CLEPA
European Association of Automotive Suppliers

AUTOMOTIVE SUPPLIERS IN THE EU

R&I vision on circularity

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Designing and manufacturing the over 30,000 parts, components and systems that make up a vehicle, automotive suppliers are a principal driving force for innovation in the European Union. Investing over €30bn yearly in research and development (R&D), suppliers have become the single, biggest R&D private investor in the EU. Over the past decades, a considerable part of these investments has been dedicated to increasing sustainability in the automotive sector. In line with the overlying European Green Deal targets, and evolving customer demands and expectations, suppliers are increasingly investing in Circularity strategies, developing a new approach to product design and manufacturing.

Circularity maximises the efficiency of resources and energy use by extending the useful life of the products, and reduces or eliminates waste during production and end-of-life, while recycling products and materials. The Circular Economy is becoming vital also in terms of addressing the increasingly high energy costs associated with production processes, material import dependencies as well as product carbon footprint reduction of materials. However, further technological progress and sector-specific knowledge is needed to unlock its full potential.

This report presents the automotive suppliers' vision for the circularity research and innovation needs of the industry, including an overview of the emerging challenges related to the growing role of circular economy in the automotive supply chain. While automotive suppliers continue to invest towards their vision for circularity in the industry, we recognise that achieving the vision entails more than technological improvements. It requires the establishment of the right legislation framework and collaboration across the ecosystem. Further, support for Research & Innovation (R&I) and the competitive scaling of innovative solutions are essential components for achieving success.

There are three main research areas where specific strategies are needed: resource efficiency, lifetime maximisation, and recycling and re-use (*as shown in Table 1*).

Theme	Circularity strategies
Natural resource efficiency	• Frugal design & material variability solutions • Prioritise use of low CO_2 footprint materials • Avoid scarce or critical materials and hazardous substances
Life-time maximisation	• Maintain performance over a longer lifespan • Facilitate repairability and maintenance of the vehicle • Upgradability as a strategy to maintain attractiveness
Giving resources a new life: material recycling and part re-using	• Facilitate multiple lifecycles of a product • Increase knowledge on end-of-life materials • Development of quality insurance criteria • Facilitate sorting and separation and recycling

Table 1: Summary of priority needs as listed in Chapter 3 of this document.

The primary conclusion of our report underscores a pressing need for specialised and innovative research and development geared specifically to address the unique challenges within the automotive industry. Furthermore, additional investment is needed, including dedicated EU public funding for R&D, pivotal to advancing towards comprehensive circularity solutions.

1 Introduction - Circularity in the automotive industry

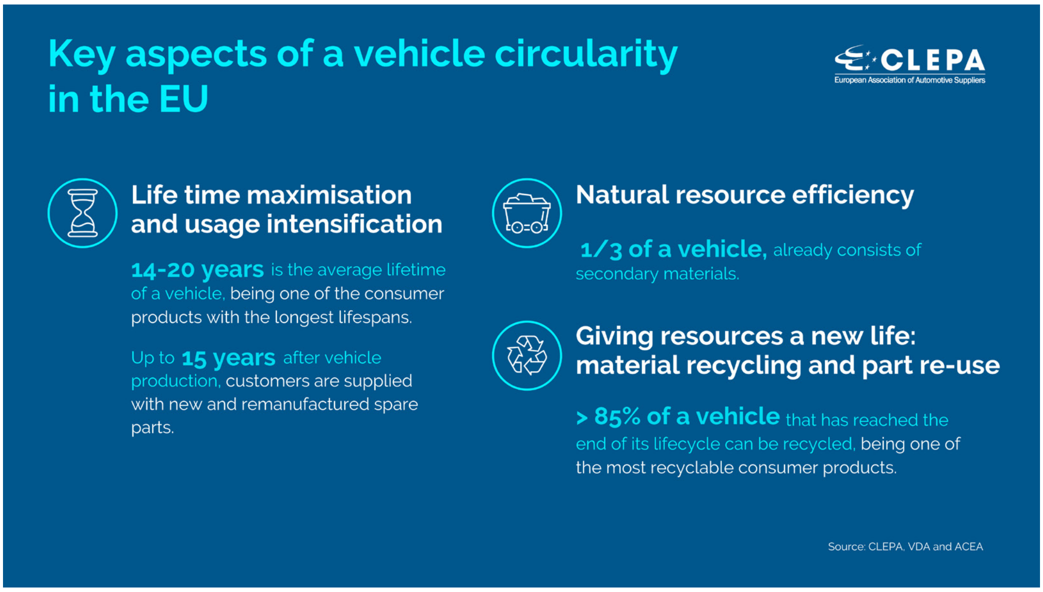

Figure 1 - Circularity KPIs in the automotive sector

To apply a circular approach in the automotive sector, policy measures must be coupled with regular industry alignments and collaboration within the value chain. The production model must foresee a holistic approach, addressing materials, energy efficiency, usage, and end-of-life (see Figure 1). Each one of these aspects presents its own challenges, which are outlined in this chapter.

1. Conflicting targets between circular economy and chemical restrictions

Solutions to improve sustainability performance of automotive parts may imply competing priorities, often ending in unavoidable trade-offs. One such particular concern in the automotive supply industry is the case of material regulations in the context of material circularity. Closing the loop of materials is often linked with the accumulation of legacy hazardous substances, i.e., restricted or prohibited chemicals, in the material supply chain. Owing to the long lifetime (>15 years) of passenger vehicles (and even longer for trucks and buses), a time lag is experienced between the most recent list of substances restricted, hence limiting the data available on their presence in end-of-life products. This is a burden passed on to recyclers and remanufactures, who must ensure that their recycled or remanufactured products are compliant with current substances regulations. Such an obligation may hamper the potential of circularity business models for the automotive industry.

2. Secondary materials must meet the automotive high-quality standards

Automotive vehicles are safety sensitive products, which means that they must comply with strict standards on technical properties, in particular for parts such as airbags, tires and seatbelts. The incorporation of recycled materials into vehicles' supply chain depends on their performance e.g., in terms of impact resistance or deformation when used in safety parts such as bumpers or painting adherence in the case of aesthetic applications. Similarly, the issue of availability must be considered. An EU-harmonised calculation and verification method to stipulate how to allocate the input recycled content to the output products. While mechanical recycling has benefits, more investments in all technologies are needed to increase recycling. In particular, chemical recycling allows the use of plastic waste, especially feedstock not suitable for mechanical recycling and it can deliver additional material for automotive applications that require high-quality recycled plastics for safety, regulatory and performance reasons. For this to succeed and be available at scale, EU harmonised rules for calculating chemically recycled content are urgently needed to intensify investments in these technologies.

3. Avoiding reliance on unsustainable supply chains

Accounting for sustainability impact of a certain material or product is often a matter of trade-offs. In the automotive sector, one striking example is the dependency on critical and conflict raw materials in the supply chain of electric vehicles, particularly Li-ion batteries, fuel cells and electric traction motors. The EU produces only 1% of all battery raw materials, and only 8% of traction motors, while 54% of global cobalt mine production originates from the Democratic Republic of the Congo; and 46% of refined cobalt production comes from China. Another example of vulnerable supply chains is the case of bio-based materials, notably bioplastics. Today, bioplastics are predominantly produced from agro-based feedstock, i.e., plants that are rich in carbohydrates, such as corn or sugarcane. This often raises questions regarding potential competition with food and feed supply.

4. Acknowledgement of lifetime maximisation as a crucial element of a circular economy

The market of spare parts allows consumers to have their vehicles repaired and hence these last longer. Within this market, the use of remanufactured parts is providing older parts with an entire second life. According to a study commissioned by CLEPA[1], remanufactured parts represent about 5% of the entire spare part market in the EU, saving about 800 kt CO2eq per annum (an amount equal to the annual carbon emissions of 120,000 EU citizens). The shift to electrification is expected to translate into[2] 30% lower sales potential for traditional aftermarket components compared to internal combustion engine vehicles. But there will be opportunities for aftermarket players to develop remanufacturing and repairing capabilities for battery systems, electric motors, e-axles and power electronics. A shift in aftermarket services from hardware to software is also expected. Preventive maintenance will also gain relevance, given that the battery is safety-critical.

5. Efficient information sharing

On the path toward circularity in the automotive industry, adequate data sharing and a harmonised reporting throughout the supply chain is a fundamental need. While Life Cycle Assessment (LCA) is commonly performed in the automotive industry based on the International Organization for Standardization (ISO) standard 14040/44, a harmonised approach to circularity in such assessments is still lacking. The European Commission is also developing product environmental footprint methodologies, with the aim to provide comparability between products. Nevertheless, accurate and reliable data on product level will be crucial[3]. Currently, the tracking of materials and substances in automotive products is ensured by the globally used International Materials Data System (IMDS), which connects the entire supply chain. The IMDS is constantly improved to respond to new regulatory requirements related to substances and material. In advance of the ELV Regulation, where recycled content quotas for plastics have been introduced, IMDS was updated to enable communication of recycled and bio-based content in materials and components[4]. In parallel, work is being done to include product carbon footprint data on IMDS. Access to data related to the use-phase can also contribute to[5].

1 Hollins, Oakdene 2021: Report on the current status, impacts and potential of the European automotive component remanufacturing industry
2 Time to act: Vehicle electrification will reshape the European Aftermarket
3 World Economic Forum 2021: Paving the Way: EU Policy Action for Automotive Circularity
4 Material Data System 2023: IMDS Release 14.0 Information
5 CLEPA 2023: Access to in-vehicle-data: For a sector-specific regulation that boots innovation and protects consumer choice

The EU legislative framework is increasingly emphasising the need for sustainable and circular products. The sector specific legislation on circularity is the End-of-Life Vehicles Directive, Directive 2000/53/EC[6], currently being revamped as a Regulation which addresses the whole lifecycle, from design to end-of-life. The proposal published by the Commission in July 2023[7] featured several new elements, including an extension of the scope to cover heavy-duty vehicles, trailers and 3–4-wheel motorcycles, and merger with the 3R Type Approval Directive. Of relevance to suppliers are the new requirements for recycled plastic content from post-consumer waste including a closed-loop target, as well as possible targets for steel, aluminium and permanent magnet materials. The longer list of parts which must be removed from end-of-life vehicles is also expected to have implications in the design phase. Furthermore, there are new provisions on the reuse, refurbishment and remanufacturing of parts, including a clarification that remanufactured parts are not waste as well as foreseen incentives to these activities. Most of the new obligations fall under the responsibility of the OEMs, including a mandatory "circularity strategy" and digital vehicle passport.

The ELV Regulation foresees interlinkages with the Batteries Regulation and the Critical Raw Material Act, which are two political files with great impact to the emerging business of EV batteries and e-drive motors. The Batteries Regulation[8] is the pilot for sustainable product legislation, with requirements from design to end-of-life of a battery, including information requirements and what will become the first digital product passport in the EU, the battery passport. The Critical Raw Materials Act[9] aims to guarantee EU's access to a secure and sustainable supply of critical raw materials. With its ambitious targets, it aims to address the fact that raw materials critical to the transformation are not sufficiently located in the EU, and for many of these materials undesirable dependencies exist on one or very few countries[10].

The ELV Regulation will be a key piece of legislation for the automotive supply industry. It reflects the Commission's goal to improve circularity in the sector, through stricter design targets, increasing and standardising available information on products, and keeping products and materials in the loop longer, through repair and remanufacturing, or recycling. Having legal guidelines for an automotive circular economy and increasing harmonisation across Member States is overall positive. It can not be underestimated, however, the complexity of implementation, considering the number of parallel applicable regulatory files in such a complex supply chain. It will be crucial for Regulators to ensure alignment between applicable legislations, such as REACH and Batteries Regulations, notably for substance restrictions, and ESPR Regulation, for issues related to definitions and, importantly, scope. Furthermore, in light of the Plastic Packaging Regulation and Critical Raw Materials proposals, alignment on plastic and CRM circularity targets will need to be aligned; and be realistic on a technical level.

The Chemical Strategy for Sustainability (CSS)[11] provides an action plan to ban the most harmful chemicals in consumer products and professional uses. One of the key actions of the CSS is the revision of the REACH Regulation[12], for which restrictions should increasingly be done with group approaches for entire groups of substances (e.g., PFAS phase-out). Removing chemicals from such a massive supply chain is a lengthy process, and it is also only applicable to new type approved vehicles. Consequently, running vehicles, spare parts and ELVs will carry the so-called legacy substances, raising issues to remanufacturers and recyclers. To address this conflict between chemical restrictions and circularity, a dedicated exemption to products placed on the market must be implemented.

6 Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles
7 Proposal for a Regulation on circularity requirements for vehicle design and on management of end-of-life vehicles
8 pdf(europa.eu)
9 European Critical Raw Materials Act (europa.eu)
10 CLEPA 2023: 'Net-zero industry: EU policy measures need to match international competition '
11 European Commission: Chemicals strategy
12 European Parliament and Council 2006: Regulation (EC) No 1907/2006

3 Research needs for circular product design

3.1 Introduction

Improving a vehicle's circularity implies using a holistic approach to the entire life cycle of the vehicle (Figure 2). While several challenges remain related to the extraction and processing level of materials, this report addresses mainly the scope of action of automotive suppliers, focusing on what could be achieved through eco-design of products. The research gaps in this chapter have been grouped into to three main themes:

- Natural resource efficiency
- Life time maximisation and usage intensification
- Giving resources a new life: material recycling and part re-use

The sections below are a first exercise to map the existing challenges associated with circularity strategies relevant for automotive suppliers. Further work may focus on setting priority topics and specifying research needs at sub-system or component level. The research needs proposed in this document must also be aligned with future legislation. The listed circularity strategies may also not be compatible with each other (e.g., designing for longevity or repairability may look differently than designing for recycling), implying none of the strategies listed below should be interpreted as a general recommendation to all components and materials. Instead, identifying the best circularity strategy for part design requires a whole lifecycle thinking, and close dialogue with the OEMs, raw material and chemical suppliers, and the recycling industry (ATFs, shredders). In addition, information on the material and product composition and carbon footprint can help to identify the most appropriate circularity strategy.

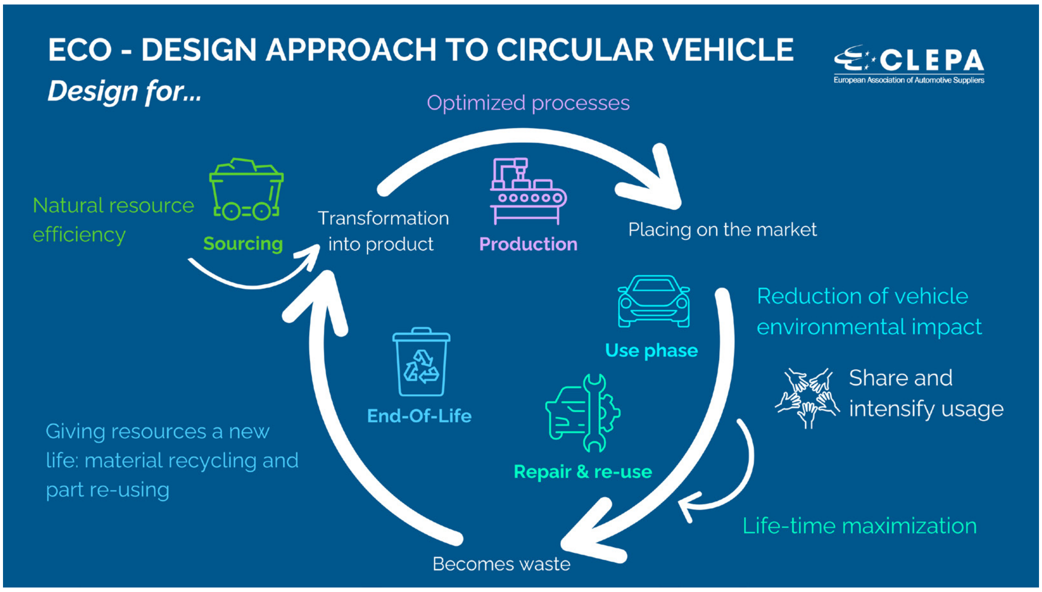

Figure 2 - Eco-design approach to circular vehicles

3.2 Natural resource efficiency

Since the automotive sector is a large consumer of resources, it is of fundamental importance to maximise material efficiency through simplified product design, e.g., so-called 'frugal design'. Design requirements such as multi-functionality, mobility and versatility lead to the production of smaller and more robust products, with components often glued together or integrated into the main product structure. Recyclability of materials is impacted by several of these design choices, associated with complexity (e.g., multilayer materials), the nature of materials (e.g., recyclability is limited for composites or multi-materials), the presence of additives and/or specific substances. For instance, the inability to remove a product's battery renders the whole product hazardous. Shredding is a common pre-processing technique for the recycling of electronic goods but wastes much of the embodied value within the products[13].

The use of sustainable, renewable, non-petrol-based materials should be favoured and used in increasing percentages. Materials that are linked to feedstocks from scarce materials, materials that are in competition with food sources (e.g., first generation biomaterials) and hazardous substances should be minimised and avoided from the design stage of products. For efficient collaboration on materials development and uptake, it is important to involve all stakeholders, projects and initiatives across industrial sectors. Furthermore, including LCA, recycling, safety, social, and cost analysis can make the materials processing and scale-up more sustainable.

Circularity Strategy	Research needs (not exhaustive)
Frugal design & material variability solutions	• Material variability reduction solutions (e.g., range of additives used) • Alternatives to multi-material components • Circular design, modularity and standardisation approaches to facilitate disassembly and material separation (e.g., reversible joins, substation strategies for multilayer materials, glues) • Collection of data related to materials, products and production processes, for example, to support materials traceability, circularity and LCA
Prioritise use of low CO2 footprint materials	• Lower-emissions metal families and alloys (e.g., recycled aluminium, new alloys) • Renewable and low impact materials with appropriate quality, quantity, and performance for automotive industry applications (e.g., recycled and bio-sourced polymers) ◦ Further development of very low or negative CO2 material from generation 2, 3 and 4 feed stocks (decoupling from food competition and Net-Zero Carbon Capture materials) • Criteria for acceptability of new classes of materials
Avoiding scarce or critical materials and hazardous substances	• Identification of suitable alternatives to scarce, critical or restricted materials (e.g., alternatives to copper, rare earth metals and lithium, etc.) • Improve efficiency of manufacturing process to reduce and control quantities (e.g., with 3D printing technologies, small batch production)

Table 2 - Research needs: natural resource efficiency

13 European Environment Agency 2017: Circular by design - Products in the circular economy

3.3 Life-time maximisation

Circular vehicles should be designed for longevity and durability, while enabling product life extension features such as maintenance, repair, remanufacturing and updates. This has a positive impact on the environment as materials are kept in use for longer, reducing the need for additional material consumption. At the same time, waste is minimised while the value of the vehicle is retained and possibly enhanced over a longer time span.

Longevity and durability go hand in hand with the ability to easily detect and anticipate possible failures or malfunctioning. Also, maintaining vehicle attractiveness over time is crucial to keep the perceived quality level and the possible residual value for the end customer.

Vehicles that are optimised for use in the sharing economy also contribute to energy and material efficiency. For these vehicles, components must be optimised to withstand a wide range of applications and be highly durable, considering a large variability of users' profiles.

Circularity Strategy	Research needs (not exhaustive)
Maintaining performance over a longer lifespan	• Solutions to maintain performance standards of critical functions (e.g., safety, powertrain) for longer periods • Solutions for feature upgrades on older-generations vehicles (e.g., retrofitting of sensors and actuators, battery systems) • Solutions (and pilot-testing) to increase repairability and upgradability (e.g., modular and standardised design strategies) • Solutions to augment robustness and durability, including in extreme conditions (e.g., protection of electronic components from environmental factors) • Digital solutions to access essential information for repair and maintenance (e.g., product design information, vehicle history, availability of spare parts)

Facilitating repairability and maintenance of the vehicle	• Understanding of aging to identify failure root causes and definition of preventive maintenance and repair strategies.
	  ◦ Definition of re-use criteria for 2nd life.
	• Predictive maintenance strategies with health monitoring sensors and contextual information (e.g., AI based)
	  ◦ Important for some vehicle subsystems such as batteries, H2 tanks/FC and safety
	  ◦ Tamper-proof beyond re-use boundaries (important for qualification or re-certification or repaired/upgraded components, particularly for safety critical components e.g., airbags, belts, steering wheel)
	• Tools for "non-invasive" conditions assessment and criteria for acceptability and decision making in repair strategy

Upgradability as a strategy to maintain attractiveness	• Solutions to maintain perceived interior quality level (e.g., "self-repairing", "self-cleaning" surfaces to maintain attractiveness and limit the maintenance/cleaning) • Solutions to replace and/or upgrade end-customer specific features impacting customer experience (e.g., surfaces, style, displays, smart surfaces, displays upgrade…) • Reversible "personalization" features to facilitate multiple lives and transfer of ownerships

Table 3 - Research needs: life-time maximisation

3.4 Giving resources a new life: material recycling and part re-using

Closed loop cycles of parts and materials[14] at the vehicle end-of-life are critical aspects of the circular approach. Already today, most of the vehicle's weight is recyclable, and the automotive industry is working continuously to further improve circularity of the individual components that comprise a vehicle.

The dismantling of ELV parts is heavily related to market demands for such parts. Specific models (depending on their brand, style, and age) utilise different parts and therefore rely on what the contemporary car fleet requirements are. Ensuring quality is a key aspect of automotive design, and for this reason more research will be needed on how to check the quality level of end-of-life components, acceptability criteria for recovered parts and overall, further improve the lifetime extension of components that can be re-used (e.g., re-use strategies for batteries or electronic components).

Finally, separation and sorting technologies to facilitate access to materials and parts will be instrumental to the implementation of multiple recovery loops, especially for the value-added components, such as rare earths, as well as continuous improvement of mechanical and chemical recycling.

The research needs proposed in this document must also be aligned with future legislation.

Circularity Strategy	Research needs (not exhaustive)
Facilitate multiple lifecycles of a product	• Solutions to facilitate the usage of a product over multiple life-cycles (e.g., by facilitating demounting, inspection, repairing,...) • Strategies to maintain quality of recycled materials over multiple loops ◦ Dedicated strategies for rare-earth and critical materials (e.g., magnets) • Solutions to allow usage of the same product in more sectors (e.g., end-of-life EV batteries used as residential storage in second-life)

Increase knowledge on end-of-life materials	• Methodologies to assess the quality of material at end-of-life for e.g.,:
	  ◦ To assess the risk of certain substances preventing recycling or reuse
	  ◦ To assess the material compositions in products/ product groups/product material mixes (e.g., percentage of recycled content)
	• Material degradation assessment methodologies based on contextual information

Development of quality insurance criteria	• Criteria (reliability, quality, economic efficiency) and standards for "re-use" of components including outside the automotive sector • Quality insurance criteria linked to vehicle history (relevant data such as degradation, may influence the selection of recovered parts)
Facilitate sorting, separation and recycling	• Develop technologies and strategies for material sorting and separation ◦ Recovery of non-metallic components, such as plastics, rubber, and textiles or composites (e.g., carbon fiber for H_2 tanks) • Facilitate the separation of hazardous substances • Continue development of chemical and mechanical recycling technologies • Build and improve effective methods and technologies to turn landfills into new mines (increase access to post-consumer material)

Table 4 - Research needs: giving resources a new life

14 Closed loop cycles of parts and materials refers to the action of re-inserting such parts and materials into the production or use phase of a product

4 Conclusions & recommendations

Through the completion of this report, several conclusions and recommendations were drawn that can serve as valuable insights for future work on circularity within the automotive supply industry.

Notably, key insights on circular product design include:

- Improving the efficiency of resources implies a design-thinking approach, through frugal design techniques and better selection of materials used with sustainability in mind.

- Ensuring the maximum possible lifetime of an automotive part implies specific design solutions, including on the choice of materials, but also possibility to repair or remanufacture. The longer a product is kept in use, the more important it will be to allow for upgradability, whether this is on a superficial level, or in hardware or software.

- Once a product reaches its end-of-life, there must be a strategic approach to the second life recyclability of material and eventually disposal. Standardised criteria to support decision making will also be needed (e.g., LCA, recycling, safety, social, and cost analysis can make the materials processing and scale-up more sustainable).

For efficient collaboration through the whole lifecycle of a product it is important to involve all stakeholders, projects and initiatives across industrial sectors.

The requirements for sustainability and circularity are progressing fast, and **dedicated and novel research into innovation needs will be essential for the European automotive industry at large to maintain its competitiveness.**

Research and innovation must be tailored to the automotive specific challenges, and additional investment, including through **EU R&D public funding, will be key for unlocking new automotive circularity solutions.**

Several efforts are ongoing from governmental bodies, industry and academia to improve circularity for the automotive industry. However, considerable work is still needed on the development of technological solutions for the existing targets in conflict between circular economy and chemical restrictions, notably to address **the accumulation of legacy substances in second-life materials and products.** While such solutions currently do not exist, fair rules for products replaced on the market are needed, through dedicated **exemptions in applicable REACH restrictions**. This will be of great importance for both remanufactured products as well as recycled materials. Improving the quality of secondary material, specifically plastics, will dictate the demand for this material in the next years. While the available secondary plastic does not meet the quality requirements, it will be crucial to keep **flexibility on recycled content targets in vehicles.**

Additional work is needed on the specific datasets and tools needed by suppliers to improve material usage at the design and production step, vehicle maintenance in the use phase and products and material loops. Nevertheless, **existing data** (e.g., as stored in the IMDS or already reported for other purposes) **should be leveraged to supply a vehicle lifecycle management platform.**

About CLEPA

CLEPA, the European Association of Automotive Suppliers, represents over 3,000 companies supplying state-of-the-art components and innovative technologies for safe, smart, and sustainable mobility.

CLEPA brings together over 120 global suppliers of car parts, systems, and modules and more than 20 national trade associations and European sector associations. CLEPA is the voice of the EU automotive supplier industry linking the sector to policy makers.

The automotive sector accounts for **30% of R&D** in the EU, making it the number one investor.

European automotive suppliers invest over **30 billion euros** yearly in research and development.

Automotive suppliers register over **39,000 new patents** each year.

Automotive suppliers in Europe generate **1.7 million** direct jobs.

For futher information, please contact:
Beatriz Ildefonso, Circularity and Materials Manager

CLEPA

Cours Saint-Michel 30g,

1040 Brussels, Belgium

www.clepa.eu

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