation*

Customer acquisition cost	The cost of acquiring a new customer in the target market
Customer lifetime value	The total revenue generated from a customer over their relationship with the company
Market penetration	The percentage of the market currently served by the product or service
Brand awareness	The level of recognition and familiarity with the brand among potential customers

5.1.5 Recommendations for overcoming barriers due to market readiness

This section discusses the recommendations based on the results of the assessment. This may include further development of the innovations, adjustments to the go-to-market strategy or additional market research.

Table 22: *Recommendations for overcoming barriers due to market readiness*

Target audience	Clearly define the target market to ensure the data are collected from the right people
Sample size	Choose a representative sample size to ensure statistically reliable results
Data analysis	Use appropriate statistical techniques to interpret the data and draw meaningful conclusions
Data quality	Ensuring the accuracy, reliability, and consistency of data sources
Data sampling	Selecting a representative sample of the target market to ensure reliable insights
Data accuracy and reliability	Ensuring the data used is from credible sources and represents a reliable snapshot of the market.
Statistical significance	Evaluating the statistical significance of findings to avoid drawing misleading conclusions
Interpretation bias	Avoiding subjective interpretations and relying on objective data analysis
Contextual understanding	Interpreting data within the broader market context and considering potential influencing factors
Stakeholder engagement	Key stakeholders like government agencies, industry players, and potential customers throughout the market readiness assessment process can be involved.
Continuous monitoring and adaptation	The market dynamics should be reviewed regularly, and the market readiness strategy should be adjusted as needed
Data-driven approach	Quantitative and qualitative data can be utilized to support decision-making and validate market readiness assessments
Data collection methods	Utilise a mix of primary research (customer interviews, surveys) and secondary research (market reports, industry data)
Qualitative and quantitative analysis	Interpret both numerical data and customer feedback for a comprehensive understanding
Regular review and updates	Market conditions can change rapidly, so periodic reassessment is crucial

To move from a conceptual assessment of market readiness towards concrete and actionable criteria, future evaluations of circular economy technologies in the electric vehicle (EV) sector should explicitly incorporate compliance, performance, and implementation benchmarks aligned

with EU regulatory and market requirements. In particular, market readiness assessments should verify whether technologies are compatible with the EU Battery Regulation by demonstrating traceability through digital battery passports, meeting recycled content thresholds, and providing transparent carbon footprint data. Similarly, readiness criteria should include the ability of EV components and materials to comply with forthcoming End-of-Life Vehicles requirements, such as design-for-dismantling, recyclability rates, and documented pathways for reuse or remanufacturing.

From an industrial and operational perspective, concrete market readiness indicators should assess whether EV-related circular solutions can be integrated into existing manufacturing and recycling infrastructures in line with the Industrial Emissions Directive (IED 2.0), including the adoption of best available techniques and compliance with environmental permitting conditions. Supply chain related criteria should further evaluate the robustness of collection, logistics, and recycling systems under the revised Waste Shipment Regulation, ensuring that material flows can be managed within regulatory constraints and at sufficient scale. In addition, stakeholder readiness should be measured through demonstrable engagement with OEMs, recyclers, policymakers, and end users, supported by pilot deployments, contractual commitments, or memoranda of understanding. Together, these concrete criteria enable a more robust and evidence-based assessment of market readiness, supporting the transition of EV circular economy innovations from demonstration to large-scale market uptake

5.2 Social Aspects Affecting Adoption

The circularity key imperatives of the European automotive industry are

- to ensure productivity and competitiveness under conditions of disruptive changes and to promote flexibility,
- to avoid/decrease dependencies and to facilitate flexibility,
- to enable/improve resilience.

The acceptance of circularity in the automotive industry and subsequently the acceptance of ZEvRA innovations is influenced by a variety of factors, ranging from economic considerations to regulatory pressures and consumer behaviour.

To understand the role of the social factors within the system, the whole system of factors which affects the adoption of circularity in the automotive industry must be described and analysed. At the same time, the interlinkages and leveraging effects among the identified factors must be considered. In a second step the factors with social implications will be analysed in terms of their interdependencies with other factors and trends and their effects. Following the PESTEL-systematic we have identified in a first step six interdependent key factor groups (Figure 8).

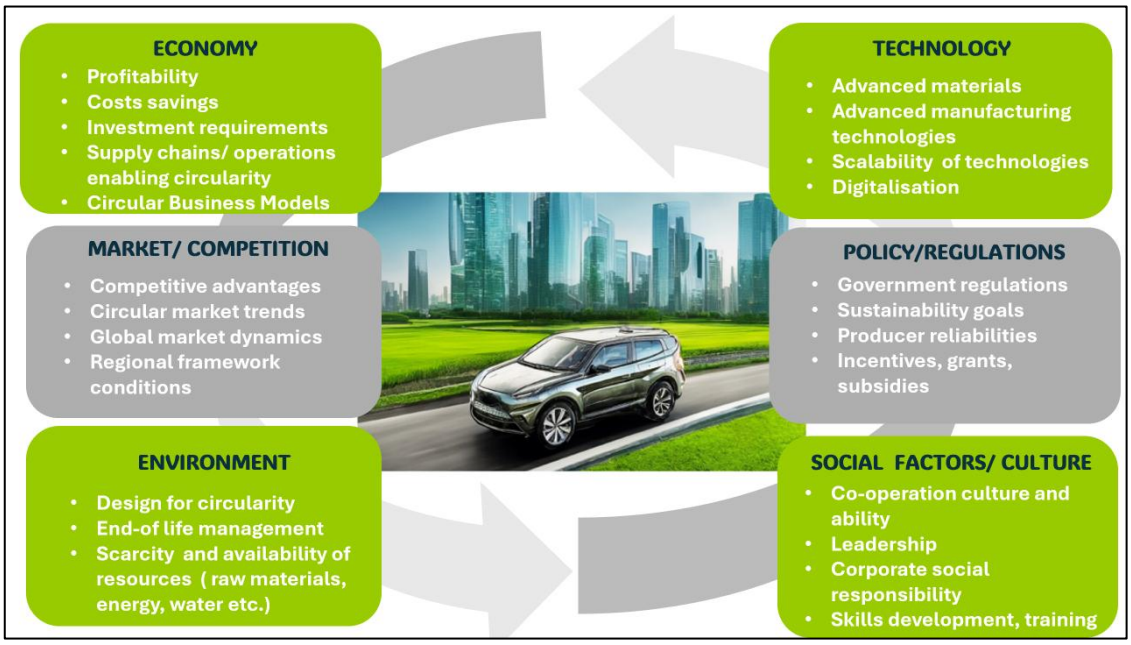

Figure 8: *System of six key factor groups which affect the acceptance of circular solutions, Source. ZEvRA consortium*

1. Economic Factors

Profitability: Companies may be interested to adopt circular practices if they see potential for new revenue streams, such as selling refurbished parts or offering leasing models.

Cost Savings: Increasing prices for raw materials and energy force industry to consider circularity to reduce material and production costs by reusing, refurbishing, or recycling components.

Investment Requirements: High upfront costs for implementing circular systems (e.g., recycling infrastructure, remanufacturing facilities) is a barrier. This is a particular obstacle for small companies, which are mostly engaged in recycling and remanufacturing businesses at local level and do not provide of high budgets and resources for investments beyond the daily business.

Collaboration across the supply chain: Consequent circularity requires not only circular practices within companies but must involve the whole value chain and consider the whole product lifecycle. Therefore, business operations should facilitate effective cooperation between manufacturers, suppliers, and recyclers as a crucial precondition of the implementation of circular business principles. That requires also efficient collection, transportation, and processing of end-of-life vehicles and components as well as standardised processes for recycling or remanufacturing.

2. Technological Factors

Material Quality and Performance are still critical for the acceptance of circularity in the automotive industry. Recycled materials, especially metals and plastics, can lose some of their properties (e.g., strength, durability) during the recycling process. This makes them unsuitable for critical safety components like chassis, engine parts, or crash structures. Furthermore, recycled

materials often lack the consistency and purity required for high-performance applications. The ZEvRA-consortium tackles some of these challenges and will provide appropriate technological solutions.

Innovation in Materials: The development of recyclable, biodegradable, and/or lightweight materials can facilitate circularity.

Advanced Manufacturing Technologies: For the processing of innovative materials, the appropriate technologies have to be developed and implemented that enable easier disassembly and reuse of components. Design for circularity should always be mandatory part of the engineering requirements of any new parts and structures.

Innovative recycling technologies: Current recycling technologies often cannot fully recover all materials at the required quality levels and scales. In that regard, further research and development has to be conducted and suitable infrastructures and business support should be provided to speed up the uptake at all levels of the value adding process and at all stages of the product lifecycle.

Digitalisation: Digitalised processes, IoT, AI, and blockchain can improve tracking, monitoring, and optimization of circular supply chains. They have a clear underestimated potential to support strategic and operational business decisions, which can anticipate various scenarios and multiple conditions. The availability of data is a crucial precondition to identify circular business opportunities and to explore them in a fast and effective way.

3. Market and Competitive Factors

Competitive Advantage: Companies that adopt circularity early may gain a competitive edge in sustainability-focused markets.

Market Trends: The demands of products and services are shifting toward sustainability and circularity. These trends will be reinforcing the acceptance of circular products and business models.

Global Market Dynamics: Currently, we observe a high dynamic of changing mindsets toward sustainability and circularity in the different parts of the global markets. Growing consumer awareness of sustainability issues can drive demand for circular products and services. A lack of information about these developments might lead to wrong assumptions on regional framework conditions and acceptance of circular products and businesses. Furthermore, differences in circularity adoption across regions influence global strategies and agendas.

Perception of Quality: Consumers may hesitate to accept refurbished or recycled parts if they perceive them as inferior.

Willingness to Pay: Consumers' willingness or ability to pay a premium for sustainable products influence the adoption of circular practices.

4. Policy and regulation

Government Regulations: Stricter environmental regulations, such as emissions standards and waste management laws, push automakers to adopt circular practices.

Incentives, subsidies: Tax breaks, grants, or subsidies for circular initiatives can encourage adoption by industry and/or consumers.

Extended Producer Responsibility (EPR): Policies that hold manufacturers accountable for the end-of-life phase of their products incentivize circularity.

5. Environmental factors

Ensure quality of life and respect toward resources: Companies are supported and accepted within their regions as soon as they respect the demand of the citizens and neighbourhood for clean and healthy environment. More often that becomes a criterion for the attraction of talents and skilled workers.

Resource Scarcity: Depletion of raw materials (e.g., rare earth metals) makes circularity more attractive.

Sustainability Goals: Corporate commitments to reducing emissions and footprints can drive circularity.

End-of Life Management: That comprises the available recycling infrastructure with facilities and know-how on processing end-of life vehicles and components. The availability and provision of specific information and data on materials specifications and tools is crucial.

Second-Life Applications: Opportunities to repurpose used components enhance circularity. Currently for that exists a range of legal and practical obstacles. They have to be analysed and removed.

6. Cultural and Organizational Factors

The acceptance of circularity in the automotive industry is a complex process influenced by a combination of economic, regulatory, technological, and social factors. Companies that successfully navigate these factors can achieve both environmental and economic benefits, while contributing to a more sustainable future. Social factors and interactions are a big leverage to explore the opportunities also in fields of economy and business development, technology, environment protection.

Corporate culture and ability/willingness to co-operate: The change toward new materials, technologies and business models require a well-developed co-operation and innovation culture within the companies and an open minded and strong leadership. A company's commitment to innovation and sustainability drives the internal adoption of circular practices and enables collaboration with various partners along the value chains. One of the obstacles is the practiced culture of competitive advantage logic among the industry players. Sometimes, it might hinder the required knowledge- and information transfer among suppliers and recyclers.

Corporate Social responsibility: Expectations and demands of stakeholders affect the uptake and acceptance of circularity principles by the industry.

Skills development, training: Skilled managers and workers with the ability to develop new strategies, to implement new technologies, to gain and to use know-how in an efficient way, to collaborate with different partners, who understand circular principles are essential for setting circularity into life and to gain value from it.

The adoption of circularity in the automotive industry is deeply intertwined with social factors. The factors to address include consumer education, workforce training, stakeholder collaboration, and policy support. For the uptake of circular business principles social factors often are underestimated or even not considered at all. Mostly, business model aspects, new materials or advanced technologies are in the focus.

5.3 Social Aspects affecting adoption of ZEvRA innovations

To assess the impact of social factors on the acceptance of ZEvRA-innovations, social factors have to be analysed against the background and interests of the involved stakeholders and addressed target groups of ZEvRA communication and information campaigns.

According to the project concept, emphasis is taken on the following target groups:

Table 23: *Addressed target groups*

 Industry All players along value chains and with any function during the whole product lifecycle and product lifetime	a) Owners, managers, strategic decision makers b) middle management, responsible department managers for Human resources, procurement/purchase, customer relationship management, research & development, logistics, marketing, sales, communication. c) workers on shopfloor and involved in all kinds of operational business
 Academia	a) Professors/teachers b) Researchers, graduates, post-doc students c) Students, undergraduates

Customers, Interested public	Customers/ car owners and users, users of mobility products and services Civil society, policy, initiatives, Media

The relevant social factors affect the activities of the ZEvRA-consortium aiming at raising awareness and acceptance of the developed innovations among the target groups. At the same time it is intended to shorten the time-to-market of the developed solutions in order to speed up the uptake of the innovations.

In the first phase of the analysis relevant social factors have been identified and analysed in terms of their impact at the planned communication and training measures for raising awareness and acceptance.

Industry

The relevant factors refer to Skills, Qualification, Safety, Success indicators, Incentive systems, Collaboration, Shared knowledge, Innovation culture.

Table 24: *Social aspects affecting adoption of ZEvRA innovation in industry*

Qualifications and skills profiles needed to implement innovations and new processes, building up and communicating long-term perspectives with new circular businesses
Support future-targeted decision making on strategies (i.e. sustainability business intelligence, use of AI-based management tools etc.)
Possible economic implications, such as investments in salaries, training measures, attraction of talents etc.,
Assessment of corporate culture and required changes, required changes of measuring success and related incentives, assessing resistance to changes, compliance culture
Measures for health, safety and security of the employees,
Possible consequences for inclusion measures,
Trainings due to new requirements in terms of data policies, communication
Efficiency and effectiveness of training delivery to limit additional workload
Updated collaboration models along the value chain, i.e. new rules for teams (shared norms, generation of shared knowledge, values, trust building, transparency, common use of shared infrastructures

Academia

Relevant social factors relate with ability and motivation to gain, to spread and to use knowledge on circularity for feasible and ambitious innovations. A well- developed scientific basis, engineering knowledge and technology understanding are crucial preconditions for any social assessments.

Table 25: *Social aspect affecting adoption of ZEvRA innovation in academia*

Induce interest and open mind towards innovations and circular solutions in all regions of the global economy
Provide skills to understand the business realities and create creative and feasible circular innovations
Provide training and skills to collaborate effectively in interdisciplinary and international teams along the value chains
Develop education campaigns on benefits of circularity and showcase success stories

Customers, interested public, media

Social factors relate with a scientific-based communication, raising awareness and building trust to the developed solutions, i.e. to show the reliability of recycled materials and of the process of measuring, testing the performance of the refurbished parts, structures.

5.4 Workforce Training Needs and Skill Gaps

Roadmap to provide an assessment of workforce training needs based on data collected and surveys conducted.

The results of Task 5.2.3 will deliver insights for the development of targeted trainings for the workforce, which will be affected by changed processes, new standards and rules for the implementation of the ZEvRA innovations.

The roadmap includes two analysis steps:

- In a first step the developed use cases of ZEvRA, the manufacturing of the parts from recycled materials will be analysed in terms of the changes against current practices. It is planned to conduct that analysis through interviews or in a workshop with the leaders of the use cases. The guidelines for the interviews/ discussions will be developed by RKW and STL and provided to the use case leaders beforehand.
- In a second step the manufacturing reality will be checked together with the current suppliers of the developed parts and with suppliers of part and structures, that can take up the developed innovations. With that step we aim to assess the base level for the planned learning process. We will consider those factors, like the demography, education levels, existing learning attitudes and provided learning- and education infrastructures, success factors etc. From that will result consequences for the contents, the formats and the design of the learning tools in order to close the gap in a most effective and efficient way.

The findings of the analysis will be presented to STL, selected OEMs and their suppliers to undergo a reality cross-check and to validate the findings before we start to develop the respective learning tools and nuggets for the affected workers.

6 Creation of Communication and Awareness Tools

The development of communication and awareness tools is essential to ensuring that ZEvRA's innovations are effectively conveyed to relevant stakeholders, fostering their understanding, acceptance, and eventual adoption. This section focuses on the creation of targeted materials such as newsletters, presentations, and pitches that will serve as key instruments for engaging with industry representatives, policymakers, academia, and other relevant audiences. These tools will be designed to address the barriers identified during the interviews and surveys, ensuring that stakeholders receive clear, relevant, and persuasive information about the benefits and feasibility of the innovations.

The communication tools will be tailored to different stakeholder groups, ensuring that the information is presented in a way that aligns with their interests and level of expertise. Newsletters will provide regular updates on project progress, research findings, and implementation successes, helping to maintain continuous engagement with consortium members and external stakeholders. Symposiums will serve as interactive platforms where industry leaders, researchers, and policymakers can exchange knowledge, discuss challenges, and explore solutions related to circular economy adoption. Presentations will be created for use at industry events, academic conferences, and policymaker briefings, providing structured and visually compelling insights into ZEvRA's objectives, findings, and innovations. Additionally, pitches will be developed to create awareness for ZEvRA's innovations and Circular Economy.

As the project progresses, the development of these tools will be closely aligned with the findings from the barrier identification process and stakeholder identification.

6.1 ZEvRA Stakeholder Groups

ZEvRA's in the GA defined stakeholders are OEM workforce, material suppliers and manufacturers (tier1-3). These are groups that can use ZEvRA innovations and are therefore also target groups to awareness and acceptability activities. In addition, there are (secondary) stakeholder groups that have an interest in the research project or are affected by ZEvRA innovations.

Table 26: *(Secondary) Stakeholder groups and their role for ZEvRA innovations*

Stakeholder group	Role
Employees: Designers, Production planners, line workers, logistic workers	Employees at all levels and in all departments play a major role in the implementation of ZEvRA innovations. They can accelerate or hinder the implementation of ZEvRA innovations.
Suppliers	They play an important role as strategic partners in procurement to secure material requirements. They are also involved in material and process research for the ZEvRA innovations.
Consumers	Consumers' purchasing decisions determine the success of products and therefore also the ZEvRA innovations. A positive attitude towards recycled materials is offset by a lack of knowledge about their properties, which leads to a reluctance to buy sustainable products.
Recycling companies	Recycling companies are important to the successful implementation of ZEvRA's innovations. They source the materials for products with ZEvRA innovations and are an important partner in CE.
Research institutes	Universities or research institutes conduct basic and applied research that helps implement ZEvRA innovations.
Industrial sectors	Industrial sectors other than automotive should have additional insights that involved in material use, ZEvRA innovations, and design for sustainability.
Policymakers (Including government officials)	Should be aware of the possibilities offered by ZEvRA innovations to adapt regulations on the circular economy.

6.2 Conducted and Planned Outreach and Engagement

The number of events to raise awareness on CE and ZEvRA were intensified from M22 on. Naturally, all events designed to increase awareness and acceptance of CE and ZEvRA innovations are also communication events and therefore equally relevant to WP6. The following list of conducted events therefore briefly describes the impact on awareness.

- 8.04.2025 RKW, APRA: Workshop on Rematec 2025 Fair, Amsterdam (32 participants from industry, academia and policy) "ZEvRA Automotive Strategy & Innovation Forum: Setting the course for a growing Circular Materials Demand" Live-voting and discussion on identified barriers to CE and ZEvRA innovations
- 10.06.2025 RKW: Meeting LVR (regional association of recycling companies) "Circularity in automotive industry," 15 key persons from industry, RTOs, policy, administration attending, ZEvRA presentation, follow-up meetings with companies planned
- 9.10.2025. Workshop on K fair (POL, RKW): ELCA audience (20 Material suppliers)
    - K fair is the biggest international fair on Rubber and Plastic materials, more than 150 000 visitors and more than 3000 stands! This event was “the place to be” to present ZEvRA for the polymer material
- 14.10.2025, RKW, project presentation at LIGHTWEIGHT EU-consortium meeting in Bratislava
- 20.10.2025 Article on MyPolymeris platform: all Polymeris members
    - MyPolymeris is the internal platform for the Polymeris members This platform is Polymeris' main interface for connecting with Polymeris' members. Information/news

to Polymeris members in targeted groups or more broadly in open groups are distributed there.

- 21.10.2025, RKW, awareness workshop with 28 companies from automotive industry,
  - validation of barriers and opportunities in the automotive sector
- 28.10.2025, RKW, project presentation at MAT4EU consortium meeting,
  - discussion of potential synergies between MAT4EU and ZEvRA
- 12.11.2025 RKW, FRA, awareness presentation at General Assembly Composites United, Augsburg
- 13.11.2025 Polymeris International Club: plastic and rubber industrials interested by International problematic (30 Participants, Material suppliers)
  - The role of the Polymeris International Club is to promote Polymeris' activities internationally.
- 27.11.2025 Meeting between two Polymeris Club:Composite Club x Polymeris End of Life Club:
  - audience of 30 industrials and academia (https://www.polymeris.fr/event/circularity-of-composites.html)
  - Polymeris organized an event at Mines Alès, an academic research center, with the aim of bringing together the End Of Life and Composites Clubs networks to discuss circularity in composite materials. It was therefore essential to talk about ZEvRA.
- 28.11.2025 French automotive webinar: automotive audience mainly industrials (30 participants) (https://www.polymeris.fr/event/why-should-a-company-join-a-european-project.html)
  - In order to reach a different audience than Polymeris' usual materials-focused audience, Polymeris proposed to their automotive cluster partners (Cara, Id4car, Nextmove, French Automotive & Mobility Network) that they organize a French-only webinar for automotive stakeholders.
- 2025, article Polymeris has worked on a press release to promote the project for its first year, including an interview with Thierry RENAULT from FORVIA. This article will be published in a French journal on polymer materials, Plastiques & Caoutchouc Magazine
- 11.12.2025, UNIBO, italian webinar within an online course, 16 participants, audience: 14 workforce OEM, 1 material supplier, 1 extrusion company
  - Awareness and acceptability: use of recycled aluminum alloys is becoming a positive value for companies and to a minor extent for the final customer; the seminar will provide some technical data to increase the acceptability of recycled Al wrought alloys for companies and customers.

Planned events

- 18.12.2025, RKW, preparation meeting for a workshop with recycled materials supplier to be held in spring 2026
- 28./29.04.2026, POL, Rubbercon 2026 fair, presence of POL to introduce the ZEvRA project and raise awareness and acceptability

- 8.-12.9.2026, Automechanika 2026 fair, ZEvRA stand to present LCT methodology (EUT), manufacturing process for the different uses cases Metal sheet and aluminium (FRA), plastic and (FCR), Glass (SIS) and Tyres (CON).

6.3 Status of Communications and Awareness Tools

The status of the key communication and awareness tools will be tracked within the progress of the ZEvRA project and reported here in the final version of the Awareness and Acceptability Report D5.3. The development of presentations and pitches to feature awareness and acceptability are under development.

6.3.1 Newsletter

A newsletter was designed to raise awareness on CE and the project's results within all interested stakeholder groups.

Seven issues are planned, to be published every two months. Each issue is assigned to a work package and following a standard structure template.

1. The Circular Mobility Challenge (WP1), Dec 25
2. Smart Tools for Circular Design/Design for Circularity (WP2), Feb 26
3. Rethinking Automotive Materials (WP4), Apr 26
4. From Concept to Practice: Manufacturing the Circular Car/Circular Manufacturing in Practice (WP3), June 26
5. Upskilling for a Circular Future (WP5), Aug 26
6. Accelerating Adoption (WP5), Oct 26
7. Circular Mobility by Design – The ZEvRA impact (all), Dec 26

6.3.2 ZEvRA annual conferences

As part of the project's communication and awareness-raising activities, ZEvRA annual conferences were established as a dedicated communication tool to support awareness and acceptability of circular economy solutions for zero-emission electric vehicles. The conferences are fully dedicated to the ZEvRA project and are open to all stakeholders interested in circularity for electric vehicles, providing a neutral platform for knowledge exchange, discussion and feedback. The events are organised in a hybrid format, combining project presentations with workshops and panel discussions, thereby facilitating engagement across industry, academia, policy and other interested actors.

The 1st ZEvRA Annual Conference was held on 27 November 2025 at the Eurecat Technology Centre in Spain. The conference represented a key dissemination and engagement milestone for the project, bringing together project partners, automotive industry representatives (including

leading OEMs such as Škoda, Stellantis, Toyota, Volkswagen, and Renault, as well as Tier-1 suppliers and engineering service providers such as Benteler and EDAG), research and technology organisations and universities (including Fraunhofer IWU, Eurecat, Northumbria University, the University of Bologna, NTNU, and other consortium partners), and other relevant stakeholders to discuss progress, challenges, and future directions related to circular economy solutions for electric vehicles.

The conference agenda focused on showcasing the objectives and interim results of the ZEvRA project, as well as facilitating knowledge exchange across academia, industry, and policy. Key agenda highlights included presentations on ZEvRA's methodological framework, technical innovations, and tools developed within the project, as well as dedicated sessions addressing barriers and enablers for circularity in the automotive sector. Interactive discussions and case-based examples enabled participants to reflect on practical implementation pathways and the relevance of ZEvRA outcomes for industry and regional stakeholders. The event also provided opportunities for networking and cross-sector dialogue among original equipment manufacturers, technology developers, and research partners.

To evaluate the effectiveness of the conference, a post-event survey was conducted among participants (see Table 27). The survey results indicate a high level of overall satisfaction with the conference. Respondents rated the organisation, structure, and relevance of the agenda positively, and the majority agreed that the conference content was aligned with their professional interests and expectations. Participants particularly valued the clarity of project presentations and the opportunity to engage in discussions with experts from different disciplines.

Table 27: *ZEvRA Feedback questionnaire for events*

Question	Question Type
1. Your institutions' role alongside the value circle	Choose option
2. About the event - The event objectives were clear and well communicated - The organisation and scheduling of the event were effective.	Likert scale 1-5
3. Content and relevance - The content was relevant to my professional or research interests. - The speakers/facilitators were knowledgeable and engaging.	Likert scale 1-5
4. Circular Economy and the ZEvRA project - The event helped me better understand the goals and innovations of the ZEvRA project. - The event increased my understanding of circular approaches in the automotive sector. - The event strengthened my confidence that Circular Economy and ZEvRA solutions can be successfully applied in industry.	Likert scale 1-5
5. Interaction and engagement - The event encouraged meaningful interaction and discussion. - I had the chance to connect or network with other participants. The event motivated me to follow future ZEvRA activities.	Likert scale 1-5
6. What did you find most valuable about this event?	Free text
7. What improvements would you suggest for future events?	Free text

Qualitative feedback further highlighted the strengths of the event, including the quality of speakers, the diversity of perspectives represented, and the practical focus of the discussions. Several respondents noted that the conference improved their understanding of the ZEvRA project's goals and increased their awareness of circular economy challenges and solutions in the electric vehicle value chain. Suggestions for future editions included allocating more time for interactive sessions, expanding the presentation of concrete project results, and enhancing opportunities for stakeholder interaction. All feedback is included in Annex C.

Overall, the 1st ZEvRA Annual Conference successfully supported the project's objectives related to awareness raising, stakeholder engagement, and acceptability of circular economy innovations. It contributed to strengthening dialogue between research and industry and provided valuable feedback to inform the organisation and content of future ZEvRA dissemination activities

The 2nd ZEvRA Annual Conference will be held in Autumn 2026 in Frankfurt or Dresden.

6.3.3 Intranet Articles

To reach a large number of OEM workforce, intranet articles to raise are planned. A standard introducing paragraph has been developed and will be distributed to the OEM partners. 1 article has been published, at least 4 articles (1 of each OEM) will follow.

- 2.12.2025, SKO, Intranet article "A Product Reborn"
    - Introducing the ZEvRA circular design approach at the internal "GreenWeek" event (10.-14.11.2025)

6.3.4 Hackathons

According to the GA, eight hackathons must be held for European and international experts and researchers. To increase the impact of ZEvRA, the hackathons will address questions from external stakeholders regarding ZEvRA innovations. A three-step process was developed to identify topics for the hackathons.

1. Quick scan (5 minutes): A short questionnaire is sent to management-level stakeholders, asking them to identify 3-5 challenges for CE and to name contacts at the problem owner level.
2. Diagnostic questionnaire (10-15 min): problem owner level to identify specific questions that are suitable for a hackathon.
3. Strategic assessment (30 min): sustainability/innovation level to understand the context of the task within the organisation and to plan the hackathon.

The hackathons will be conducted in 2026, starting with an internal pilot hackathon, planned in January 2025.

6.3.5 KPI Status

Regarding the number of reached stakeholders related to awareness and acceptability, the number of stakeholders reached to date is still low. This is partly due to the phased implementation of communication and engagement activities within the project timeline. However, a significant increase in outreach is planned for the last project year, reflected in an expanded number of events and targeted communication measures in autumn 2025. In particular, OEM workforces will be addressed more systematically through internal communication channels such as OEM intranets, which are expected to substantially increase stakeholder reach and engagement. These measures are anticipated to contribute positively to KPI achievement in the last reporting period. The number of conference participants is part of the ongoing evaluation and is not yet included in the KPIs.

Table 28: *Number of stakeholders reached for raising awareness*

Type of stakeholder	# stakeholders reached	# stakeholders KPI
Material suppliers	51	350-700
Manufacturers	61	600-800
Workforce OEM	24	1000-1200

7 Conclusion and Next Steps

This report has outlined the structured approach and data collection methodology for Task 5.1, detailing the process of identifying barriers to the adoption of the ZEvRA's innovations and developing strategies to overcome them. The work conducted so far has provided an assessment of potential barriers based on stakeholder engagement, regulatory frameworks, industry practices, and market conditions. Through a combination of state-of-the-art analysis, gap identification, and direct stakeholder consultations, the report has established a solid foundation for addressing the challenges associated with the ZEvRA's innovations within the automotive sector. Dedicated communication tools have been established to support awareness and acceptability. These communication activities will be further expanded in the upcoming project phase to increase stakeholder reach and engagement, particularly among ZEvRA's key stakeholders.

7.1 Summary of Initial Insights

The analysis conducted has identified key gaps in circular economy education, workforce readiness, and industry adoption. The findings suggest that while there is increasing regulatory support for circular economy initiatives, significant barriers remain in terms of aligning educational programs with industry needs, securing material supply chains, and ensuring economic feasibility. Stakeholder engagement has revealed that resistance to change, technical uncertainties, and the complexity of integrating innovations into existing business models remain pressing challenges. At the same time, opportunities have emerged in the form of industry-led training initiatives, regulatory incentives, and growing market interest in sustainable production. The insights gained from the interviews and literature review have allowed the project to define a clear framework for addressing these barriers, ensuring that solutions are tailored to the realities faced by companies, researchers, and policymakers. This report serves as a key milestone in this process, capturing the status of the work and setting the direction for future research and refinement.

Key barriers to ZEvRA's innovations identified in the analysis are the necessity for recycled materials to meet the same technical specifications and performance standards as virgin materials, particularly for safety-critical components. Another major barrier is securing a stable and high-quality supply of recycled materials for ZEvRA innovations. Industry representatives expressed concerns about the scalability of secondary material use, particularly if large-scale adoption were to take place. Ensuring a consistent and reliable feedstock for secondary materials remains a significant obstacle to the widespread integration of circular economy innovations.

Economic viability and cost competitiveness were also highlighted as major concerns. In the current market, high-quality recycled materials can be more expensive than virgin alternatives due to labor-intensive disassembly processes. While energy savings in casting secondary aluminium may offset some costs, an extended casting process could lead to additional

expenditures. OEMs and suppliers suggested that higher costs for recycled materials might be justifiable in premium vehicle segments or under regulatory pressure, but cost sensitivity remains a key factor influencing material choices. Additionally, employee reluctance to adopt more expensive alternatives presents an internal resistance that must be addressed.

Integration into design and production processes presents further challenges. Currently, secondary materials are not systematically considered in product design, leading to missed opportunities for efficient integration. For cast aluminum, communication gaps between product design and manufacturing processes hinder alignment, requiring better collaboration between design and production teams. Designers also need a more comprehensive understanding of the material properties of ZEvRA innovations to effectively incorporate them into product development. While existing infrastructure may support certain secondary materials, adapting design geometries to accommodate recycled inputs remains a critical task for ensuring seamless production integration.

Addressing these barriers will require coordinated efforts across supply chain management, design adaptation, economic incentives, and regulatory frameworks to ensure the successful implementation of ZEvRA's innovations.

7.2 Plan for Upcoming Work and Deliverable Update

Building on the work completed so far, the next phase will focus on finalising and further deploying the communication and awareness tools developed within the task, while intensifying stakeholder engagement activities. In addition to the established tools such as newsletters, the annual conference and targeted intranet articles, presentations and concise pitches will be developed to support consistent and effective communication across different stakeholder groups and events.

A significant share of the remaining project activities will be dedicated to the organisation and implementation of interactive engagement formats, including hackathons and the second ZEvRA annual conference. These events will serve as key instruments to raise awareness, gather feedback, and improve the acceptability of CE and ZEvRA'S solutions among industrial and non-industrial stakeholders, with particular attention to the automotive ecosystem.

For the final version of the Awareness and Acceptability Report (D5.3), the results obtained throughout the task will be reviewed and consolidated. In particular, the impact of the awareness and acceptability activities will be analysed and presented, including event feedback and communication measures. This final update will provide an evidence-based assessment of how the implemented actions contributed to increased awareness, improved acceptability and stakeholder readiness for the adoption of ZEvRA innovations.

8 References

[1] European Parliament. How the EU wants to achieve a circular economy by 2050. [Online]. Accessible at https://www.europarl.europa.eu/topics/en/article/20210128STO96607/how-the-eu-wants-to-achieve-a-circular-economy-by-2050 (accessd on 14.12.2025)

[2] Directive (EU) 2024/825 of the European Parliament and of the Council amending Directives 2005/29/EC and 2011/83/EU as regards empowering consumers for the green transition through better protection against unfair practices and better information. Official Journal of the European Union, 2024

[3] Cedefop – European Centre for the Development of Vocational Training. Skills for a circular economy, Luxembourg: Publications Office of the European Union, 2020.

[4] Directive (EU) 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives. Official Journal of the European Union, 2008.

[5] Directive (EU) 2018/851 of the European Parliament and of the Council amending Directive 2008/98/EC on waste, Official Journal of the European Union, 2018

[6] Regulation (EU) 2020/852 of the European Parliament and of the Council on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088, Official Journal of the European Union, 2020.

[6a] Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020, and repealing Directive 2006/66/EC

[6b] European Commission, Proposal for a Regulation on circularity requirements for vehicle design and the management of end-of-life vehicles. [Online]. Accessible at: https://environment.ec.europa.eu/publications/proposal-regulation-circularity-requirements-vehicle-design-and-management-end-life-vehicles_en (accessed on 23.12.2025)

[6c] European Commission, Waste shipments. [Online]. Accessible at: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-shipments_en (accessed on 23.12.2025)

[7] European Commission. A new Circular Economy Action Plan – For a cleaner and more competitive Europe, COM (2020) 98 final, 2020

[7a] European Commission. The Clean Industrial Deal: A joint roadmap for competitiveness and decarbonisation, COM (2024) final, 2024.

[8] Directive (EU) 2024/1799 of the European Parliament and of the Council on common rules promoting the repair of goods and amending Regulation (EU) 2017/2394 and Directive (EU) 2019/771, Official Journal of the European Union, 2024

[9a] Directive (EU) 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles, Official Journal of the European Communities, 2000

[9b] European Commission. Communication from the commission to the European Parliament, The European Council, The Council, The European Ergonomic and Social Committee and The Committee of the Regions. Union of Skills. COM (2025) 90 final, 2025

[9] I. Giannoccaro et al. 'Features of the Higher Education for the Circular Economy: The Case of Italy', Sustainability, 2021, 13, 11338, 2021.

[10] S.-M. Renfors. Education for the circular economy in higher education: an overview of the current state. International Journal of Sustainablilty in Higher Education, Vol. 25, No. 9, p 111-127, 2024

[11] Studyportals B.V. [online]. Available at www.bachelorsportal.com, (accessed on 13.12.2025)

[12] Studyportals B.V. [online]. Available at www.mastersportal.com, (accessed on 13.12.2025)

[13] TREE project (Micro- and project-based learning programme for Teaching ciRcular Economy and Ecological awareness in VET). Methodological Material. 2022

[13a] Cedefop (2021). The green employment and skills transformation: insights from a European Green Deal skills forecast scenario. Luxembourg: Publications Office, 2021

[14] E. A. Martínez Ceseña. TRANSIT project (Transition to Sustainable Future Through Training and Education, GA 101075747) D3.1 Knowledge Gaps and Best Practices Report

[15] Green Skills for Circular Economy. Online course 'Building skills for circular economy' [online]. Accessible at https://circular-skills.org/online-course/ (accessed on 14.12.2025)

[16] CircuLab Academy. Online course 'Unlock the potential of the Circular Economy' [onlinie]. Accessible at https://circulab.academy/courses/activate-circular-economy/ (accessed on 14.12.2025)

[17] A. Sikander. Innovative Approaches to Workforce Training for a Circular Economy. International Journal of Green Skills and Disruptive Technology, Vol. 1, No. 1, p. 47-57, 2024

[17a] DaCapo project 'Digital assets and tools for circular value chains and manufacturing products', GA 101091780. D7.4 Training and digital upskilling plan. 2025

[17b] Renée project ' Flexible Remanufacturing using AI and Advanced Robotics for Circular Value Chains in EU Industry'. D6.1upskilling the workforce for remanufacturing, 2025

[18] L. Summerton et al. Industry-Informed Workshops to Develop Graduate Skill Sets in the Circular Economy Using Systems Thinking. Journal of Chemical Education, 2019, 96, p. 2959-2967, 2019

[19] BUILD UP European portal. BUILD UP Skills initiative to Business 3/2015-08/2018 [online] Accessible at https://build-up.ec.europa.eu/en/bup-skills (accessed on 14.12.2025)

[19a] European Circular Economy Stakeholder Platform (ECESP). Circular Economy Stakeholder Dialogue Report, 10.04.2025

[20] Res4city project. 'Upskilling students and members of the workforce to prepare for green transition, in support of a low carbon economy', access to micro credentials [online]. Accessible at https://www.res4city.eu/ (accessed on 14.12.2025)

[21] European Circular Economy Stakeholder Platform ECESP. Knowledge Hub [online]. accessible at https://circulareconomy.europa.eu/platform/en/knowledge-hub (accessed on 14.12.2025)

[22] TU Delft Learning for Life. Course 'Engineering Desing for a Circular Economy' [online], accessible at https://online-learning.tudelft.nl/courses/engineering-design-for-a-circular-economy/ (accessed on 14.12.2025)

[23] TU Delft DelftX. Course ''DelftX: Circular Economy: An Introduction [online]. Accessible at https://www.edx.org/learn/circular-economy/delft-university-of-technology-circular-economy-an-introduction (accessed on 14.12.2025)

[24] Universiteit Leiden. Course 'Eine Kreislaufwirtschaft der Metalle: Auf dem Weg zu einem nachhaltigen Gesellschaftlichen Stoffwechsel', [online], accessible at https://www.coursera.org/learn/circular-economy-metals (accessed on 14.12.2025)

[24a] EIT Manufacturing. 'Manufacturing Innovation Webinars' [online], Accessible at https://www.eitmanufacturing.eu/what-we-do/education/education-programmes/manufacturing-innovation-webinars/ (accessed on 14.12.2025)

[24b] eu academy. Education platform 'energy, climate change & the environment' [online] accessible at https://academy.europa.eu/topics/energy-climate-change-environment/ (accessend on 14.12.2025)

[25] VDI Verein Deutscher Ingenieure. 'VDI-Round Table Circular Economy für Kunststoffe' [online], Accessible at https://www.vdi.de/ueber-uns/politischer-dialog/dialog-events/vdi-round-table-circular-economy (accessed on 14.12.2025)

[26] Circular Economy Forum Austria. 'Circular Innovation Talks' [online], Accessible at https://www.circulareconomyforum.at/programm/circular-innovation-talks/ (accessed on 14.12.2025)

[27] European Roundtable on Sustainable Consumption and Production (ERSCP). 'Next roundtable 2025' [online], accessible at https://erscp.eu/next-roundtable/ (accessed on 14.12.2025)

[28] European Commission. EU Green Week 2025 [online], accessible at https://environment.ec.europa.eu/events/eu-green-week-2025-06-03_en (accessed on 14.12.2025)

[29] European Circular Economy Stakeholder Platform (ECESP), ' EUIndTech2025 – Industrial Technologies and Materials for Sustainable Europe' [online], accessible at https://circulareconomy.europa.eu/platform/en/news-and-events/all-events/euindtech2025-industrial-technologies-and-materials-sustainable-europe (accessed on 14.12.2025)

[30] European Commission. Directorate-General for Communication. Article ' Single-use plastics: are you #ReadyToChange?' [online], accessible at https://commission.europa.eu/news/single-use-plastics-are-you-readytochange-2018-06-05_en (accessed on, 14.12.2025)

[31] Re_fashion project. (Circularity in fashion) [online]. Accessible at https://refashion.fr/citoyen/fr/campagne-rrrr (accessed on 14.122025).

[32] t-rex project (Textile Recycling Excellence), GA 101060343 [online], accessible at https://trexproject.eu/news-article/15-examples-of-citizen-engagement-activities-to-inspire-action/ (accessed on 14.12.2025)

[33] European Circular Economy Stakeholder Platform (ECESP) Start page [online], accessible at https://circulareconomy.europa.eu/platform/en (accessed on 14.12.2025)

[34] TRANSIT project (TRANSITion to sustainable future through training and education), GA 101075747, start page [online], accessible at https://transitproject.eu/ (accessed on 14.12.2025)

[35] CICLO project, start page [online], accessible at https://ciclo-project.eu/ (accessed on 14.12.2025)

[36] IChemE, Circular economy webinar series [online], accessible at https://www.icheme.org/knowledge-networks/knowledge-resources/priority-topics/responsible-production/circular-economy-webinar-series/ (accessed on 14.12.2025)

[37] plasticpollutioncoalition, Webinars [online], accessible at https://www.plasticpollutioncoalition.org/learn/webinars (accessed on 14.12.2025)

[38] CircularPSP project (Public Service Platforms for Circular, Innovative and Resilient Municipalities through PCP), start page [online], accessible at https://circularpsp.eu/project/ (accessed on 14.12.2025)

[39] A. Guerreschi et al. ' Barriers to Efficient Knowledge Transfer for a Holistic Circular Economy: Insights towards Green Job Developments and Training for Young Professionals', Youth, 2023, 3, p. 553-578, 2023

[40] KULeuven/MICHELLE project. Report: Skills on a circular path. Modelling future circular economic scenarios and transformations in sectoral, occupational and skills structures of the Belgian labour market. Accessed online at https://hiva.kuleuven.be/nl/onderzoeksmap/thema/klimaatendo/p/themas/MICHELLE (accessed on 14.12.2025), 2024

[41] S. Ul-Durar et al. ' Integrating knowledge management and orientation dynamics for organization transition from eco-innovation to circular economy', Journal of knowledge management, 27, 8, p. 2217-2248, 2023

[42] M. Tiippana-Usvasalo et al. 'The role of education in promoting circular economy', International Journal of Sustainable Engineering, 16, 1, p. 92-103, 2023

[43] D. Holzer et al. ' Mind the gap: Towards a systematic circular economy encouragement of small and medium-sized companies', Journal of cleaner production, 2021, 298, 126696, 2021

[44] BUILD UP skills project, GA 649737, D4.5 Monitoring and lessons learned, 2018

[45] The European Committee of the Regions (CoR). Opinion of the Committee of the Regions – The role of local and regional authorities in the transition to a circular economy (C/2024/5365), Official Journal of the European Union, 2024

[46] B. I. Chigbu. ' Advancing sustainable development through circular economy and skill development in EV lithium-ion battery recycling: a comprehensive review', Frontiers in Sustainability, doi: 10.3389/frsus.2024.1409498, 2024

[47] D. Sumter et al. ' Key Competencies for Design in a Circular Economy: Exploring Gaps in Design Knowledge and Skills for a Circular Economy', Sustainability, 13, 776, 2021

[48] S.-M. Renfors. Education for the circular economy in higher education: an overview of the current state. International Journal of Sustainablilty in Higher Education, Vol. 25, No. 9, p 111-127, 2024

[49] TREE project (Micro- and project-based learning programme for Teaching ciRcular Economy and Ecological awareness in VET). Start page [online], accessible at https://treeproject.eu/ (accessed on 14.12.2025)

[50] Build Up Skills NL, platform [online], accessible at https://buildupskillsnederland.nl/ (accessed on 14.12.2025)

[51] The European Commission 'The European Green Deal. Striving to be the first climate-neutral continent', web site [online], accessible at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (accessed on 14.12.2025)

[52] D. Wallom. Improving exploitation of Project outcomes using Market and Technology Readiness Levels. European forum of the software research community, project GA 957044, [online], accessible at https://swforum.eu/sites/default/files/2021-05/SWForum_MTRL_Webinar_26.05.2021.pdf (accessed on 14.12.2025)

[53] A. Hoffmann Trevisan et al 'Enhancing Circular Economy education and training for the manufacturing sector: A holistic skills framework', Journal of Environmental Management, 380 (2025), 124982, 2025

[54] N. Teixeira. 'Circular economy perspectives: challenges, innovations, and sustainable futures', Discover Sustainability, (2025) 6:738, 2025

[55] H. Martin. 'Skills for a Circular Economy Transformation—A Regional Case Study From Sweden', International Journal of Training and Development, 2025, 29: 299-308

[56] M. Smol. 'Public awareness of circular economy in southern Poland: Case of the Malopolska region', Journal of Cleaner Production, 198 (2018), p. 1035-1045, 2018

[57] ZEvRA consortium: ZEvRA Automotive Strategy & Innovation Forum: Setting the course for a growing Circular Materials Demand – Summary of outcomes

9 Annex

A: Questionnaire Gap Analysis

B: Interview Questionnaire to barriers to ZEvRA's Innovations

Potential barriers to ZEvRA's innovations

Background: In task 5.1 a plan to overcome barriers for acceptance of ZEvRA innovations will be created.

To identify barriers, we would like you to answer the following questions. The questions are conducted by individual use case.

What type of consortium partner does your organization belong to? (OEM/Industry/Academic/Cluster)

In which use cases is your organisation involved?

Use-case: «Usecase»

(Potential) barriers to ZEvRA's Innovations:

1. Design and Construction:
   1.1. How do the physical properties of «innovation» (e.g., strength, flexibility) affect design constraints (e.g. structural integrity, safety)?
   1.2. Are there limitations on the use of «innovation» in the design (e.g., structural components, safety features, aesthetics, aerodynamics, awareness of designers)?
   1.3. Are there limitations in the use of «innovation» in the design process (e.g. awareness of designers, implementation of «innovation» in the design process)
   1.4. Are there any communication barriers between design, production, and material teams that hinder effective integration?
   1.5. What measures or strategies do you propose to overcome the challenges?
2. Technical Feasibility and Quality:
   2.1. What challenges do you face in integrating «innovation» into current production processes?
   2.2. How do the properties of «innovation» compare to those of new materials in terms of durability and performance?
   2.3. What measures or strategies do you propose to overcome the challenges?
3. Cost and Economic Considerations:
   3.1. How do the costs of «innovation» compare to those of virgin materials/conventional methods?
   3.2. Are there any additional costs associated with adapting existing production lines to accommodate «innovation»?
   3.3. How do «innovation» affect production lead times or efficiency?

3.4. What economic incentives or disincentives exist for using «innovation» in production?
3.5. What measures or strategies do you propose to overcome the challenges?

4. Supply Chain and Availability:
   4.1. What challenges exist in securing a consistent and reliable supply of high-quality «innovation»?
   4.2. How do you rate the availability of end-of-life feed for new «innovation» cycles?
   4.3. What measures or strategies do you propose to overcome the challenges/improve the rate?
5. Regulatory and Compliance Issues:
   5.1. Are there any regulatory barriers or compliance issues related to using «innovation» in car production?
   5.2. How do industry standards and regulations influence the adoption of «innovation»?
   5.3. What measures or strategies do you propose to overcome the challenges?
6. Employee Training and Acceptance:
   6.1. How do you estimate the circularity expertise regarding «innovation»?
   6.2. What training or educational initiatives are necessary for employees to effectively work with «innovation»?
   6.3. How do production engineers, line workers or other employees perceive the use of «innovation»? Are there any reservations or resistance?
   6.4. What measures or strategies do you propose to overcome the challenges?
7. Production Technology and Infrastructure:
   7.1. Is the current production infrastructure capable of handling «innovation» without significant modifications?
   7.2. What technological innovations or upgrades would facilitate the integration of«innovation» into the production process?
   7.3. How do recycled materials impact the ease of manufacturability in technical methods (e.g. joining methods other materials?
   7.4. What measures or strategies do you propose to overcome the challenges?
8. 8. Environmental Impact and Sustainability:
   8.1. How do «innovation» affect the overall environmental footprint of electrical vehical production?
   8.2. Are there specific environmental benefits or drawbacks associated with using «innovation» that influence their adoption?
   8.3. What measures or strategies do you propose to overcome the challenges?
9. Collaboration and Partnerships:

9.1. What role do collaborations with recycling companies or material suppliers play in the successful implementation of «innovation»?

9.2. Are there existing partnerships that support the use of «innovation», and how effective are they?

9.3. What measures or strategies do you propose to overcome the challenges?

10. Marketing and Customer Relationship

10.1. Do consumers perceive cars made with «innovation» as lower quality or inferior in design?

10.2. What measures or strategies do you propose to overcome the challenges?

11. Implementation and roll out timeline

11.1. Do you see any challenges to keep ZEvRA's objective of implementing to improve zero emission approaches in the life cycle and value chain of at least 59% of European EV's by 2035 coming from «innovation»?

12. In which process step from design to production or shipping should employees be aware of circular economy or have a deeper knowledge of CE regarding the innovations of «Usecase»?

13. Are there any other challenges to the acceptance of «innovation» that you can think of?

C 1st Annual ZEvRA Conference Feedback results

ID	Start time	Completion time	Email	Name	Language	Last modified time	Your institutions role alongside the value circle	The event objectives were clear and well communicated.	The organisation and scheduling of the event were effective.	The content was relevant to my professional or research interests.	The speakers/facilitators were knowledgeable and engaging.	The event helped me better understand the goals and innovations of the ZEvRA project.	The event increased my understanding of circular approaches in the automotive sector.	The event strengthened my confidence that Circular Economy and ZEvRA solutions can be successfully applied in industry.	The event encouraged meaningful interaction and discussion.	I had the chance to connect or network with other participants.	The event motivated me to follow future ZEvRA activities.	What did you find most valuable about this event?	What improvements would you suggest for future events?
1	11.27.25 14:56:49	11.27.25 15:00:47	anonymous		Deutsch		reserach and developm	Disagree	Disagree	Strongly agree	Agree	Agree	Agree	Neutral	Agree	Disagree	Neutral	The perspectives of the OEMs (esp. the Recycling Factories of Toyota)	Sticking to the timetable
2	11.27.25 14:56:47	11.27.25 15:01:01	anonymous		English (United Kingdom)		reserach and developm	Agree	Agree	Strongly agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	The very concrete examples mentioned during the panels	
3	11.27.25 15:02:35	11.27.25 15:05:35	anonymous		English (United Kingdom)		supplier	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree	Agree	Strongly agree	Agree	Neutral	Agree		
4	11.27.25 15:02:18	11.27.25 15:06:35	anonymous		English (United Kingdom)		reserach and developm	Agree	Agree	Neutral	Agree	Neutral	Agree	Agree	Agree	Agree	Strongly agree	Workshop	More detailed info regarding project developments
5	11.27.25 15:07:39	11.27.25 15:08:32	anonymous		English (United Kingdom)		consultant / external en	Strongly agree	Agree	Agree	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Agree	Informative	
6	11.27.25 15:07:42	11.27.25 15:08:52	anonymous		Deutsch		consultant / external en	Agree	Agree	Strongly agree	Agree	Neutral	Agree	Strongly agree	Agree	Strongly agree	Strongly agree	Exchange	Something to touch
7	11.27.25 15:08:01	11.27.25 15:09:11	anonymous		Deutsch		consultant / external en	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree		
8	11.27.25 15:07:48	11.27.25 15:09:14	anonymous		English (United Kingdom)		policy / administration	Agree	Agree	Agree	Agree	Agree	Neutral	Agree	Agree	Agree	Agree	great representatives, insightful workshop	
9	11.27.25 15:07:45	11.27.25 15:09:32	anonymous		Deutsch		OEM	Agree	Agree	Agree	Strongly agree	Agree	Agree	Agree	Agree	Agree	Agree	Networking and the different perspectives among the participants	
10	11.27.25 15:07:49	11.27.25 15:09:33	anonymous		English (United Kingdom)		supplier	Strongly agree	Strongly agree	Strongly agree	Agree	Strongly agree	Agree	Strongly agree	Strongly agree	Agree	Strongly agree		
11	11.27.25 15:08:02	11.27.25 15:09:36	anonymous		English (United Kingdom)		reserach and developm	Strongly agree	Agree	Agree	Agree	Strongly agree	Agree	Agree	Agree	Strongly agree	Agree	Good panel discussions	More demonstrations
12	11.27.25 15:07:45	11.27.25 15:09:44	anonymous		English (United Kingdom)		supplier	Agree	Strongly agree	Agree	Agree	Agree	Neutral	Strongly agree	Strongly agree	Agree	Agree	Speakers Competence	Nothing
13	11.27.25 15:07:31	11.27.25 15:09:48	anonymous		Deutsch		reserach and developm	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Agree	Agree	Strongly agree	Q&A	Less panel discussions more presentations
14	11.27.25 15:07:37	11.27.25 15:09:52	anonymous		English (United Kingdom)		consultant / external en	Strongly agree	Agree	Agree	Strongly agree	Strongly agree	Agree	Neutral	Agree	Agree	Agree	Possibility to discuss diferent topics and solutions	-
15	11.27.25 15:07:40	11.27.25 15:09:59	anonymous		Deutsch		OEM	Agree	Agree	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Connecting with all involved, sharing what everybody in the valuechain needs to solve	More networking activities for the Zevra members
16	11.27.25 15:07:52	11.27.25 15:10:05	anonymous		English (United Kingdom)		consultant / external en	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Neutral	Strongly agree	The expert panel discussions in the morning sessions	Some more movement in between sessions, networking games, zevra knowledge games to show awareness of the project success in the next conference
17	11.27.25 15:07:58	11.27.25 15:10:07	anonymous		English (United Kingdom)		manufacturer	Agree	Strongly agree	Agree	Agree	Agree	Strongly agree	Agree	Strongly agree	Agree	Agree	Questions and anwers	
18	11.27.25 15:07:50	11.27.25 15:10:08	anonymous		English (United Kingdom)		consultant / external en	Agree	Strongly agree	Agree	Agree	Neutral	Agree	Neutral	Agree	Agree	Neutral	Great Panel discussions	More Interaction with the Audience
19	11.27.25 15:07:41	11.27.25 15:10:11	anonymous		English (United Kingdom)		OEM	Agree	Strongly agree	Agree	Agree	Strongly agree	Agree	Neutral	Agree	Strongly agree	Agree	Acknowledge about zevra project or sumilar activities no future	Show more tangible results
20	11.27.25 15:07:40	11.27.25 15:10:17	anonymous		English (United Kingdom)		reserach and developm	Strongly agree	Strongly agree	Agree	Agree	Strongly agree	Agree	Agree	Strongly agree	Agree	Strongly agree	Panels and interactive sections	
21	11.27.25 15:07:46	11.27.25 15:10:17	anonymous		English (United Kingdom)		OEM	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	Agree	Agree	Strongly agree	Neutral	Strongly agree	présentations of all the workkng groups and live discussions	none
22	11.27.25 15:07:52	11.27.25 15:10:34	anonymous		English (United Kingdom)		OEM	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Strongly agree	Agree	Realize the goal as a team	Summary charra
23	11.27.25 15:07:55	11.27.25 15:10:38	anonymous		English (United Kingdom)		reserach and developm	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree		
24	11.27.25 15:07:42	11.27.25 15:10:41	anonymous		Deutsch		consultant / external en	Agree	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree	Agree	Agree	Strongly agree	Strongly agree	Meeting / discussion with experts from industry and research	Dedicate a bit more time, may be 1,5 days
25	11.27.25 15:08:00	11.27.25 15:13:39	anonymous		English (United Kingdom)		manufacturer	Agree	Agree	Agree	Neutral	Agree	Strongly agree	Strongly agree	Agree	Agree	Agree	Shift of mindset	Maybe standing instead of sitting for panelists.. One can see all of them
26	11.27.25 15:11:50	11.27.25 15:14:40	anonymous		English (United Kingdom)		PhD student	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Agree	Agree	Strongly agree	Neutral	Agree		
27	11.27.25 15:08:15	11.27.25 17:20:03	anonymous		English (United Kingdom)		supplier	Neutral	Agree	Agree	Agree	Neutral	Neutral	Neutral	Agree	Agree	Agree	Different perspectives, OEM partcipation, networking	Be clearer about project status, achievements and plan until completion.
28	12.2.25 13:47:05	12.2.25 13:53:51	anonymous		English (United Kingdom)		supplier	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Agree	Agree	understand the different declination of the common target, at the different sectors of the same business	having now clarified the common target, the next event should enter more in the details and make the attendees a lot more active in the discussion
29	12.3.25 7:42:18	12.3.25 7:44:01	anonymous		Deutsch		consultant / external en	Agree	Strongly agree	Strongly agree	Strongly agree	Agree	Agree	Strongly agree	Strongly agree	Agree	Agree	7 or 8 OEMs were present and open for discussion. This is a great achievement and was very valuable!	The space unluckily was a bit too small
30	12.3.25 13:36:22	12.3.25 13:39:28	anonymous		English (United Kingdom)		reserach and developm	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	The panels and OEM contribution	Bigger rooms, more engagement, see the results
31	12.5.25 9:14:58	12.5.25 9:16:30	anonymous		English (United Kingdom)		reserach and developm	Strongly agree	Agree	Agree	Agree	Agree	Agree	Neutral	Strongly agree	Strongly agree	Agree	More interaction activities	

