



Zero Emission electric Vehicles enabled by haRmonised circulaRity

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Awareness and Acceptability report

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ZEVR project abstract

ZEVR'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, ZEVR 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), unfilled/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.

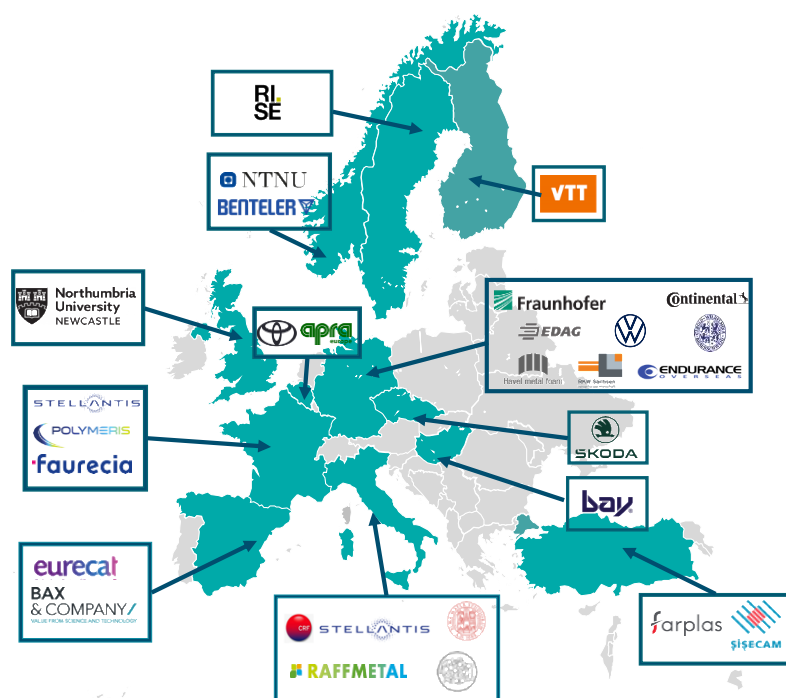


Figure 1 ZEVR Consortium

To maximise the outreach of our methodology and zero emission solutions, ZEVR 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. ZEVR'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.

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Abbreviations and Acronyms

Table 1 Abbreviations and Acronyms

Abbr.	Full name
AI	Artificial Intelligence
CE	Circular economy
CEA	Energy Academy
CEAP	Circular Economy Action Plan
Cedefop	European Centre for the Development of Vocational Training
CINEA	Climate, Infrastructure, and Environment Executive Agency
DfC	Design for Circularity
ECESP	European Circular Economy Stakeholder Platform
EIT	European Institute of Innovation and Technology
EoL	End of Life
EPR	extended producer responsibility
ESD	Education for sustainable development
EU	European Union
EV	Electric vehicle
FRP	Fibre-reinforced plastic
GCCE	Green Chemistry Centre of Excellence
GPP	green public procurement
IoT	Internet of Things
LCA	Life Cycle Assessment
LCT	Low-carbon technologies
LFT	Long fibre TP
MC	micro-credential
MOOC	Massive Open Online Course
MRL	Market Readiness Level
NGO	Non-governmental organisation
OEM	Original Equipment Manufacturer
OES	Original Equipment Service
PBL	Project-based learning
PET	Polyethylene terephthalate
PP	Polypropylen
R&D	Research and Development
RES	Renewable energy systems
ROI	return on investment
SME	Small and medium-sized enterprises
SOTA	State of the art
TREE	Teaching ciRcular Economy and Ecological awareness in VET schools
TRL	Technological Readiness Level
VET	Vocational Educational and Training

YENESIS	Youth Employment Network for Entergy Sustainability in Islands
ZEvRA	Zero Emission electric Vehicles enabled by haRmonised circularArity

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Executive summary

This Awareness and Acceptability Report presents the foundational work carried out under Task 5.1 to advance the 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, knowledge gaps persist, particularly within the industrial workforce, where only a fraction of employees are familiar with CE concepts. ZEvRA aims to bridge this gap through a structured awareness and acceptability program that engages key stakeholders, strengthens human capital in research and innovation, and provides specialised training to facilitate the adoption of CE practices.

A structured methodology was applied to assess the current state of CE awareness and acceptance. The report first provides a state-of-the-art (SOTA) analysis, examining existing policies, training programmes, industry initiatives, and best practices to establish a comprehensive understanding of CE education and workforce development. This is followed by an in-depth identification of gaps and barriers hindering the integration of CE principles in the automotive sector, with a particular focus on technical, economic, regulatory, and organisational challenges. Key barriers identified include the necessity for recycled materials to meet stringent performance standards, the limited and inconsistent supply of high-quality secondary materials, economic constraints affecting cost competitiveness, and integration challenges within design and production processes. Broader systemic challenges, such as consumer perceptions, aesthetic limitations, and logistical costs, further complicate the transition toward circularity.

To address these barriers, a multistep approach has been carried out. The first step involved conducting targeted interviews with Original Equipment Manufacturers (OEM) and Original Equipment Services (OES) to gather industry-specific insights into the feasibility of CE innovations and the factors limiting their adoption. The second step, which is currently in progress, will involve a broader survey of industry and academia to validate and deepen the findings from the interviews. Based on this analysis, concrete measures will be developed to facilitate the implementation of CE innovations, focusing on regulatory alignment, technical integration, economic incentives, and workforce upskilling. A key component of this approach will be the creation of tailored communication and awareness tools, including newsletters, symposiums, presentations, and digital learning platforms, designed to engage stakeholders and increase the visibility and acceptability of CE solutions.

The work described in this report establishes the framework for ongoing efforts in Task 5.1. The findings from the interviews and surveys will inform the next phase, where targeted strategies will be refined and tested in real-world applications. The development of structured evaluation mechanisms will allow for continuous assessment of the effectiveness of awareness and training measures, ensuring that the project remains adaptive to industry needs and policy developments. This deliverable represents a key milestone in advancing circularity in the automotive sector by

providing a structured, data-driven foundation for stakeholder engagement, workforce training, and the large-scale implementation of sustainable innovation.

1 Introduction

The transition to a CE 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 CE 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 programme that maximises the impact of CE 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.

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 specialised training for the industrial workforce. Additionally, it will promote innovation in automotive technology and CE 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.

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 CE practices. Second, it strengthens research and innovation capabilities by providing specialised 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 CE principles are embedded in technical training and professional development.

This Awareness and Acceptability Report outlines the foundational work for work package 5, prepared in Task 5.1 "Awareness and Acceptability", presenting an updated assessment of the state of awareness and acceptability of CE 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 real-world 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 CE 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 (SOTA) analysis forms the theoretical basis for the development of the plan to overcome barriers for acceptance of ZEvRA innovations.

The aim of the SOTA analysis is to provide a comprehensive and systematic overview of existing research, practices and technological advances related to the promotion of the CE. 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 CE practices at a European level.

2.1 Purpose of the SOTA analysis

The purpose of the State of the Art (SOTA) analysis on CE awareness and training is to provide a comprehensive overview of existing knowledge, initiatives, and best practices that support the transition to a CE across the automotive industry and other relevant sectors in Europe. This analysis aims to identify current educational and training programmes, 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 analysis will offer insights into the strengths and weaknesses of current CE training efforts. The SOTA analysis aims to ensure alignment with EU policies and strategic frameworks related to CE and sustainable skill development.

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

As the project progresses, the results of this SOTA analysis will be reviewed and refined to incorporate additional insights from the automotive industry, stakeholders and emerging developments in CE education and training. This iterative approach ensures that recommendations remain relevant, practical, and aligned with industry needs and policy objectives.

2.2 Scope of the SOTA analysis

The State-of-the-Art (SOTA) analysis was conducted to assess the current landscape of 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 programmes, 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 that influence CE education and training. The goal was 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. This provided insights into the existing theoretical and practical frameworks used in 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 review of CE-related university curricula, degree programmes, 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 analysed to identify past and ongoing initiatives related to CE education and workforce development.
- University websites and academic databases were reviewed to compile degree programmes, vocational training, and specialised 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 (CE) in the European Union (EU).

2.3.1 Policy & Strategic Frameworks

The European Green Deal is the overarching strategy for a sustainable EU economy. Moving to a CE paradigm is at its core for achieving climate neutrality in the EU by 2050. [1] The second Circular Economy Action Plan (CEAP) for the CE is decisive for the promotion of the CE 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 CE, 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 CE, 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 CE. 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 CE. 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 CE, 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 investments will be made under the European Social Fund Plus, the European Union main instrument for supporting investments in education and training systems, lifelong learning and social innovation. [7]

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 CE. [8]

2.3.2 Existing Training & Education Programmes

University and vocational training programmes on CE. Industry-led upskilling and workforce development initiatives.

University Programmes 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 CE 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 CE, CE for energy storage, CE design and development, circular and sustainable waste management, economics for the CE, and material design for CE. [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, more than 4,200 bachelor's programmes and 5,700 master's programmes on the CE are currently listed at more than 1,500 universities. [11], [12] Some universities, such as Delft University of Technology in the Netherlands, have developed special programmes that focus on the principles of the CE. Aalborg University offers an MSc in Sustainable Energy Engineering, which aims to provide students with knowledge on the development of sustainable energy systems. The Royal Institute of Technology KTH has established an MSc programme in Smart Electrical Grids and Systems with the EIT label (European Institute of Innovation and Technology), which is widely recognised and standardised. The figures for the study programmes will be analysed in more detail during the project.

Vocational Education and Training (VET) Programmes 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 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 CE 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 CE 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 CE 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 CE should also be a priority. [3]

In the energy sector, there are a number of training initiatives for the CE: The Energy Academy (CEA) is a key initiative that offers training seminars and exams for vocational qualifications in the CE, in addition to renewable energy, energy efficiency, sustainable tourism and financing. Another programme is the Youth Employment Network for Energy Sustainability in Islands (YENESIS), which focuses on preparing young people (25-29 years) for green jobs in the fields of energy efficiency, renewable energy and sustainable mobility. This programme 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 programme 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 CE. [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 CE. [13] Examples of micro-learning include the “Green skills for circular economy” course [15] and the course from Circulab academy [16].

The BUILD UP Skills is a European Union initiative for the construction sector for skills uptake, also aiming at decarbonisation and CE. It was launched in 2011 and is currently funded under the LIFE Clean Energy Transition programme 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 CE, such as circular construction and energy-efficient construction. [19]

Industry-Led Upskilling and Workforce Development Initiatives

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

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

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 CE. This initiative covers key areas identified by industry, including resource efficiency, regulation, life cycle thinking, commercialisation, 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 programmes.

- The RES4CITY project developed and implemented a micro-credential (MC) programme focused on the green energy transition utilising online modules, reading materials, and assessments. The project's aim is to promote sustainability and circularity in cities with a 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 CE principles [15], available at <https://circular-skills.org/online-course/>.

- The CE introduction course, a self-paced two-hour online course to understand CE 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 CE. [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 CE. [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 CE as part of its Sustainable Engineering Design Professional Certificate Program. Topics are CE 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 CE of metals. [24] Available at <https://www.coursera.org/learn/circular-economy-metals>.

2.3.3 Awareness and Communication Efforts

In the table below is a selection of communication tools for CE 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
App	BUILD UP Skills NL	Contains a database for construction training in Europe and some specific EU countries. It also contains a community-managed content repository.	Practitioners and craftsmen in the construction value chain
Graduate Workshops	Green Chemistry Centre of Excellence (GCCE) at the University of York/RenewChem	Annual series of graduate workshops using systems thinking to implement CE in the chemical industry	Graduate chemistry students
Round table discussion	European Circular Economy Stakeholder Platform (ECESP)	Stakeholder Dialogue on 10 April to discuss key EU	Businesses, public authorities and NGOs to knowledge

		initiatives shaping the CE community	communities and other civil society organisations
Round table	VDI Verein Deutscher Ingenieure	VDI-Roundtable CE 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, interdisciplinary dialogue. (in German)	Austrian decision-makers and multipliers at various administrative levels, including federal Austrian states, cities, regions and municipal 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 CE	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	stakeholders from research organisations, industry, industry associations, NGOs and policy makers [29]

		and business, and community in action;	
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, organisations [33]
Online Platform	TRANSIT - Transition to a Sustainable Future through Training and Education	The project website serves also as a platform for educational 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 CE.	Chemical engineers [36]

Webinar	Plastic Pollution Coalition	Webinar series on the latest information and resources to stop plastic pollution	Public [37]
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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]
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 programmes. [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]
Overlooking soft skills:	Training programmes 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]
Lack of clarity on CE application advantages	The advantages of CE application are often unclear. [39]
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]
Lack of standardised programmes and certifications	The absence of globally recognised 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]
Varying required skillsets	Skill requirements for CE often differ based on specific project or industry challenges. [39]
Insufficient upskilling opportunities	There's a need to secure upskilling opportunities for workers to implement circular principles. [40]
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 CE 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]
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]
Absence of key performance indicators	The lack of key performance indicators for ECE is also a limitation. [39]
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]

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 marginalised 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]
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]
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]
Need for public awareness	Institutions need to focus on public awareness programmes 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 programmes.

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
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	understand what the CE really means and the related opportunities it presents. This lack of fundamental knowledge hinders the adoption of CE principles. [3], [39], [42]
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 CE approaches. [43]
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]
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]
Lack of standardised programmes, certifications and knowledge	The absence of globally recognised standards in CE training makes it difficult to assess and compare skills and knowledge. [14], [39]
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]
Varying required skillsets	Skill requirements for CE often differ based on specific project or industry challenges. [39]
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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 CE 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]
Focus on traditional models	Convincing organisations 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]
Lack of practical examples and best practices	There is a limited amount of readily available best-practice examples of CE implementation that industries can learn from. [39]
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]

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.

Table 5 Identified Regulatory Barriers

Regulatory Barriers	
Limitations of voluntary approaches	Voluntary EU initiatives, such 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 labour 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]

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 CE 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]
Lack of reporting mechanisms	Reporting mechanisms on regulatory barriers are lacking at both national and European levels. [45]
Inadequate funding for R&D	Current policies fail to adequately fund research and development initiatives about recycling technologies. [46]
Administrative and legal obstacles	There are administrative and legal obstacles to a circular sharing and service economy. [7]
Need for a supportive regulatory environment	Creating the right regulatory environment is crucial for innovation in circular solutions, materials, and business models. [7]
Policy and legal frameworks	Policy and legal frameworks can act as barriers to the successful development and implementation of circular product-service systems. [47]
Need to understand laws and regulations	Understanding laws and regulations is essential to promote the CE. [48]

Table 6 Identified Market Barriers

Market Barriers	
Labor shortage	A growing labour shortage, even for traditional work, can make companies less inclined to explore new kinds of business such as a sustainable built environment. [44]
Perception of sustainability as cost	Sustainability is associated with costs rather than an investment. [43]
High investment costs	High upfront investment costs for sustainable innovations act as a market barrier. [43]
Low virgin material prices	Low virgin material prices can also hinder the competitiveness of circular alternatives. [43]
Lack of consumer demand	A lack of consumer demand to address environmental issues is an inhibiting factor. [43]
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 CE. [7]

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]
Weak innovation activity	Weak innovation activity may limit the capability of businesses to make the shift towards a circular economy. [3]

2.5 Best Practices & Lessons Learned

2.5.1 Successful CE Training & Upskilling Programmes

Following successful training and upskilling programmes on CE 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 CE, fostering energy-efficient and environmentally sustainable building practices. The BUILD UP Skills initiative serves as a successful model for upskilling professionals in CE practices within the construction sector. By combining digital tools, practical training, and stakeholder collaboration, the programme 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 CE 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 programmes 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 CE principles into mainstream construction training.
 - Scalable upskilling framework combined of digital tools and on-site training.
 - Data-driven monitoring revealed steady engagement with training programmes, 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 principles into vocational education and training (VET) schools. The project sought 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 CE. [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 CE education into VET curricula.
 - Strengthen links between VET institutions and businesses practising sustainability.
 - Increase student employability by providing relevant green skills.

- Promote eco-friendly habits and sustainability awareness among students.
- Support industries in transitioning towards CE models.
- Implementation and methodology
 - Project-Based Learning (PBL): Encourages hands-on, real-world problem-solving activities where students engage with CE 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-orientated 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, eco-designers, 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 CE 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 programme 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 specialised courses and workshops
 - Industry professionals via re-skilling and upskilling programmes
 - Government and policy-makers to align education with EU sustainability goals

- Community members through surveys, awareness campaigns, and participation in sustainable initiatives
- Outcomes and Impact
 - More than 489 participants across 29 countries engaged in training programmes
 - Project ongoing

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 programmes, 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 programmes 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 categorised to provide a structured overview of current challenges in CE education and training.

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 programmes 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 programmes. 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 programmes, 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.

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 standardised 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 programmes to provide flexible lifelong learning opportunities.
 - Expanding Access to Practical Training & Demonstration Projects:

- Develop more living labs, apprenticeships, and work-based training programmes 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 harmonised regulatory frameworks that align CE education policies across EU member states.
 - Introduce economic incentives for CE upskilling programmes, such as tax reductions for companies investing in employee training.
 - Improve validation of informal and non-degree training programmes 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.
 - Utilise 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 strategies to create awareness for CE and for overcoming the barriers to the ZEvRA innovations. For the next Awareness & Acceptability Report (D5.2), the results of the SOTA will be reviewed and, if necessary, supplemented and adapted to current developments in the state of the art.

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 programmes
- 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 organisational, 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 electric vehicle (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 overcome.

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 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 the 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 making 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 the 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 1) represents the general information for SWOT analysis:

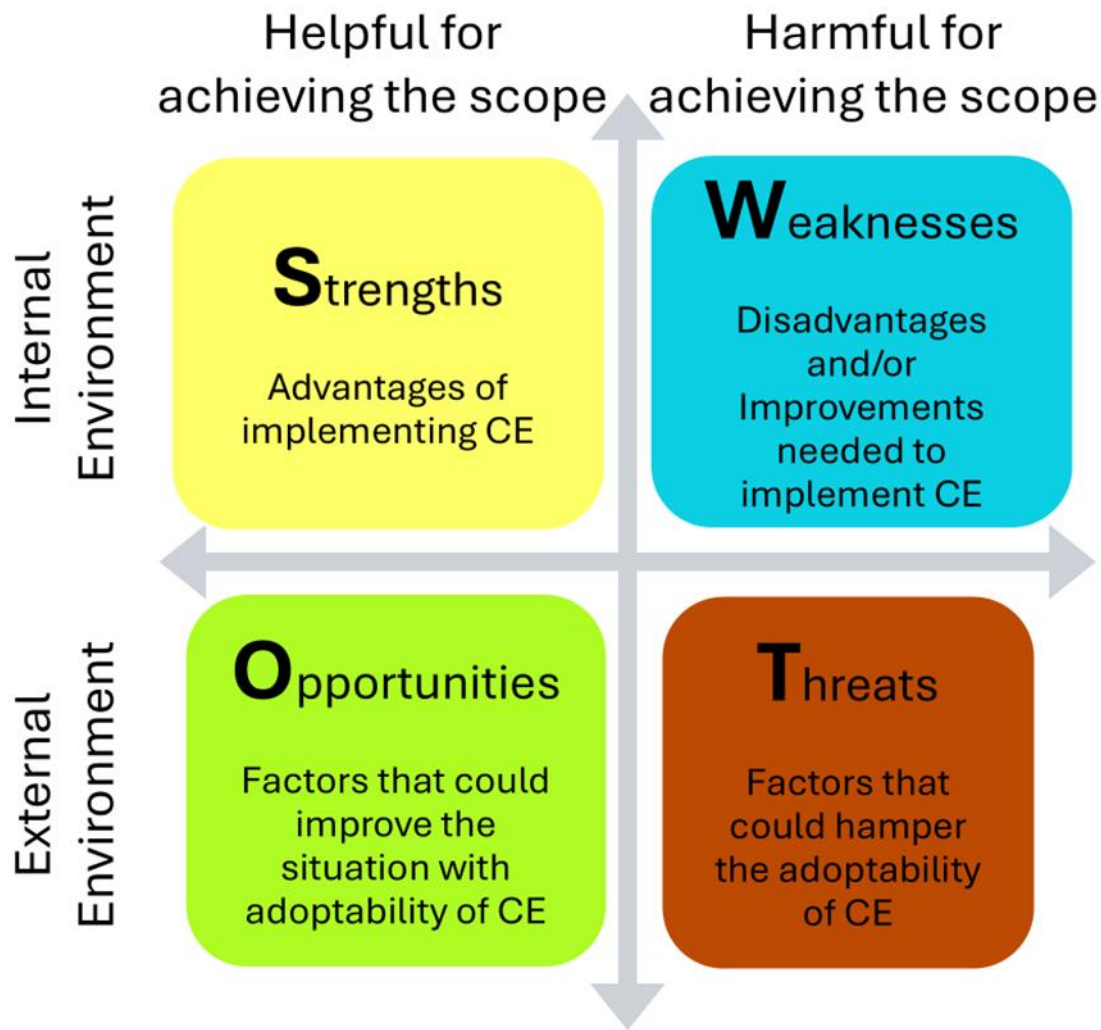


Figure 2 Diagram of SWOT analysis

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, which 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 for the industry partners and public. Furthermore, at the next level of analysis, factors that might be helpful in emphasising 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 in accordance with the responses received from 18 industry partners.

The following chart (Figure 2) represents the knowledge of CE in accordance with the 18 industry partners. More than 50% of the responses denote 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 denote certain opportunities for the implementation of knowledge of CE. This involves recycling all waste that is produced, finding methods to extend the life cycle of products/materials, and implementing sustainable designs of materials/products according to CE principles.

Knowledge about Circular Economy (CE) (Please answer based on your organisation and related to ZEvRA innovation)



Figure 3 Chart representation about knowledge of CE

The following chart (Figure 3) 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 denote a threat regarding not being willing to pay a premium for products that are produced sustainably in a CE. This will be further explained and explored in Section 5.3 Economic Gap.

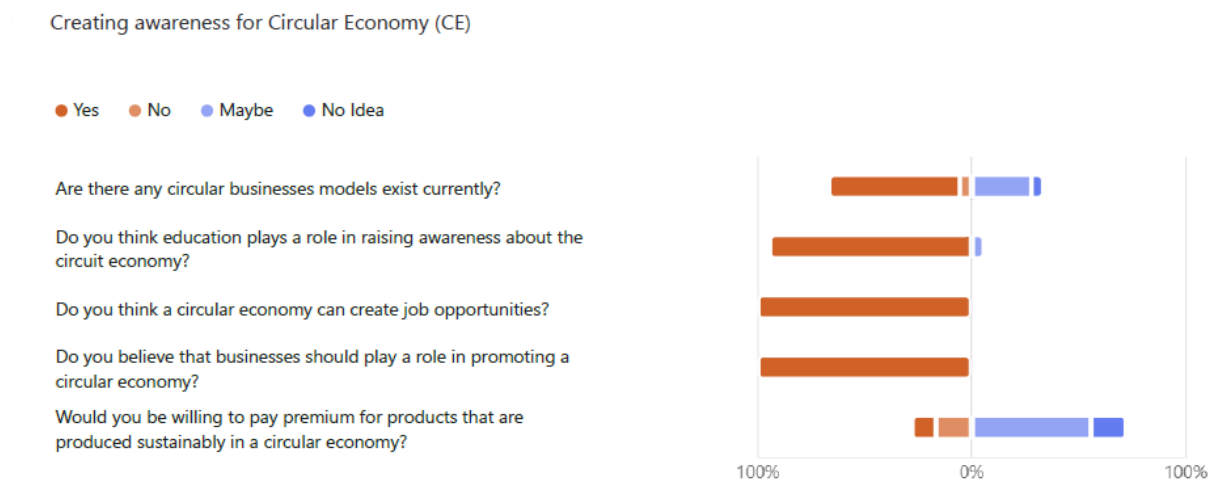


Figure 4 Chart representation about creating awareness for CE

The following chart (Figure 4) 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, recycle, and etc.).

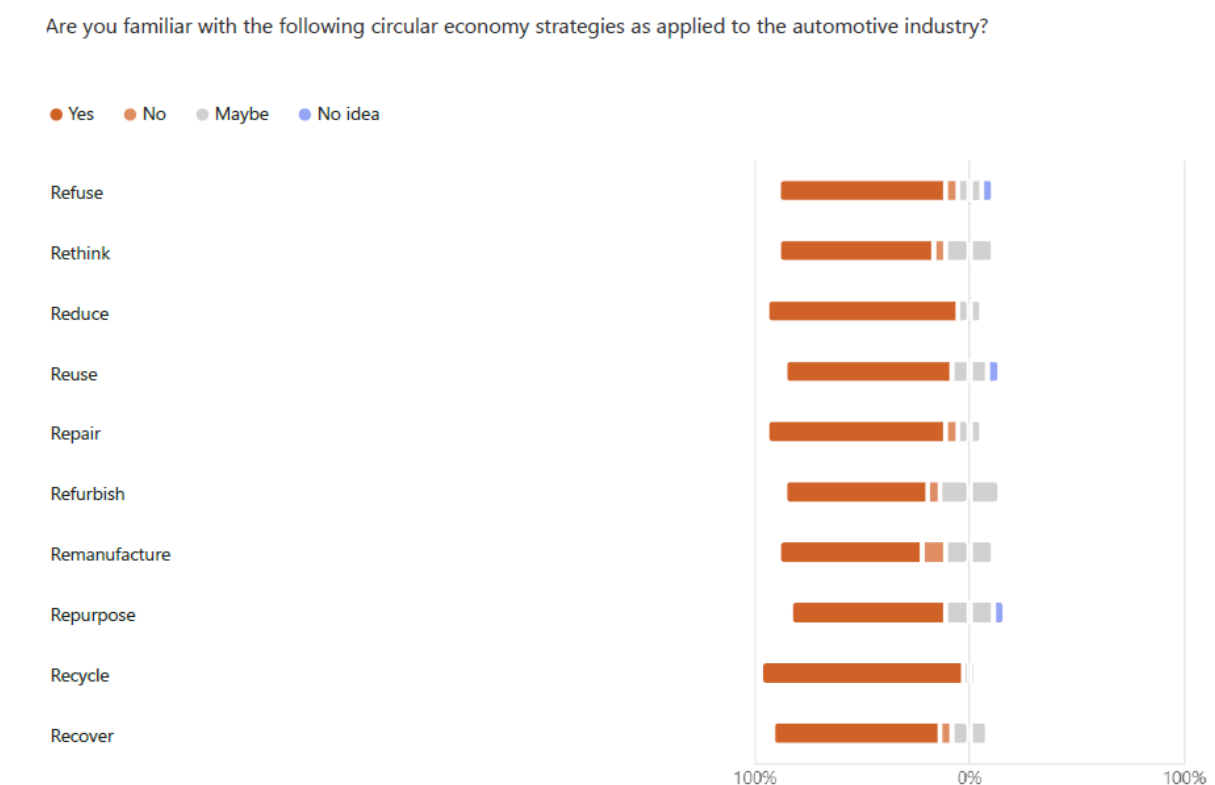


Figure 5 Chart representation of CE strategies applied to the automotive industry

The following chart (Figure 5) 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 serve as strengths in the gap analysis.

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

Are you familiar with the following circular economy business models in the automotive industry?

● Yes ● No ● Maybe ● No idea

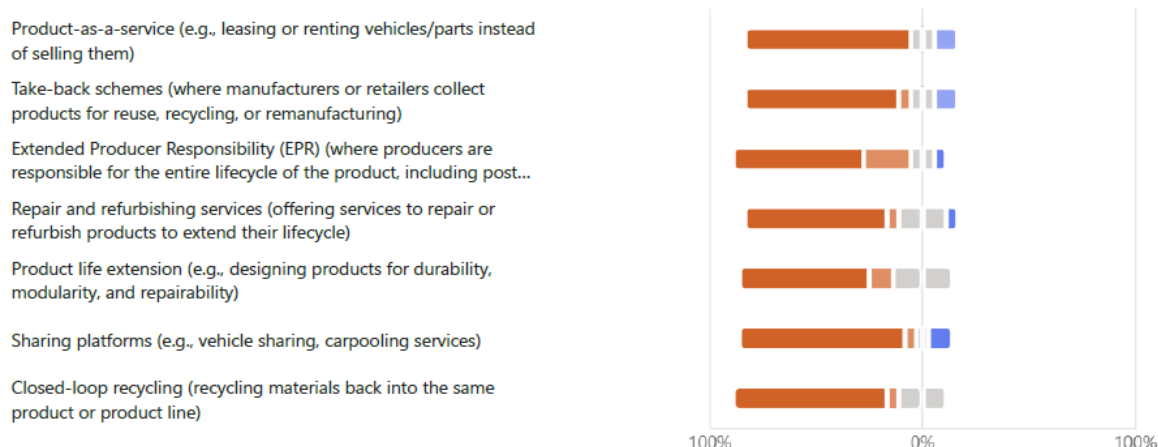


Figure 6 Chart representation of CE business models in the automotive industry

3.3.2 Desired state

The EU CEAP [7] mandates making sustainable products the norm in the EU, which focuses on the sectors that use most resources and where the potential for circularity is high. This would require a significant increase in investment to ensure material footprint and resource productivity and consumption footprint. It also empowers consumers and public buyers in ensuring less waste and making circularity work for people, regions, and cities. This requires a significant increase in education and creating awareness for the people (i.e., consumers, buyers, businesses, public, etc.) regarding CE strategies and their implementations.

The EU Green Deal [51] mandates 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.

3.3.3 Identified Gaps

The following table (Figure 6) 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 taken into consideration towards

these, as there are fears of a lack of 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 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 training and lack of practical education - CE might be costly and not competitive mid-team - Lack of a 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 - Funding to develop products/concepts/platforms for industry - Networking with other stakeholders (materials suppliers, OEMs, recycling companies, etc.)
Threats	- Not all waste produced is being recycled. - Perception that circular products are of lower quality or durability - Needing time and resources versus businesses receiving 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 economic gaps

Technological Gap	• Description: Lack of infrastructure (e.g., for take-back schemes or recycling) • Root cause: High implementation 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

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 in certain areas are being highlighted in this section. Many businesses and organisations are not rooted in industrial sectors, which means they might not even realise 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 of what the other organisations can offer to help them transition. There are 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 a CE 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 CE 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 help 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 help 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 how products are designed can encourage CE processes and promote sustainable consumption of products that are being manufactured in 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 to last 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 licences can aid to promote the implementation of CE. This also includes reducing the environmental footprint, diversifying 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 will 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. This stakeholder-driven approach will help prioritise the most critical barriers and design pragmatic, actionable solutions to overcome them.

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 the CE. Communication materials such as newsletters, pitches and presentations will be created, 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 CE in general within the industry. The first step involves direct engagement with key stakeholders, particularly OEMs and 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 CE principles.

Following the initial interviews, the findings will be analysed and expanded through a broader survey 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 CE solutions.

4.2.1 Approach to interviewing

- Describe the development of the questionnaire
- Explain the structure of the questionnaire
- Introduce the procedure of interviewing the consortium OEM and OES

Questionnaire

The first section gathers background information on the consortium partner's role in the project, identifying whether the organisation belongs to the category of an OEM, an industrial partner, an academic institution, or a cluster. Additionally, it records the specific use cases in which the organisation is involved to ensure that responses are relevant to the innovations being assessed.

The questions are conducted by ZEvRA's individual use cases with their assigned innovations. Table 6 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 CO ₂ e emissions by 4.4 t/t of steel.
Wrought aluminium	Maximised 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, and Zn to maintain properties.
Cast aluminium	Maximised recycling content with 100% scrap (vs. 40% common practice ²⁶). Alloy development as in the wrought version. Adapting of HPDC for specimen and prototype. Introduction of ribs directly in the casting process for a 20% improved lightweight design.

Aluminium foam	Mixed aluminium scrap is fully used for producing new foam at a 100% recycling rate. The foaming process will be adapted prior to the simulation and production of the 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 fibre preregs and GMT (chopped fibre preregs) and pellets/flakes of long fibre 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 the automotive industry or packaging. Feedstock of fibre will come from other industries (e.g., wind turbines, aeronautics).
Glass	Automotive glass will be processed using fewer chemicals and less water in the manufacturing phase, and photovoltaic cells (output power ranging between 40-100W/m ²) 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 tyres 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 organisation 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](#).

Interviews

The approach to interviewing OEMs and OESs for the first step of barrier identification follows a standardised process to ensure the accuracy and reliability of responses. Each interview is conducted via web call with a suitable representative from the consortium partners. The responses are transcribed to capture detailed insights, after which the transcribed answers are sent back to the interviewees for review. The interviewees are then invited to provide written comments, clarifications, and any additional information to refine their responses. Once the necessary revisions have been incorporated, the interviewees provide final approval of the content. 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 will 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, seven interviews have been planned, with five interviews already completed. One additional interview has been partially conducted, with further discussions planned to gather complete insights. Another interview is scheduled to take place, ensuring that all relevant stakeholders are consulted. The analysis phase is also underway, with one interview fully analysed and incorporated into the project's assessment. The remaining interviews will be systematically reviewed and analysed for D5.2 to ensure a comprehensive evaluation of the identified barriers. As the interviews progress, insights will continue to be refined and validated, contributing to a deeper understanding of the challenges associated with the implementation of ZEvRA's innovations. These findings will be integrated into 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 7 shows a summary of the analysed interviews so far.

Table 10 Summary of the interviews

ZEvRA use-case/Innovation	Barriers
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. - If the alloy contains too much copper or iron, current joining technologies might not be suitable, requiring the qualification of alternative (potentially costly and time-consuming) joining technologies. - Internal specifications for vehicle interiors regarding fogging and odour can exclude some secondary materials or material sources.
	Economic Barriers: - Recycled material of the same quality is currently more expensive than virgin material due to high labour costs associated with manual disassembly. - Resistance from employees due to the higher costs of recycled materials. - 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.
	Supply Chain Barriers: - Securing a consistent and reliable supply of high-quality recycled wrought aluminium is a challenge. - 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.
	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.
	Implementation Barriers: - The use of secondary materials is not clearly implemented in the design process currently.

	- Defining a specific use case for wrought aluminium to meet ZEvRA's objectives is a challenge.
Cast aluminium	Technical Limitations: - Adjusting/improving the design geometry to the manufacturing (casting) process, considering limitations in injection, is necessary. - Fully characterising 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. Supply Chain Barriers: - Increasing demand for secondary aluminium when implementing "innovation" is a challenge. - 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. - Transferring the results of the use case to the entire vehicle (all components of this material) is a challenge for ZEvRA's objectives.
Steel	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. - Technical restrictions exist when using old steel components, e.g., due to sheet thicknesses. Implementation Barriers: - Finding an application for recycled steel in the vehicle is a challenge for ZEvRA's objectives
Plastics	Regulatory Barriers: - Regulatory hurdles can arise if substances are banned while products containing those substances are still in circulation (e.g., PFAS) Supply Chain Barriers: - When developing new material streams, it is important not to cannibalise other industries (e.g., PET from bottles), making it better to rely on one's own products.
Aluminium Foam	Implementation Barriers:

	- Finding an application for aluminium foam in the vehicle at all is a challenge for ZEvRA's objectives.
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4.3 Analysis of the Interviews Strategies for Overcoming Barriers

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

The necessity to meet technical specifications and performance standards: The interviewees repeatedly emphasise 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. This overarching requirement means that any limitations in the properties or performance of recycled materials pose a fundamental barrier to their broader application.

Challenges in 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. The need to build resilient supply chains and manage the logistics of material flows are critical issues. The potential for increasing demand to outstrip the 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. 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. 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.

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 incentivise circular practices, all of which can hinder the smooth implementation of a fully circular economy across various industries.

Several key points will be addressed for the barriers to recycling and circular practices. Firstly, there are material limitations; for instance, some plastics just do not have the recycling abilities to turn them into high-quality products again, which puts a damper on their potential to be part of a circular economy. The next point would be on design challenges whereby if the products are not designed with disassembly in mind, it makes recycling tedious and less efficient. The complexity of supply chains is a challenge in terms of the process of collecting, sorting, and getting recycled materials back into the production cycle. On the consumer side, there is the perception issue where many people might shy away from circular products if they think they are of lower quality or pricier, even when they are actually better for the planet in the long run. Economic barriers also play a role; companies may hesitate to invest in new technologies and infrastructure needed to support circular practices because of the hefty upfront costs. Lastly, the regulatory landscape does not always help. Without strong regulations that encourage these sustainable practices, it can be tough for businesses to fully commit to going circular. It is clear that while the idea of circularity is promising, there are quite a few hurdles to tackle.

4.4 Next steps

The next steps in the barrier identification process will focus on completing the remaining interviews with OEMs and OESs within the project consortium. These interviews, scheduled to be finalised and analysed by M 24, will provide additional insights into the challenges faced in implementing circular economy innovations. Once all interviews are completed, the findings will be systematically reviewed to ensure a comprehensive understanding of the identified barriers.

To deepen the knowledge gained from the interviews, broader surveys will be conducted targeting industry representatives and academic institutions. These surveys will help validate the findings from the interviews while capturing additional perspectives from key stakeholders involved in ZEvRA innovation adoption. The results will provide further clarity on sector-specific barriers and possible solutions, helping to refine the project's approach to overcoming barriers to ZEvRA innovations. In parallel, 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 insights gathered, concrete measures will be developed to address the identified barriers and facilitate the successful adoption of the ZEvRA's innovations. These measures will focus on improving technical feasibility, addressing regulatory and compliance issues, supporting workforce training, and enhancing market readiness for circular economy solutions. To ensure that these measures are effectively communicated and widely accepted, targeted communication tools will be developed. These tools will include newsletters, workshops, symposiums, and industry events designed to engage stakeholders, share knowledge, and raise awareness about the benefits of circular economy practices.

To assess the impact and effectiveness of these barrier mitigation strategies, evaluations and feedback mechanisms will be implemented. These evaluations will track stakeholder engagement, industry adoption rates, and the extent to which regulatory frameworks support the transition to circular economy models. 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 innovations under consideration and their contributions to ZEvRA's harmonised 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 harmonised circularity strategy will be replicable for all the European OEMs, since validation will enable brand-independency. ZEvRA will also 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 (End of Life), 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, analysing customer needs and pain points, evaluating competitive landscape, and assessing regulatory environment via utilising 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.

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 analysing factors like customer demand, competition, regulatory environment, and the company's own capabilities to identify potential barriers and opportunities before launching, ultimately aiming to maximise the chances of successful market penetration and minimise 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 capitalising on opportunities.

Table 11 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 product 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.
Analysing the 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 analysed.

Table 12 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 commercialisation.
Identify critical development milestones	The key steps needed to advance the technology to a higher TRL level should be determined.

Table 13 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 analysed.

Table 14 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 15 Key criteria to assess in a market readiness assessment

Market analysis	Market size: Total potential customer base and growth rate
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	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 16 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 to be willing to try the products and continue using it?

Table 17 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 “Optimised”, where each stage represents a progressively higher level of data management capability, encompassing aspects like data governance, quality, accessibility, and utilisation for informed decision making.

Table 18 Key elements of a data maturity scale

Level 1: Initial (Ad-hoc)	Characterised 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, standardised 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 optimise business processes
Level 5: Optimised (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 19 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 organisation'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 includes how the data should be treated. Next would be the data quality, which includes having accurate and timely data that 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, organisations can truly elevate their data maturity and harness its full potential.

Table 20 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 prioritisation: 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 visualisation: 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, competitive 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 21 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	Analysing 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 purchase
Market trends	Identifying emerging trends, regulatory changes, and technological advancements that could impact the market readiness of the product

Table 22 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 23 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 utilised 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

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-systematics, we have identified, in a first step, six interdependent key factor groups.

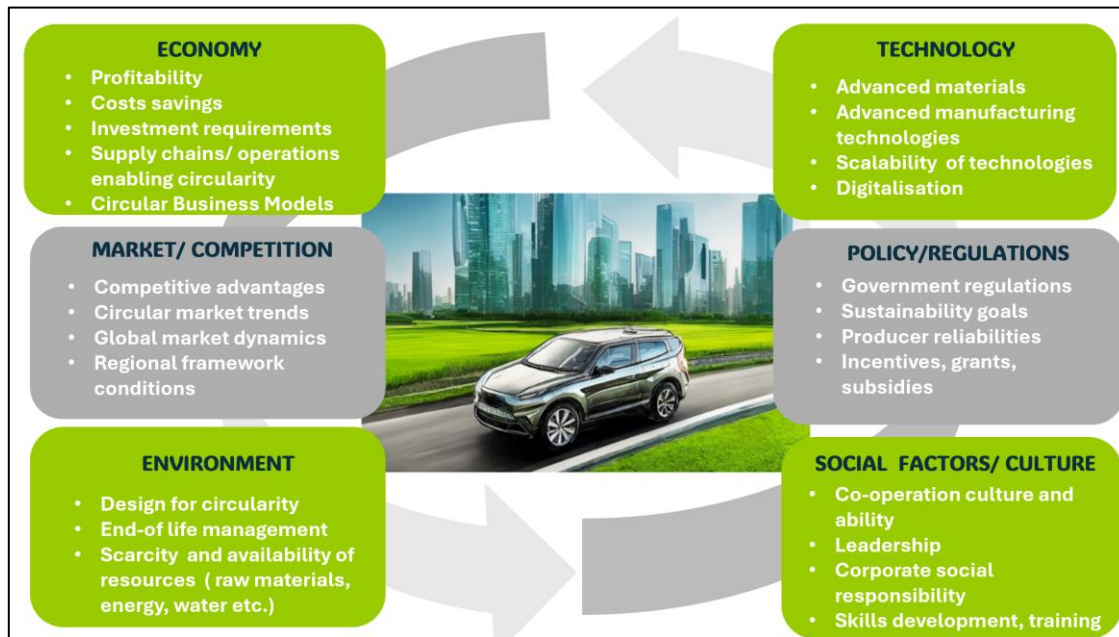


Figure 7 System of six key factor groups which affect the acceptance of circular solutions. Source: ZEvRA consortium

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) are a barrier. This is a particular obstacle for small companies, which are mostly engaged in recycling and remanufacturing businesses at the local level and do not provide 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 a 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 have 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 optimisation 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 influences 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 incentivise 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 a 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, there exists a range of legal and practical obstacles. They have to be analysed and removed.

6. Cultural and Organisational 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, and environment protection.

Corporate culture and ability/willingness to cooperate: The change toward new materials, technologies and business models require a well-developed cooperation 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 practised 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 and 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, and 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 24 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
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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 on 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 25 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 the 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 to the 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 26 Social aspects 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 the benefits of circularity and showcase success stories

Customers, interested public, media

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

5.4 Workforce Training Needs and Skill Gaps

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

- Training needs analysis: Identify and analyse gaps in skills (D5.2/3)
- Workforce Data: Key findings on workforce demographics, skill levels, and training requirements. (D5.2/3)

The results of Task 5.2.3 will deliver insights for the development of targeted training 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 parts 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 Plan to survey Industry and Academia

Following the completion of the barrier identification process in the project's OEM and OES, the next step will involve conducting a targeted survey among industry and academia to further refine and validate the findings. The purpose of these surveys will be to deepen the understanding of the challenges associated with the implementation of ZEvRA innovations and to gather additional insights on potential solutions to overcome these barriers.

The surveys will be designed to assess key issues identified during the interview phase, including technical feasibility, regulatory and compliance challenges, economic considerations, and workforce training needs. The survey will help to determine the extent to which academic curricula and training programmes align with industry needs, addressing the mismatch between education and the practical skills required for implementing circular economy principles.

Since the survey will be developed after the completion of the interviews, its structure and focus areas will be informed by the key findings from the interviews. This approach will ensure that the survey targets the most relevant topics and captures meaningful data that can directly support the development of strategies to overcome barriers. The results will be analysed in conjunction with the interview findings, contributing to a more detailed and well-rounded assessment of the challenges and opportunities related to the implementation of circular economy innovations.

Proposed Methodology for Surveys

The development of the surveys will follow a structured approach, ensuring that they effectively capture the perspectives of industry representatives and academic institutions. The first step in this process will be selecting the appropriate communication types and channels for distributing the survey based on the target groups derived from the interviews. To reach a broad audience and encourage participation, a combination of different communication channels, like direct email outreach, industry and academic networks, events and project-related communication channels, will be used. Additionally, leveraging established consortium partner networks will help ensure that the survey reaches relevant stakeholders with expertise in circular economy implementation.

Once the communication strategy is established, the next step will be to create the survey questions. These questions will be designed based on the findings from the barrier identification process, ensuring that the survey addresses the most critical challenges that have been identified through interviews with OEMs and OESs. The questions will aim to assess the relevance and severity of these barriers across different industries, identify sector-specific obstacles, and gather insights into potential solutions. The survey will balance structured different types of questions to ensure a comprehensive understanding of the barriers while allowing for the collection of qualitative insights that may not have been captured during the interview phase.

To ensure that the survey process runs efficiently, a plan and timetable will be established until M24. This will include defining key milestones such as finalising the survey questions, setting up

the online platform for distribution, launching the survey, and setting deadlines for responses. The timetable will also include a phase for data collection and follow-up, ensuring that enough responses are gathered to provide meaningful conclusions. After the response period, a structured analysis phase will be conducted to interpret the results and compare them with the interview findings. The insights gathered will play a crucial role in shaping the final strategy for overcoming barriers to ZEvRA innovations and raising the awareness of ZEvRA innovations within the industry.

7 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, symposiums, presentations, and pitches that will serve as key instruments for engaging with industry representatives, policymakers, academic institutions, 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 CE.

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

7.1 Stakeholder and Target Group Analysis

Impact: ZEvRA's innovations will focus on improving the circularity of 84% of the materials mix by demonstrating the 8 physical use cases. The extrapolation of results will allow replicating the targeted materials in other structures and components. A further assessment with different scenarios at the vehicle level will be made through a digital twin (T3.5). Increased user acceptability of zero tailpipe emission vehicles, improved air quality, a more CE and reduction of environmental and health impacts.

We'll estimate this impact by evaluating the number of stakeholders at reach of ZEvRA that will benefit from our dedicated programme (WP5) for raising awareness and acceptability (Table 16).

Upskilling Pathways initiative (T5.1), led by APRA: Material suppliers 350-700, Manufacturers 600-800, Workforce OEMs 1000-1200

ZEvRA will reach 3.7K stakeholders in total (together with T6.1) along the entire automotive value chain for raising awareness and acceptability.

How?

Table 27 Stakeholder groups and their role in promoting ZEvRA innovations

Stakeholder group	Role
Employees: designers, production planners, line workers, and 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.
OEMs	OEMs provide the impetus for the introduction of ZEvRA innovations through their products and set technological trends and standards.
Consumers	Consumers' purchasing decisions determine the success of products and therefore also the ZEvRA innovations. A positive attitude towards sustainable products is offset by a lack of knowledge about their properties, which leads to a reluctance to buy sustainable products.
Recycling companies	Recycling companies participate in research partnerships. They source the materials for products with ZEvRA innovations and are an important partner in the circular economy.
Research institutes	Universities or research institutes conduct basic and applied research to develop ZEvRA innovations. They enter into research partnerships with companies.
Industrial sectors	Industrial sectors should have additional insights that are involved in material use, recycling, and design for sustainability.

Polymakers (Including government officials)	Collect feedback from polymakers to ensure a holistic understanding of the current state of CE adoption.
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Target groups

Table 28 Target groups and communication focus for ZEvRA innovations

Target group	Communication focus
Product design teams	- Material properties of ZEvRA innovations to ensure these are considered when realising product requirements. - Enhance communication and balance expectations and limitations between product and process design. - New design paradigms for improved processes
Production teams	- changes to production when implementing ZEvRA innovations, e.g., process times, production parameters - Properties and environmental benefits of parts or products with ZEvRA innovations
Product development of OEM	Properties and environmental benefits of ZEvRA innovation parts and processes.
Material development teams	Material properties of ZEvRA innovations
Suppliers	Systematic inclusion of ZEvRA innovations in component specifications. Collaboration with suppliers is crucial for material and process research and to secure material requirements for ZEvRA innovations
Recycling companies	Foster cooperation throughout the supply chain to secure a consistent volume of secondary materials for ZEvRA innovations
OEMs	Promote internal sustainability strategies and guiding principles to address regulatory requirements for increased use of ZEvRA innovations.

Consumers	Communicate the environmental benefits of using ZEvRA innovations for promotional purposes.
Employees:	- Training and educational initiatives for employees to effectively work with ZEvRA innovations. - It is important to address reservations and resistance that may arise from using ZEvRA innovations. - All employees should be aware of circular economy principles
Industrial partners	Utilising communication strategies to promote and implement practices that keep materials in circulation, minimising waste, and maximising resource usage
Policymakers (including government officials)	Communicate and be responsible for developing and implementing communication strategies to educate the public about the principles and benefits of CE

The following list will be updated on the basis of the refined findings as the project progresses.

Table 29 Preliminary list of communication tools and targeted groups

Tool	Target group
Workshops and training sessions	Design teams, production teams, material development teams
Design guidelines and manuals	Design teams
Periodic meetings	Production teams
Technical documentation	Production teams
Online forums or Q&A sections	Production teams, suppliers
databases	Material development teams, Recycling companies
Webinars	Suppliers, Recycling companies

Reports	OEMs, politics, research institutes
Executive summaries	OEMs
policy briefings	OEMs, politics
Social media engagement	Consumers, politics, employees
Video nuggets	Production teams, employees
Website content	Consumers, politics
newsletters	Consumers, politics, research organisations
(Virtual) Suggestion boxes	Employees
Research papers	Research organisations

7.2 Planned Outreach and Engagement (Pitches, Symposiums, Workshops)

As part of the planned work, the outreach and engagement will be systematically defined based on the stakeholder and target group analysis conducted during the project. This process will involve identifying and describing the preliminary communication tools that will be used to engage stakeholders and promote the adoption of project innovations. In addition to defining the tools, specific communicators and disseminators will be designated to ensure that information is effectively shared within and beyond the consortium. Furthermore, key performance indicators and timetables will be established to monitor the effectiveness of the communication tools and ensure timely execution.

The following are the outreach and engagement planned so far.

Articles

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.

Event, exhibition

Polymeris will communicate widely on its booth during the JEC World trade show in Paris in March thanks to communication material provided by Bax. In particular, Polymeris will be hosting a networking cocktail party for its European partners on its booth in order to create synergies between European projects and partners on composites. It will be a great opportunity for ZEvRA

to enlarge its stakeholder list and develop future collaborations with other projects, networks and initiatives. Moreover, a session on ZEvRA and another European project will take place also during the JEC World fair, on the Open Stage (BIOntier and ZEvRA: Two Major Projects on Sustainable and High-Performance Composites, Hall 6 D114), handled by Polymeris and Forvia.

Workshops

In order to create synergies with other initiatives and maximise the impact of ZEvRA, Polymeris as a partner of CRADLE-ALPs project, is organising an oral presentation on ZEvRA during an online workshop on composite materials and the automotive industry of CRADLE-ALPs project. This opportunity would be an interesting way of reaching another type of stakeholders than in international fairs like the JEC World, gathering feedback from them and increasing the potential for exploitation at the end of the project.

APRA will hold a workshop on 8 April 2025 at the Rematec trade fair and online to gather suggestions for overcoming the shortage of recycled materials. The Rematec trade fair focuses on automotive remanufacturing and, due to the automotive industry, is very well suited to receive suggestions for the extraction of recycled materials. In addition, there is a lot of experience in remanufacturing with the development and operation of material cycles. The workshop will last approx. 2 hours, and 20-40 participants are expected.

7.3 Status of Communications and Awareness Tools

The status of the communication and awareness tools will be tracked within the progress of the ZEvRA project and reported here in the upcoming versions of the Awareness and Acceptability Report D5.2 and D5.3.

8 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 initial assessment of potential obstacles 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. The findings so far emphasise the critical role of targeted awareness and training measures in facilitating the successful integration of circular economy principles across industry and academic settings.

8.1 Summary of Initial Insights

The analysis conducted so far 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 programmes 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 current status of the work and setting the direction for future research and refinement.

One of the key barriers to ZEvRA's innovations identified in the initial phase of the analysis is 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 labour-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 aluminium, 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.

8.2 Plan for Upcoming Work and Deliverable Updates

Building on the work completed so far, the next phase will focus on finalising the data collection process and refining the initial findings. The remaining interviews with OEMs and OESs will be completed and analysed to ensure that all relevant stakeholder perspectives are captured. The next step will be the launch of a broader industry and academic survey to validate and deepen the understanding of the identified barriers. The insights gained from this expanded data collection will be systematically reviewed and integrated into the next version of the report, ensuring a more comprehensive and detailed assessment of the challenges and potential solutions.

The refinement of the findings will also involve a deeper exploration of the gaps identified in the state-of-the-art analysis. New findings will be incorporated, and relevant research updates will be continuously monitored to ensure that the analysis remains aligned with the latest industry trends and policy developments.

As the project progresses, the development of communication and awareness tools will play an increasingly important role in facilitating stakeholder engagement. The creation of newsletters, symposiums, presentations, and other outreach materials will be based on the findings from the barrier assessment, ensuring that communication efforts are targeted and effective. The impact of these initiatives will be systematically evaluated to measure their effectiveness in raising awareness and increasing acceptance of ZEvRA's innovations.

This report marks the first step in a continuous process of research, analysis, and strategic development. In the coming phases, the focus will shift toward the creation of measures to address

the identified barriers, supported by structured evaluation mechanisms to track progress and impact of the awareness of ZEvRA's innovations and CE. The data collection and analysis efforts outlined in this report will be reviewed and refined in the subsequent versions of the report, D 5.2 and D 5.3, ensuring that the ZEvRA's approach remains adaptive and responsive to emerging challenges. By maintaining a strong emphasis on industry collaboration, policy alignment, and stakeholder engagement, the project will continue to advance the integration of CE principles, contributing to long-term sustainability and innovation within the automotive sector.

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10 Annex

A: Questionnaire Gap Analysis

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. 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?