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WORLD ECONOMIC FORUM

Paving the Way:
EU Policy Action for Automotive Circularity

CIRCULAR CARS INITIATIVE

JUNE 2021

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Foreword from the European Commission

Adina Vălean
EU Commissioner
for Transport

The European Green Deal is the European Union's answer to the climate crisis and continuing resource exploitation. It lays out solutions for transitions to a fundamental transformation of our economic systems, operating within our planetary boundaries and aligned with a 1.5°C scenario. This means decoupling resource use and economic activity and embracing resource efficiency as a competitive advantage.

The automotive industry is at the center of this new growth paradigm, generating over 7% of Europe's GDP. However, road transport also accounts for some 20% of total carbon emissions in the EU,[1] while consumption of transport products and services in the EU requires approximately 1460kg of primary raw materials per person, each year.

Electrification of vehicle fleets is gaining pace at unprecedented speed. In parallel, we need circular approaches to enable decarbonization and to reduce the automotive industry's dependence on primary materials. However, the industry still has a long way to go, as existing market barriers hinder the fast uptake and implementation of circularity principles.

Policy action is urgently needed to create conducive framework conditions for circular material and product use and for services. The European Commission has an ambitious roadmap to act on this. In the context of the European Green Deal and COVID-19 recovery, EU policy-makers are now at a defining moment as they work to pave the way towards automotive circularity.

The Circular Cars Initiative EU policy action roadmap provides a timely and compelling synthesis of the policy ideas that will inform and inspire EU-level policy-making. This will fuel our efforts to further advance the circular economy agenda with a view to reduce the EU consumption footprint and double our circular material use rate in the coming decade. The automotive sector can support it by accelerating the use of circular materials, higher value-retention processes, and improve the utilization of vehicles. However, we are fully aware of the complexity of this effort, which cannot be underestimated. System interlinkages, structural and political lock-ins, as well as questions on economic and social effects need to be duly considered.

We welcome the contribution of the CCI and look forward to engaging with industry stakeholders to shape an ambitious European Green Deal agenda for a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use.

Foreword

Christoph Wolff
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The automotive industry is a driver of Europe's economic value creation, competitive sovereignty, and societal wellbeing. But road transport is also responsible for 20%[2] of Europe's greenhouse gas emissions and emissions from vehicles' materials are expected to account for 60% of the total vehicle life-cycle emissions by 2040.[3] The European Green Deal and COVID-19 recovery provide a unique opportunity for the European automotive value chain to accelerate the transition to a resource-efficient, low-carbon future. Technology and policy have to align on a common pathway for this transition to master the next decade.

The Circular Cars Initiative (CCI) is a partnership between stakeholders from the entire automobility ecosystem that leverages circularity principles to minimize total life-cycle emissions, with a special emphasis on manufacturing and material emissions. The initiative's overarching goal is to facilitate the transition towards an automobility system that is convenient, affordable, and firmly grounded within a 1.5°C climate scenario. The CCI represents the first organized industry effort that targets the carbon and resource impacts of vehicle materials across all life-cycle phases. It complements existing initiatives that drive the electrification or efficiency of urban mobility, such as the Forum's Global New Mobility Coalition (GNMC), or WBCSD's Transforming Urban Mobility (TUM) programme.

The CCI takes a systemic approach to automotive sustainability, accounting for the build, the use and the dismantle phase. It explores how technology and business levers can maximize the resource value of cars, minimize life-cycle emissions, and unlock new opportunities. In 2020, CCI established its state-of-the-art knowledge on the fundamentals of automotive circularity: materials, business models, and a policy research agenda. In 2021, building on this, CCI is kickstarting two proofs of concept, making a nascent taxonomy actionable, and building policy dialogues with decision makers.

The policy workstream of the CCI, led by SYSTEMIQ, leverages the community's industry, regulatory, and scientific expertise to co-shape policy positions that will set the scene for further uptake of circular materials, products, and services. The EU Policy Action Framework outlined in this report will help policy-makers and industry players to accelerate the transition to a circular economy in the automotive industry.

We wish to thank SYSTEMIQ, under the leadership of Matthias Ballweg, Tilmann Vahle and Marie Wehinger, for their extensive community engagement and thought partnership on the policy stream. We are also appreciative of the ongoing work of Alexander Holst and Wolfgang Machur from Accenture Strategy, and Eric Hannon from McKinsey & Company. Promising years lie ahead for automotive circularity, driven by industry and policy collaboration.

Foreword from the World Economic Forum and SYSTEMIQ

Maya Ben Dror
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Head of Mobility and EU Policy, SYSTEMIQ

In 2020, the fundamental work of the CCI showcased the pathways, solutions, and impacts of a circular automotive transition. In 2021, the CCI is focusing on the acceleration and operationalization of this transition. Policy action can help close existing market gaps and even leapfrog to a sustainable automotive industry.

The CCI's policy work, led by SYSTEMIQ, currently focuses on actions by European Union (EU) institutions. It aims to capture the window of opportunity created by the European Green Deal and COVID-19 recovery. Among other activities, it builds on the CCI's initial policy research agenda, and on SYSTEMIQ's System Change Compass work, which was created, together with the Club of Rome, to guide the way towards a systemic implementation of the European Green Deal. The EU already has a robust legal basis that can readily foster novel automotive circularity. Moreover, progress achieved in Europe may be replicated in similar legislation and approaches across the globe.

Current EU policy for circular cars, for the most part, takes place in isolation, and vested interests complicate policy-making. Risk-based approaches to policy-making result in incremental changes only, and product-based optimization tactics omit system dynamics. A systemic approach to policy, with complementary tools and system-wide changes, will provide an opportunity to advance towards accelerated circularity. This report concludes that scaled and holistic automotive circularity that is cognizant of the life-cycle impacts of vehicles – including recycling and value-retention processes (e.g. remanufacturing and refurbishment) as well as mobility assets' utilization maximization (e.g. through shared mobility and efficient fleet management) – will achieve the desired carbon and resource efficiency, while creating business value.

The results of this work have been made possible through dozens of touchpoints with CCI community members and external experts, who provided invaluable insight that informed the positions formulated in this paper. It complements existing initiatives that are driving the shift to zero emissions vehicles and mobility systems, such as the Forum's Global New Mobility Coalition (GNMC). We thank the many contributors to this work and intend to continue harnessing the power of the CCI's engaged community of industry leaders and regulators to drive towards circularity in automotive.

Building on this EU policy roadmap, the CCI community – which represents substantial industry voices – is engaging with the relevant Directorate Generals of the European Commission and will start discussions with policy-makers in member states and European cities. The goal is to enable a harmonized approach to policy-making for automotive circularity that ultimately aims for carbon and resource efficiency. We welcome stakeholders to join us on this journey.

Executive summary

The European Green Deal and COVID-19 recovery funds offer a window of opportunity for policy-makers and industry players to act, and put the automotive industry on a transition pathway to a Paris-aligned, circular future. The value at stake for industry, society, and environment is immense: road transport accounts for 20% of Europe's carbon emissions.[4] Other environmental impacts, such as biodiversity loss and water stress, are also a result of the industry's tremendous resource use. In addition, social downsides of road transport include casualties from accidents, as well as air and noise pollution. However, the automotive industry also contributes approximately 7% of Europe's GDP,[5] provides high-quality jobs, and industrial innovation. This contrast exemplifies the tensions that accompany the sector's circular transition.

To address this, the EU is conducting various important revisions of key legislations and complementary policy tools in the coming years. Policy-makers in the EU now have the opportunity to use upcoming policy changes to create stable conditions for the capital-intensive automotive industry and send clear signals for automotive circularity.

Businesses along the automotive value chain should mobilize policy-makers to align upcoming measures with the collective vision of the CCI. This report provides an overview of these measures, all aiming to improve four circularity principles:

1. Expand performance assessment from tailpipe emissions to a **life-cycle-based perspective** along the value chain, to enable more rational and effective policy- and decision-making for the mobility and manufacturing sectors at large.

2. Accelerate the use of **circular, low-carbon materials** to scale demand and improve recycling markets, with a focus on metals, plastics, and battery materials.

3. Re-focus circularity on higher value retention processes by extending the practice from recycling to **vehicle life extension** via reuse and remanufacturing.

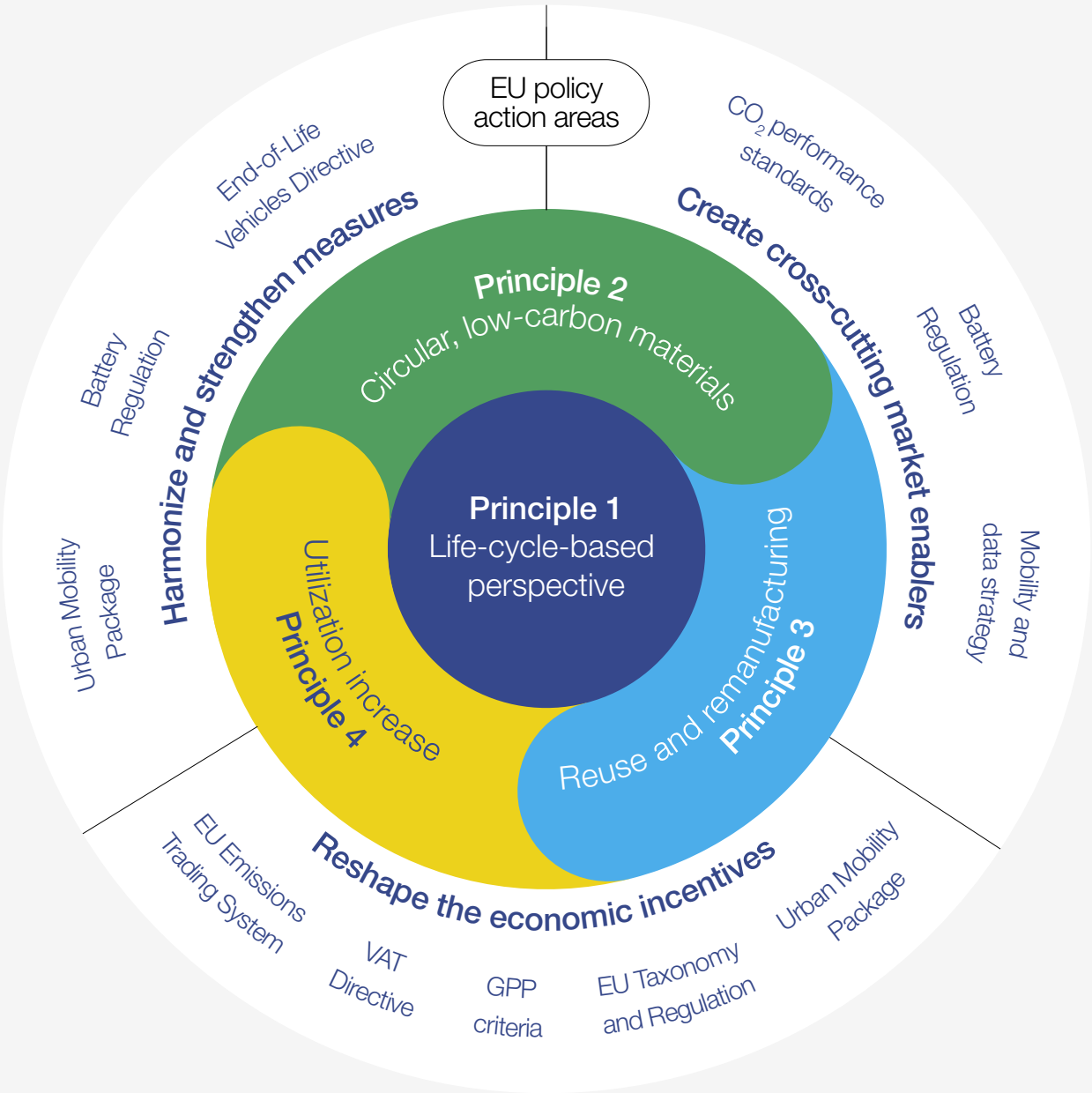
4. Improve the **utilization of vehicles** by fostering fleet management and pooled vehicles.

The CCI's EU policy roadmap for automotive circularity outlines three policy action areas that will work hand in hand to accelerate the circularity principles (see figure 1).

- **Create new, cross-cutting market enablers** for the transformation to a circular automotive industry (i.e. integrate life-cycle perspectives in relevant carbon legislation and improve data availability via digital product passports and data spaces).
- **Reshape the economic incentives** (taxation systems, carbon pricing, access to investments) to enable profitability and investability of circular products and services.
- **Harmonize and strengthen existing policy measures** (with a focus on legislative policies such as the End-of-Life Vehicles Directive, the Battery Regulation proposal, and vehicle access regulation) across life stages and components.

Across these three policy action areas, this report presents main policy interventions linked to specific EU "lock-in moments" – major policy revision processes – that will set the benefits of a circular automotive industry in motion (see Figure 2). Five of these are highlighted as priority policy interventions. The CCI, as a tailored enabling platform for automotive circularity, supports this process by honing and disseminating policy suggestions together with the automotive value chain.

FIGURE 1 **EU Policy Action Framework to accelerate automotive circularity**



Source: SYSTEMIQ

FIGURE 2 | **Key EU policy interventions for accelerating automotive circularity**

1

Why EU policy action for circular cars is needed now

The European Green Deal and COVID-19 recovery offer an opportunity for the automotive industry to accelerate circularity.

vehicle material emissions are expected to account for

60%

of the total vehicle life-cycle emissions by 2040

In the EU, due to the European Green Deal and COVID-19 recovery funds, policy-makers and industry players now have an opportunity to act, and put (auto)mobility on a transition pathway to a Paris-aligned, low-carbon, circular future. The value at stake for industry, society, and environment is immense: road transport accounts for 20% of Europe's carbon emissions, not taking into account upstream and downstream emissions.[6,7] Other environmental impacts, such as biodiversity loss and water stress, are also a result of the industry's immense resource use. In addition, social downsides of road transport include casualties from accidents, as well as air and noise pollution. However, the automotive industry also contributes approximately 7% of Europe's GDP,[8] and provides high-quality jobs, and industrial innovation. This contrast exemplifies the tensions that accompany the sector's circular transition.

To address this, in 2021-2022, the EU is conducting various important revisions of key legislations and complementary policy tools. In addition, COVID-19 recovery funds are being distributed, with a minimum of 37% of the EU's budget earmarked to the green transition. Depending on the ambition level and design, these policy interventions could either create a step change towards automotive circularity or result in incremental changes. If successful, it would prepare the capital-intensive industry – with its long product life-cycles – to remain competitive in the fast emerging, zero-carbon, low-material-intensity future. The need for action to drive automotive circularity has been prominently featured by the European Commission in the Circular Economy Action Plan and the Sustainable and Smart Mobility Strategy. Policy-makers in the EU now have the opportunity to use upcoming policy changes as a boost for automotive circularity, and businesses along the automotive value chain should mobilize policy-makers to take this opportunity.

This policy brief proposes a summary by the CCI of the most important actions for EU policy-makers, to accelerate the transition to a circular automotive industry. It outlines three policy action areas, each linked to specific EU lock-in moments for policy revisions, adoptions, or introductions over the coming years, targeting the progression of specific principles of automotive circularity. A comprehensive set of policy measures must work hand in hand: legislative revisions and stimulus packages have to be complemented with information availability, economic incentives, public procurement and private investment support to enable a systemic shift with economic, environmental, and social benefits. Decision makers on a supranational level, and in member states, can use this brief to advance both current and novel policy tools for circularity.

This EU policy roadmap matches the findings of the previous work of the CCI[9] towards a concrete policy framework to make automotive mobility sustainable and circular within the context of the European Green Deal. The appendix of this report contains details on EU and global policy efforts for automotive circularity and national circularity metrics frameworks.

To leverage the European Green Deal most effectively for automotive circularity, all actions should support the expansion to a life-cycle-based perspective of the industry along the automotive value chain. In alignment with the Automotive Circularity Taxonomy developed by the CCI (see Figure 3), the measures intend to scale the use of circular, low-carbon materials, re-focus circularity from recycling to vehicle life extension via reuse and remanufacturing, and improve the utilization of vehicles by fostering fleet management and shared vehicles.

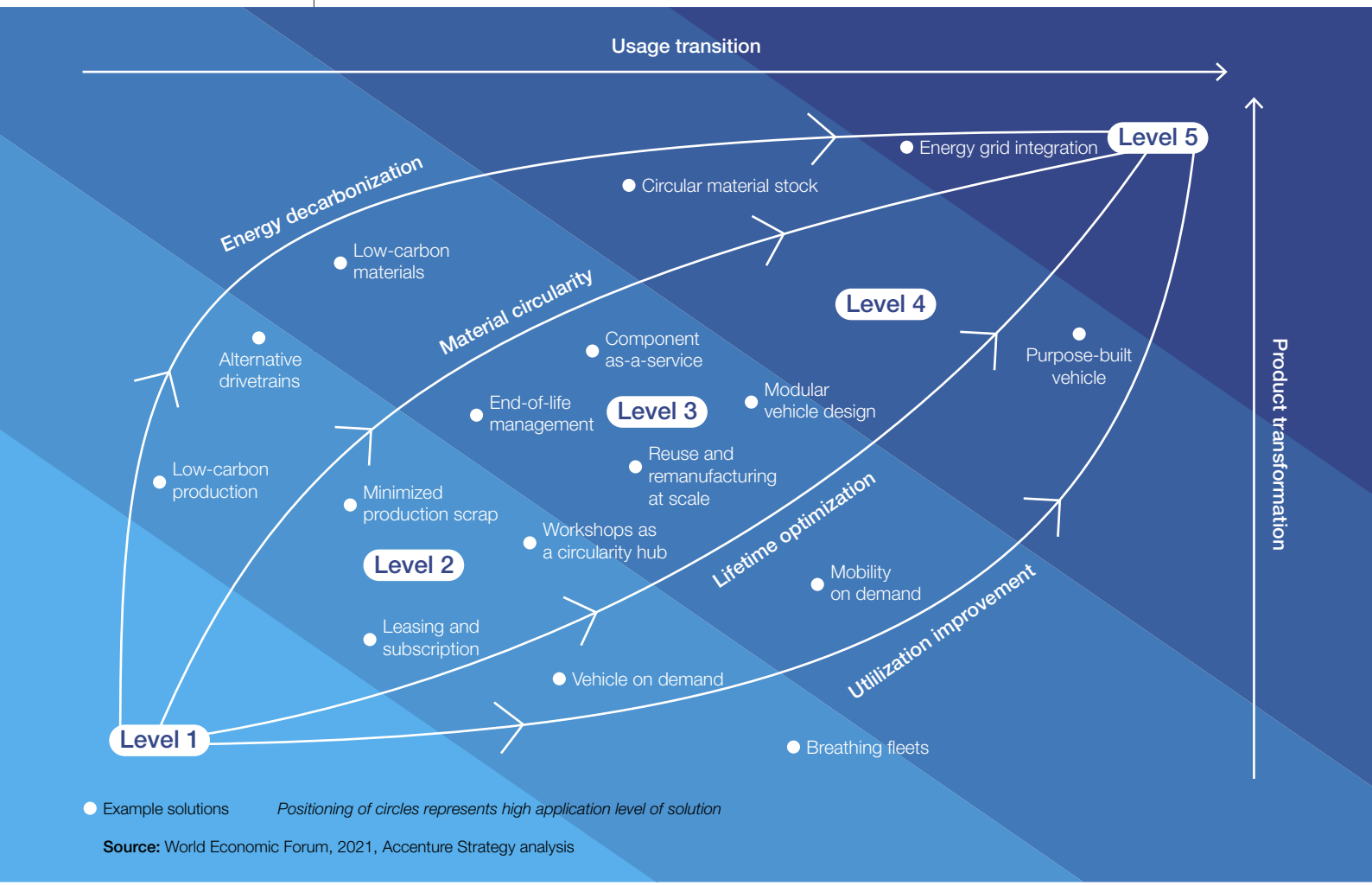
> Ambitious policy revisions and introductions are important to prepare the capital-intensive automotive industry to remain competitive in a fast emerging, low-carbon, and resource-efficient mobility ecosystem.

As the transition from internal combustion engine vehicles (ICEVs) to battery electric vehicles (BEVs) accelerates, policy priorities for ICEVs must focus on fleet replacement with BEVs[10], occupancy increases, and material circularity. Simultaneously, policy priority for BEVs must include the uptake of all circularity levers, including lifetime extension.[11] As with any transition policies, the actions recommended here should be embedded in programmes that support the necessary re-skilling of, and an equitable transition for, value chain players to lower the transition costs for industry and society.

Energy decarbonization is key for low-carbon mobility, and is the fourth pillar of the CCI Taxonomy. The CCI strongly supports the transition to electric vehicles and believes automotive circularity to be supportive of that trend – as endorsed analytically by the Global Battery Alliance, and others.[12] While that transition appears to have crossed a tipping point for exponential dynamics – with a majority of original equipment manufacturers (OEM) having published ambitious electrification strategies or outright phase-outs of ICEVs,[13] electric vehicles still face an uphill battle due, in part, to fossil fuel subsidies and tax benefits for ICEVs. While it is critical to address these hurdles, policy action to accelerate energy decarbonization and vehicle electrification is not the focus of this paper, as the subject is already addressed by various ongoing initiatives and activities. However, the acceleration of the widespread utilization of renewable energy for the production and operation of vehicles, and the rapid adoption of low-emission drivetrains, is paramount to enable a low-carbon automotive industry.

The transition to a circular economy represents a system change. Policy action is just one part of this change. It is indispensable that actors across the automotive landscape collectively shape the transition. While coherent policy action is key to aligning efforts and providing guidance and a level playing field for the transition of the market actors, other organizations and actors both from within and outside of the industry also play a role in fostering circularity. For example, insurance companies have the potential to leverage incentivization systems for automotive circularity through rewarding the use of sustainable vehicle parts with lower insurance rates, and behavioural change of consumers is key to supporting the transition. Likewise, financial institutions have a crucial role to play in supporting the industrialization of circular business models and their supportive infrastructures. Moreover, collaboration across the value chain (e.g. between OEMs, material producers, and recyclers) enables further circular processes.

FIGURE 3 **Automotive Circularity Taxonomy**



Source: World Economic Forum, 2021, Accenture Strategy analysis

2

Policy action can mitigate barriers and strengthen drivers of automotive circularity

Policy action is needed to overcome hurdles and scale the use of circular materials, products, and services.

The automotive industry is increasingly transforming its operations in line with circular principles.[14] Basic circular economy measures, such as repair and recycling of vehicles, are already well established and automotive manufacturers comply with the European legislative end-of-life vehicle handling requirements.[15] Vehicles' lifetimes are long, at an average age of 11.5 years in the EU.[16] In this vein, there are promising examples from the industry, demonstrating how reuse, remanufacturing, refurbishment, and utilization improvements can unleash high-value circularity. If successfully scaled, these could create ripple effects for other industries: for example, Renault recently laid out plans for a factory dedicated to improving vehicle material use and reuse, and aims to extend vehicles' lifetimes through an incubator and a training centre.[17] BMW is also tapping into circular economy potentials through partnerships with suppliers to process steel in a closed loop. The company announced in March 2021 that it would build, "the world's greenest car" using circular economy principles and a "secondary first" principle for car design and sourcing. Volvo is offering "vehicle-as-a-service" through an all-inclusive, subscription-based leasing offer. Analogous to this, major European car manufacturers have announced ambitious carbon-neutrality objectives in the past years (e.g. Daimler, Renault, Volkswagen, and Peugeot).

But the automotive industry is still not on track to effectively implement the circular economy levers. Especially at a system level, the utilization of vehicles is highly inefficient, as European cars are parked for approximately 92% of the day and, on average, carry only 1.6 people.[18] Moreover, higher value-retention processes for materials and components remain underutilized, and reuse, remanufacturing, and recycling systems lack scale,[19] leaving room for action.

Market- and policy-related barriers hinder the uptake of circular processes, products, and services in the automotive industry, and policy action is insufficiently addressing these market failures while simultaneously creating counterproductive incentives:[20]

Market-related barriers

- **Prevailing consumer habits and use patterns** lead to inefficient use of vehicles, car lock-in, and old vehicle fleets (low but long usage).
- **Traditional business models** focus on selling cars as a product rather than as a service due to, among other reasons, the capital-intensive vehicle development and manufacturing process. This limits transparency and incentives to adopt and finance circular products or services (e.g. car- and ride-sharing or preservation of end-of-life vehicles' materials, leading to many missing vehicles).
- **Financial and performance metrics and competitive dynamics** incentivize the development and production of larger, heavier and more powerful vehicles, which conflicts with the need for down- or right-sizing of vehicles to fulfil resource and climate targets, and make efficient use of urban space.
- **A lack of data availability** for integrated, sustainable mobility systems, poor vehicle life-cycle management across the value chain and difficult information access – due to competitive industry landscapes and slow implementation

of technological solutions – derails implementation of new circular processes.

– **Economic framework conditions** are out of sync with environmental challenges and incentivize linear business models as negative environmental and social externalities are not reflected in market and product prices.

– **Infrastructure and alternative modes of transport** are not designed to improve mobility system efficiency: cities are built for cars, disincentivizing other modes of transport, and public transport is lacking in many places.

Policy-related barriers

> There are still an amplitude of possible policy measures that could be leveraged to systemically support a circular car economy.

– **Regulatory CO_2 performance metrics** only cover tailpipe emissions and fail to take a life-cycle perspective.

– **End-of-life legislation** focuses on recycling but lacks specific quality requirements, which disincentivizes the need to design for high-value recycling and product life extension.

– **Transparent data on material composition of vehicles,** even though required to enter the EU market, is not publicly available and there is no vision of material composition evolution at aggregated scales.

– **Lack of clarity of the potential benefits of utilization increases** leads to a gap in conducive government frameworks to support shared mobility – and the COVID-19 pandemic negatively affected shared mobility uptake.[21]

– **Taxation systems** do not reflect externalities in market prices or incentivize the use of resource-intensive cars and they erase the economic benefits of market efficient solutions, while creating imbalanced pricing of infrastructure and service provision between different modes of mobility.

– **Public and private capital** is not channelled sufficiently into sustainable economic ecosystems to support automotive circularity.

– **Mobility-related policy is spread across EU, national, regional, and local authorities** which makes harmonization and implementation of effective measures difficult at scale.

– **Social implications** of the circular transition of the automotive industry are not sufficiently understood and supportive measures to prepare an equitable transformation are missing.

Policy action is needed to help mitigate these barriers, ensure a level playing field, effective mitigation of societal downsides, and efficient functioning of markets. Policy action has proven to be a critical driver of sustainability transitions. In the case of coal, for example, policy-led phase-outs are central to accelerating the industry transformation in a timeframe which would have otherwise taken many more years. Inversely, policy has the power to keep dwindling industries such as coal alive – often at high costs to society. While the status quo of EU policy action for automotive circularity is advanced in comparison to other countries globally, it still does not sufficiently support the industry on its road to a resource-decoupled, low-carbon future.[22] Alongside the removal of counterproductive measures, there are still an amplitude of possible policy measures that could be leveraged to systemically support a circular car economy and the CCI aims to address this.

BOX 1

COVID-19 represents an inflection point for the automotive industry

There have been decreases in overall mobility demand of up to 90% during lockdowns, accompanied by an increasing share of private mobility. Carpooling declined by 60% to 70% in 2020, compared to the previous year. The European automotive industry saw staggering production losses of up to 3.6 million vehicles in the first half of 2020.[23]

Vehicle sales are not expected to return to pre-pandemic levels until 2023. Despite the overall decrease in sales, COVID-19 recovery packages have helped to accelerate the uptake of BEVs immensely.[24]

These impacts are a hard hit for the industry. But COVID-19 also represents an inflection point. For example, various cities, countries, and corporates have announced ambitious carbon commitments in the past year.[25] The recovery process – funds and regulation alike – can be used to prepare the automotive industry for a sustainable transition, in line with the calls by industry to, "build back better".[26] Capitalizing on this momentum to initiate change across the automotive value chain could be a turning point to accelerating automotive circularity.

3

How a set of policy development principles guides the way

Policy development principles for automotive circularity guide policy action to improve resource and carbon efficiency.

Based on the CCI framework, four high-level policy development principles for automotive circularity should guide policy action to ensure compatibility with the carbon and resource goals of the EU (see Figure 4):

Principle 1: Policy for automotive circularity has to account for vehicle life-cycle emissions per passenger kilometre. This would influence the perspective of policy and industry away from optimizing tailpipe emissions and units sold, to a circular life-cycle-based view that also includes carbon emissions embedded in the vehicle materials, and effects from end-of-life management. This is important in light of the uptake of BEVs, by which vehicle emissions shift from use phase to production phase and the potentials of sound life extension and end-of-life management increase. Moreover, a utility-based perspective of the vehicle that considers the occupancy per vehicle would allow for optimizing the resource and carbon footprints of the mobility system at large, including other modes of transport.

Principle 2: The automotive industry should leverage the use of circular, low-carbon materials to accelerate the scale of demand for these materials across industries, resulting in carbon and resource efficiency both in the automotive sector and beyond. This includes more transparency about the material composition of each vehicle, better collection of end-of-life vehicles, high-quality recycling, and use of recyclable and recycled materials.[27] This is relevant for BEVs and ICEVs, but especially important for critical battery materials, and materials with high carbon intensity like steel and aluminium.

Principle 3: Automotive circularity needs to expand the focus from recycling to product life extension through reuse and remanufacturing, to ensure maximum lifetimes of vehicles and avoid obsolescence (e.g. of vehicle software). This would promote higher retention of economic value and embodied energy. Recycling is a non-negotiable process at the end of a vehicle or vehicle parts' lifetime – but uptake of reuse and remanufacturing also must be fostered. Both circular levers require well-established producer responsibility mechanisms and adapted design approaches. Vehicle life extension is mainly important for BEVs, as the policy priority for ICEVs must be to replace them with low-emission vehicles.[28]

Principle 4: The utilization of vehicles needs to be increased through wider adoption of, and improved, fleet-based management and shared mobility (car- and ride-sharing) solutions, especially as part of integrated, intermodal mobility offers. As highlighted by the UN International Resource Panel, this step is crucial as it promises the highest impacts of all the material efficiency strategies.[29] The improvement of vehicle utilization rate and occupancy is vital for both BEVs and ICEVs as it not only spreads vehicle impacts across more utility (passengers or goods transported) but could also promote innovation by supporting purpose-built vehicles for mobility-as-a-service (MaaS) applications. Similarly, vehicles' life extension, recollection, and material circulation can be improved if vehicles are continuously held in shared fleets, as incentives for lifetime optimization of these cars is higher.

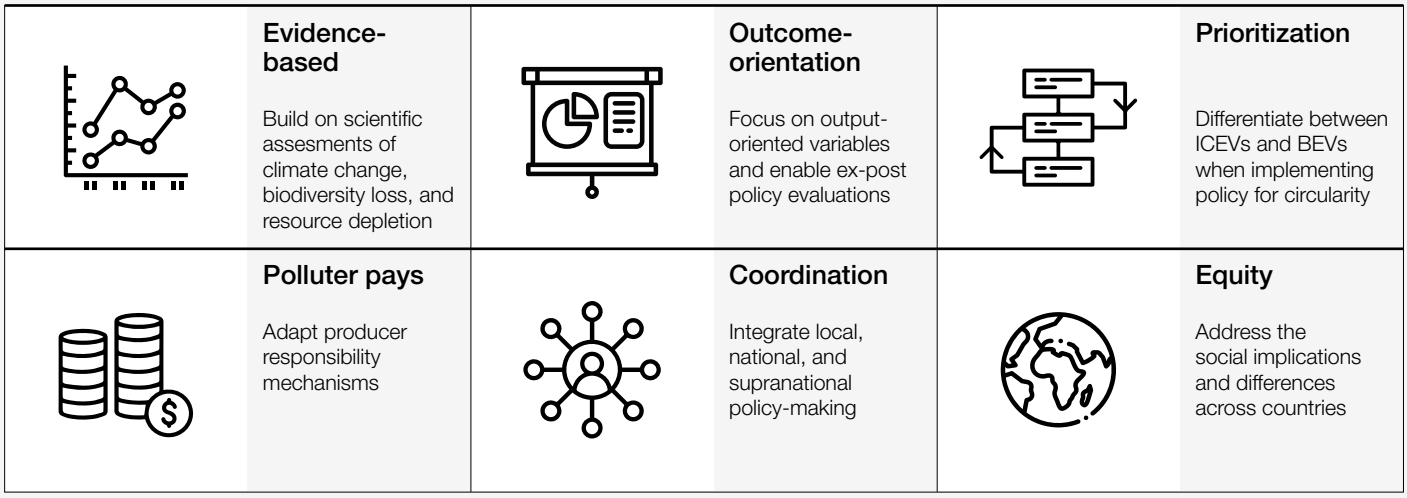
> The perspective of policy and industry has to expand from optimizing tailpipe emissions to a circular life-cycle-based view.

FIGURE 4 | **Policy development principles based on the automotive circularity levers**

CE levers*	4 policy development principles	Goal
Material circularity	**1** **Account for the life-cycle** of the vehicle per passenger killometer **in emissions performance assessment**, including carbon embedded in materials	**Carbon efficiency**** Life-cycle CO_2e emissions (g) / passenger km
Lifetime optimization	**2** **Accelerate the use of circular, low-carbon materials** to scale general demand for quality recyclates	
	3 **Expand focus of circularity** from recycling to higher-value measures such as reuse and remanufacturing	**Resource efficiency**** Non-circular resource consumption (g) / passenger km
Utilization improvement	**4** **Optimise utilization factor** by supporting fleet management and shared mobility on demand solutions as part of intermodal mobility systems	

* Stakeholders and their needs differ between levers.
** At vehicle level, simultaneously ensuring that absolute transport sector impacts are reduced in line with planetary boundaries.
Source: SYSTEMIQ based on Accenture Strategy analysis

FIGURE 5 | **Policy design considerations**



Source: SYSTEMIQ

The recommendations of this policy brief rest on six general policy design considerations (see Figure 5):

- **Evidence-based**. The justification for action is grounded in scientific assessments on climate change, biodiversity losses, and resource depletion accelerated by the current (auto)mobility system. They highlight the urgency to counteract the current environmental impacts of production and consumption systems.[30, 31] As the two previous reports of the CCI[32, 33] have described, in line with the foundational analyses performed by the UN International Resource Panel, circular economy action can provide effective solutions to counteract these negative impacts and help maintain a safe operating space for humanity, within planetary boundaries.

- **Outcome-orientation**. The recommendations aim to improve the carbon and/or resource efficiency of cars. However, for many of the recommended policies, no reliable evaluations of the effectiveness of measures exist. The implementation of the proposed policy recommendations should therefore be accompanied by both ex-ante (planned) and ex-post (empirical) policy evaluation to ensure their effectiveness in contributing to an automotive sector that is aligned with a 1.5°C goal and operates within planetary boundaries.[34]

- **Prioritization.** Policy action for circularity must not distract from the reduction of use-phase emissions as ICEVs are replaced by BEVs in the coming years. Policies that increase vehicles' lifetimes and extend the performance assessment of CO_2 to the production and end-of-life phase must include clear guardrails, meaning that these are focused on increasing BEVs' lifetime and life-cycle assessments. Instead of prolonging their use, the policy priority for current ICEV fleets should be replacement[35] with lower carbon alternatives, to eliminate the lion's share of emissions related to their use phase, during which 65% to 80% of their life-cycle emissions are generated.[36]

- **Polluter pays.** The "polluter pays" principle presents a foundational approach to effective policy-making for a circular economy[37] and is adopted through the integration of producer responsibility mechanisms, as reflected in many EU environmental legislations, including the ELV Directive. Social impacts of policy, such as increased costs for mobility (e.g. through taxes), should always be taken into account.

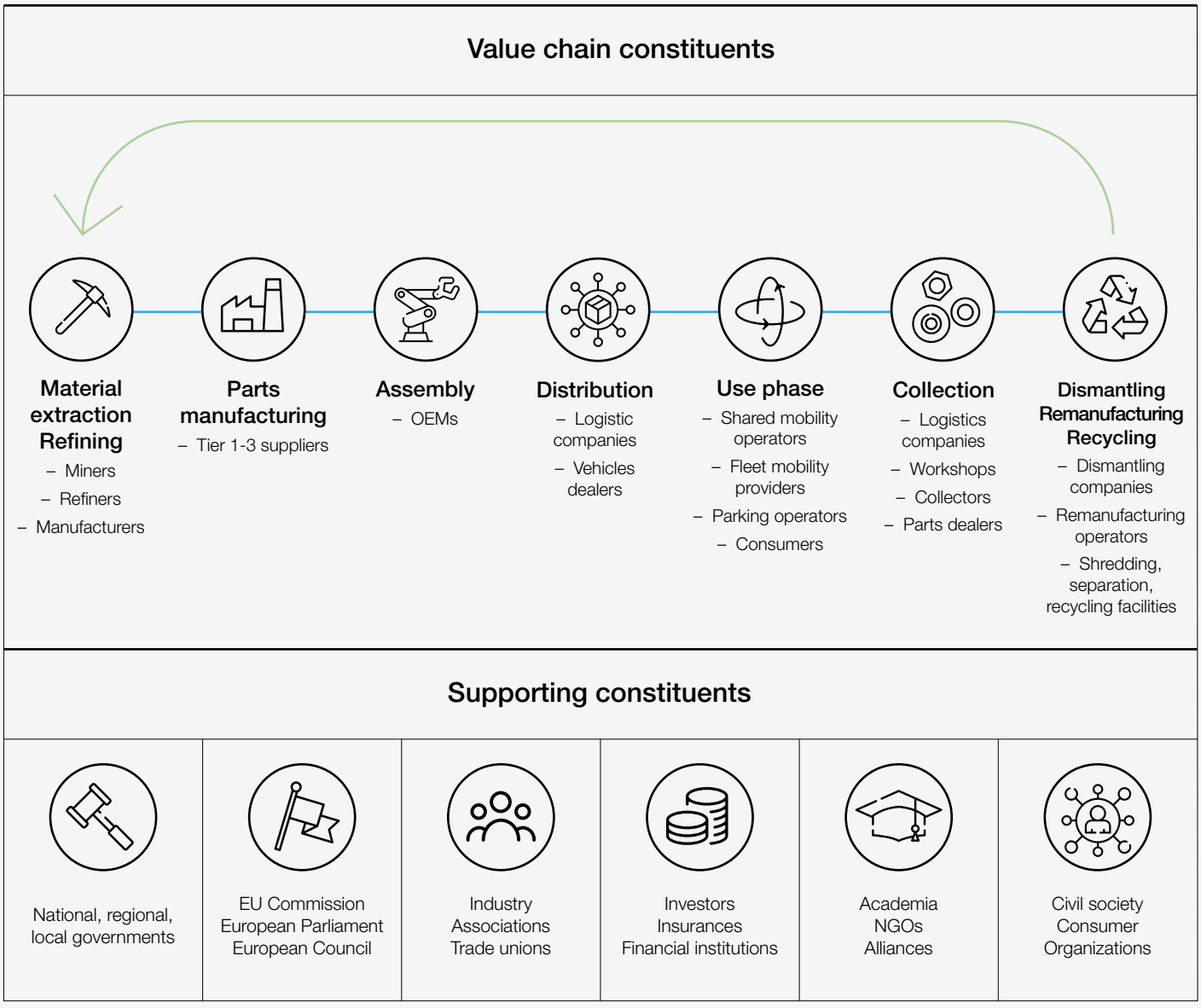
- **Coordination**. Policy action for automotive circularity requires the coordination of various public bodies (e.g. within the European Commission, DG MOVE, DG ENVIRONMENT, and DG COMPETITION) to achieve a combination of policy action for the build and the use phase of vehicles.[38] Many of the proposed recommendations in this policy roadmap require close coordination between distinct policy-makers and different regional levels.

- **Equity**. The transition to a circular automotive industry will not only have implications for business models and processes, but will also affect the automotive workforce. While existing studies consistently showcase that a circular economy transition will create additional jobs,[39] implementing measures to prepare employees for possible impacts (e.g. by re- or upskilling) is key. Moreover, policy measures have to take into account the global economic and political implications of automotive circularity, and the different situations of countries globally, ensuring measures are tailored to each situation and knowledge is transferred from fast-movers to others.

❝ Instead of prolonging their use, the policy priority for current ICEV fleets should be replacement with lower carbon alternatives.

Stakeholders along the automotive value chain must collaborate to make automotive circularity a reality. Due to the bandwidth of levers, the industry will need to be guided towards a circular economy by multiple organizations of varying sizes and business models (see Figure 6).

FIGURE 6 **Automotive circularity value chain and supporting constituents**



Source: SYSTEMIQ

4

What policy-makers should do to enable circularity

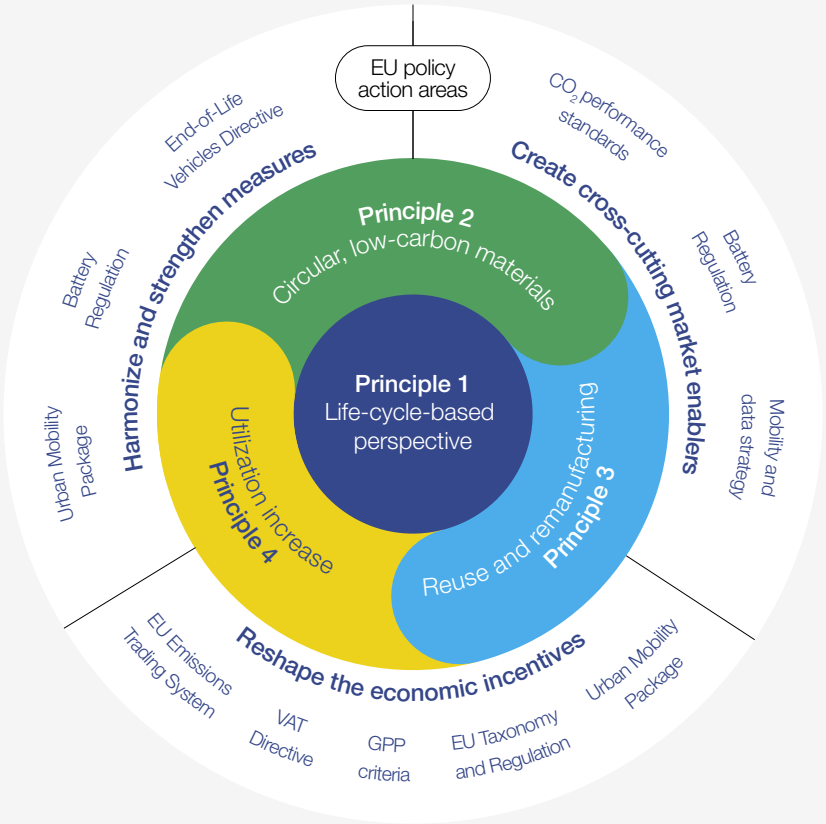
A policy mix of cross-cutting market enablers, reshaped economic incentives, and harmonized and strengthened measures will accelerate the circular car transition.

The EU can guide, incentivize, and support member states in the implementation of policy interventions, even in areas without a clear EU mandate.

To support the circular transition of the automotive industry, we recommend a package of policy action that calls on EU policy-makers to act on three areas: 1) creating cross-cutting market enablers, 2) reshaping economic incentives, and 3) harmonizing and strengthening measures that reflect the systemic dynamics of automotive circularity (see Figure 7). This policy mix aims at improving systemic resource and carbon efficiency, and these actions should not only improve efficiency over the life-cycle per passenger kilometre at individual vehicle level, but should also optimize for economy-wide impacts (e.g. by controlling rebound effects from lowered transport costs due to improved utilization, which may lead to higher total passenger kilometres travelled).

After a thorough analysis of the current automotive policy framework, these three areas have been identified as they sum up the most needed policy changes and relate to EU lock-in moments which can be leveraged to achieve a transition to automotive circularity. Each area focuses on different aspects, taking into account varying types of policy instruments, ranging from economic tools to regulation and information.

FIGURE 7 **EU Policy Action Framework to accelerate automotive circularity**



Source: SYSTEMIQ

The EU only holds regulatory competences in a section of the required policy action areas. Economic policy, for example, is a prerogative of each member state.[40] Employment policy, urban planning, and, depending on the size, public investments are other examples of areas currently in the realm of the member states and, partly, of city authorities. But even in areas without immediate legislative mandate, the EU has the potential to guide, incentivize, and support member states and cities in the implementation of other policy interventions. The three, identified policy action areas aim at EU-level policy-making, with the purpose of generating EU-wide, harmonized approaches to circularity, not least to achieve a level-playing field between European companies. Moreover, due to the tendency to replicate policy globally, actions taken at EU level may have follow-on effects and corresponding impacts on other economies around the world.

4.1 Create cross-cutting market enablers

The first policy action area centres around the establishment of cross-cutting enabling mechanisms.

On the one hand, this includes the creation of consistent metrics that take a life-cycle perspective in regulations. On the other hand, better cross-value chain data availability has to be supported and mandated by policy-makers to allow for the application of circular services. By creating these enabling mechanisms, policy-makers can help to overcome barriers related to information asymmetry and outdated performance standards. The following recommendations should be implemented by policy-makers to establish the needed supporting mechanisms in the EU:

Recommendation 1.1

Adopt a life-cycle-based approach for CO_2 performance measurement that takes emissions from vehicle manufacturing and use into account

Policy development principle
Life-cycle-based perspective

Barrier
Companies are incentivized to optimise use phase emissions due to the regulation on EU CO_2 standards and emissions beyond tailpipe are neglected. No incentive exists to implement circulatory principles along the value chain

EU policy options
CO_2 performance standards for cars and vans, Battery Regulation

Stakeholders
All stakeholders along the value chain from material extraction to recycling

Rationale

The adoption of a life-cycle-based assessment for a vehicle's CO_2 performance, including embedded carbon footprints, will incentivize firms to reduce build and use phase emissions. This policy change is needed to avoid a shifting of emissions from the use phase to build and end-of-life phase, as BEV uptake accelerates (see Figure 8). Overall, carbon and resource efficiency across the life-cycle would be increased as automotive players and material suppliers comply with the targets for life-cycle emissions. This paradigm shift would result in beneficial outcomes in terms of resource use patterns, production processes, and end-of-life management.

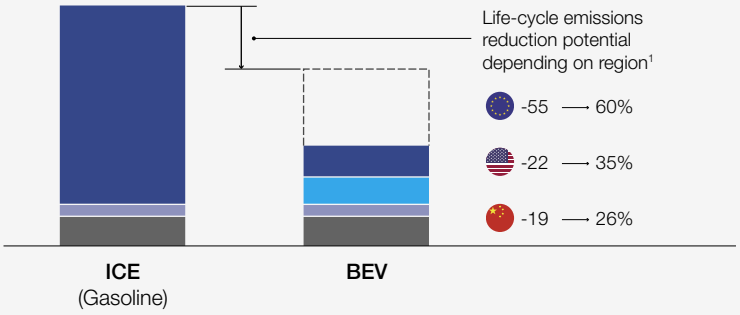
Current status

Today, tailpipe emissions account for most of cars' CO_2 emissions and the EU CO_2 performance standards for cars and vans[41] therefore regulate vehicles' performance based on the emissions released during the use phase.[42] These performance standards are complemented with a fiscal incentive that penalizes unmet targets, which tighten over time. This continuous nudging supports compliance with the emission reduction targets. However, the EU CO_2 emission standards currently omit emissions from the vehicle production, end-of-life, and other related aspects of a vehicle's life-cycle. The performance standards for new cars and vans are under revision in 2021 and the European Commission will review the possibility of adopting a life-cycle-based assessment for the directive by 2023.[43] The adoption of a life-cycle perspective for the assessment of passenger vehicles' CO_2 emissions has also already been discussed by public authorities, industry, and academia, not least due to the possibility to accelerate the uptake of synthetic and advanced alternative fuels.[44] In line with this approach, the Battery Regulation proposal has been equipped to increase transparency around the life-cycle emissions of batteries fitted in BEVs (and all batteries above 2kWh capacity) and proposes the establishment of targets for the carbon footprint of batteries.[45]

> The adoption of a life-cycle-based assessment for vehicles' CO_2 performance policies is needed to avoid a shifting of emissions from the use phase to the build and end-of-life phase as BEV uptake accelerates.

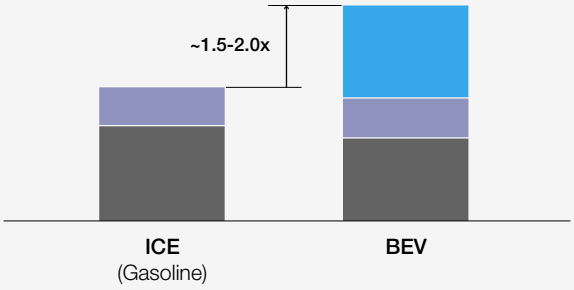
FIGURE 8 | **Investigation into BEV vs. ICEV life-cycle and material emissions**

Life-cycle emissions



BEV life-cycle emissions could be substantially lower and depend on use of green electricity in power mix

Material emissions



1.5-2.0x higher material emissions for BEV vs. ICEV due to energy-intensive battery production

1. Reduction potential also dependent on vehicle segment with smaller vehicles with typically higher emission reduction potential.

Source: World Economic Forum, 2021, Global Battery Alliance, McKinsey analysis

Recommended policy action

To incentivize the use of circularity levers across the life-cycle, carbon performance assessments must be extended. However, in the transition period from ICEVs to BEVs, it should primarily be ensured that legislation continues to drive the uptake of zero emission vehicles[46], and this should be streamlined only as they have established a firm foothold in vehicle sales.

It is first proposed, therefore, that carbon footprint disclosure requirements and a gradual introduction of maximum threshold targets for BEV batteries are introduced to expand the emission performance perspective to the complete life-cycle, as outlined in the Battery Regulation proposal of the European Commission. Such targets must be set in consistency with Paris-aligned carbon emissions abatement pathways (maximum 1.5°C global warming).

Second, the CO_2 emission performance standards for cars and vans should remain focused on end-of-pipe emissions to drive the uptake of zero-emissions vehicles.[47] The regulation must be brought into alignment with the revised EU climate targets, and assessment criteria should reflect the empirical reality of emissions performance during vehicle use. To pave the way for a life-cycle perspective of carbon emissions, this should be complemented by requirements for original equipment manufacturers (OEM) to publish life-cycle assessments (LCA) for vehicles.

Third, the CO_2 emission performance standards should be prepared for reflecting a life-cycle perspective when, in the long-term, electric vehicles will come to dominate the market. Then, the policy should be revised to include the complete vehicle life-cycle, by streamlining the carbon footprint targets of the Battery Regulation in one comprehensive policy tool. Performance standards on tailpipe emissions should be extended to requirements on the emissions of a vehicle across its life-cycle, e.g. production, use (including upstream emissions from energy used to propel the vehicle), and end-of-life.

Currently, the International Organization for Standardization (ISO) standard 14040/44 for life-cycle-based assessments is widely used in the automotive industry to create LCAs. Moreover, the European Commission has developed a new methodology, called the product environmental footprint, which aims to provide comparability between products. At the moment, it is not clear which life-cycle methodology is best suited for integration into vehicle emission policies. Agreement on this (between industry and policy) still needs to be reached, and ways to accredit carbon savings from lifetime extension (especially battery second life) and recycling must be developed carefully, based on real data and in alignment with global stakeholders. It has been proposed that an independent body may be best suited to create a policy-appropriate LCA standard for vehicle life-cycle management, bridging gaps between the ISO and product environmental footprint (PEF) standards.[48]

Outlook

Next to life-cycle-based assessments, a utilization factor per passenger would move the needle towards circular mobility even further. Accounting for the utilization factor through the inclusion of passenger kilometres would further advance the emission reduction of the transport sector by decreasing structural inefficiencies in vehicle use and allowing comparability between different transport modes: how to exactly achieve this legally and technically would still need to be determined.

Policy development principle
Life-cycle-based perspective

Recommendation 1.2

Improve data availability for the life-cycle management of materials and shared mobility through digital multi-stakeholder platforms

Barrier
Lack of information for circular material handling complicates the use of value-retention strategies; silo-like approach to mobility data prohibits widespread use of shared mobility

EU policy options
Mobility Strategy, European Strategy for Data, Circular Economy Action Plan

Stakeholders
All stakeholders along the entire value chain from material extraction to recycling, shared mobility operators, public transport providers, governmental institutions

Rationale

Both the life-cycle management of materials and multi-modal mobility platforms require access to high-quality and accurate, standardized, often real-time data:

- **Life-cycle management of materials:** The efficient life-cycle management of materials requires an abundance of information across vehicle lifetimes: from static data about material composition (e.g. components, hazardous substances, primary vs. secondary material), and repair and dismantling information, to dynamic data on vehicle or battery whereabouts, end-of-life processes, and vehicle/component condition or state of health (see Figure 9).[49] The inclusion of responsible sourcing information and the environmental footprint of each value chain step should also be collected. Such data availability can enable informed decision-making for the optimal end-of-life processes based on environmental and economic criteria, provide the basis for new circular business models, and contribute to a reduction of unknown vehicle whereabouts.[50]
- **Multi-modal mobility:** Democratizing access to mobility data across transport modes enables the integration of shared mobility offers in multi-modal transport platforms. Hereby, these become accessible to a wide customer base. The collection of real-time mobility data (including floating car-sharing data) and integrated information about the transport infrastructure on a local, regional, and national level is necessary. Mobility data spaces could also form the foundation for new, innovative business models, such as breathing fleets.[51] Next to this, mobility data spaces enable transparency around carbon emissions per trip. Users could thereby decide between various route options depending on the environmental impact. Transparency around CO_2 emissions per trip can be coupled with incentivization practices to nudge sustainable consumer choices. In the case of automotive circularity, these could involve clearly indicating the emissions of a ride-hailing trip in comparison to an individual car trip, a pooled ride, or other modes of transport.

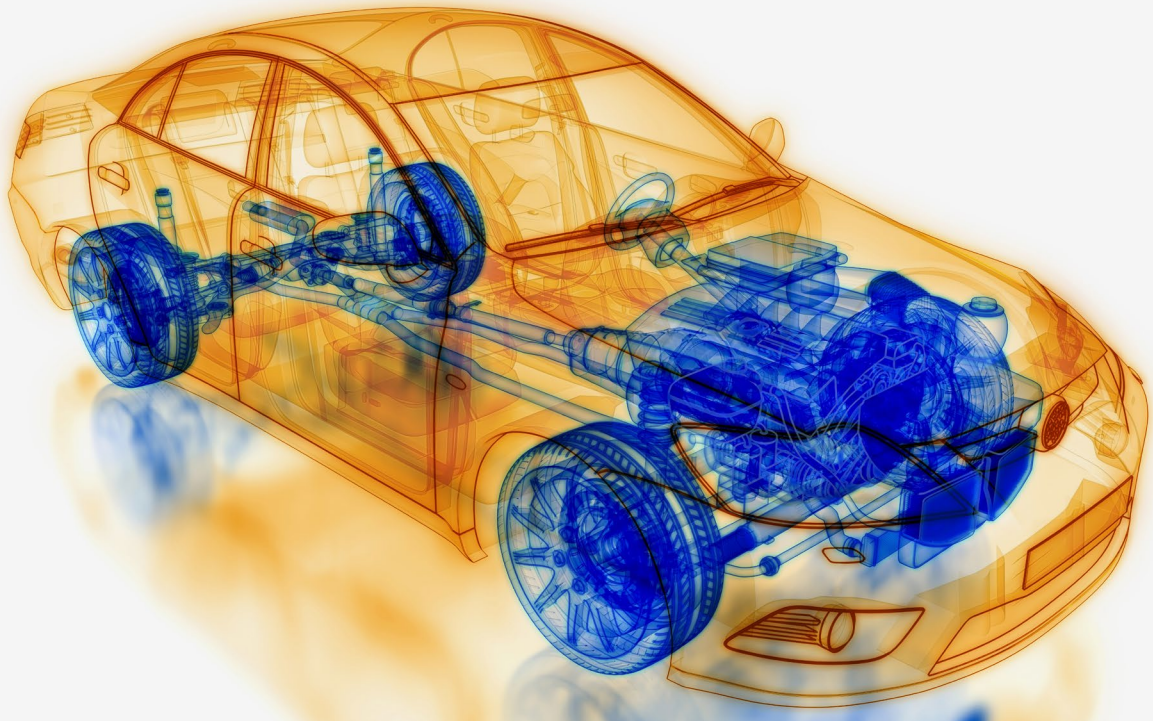
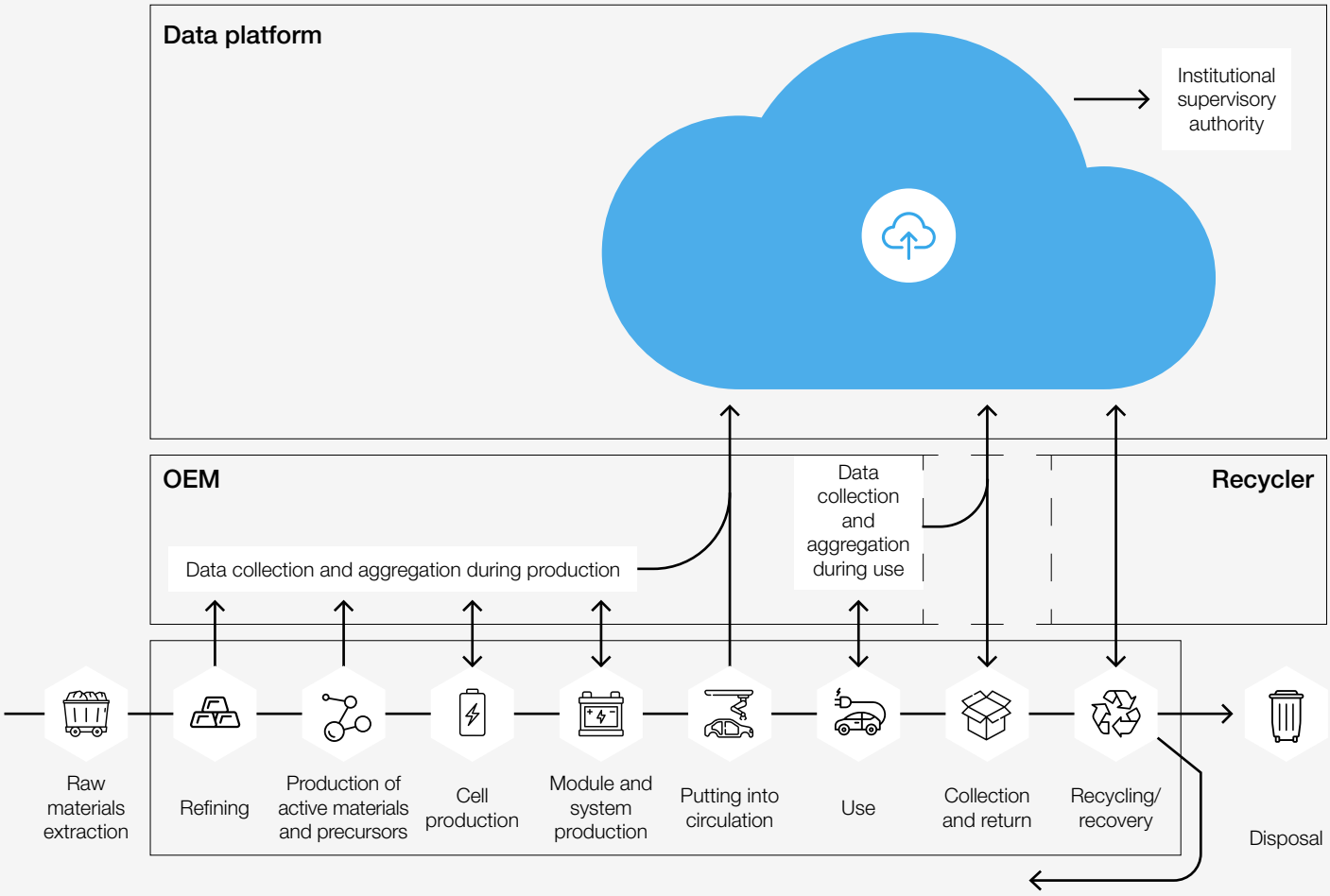


FIGURE 9 | **Illustrative example of the information flows needed to promote the high-quality recycling of traction batteries**



Source: Circular Economy Initiative Germany, 2020

> Data availability has been a focus topic of EU policy-making in the past years. The European data strategy has highlighted the importance of a single market for data, improved data access, and data governance that enables efficient data-sharing.

Current status

Data availability has been a focus topic of EU policy-making in the past years. The European data strategy has highlighted the importance of a single market for data, improved data access, and data governance that enables efficient data-sharing.[52] As a result, the European Commission has already started to address data availability for the life-cycle management of materials and mobility data access:

- **Life-cycle management of materials:** The automotive industry already collects ubiquitous amounts of data to enable supply chain coordination. Examples for digital information platforms are the International Dismantling Information System (IDIS) and the International Material Data System (IMDS), while regulations such as the Directive 2005/64/EC[53] on the type-approval of motor vehicles with regard to their reusability, recyclability, and recoverability oblige firms to report various informational aspects on vehicles to type-approval authorities, such as the material breakdown of the vehicle aggregated at a high level following ISO 22628:2002. At the same time, the European Commission has made plans to set up a European Green Deal data space to enable circular economy practices, with a European Battery Passport as one of several digital product passes. The strategic data infrastructure project of several member states,[54] Gaia-X, also aims at improved data availability and governance across the EU. Currently, information availability is still confidential or fragmented, access is often linked to high transaction costs, and the data is not actionable, especially for smaller value chain players.
- **Multi-modal mobility:** The EU has already made plans to establish a data space for mobility, including a focus on both specific and cross-modal transport sectors. In this context, the Commission will review various key directives to enable effective sharing of the needed data across public and private actors. The Gaia-X project foresees a European-wide data space for mobility.[55] In Germany, the "data space mobility", administered by the National Academy

Policy-makers should initiate, support, and provide funding for the development of European-wide, interoperable, cross-company vehicle life-cycle management platforms and multi-modal mobility data spaces.

for Sciences and Engineering (acatech), was launched in 2020. Acatech orchestrates the set-up of the data space as a neutral, scientifically-oriented and technically-experienced actor. On a local level, Finland has already integrated the multi-modal transport platform Whim, which enables seamless travel across different transport modes. Another example is Jelbi, a public-private partnership between the public transport operator BVG and several micro-mobility providers, as well as car-sharing models.[56]

Recommended policy action

Firstly, EU policy-makers should increasingly require the disclosure of necessary data for the life-cycle management of vehicle materials and multi-modal mobility platforms.

- **Life-cycle management of materials:** Legislation on batteries, end-of-life vehicles, and CO_2 performance standards must increasingly require the disclosure of critical data sets to increase transparency and enable threshold-related policy-making (see recommendations 1.1, 3.3, and 3.5). Such data sets include the carbon footprint of batteries, materials used in vehicle components, and the amount of recycled content, among others.

- **Multi-modal mobility:** Cross-organizational infrastructure data, payment data, and vehicle data, among others, needs to be shared more efficiently between public and private organizations to allow for multi-modal mobility platforms.[57] Information on the life-cycle carbon footprint of shared mobility trips in comparison to public transport rides should be made available by OEMs, shared mobility providers, and public transport operators to enable informed-decision-making.

Secondly, policy-makers should initiate, support, and provide funding for the development of European-wide, interoperable, cross-company vehicle life-cycle management platforms and multi-modal mobility data spaces. Gaia-X can form the backbone for these data spaces. While data standardization and interoperability are mainly driven by industry bodies, EU policy-makers should initiate and support such processes. Policy-makers should also support the design of appropriate monetization strategies between stakeholders, ensuring that data-sharing is incentivized appropriately and data value is reimbursed adequately.[58] Free access to public data should be improved as proposed in the EU's data strategy. Data marketplaces for proprietary data are one possible way of monetizing data access and can enable demand and supply-based monetization strategies.[59] Other options exist for the sharing of proprietary data, such as bilateral agreements, regulatory data disclosure requirements, licensing, or partially open data.

- **Life-cycle management of materials:** In the case of vehicle material life-cycle management, the prioritization to first establish a European Battery Passport is justified, due to the significant impact potentials of battery production. Subsequently, expanding a European-wide Battery Passport to the entire vehicle is the next step needed to improve data availability on other materials and their impacts, such as steel, aluminium, or plastics. Supporting the circular management of vehicles should build on similar initiatives, such as the global commons Battery Passport project of the Global Battery Alliance, or innovative individual software solutions, such as Circulor, a provider of traceability software for the value chain. One cross-value chain collaborative project space is Catena-X, which intends to build interoperable data solutions based on Gaia-X.[60] Next to the creation of interoperable data gateways, interoperability also requires data standardization.[61] Standardization can build on various existing initiatives: ISO 22628:2002[62] sets the frame for the recyclability of vehicles and the European Commission has established the product environmental footprint[63] for a standardized LCA methodology. At the same time, industry associations are working on classification systems for materials and reused parts. Technically, examples can be found in the International Dismantling Information System (IDIS)[64] or the International Material Data System (IMDS).[65] Open standards exist in the form of GS1,[66] International Data Spaces (IDS),[67] or FIWARE.[68] Integrating and expanding such approaches in a battery and, later, vehicle passport, should be a collaborative effort by industry that policy supports and coordinates. Existing data (e.g. as stored in the IDIS or already reported for other purposes) should be leveraged to supply a vehicle life-cycle management platform. It must be ensured that these existing data collection points are effectively merged as part of an overarching platform.

- **Multi-modal mobility:** Data on mobility systems and real-time traffic has been collected for many years. Platforms, interoperability, and standards are therefore well-developed compared to material life-cycle management. However, various issues must still be addressed, such as the issue of pan-European data-sharing, as National Access Points (NAPs) are currently not designed for interoperability, which results in a barrier to a pan-European transport system.[69, 70] Moreover, data standards (formal, informal, metadata, etc.[71]) for mobility data are in use, but more open data standards and improved harmonization should be fostered.[72]

Thirdly, legislation on data governance must be adapted to effectively steer data-sharing and privacy- and security-related considerations. For data privacy and security, the EU and its members already have various legislative pieces in place

which need to be taken into consideration and possibly adapted, such as GDPR (EU level) or member state legislation. Especially for mobility data, sensitive personal data has to be governed carefully, obtaining to the data sovereignty of the person and preventing the development of monopolistic market actors that could inhibit efficient functioning of mobility markets.[73] The EU has also already taken the first steps towards improved data sharing with the *Proposal for a Regulation on European data governance.*[74] This proposal sets forth new sector-specific legislation for data access in the automotive industry and environmental information across Europe.[75] Sharing obligations and access rules among value chain participants must be clearly defined to balance data availability with protection of intellectual property, personal data, and data security. To improve carbon and resource efficiency, mandatory sharing of specific data is essential. Concerns about sensitive data can be avoided by restricting the data-sharing requirements to data sets that are strictly necessary (especially with a focus on protecting customer rights)[76] and, ideally, already available.[77] As small and medium-sized players often do not have the capacity to digitize all processes and information, support should be provided to onboard the complete value chain.

4.2 Reshape the economic incentives

The second policy action area addresses the economic incentives that will help to support an automotive circular economy transition.

Tax changes or carbon market mechanisms can account for negative externalities by compensating for market price differences between 'green' products and 'less green' products, and nudging consumers and companies to shift their choices.[78] Similarly, increasing the flow of investments into automotive circularity at scale, both from public and private sources, will help to address the challenge of insufficient access to finance for circular products and services.[79] The lack of consistent categorization, knowledge about their economic and environmental potentials, too little public-private collaboration through research funds, and insufficient application of public procurement hinders investments at scale. Policy must address these gaps to help steer investments into business models aligned with sustainability targets and bridge interim transition cost gaps.

Policy development principle
Circular, low-carbon materials; reuse & remanufacturing

Recommendation 2.1

Establish significant carbon pricing mechanisms to leverage decarbonization potentials of automotive circularity

Barrier
Environmental costs are not reflected in market prices, leading to skewed incentives and decision-making by companies

EU policy options
EU Emissions Trading System (ETS), Carbon Border Adjustment Mechanism

Stakeholders
Miners, refiners, tier 1–3, OEMs

Rationale

The effects of carbon pricing systems on circularity levers will be significant if:

- The emissions of circular materials and business models are substantially lower than those of virgin materials and linear business models.
- A very high carbon price is in place, paired with a Carbon Border Adjustment Mechanism,[80] which protects EU companies from international competition that does not yet internalize carbon costs, including by phasing out free carbon allowances.[81]
- The increased carbon costs are passed on effectively to the manufacturing companies.

A circular scenario in the automotive industry could reduce emissions of up to 75% per passenger kilometre by 2030 compared to baseline scenarios (see Figure 10).[82] The carbon abatement cost curve, developed by McKinsey for the CCI, shows that in the case of BEVs, 97% of material emissions could be abated by 2030, without any net material cost increases. This number is lower for ICEVs, but in both cases a significant carbon price would change the economics of emission abatement costs. For example, in the case of steel, a €100/tonne CO_2 carbon tax is estimated to be necessary to sufficiently promote price competition with hydrogen-based, direct reduced, iron steelmaking[83,84] and increase the attractiveness of high-quality, scrap-based steel.[85]

FIGURE 10 | **Carbon efficiency potentials of automotive circularity in 2030**

Level 3 impacts of pathways (2030) Shift from ICE hatchback (Level 1, 2020) to BEV hatchback (Level 3, 2030)	Carbon efficiency Life-cycle CO2e emissions [g] / passenger km
Energy decarbonization	up to -60%
Material circularity	up to -35%
Lifetime optimization	up to -35%
Utlilization improvement	up to -30%
All four pathways combined	up to -75%

Source: World Economic Forum, 2021, Accenture Strategy analysis

Current status

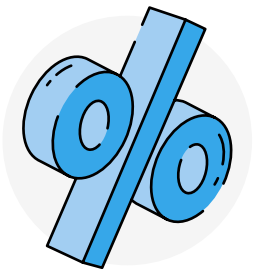
Low prices and large exceptions from carbon mechanisms limit the effects of carbon pricing significantly. Prices in the European Emissions Trading System were on average ~25 EUR per tonne CO_2e in 2019.[86] The introduction of a Carbon Border Adjustment Mechanism is currently being discussed in the EU to avoid carbon leakage and ensure a level playing field. Separate from the upstream emission pricing is the ongoing discussion to integrate transport fuels into the EU Emissions Trading System (ETS). However, various studies have shown that the inclusion of transport fuels into the ETS might fail to result in the desired shifts among consumers and has high risks of causing negative economic and social side effects.[87]

Recommended policy action

EU policy-makers are called to implement an effective Carbon Border Adjustment Mechanism which includes the phasing out of free carbon allowances from the EU ETS as a key intervention to ensure that it effectively influences the uptake of low-carbon, circular materials and services.

Outlook

In the future, it should be explored how the ETS could be amended to allow for more effective, diversified, and targeted interventions. This could include complementing it with additional tools or structuring it into different branches (either on EU-level or member state-level). If designed right, carbon pricing mechanisms can fundamentally impact the economics of circular materials and services, and thereby significantly help to mitigate price premiums.



A circular scenario in the automotive industry could reduce emissions of up to 75% per passenger kilometre by 2030 compared to baseline scenarios.[82]

Policy development principle
Reuse & remanufacturing
Utilization increase

Recommendation 2.2

Implement VAT reductions for circular products and services

Barrier
Consumer preferences and differences in price points mitigate the adoption of circular products and services

EU policy options
Circular Economy Action Plan, Common System of VAT

Stakeholders
Consumers, shared mobility operators, remanufacturers

Rationale

VAT reductions are a common policy tool to propel demand or help businesses obtain more revenue through their sales. They can also be applied to products or services with a lower carbon and resource footprint to eliminate differences in price points. For example, Sweden has lowered the tax for the repair of clothes, bicycles, and other goods.[88] Norway's 0% VAT for electric vehicles, among other incentives, resulted in the country having the highest share of electric vehicles within newly registered cars in Europe.[89] VAT rates across Europe are, on average, about 20% for car-sharing, while rates for taxis and public transport typically benefit from lower rates of around 7% to 10% VAT.[90]

Current status

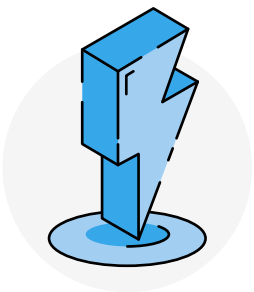
In the EU, VAT is harmonized and member states must oblige with certain rules. At the moment, it is still difficult for countries to reduce VAT for certain products or services based on their environmental impact.[91] The EU's Circular Economy Action Plan already points out that member states should be enabled to use VAT to promote circular products and services, with a focus on repair.[92]

Recommended policy action

VAT reductions should be considered for repair services as well as remanufactured and refurbished products, spare parts with recycled content, and car- and ride-sharing. The European Commission should enable the flexible implementation of VAT changes for environmental reasons, and EU member states are recommended to make use of these to establish pull mechanisms that increase the demand and supply of products or services based on circularity principles. VAT reductions must, however, be based on verifiable, transparent data sources and supply chains to avoid misuse.

Outlook

In the future, EU and member states must move beyond solely utilizing VAT as a taxation mechanism to drive automotive circularity. One central dimension of this will be to develop additional, conducive national taxation systems for the circular economy in general, for example, by shifting taxes from labour to resources and revising company car taxation. Such taxation shifts contribute to a just transition, for example, by creating jobs through fewer labour taxes. These taxation systems are not in the merit of the European Commission or Parliament, but progressive member states can lead the political agenda on updating these systems and the EU can provide guidance and technical assistance to member states.



Norway has a 0% VAT rate for electric vehicles,[89] among other fiscal incentives, leading to one of the highest shares of electric vehicle registrations in Europe.

Policy development principle
Life-cycle-based perspective

Recommendation 2.3

Develop Green Public Procurement (GPP) standards and targets to channel public capital towards automotive circularity

Barrier
Consumer preferences and high transition costs mitigate the adoption of automotive circularity; public capital is not channelled into sustainable businesses to scale demand

EU policy options
GPP criteria and mandatory reporting, Circular Economy Action Plan

Stakeholders
Public institutions, shared mobility operators, OEMs, remanufacturers, recycling facilities

Rationale

In the EU, government spending on goods and services represented around €2 trillion in 2017, accounting for approximately 13.3% of EU's GDP (excluding utilities).[93] Public institutions should use this purchasing power to accelerate automotive circularity by boosting demand and generating certainty for investments.

Current status

Green Public Procurement (GPP) and circular procurement is increasingly discussed in the EU. The Circular Economy Action Plan foresees mandatory reporting on GPP and the proposal of minimum mandatory GPP criteria and targets specified for sectors.

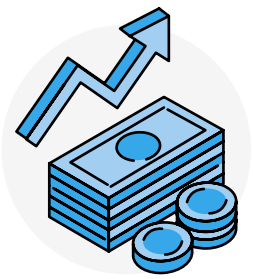
Recommended policy action

GPP for automotive circularity should be tackled through three criteria:

Firstly, to support reuse and remanufacturing, public bodies should purchase repaired, remanufactured, or refurbished vehicle components for the maintenance and repair of public fleets (e.g. as postulated in the US Federal Vehicle Repair Cost Savings Act in 2015[94]). Public institutions should ensure that vehicle end-of-life management is handled by authorized treatment facilities and reporting processes on vehicle disposal are in place.

Secondly, public authorities should stimulate market demand for shared mobility packages by offering these to public sector employees. The city of Bremen, for example, reduced its business trip CO_2 emissions and fleet costs by switching to a local car-sharing service[95] and, in Sweden, several cities promote car-sharing through public contracts.[96]

Finally, once more granular and standardized recycled content data becomes available, public institutions should steer their long-term procurement budgets towards vehicles with minimum recycled material quotas. The EU Clean Vehicles Directive[97] can act as a design model for implementing minimum GPP criteria. As many products create both economic and environmental costs in their use phase and in the end-of-life phase, considering the entire life-cycle impacts would enable a holistic public procurement approach. A good example for a life-cycle analysis in public procurement is the Dutch DuboCalc tool and CO_2 performance ladder.[98]



Government spending in the EU totalled up to 13.3% of GDP in 2017.[93]

Policy development principle
Life-cycle-based perspective

Recommendation 2.4

Leverage the EU Taxonomy to channel capital into circular markets

Barrier
Public subsidies and private investments are insufficiently used to develop and scale circular products and services

EU policy options
EU Taxonomy and Taxonomy Regulation, COVID-19 Recovery Funds, EU Budget

Stakeholders
All stakeholders along the entire value chain from material extraction to recycling and shared mobility providers

> The EU Taxonomy for Circular Economy can help investors, companies, and governments to make well-informed sustainable investments efficiently. The Taxonomy should incorporate a priority order of circular activities to support the application of holistic, high-value circular principles.

Rationale

The EU and national governments can accelerate the transition to a more circular automotive sector with direct investments into research and development of new technologies (e.g. via research grants), infrastructure investments, and by contributing to the funding of technology start-ups and innovative companies (e.g. via accelerator programmes). The enabler markets for automotive circularity (end-of-life recycling, remanufacturing and shared mobility) offer significant investment opportunities over the coming years.[99] Channelling more capital into these markets will improve their technology and processes, support demand, and ultimately raise their profitability. This would increase global competitiveness and develop new key markets in Europe. In the vehicle recycling market, direct investments into battery recycling, automated vehicle dismantling processes, and digital information platforms would bolster the competitiveness and supply of secondary materials. Finance for innovative remanufacturing facility pilots and reverse logistics systems, such as hubs where manufacturers and remanufacturers can work in close collaboration,[100] will support an increased share of remanufactured components in car fleets. In the shared mobility market, investments in the necessary infrastructure and technology (e.g. digital infrastructure and autonomous vehicles), as well as public-private collaboration and marketing, will help mobility providers to develop profitable business models, and grow their market coverage and share.

Current status

Between 2014 and 2017, EU governments and member states subsidized the production and consumption of fossil fuels with €112 billion annually.[101] Re-directing these financial flows and deploying this government spending to accelerate sustainable products and services, such as circular automotive solutions, requires a new approach to public capital allocation. The EU has several suitable finance vehicles and programmes to do so: for example, the European Investment Bank (EIB), Horizon Europe, InvestEU, national development and promotional banks via the Joint Initiative on Circular Economy,[102] and the €750 billion Next Generation EU (NGEU) COVID-19 recovery package. Furthermore, the configuration of the EU Taxonomy for Circular Economy will play an important role in funnelling capital into circular business models by providing a common classification system for environmentally sustainable economic activities.[103] Next to providing guidance for investors on what is classified as circular and clean, it will also link into company reporting through the European Commission on non-financial reporting disclosure. The circular economy transition is one of six environmental objectives of the Taxonomy, in which the initial, detailed, technical screening criteria for circularity are expected to be published in Q2/Q3 of 2021 (and enter into company reporting in January 2023). The criteria is expected to be closely aligned with the ISO standards on Circular Economy (ISO/TC 323) which are currently under development.[104] To support the development of the circularity criteria of the Taxonomy, the European Commission's Support to Circular Economy Financing Expert Group has published a sector-agnostic categorization system which sets a generic baseline for a circular economy taxonomy.[105]

Recommended policy action

EU policy-makers should follow these two recommendations to support public and private investment flows into enabling markets for automotive circularity:

Firstly, EU policy-makers should develop a coherent EU circularity classification to create investment certainty and support investors and companies with a sustainability mandate to make well-informed investments efficiently and at scale. One issue with the EU Taxonomy efforts so far is that it is yet to cover all industries in sufficient detail. Given the importance of the automotive sector in Europe, the Taxonomy should look to cover all economic activities that substantially contribute to the transition to a circular automotive sector (compare economic activities for climate change mitigation in EU Taxonomy).[106] These activities should particularly include: the maintenance and repair of vehicles; reuse, remanufacturing, and refurbishment of car parts; recycling of end-of-life vehicles and batteries; shared mobility; and other enabling activities, such as design for circularity, reverse logistics, and digital infrastructure.

The technical screening criteria also need to account for the differences in performance of circularity levers: the criteria should incorporate hierarchies of circular economy principles, for example, that remanufacturing is more thermodynamically efficient than recycling.[107]

Secondly, EU and member states should consistently use the EU Taxonomy to channel public subsidies and incentivize private investment for automotive circularity markets. Companies along the value chain must be provided with access to financing and government support, with a specific focus on business activities that support the development of a circular car economy. COVID-19 recovery funds will be distributed before the EU Taxonomy for Circular Economy is published, but EU policy-makers can still use this opportunity to provide financial capital to enabling markets, followed by a more stringent application of the EU Taxonomy in future capital allocations.

Recommendation 2.5

Policy development principle
Utilization increase

Support the establishment of conducive pricing systems for shared mobility

Barrier
Current pricing systems overly incentivize the use of individual cars as they are often based on favourable taxation systems and infrastructure costs are not internalized sufficiently

EU policy options
Urban Mobility Package

Stakeholders
Shared mobility providers, parking operators, consumers, OEMs

Rationale

Price competitiveness of sustainable transport modes in comparison to private vehicle use significantly impacts the transport choice of consumers. Current taxation and fee systems are unable to support increased occupancy of vehicle fleets. Reshaping these systems is expected to shift consumer decisions and behavioural patterns, with a goal of reducing transport-related CO_2 emissions and resource use through an increase in shared mobility.[108]

Current status

Many fees and insurances for private vehicles are pre-paid annually or monthly, leading to a significant underestimation (of up to 50%) of the costs of individual car ownership.[109] Shared mobility offers, on the other hand, are usually paid on a per-trip basis. The price for shared mobility is subject to (on average) 20% VAT in the EU, while costs for resident on-street parking are often surprisingly low (e.g. a maximum of €30 in Germany per year, as per national regulation).[110] The infrastructure (or road) costs of individual car ownership are mainly (with the exemption of highway and some bridge or tunnel tolls) covered by the government, representing another cost externality which is not reflected visibly in prices. These cost structures lead to externalized or lower perceived costs of private vehicles, and therefore excessive use.

Recommended policy action

Pricing structures of private vehicle use and shared mobility must be changed to incentivize increased occupancy of vehicles. As the EU does not have a mandate in most of these pricing aspects (with VAT as exemption), EU policy-makers should use the Urban Mobility Package to raise awareness and offer guidance and technical assistance on national and local policy measures. Member states and local governments should evaluate the possibilities to increase resident parking fees for private vehicles (with potential exemptions if these are offered for peer-to-peer car sharing), lower toll fees for shared vehicles,[111] and evaluate the possibilities to reduce VAT for shared mobility. It is, however, important to consider the social effects of changes in access to mobility and excessive impacts on economically disadvantaged societal groups.

4.3 Harmonize and strengthen existing measures

The third policy action area concentrates on the harmonization and strengthening of effective legislations to increase their impact.

The current EU circularity-related policy framework was developed in line with a linear automotive industry, in which vehicles are sold as products and policy focuses on safe use and disposal. As such, some policies are not designed to induce a productive, circular automotive system which maximizes value and minimizes environmental footprints across vehicle lifetimes. While there are several powerful policies in place (such as end-of-life policies), there is still room for improvement, especially in adhering to the extended producer responsibility concept. This policy action area identifies these improvement potentials with a focus on the ELV Directive (see Appendix C for more information on the ELV Directive's evaluation), the Battery Regulation proposal, and the Urban Mobility Package.

Policy development principle
Circular, low-carbon materials; reuse & remanufacturing

Recommendation 3.1

Improve the ELV Directive by including targets for specific value-retention processes

Barrier
The ELV Directive predominantly promotes recycling as no separate targets for specific value-retention processes (refurbishing, remanufacturing, etc.) exist

EU policy options
ELV Directive, Waste Framework Directive

Stakeholders
Remanufacturers, workshops, collectors, part dealers, dismantlers, shredding, separation and recycling facilities

Rationale

Value-retention processes (reuse, remanufacturing and refurbishment, etc.) have a better carbon and resource footprint than recycling. For example, remanufacturing can reduce emissions by 70% to 90% compared to new production.[112] Setting specific targets for value-retention processes in the ELV Directive should lead to their uptake and thereby unlock cost savings, and reduce the environmental impact of vehicle repair and production.

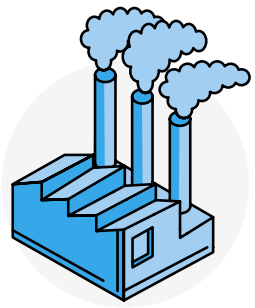
Current status

With an average of 11.5 years of age (in the EU), cars' longevity is higher than that of most other products. Reuse, repair, and remanufacturing of vehicles and vehicle parts are already an important part of the automotive industry's value chain but are not conducted at thec scale necessary to align the automotive industry with a low-carbon, resource-efficient mobility system. Figure 11 signals the potential of the automotive industry to accelerate the uptake of these value-retention processes and the possibility of policy to incentivize this (with a focus on extending the lifetimes of BEVs to enable replacement of ICEV fleets).

Recommended policy action

The ELV Directive should be adjusted to include the specific acknowledgement of value-retention processes (e.g. reuse, repair, refurbishment and remanufacturing).[113]

The ELV Directive establishes two targets, for reuse and recovery, and for reuse and recycling.[114] While the attainment of higher value-retention processes falls under the reuse definition, the specific processes (e.g. refurbishment and remanufacturing) are neither specifically mentioned in the ELV Directive,[112] nor do they have separate targets. Their explicit integration has also been hindered by

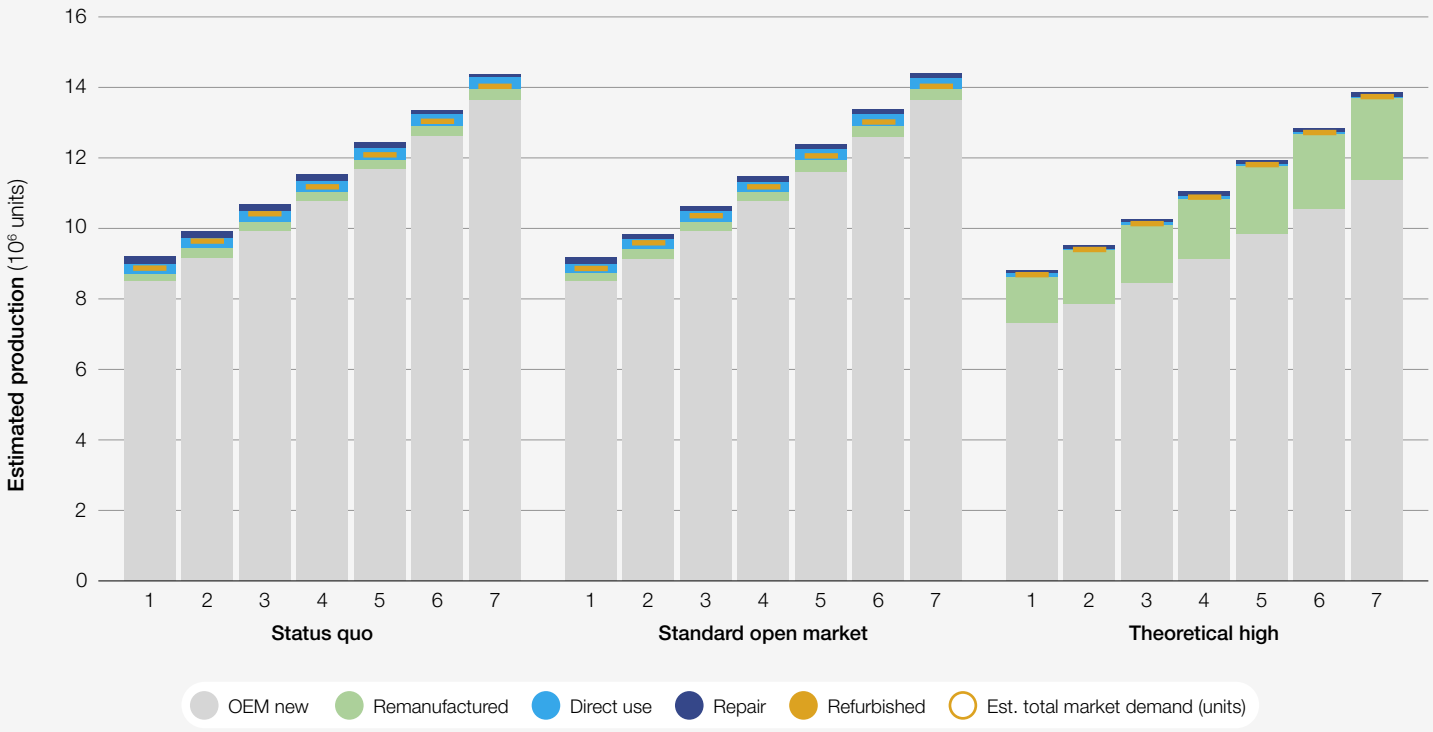


Remanufacturing can reduce emissions by 70% to 90% compared to new production.[112]

the lack of clear definitions on the waste status of vehicles, which is currently covered in the Waste Framework Directive and implemented differently by member states. Remanufacturing, for example, is not explicitly mentioned in the ELV Directive as an end-of-life activity, even though it falls under the reuse and recovery targets of the Directive. As remanufacturing of parts may take place across the vehicle life-cycle, the clear attribution to the vehicle's end-of-life is difficult.[115]

The ELV Directive needs to be revised in alignment with the Waste Framework Directive and related Waste Shipment Regulation[116] now being reviewed to allow for the differentiation between the waste and non-waste status of vehicle parts, depending on the condition of the dismantled parts. This will enable the alignment of the ELV Directive with the waste management hierarchy of the EU[117] and the inclusion of specific targets[118] for high-value recovery strategies to improve carbon and resource efficiency.

FIGURE 11 **Estimated German production of vehicle parts relative to estimated demand in Germany over a seven-year scenario**



Source: International Resource Panel, 2018

Policy development principle
Circular, low-carbon materials

Recommendation 3.2

Strengthen recovery targets through specification based on material type and quality of recovery

Barrier
Undifferentiated targets and lack of requirements for quality of recyclates lead to strong downcycling and loss of all but the most economically viable recyclates

EU policy options
ELV Directive, Battery Regulation

Stakeholders
Remanufacturers, workshops, collectors, part dealers, dismantlers, shredding facilities, separation facilities, recycling facilities

Rationale

Steel, aluminium, and plastic are the biggest drivers of carbon emissions from materials in ICEVs (see Figure 12). With the shift to BEVs, battery material emissions become crucial. Leveraging circular principles to decarbonize these materials must therefore be a policy priority and high-value recycling is essential to achieve this. The change from product weight-based recovery rates to those differentiated by material-type and the requirement of minimum material qualities are key to limit the downcycling of vehicle materials. This policy change will accelerate the supply of high-quality recyclates that can be used for higher value applications including vehicle production and will support investments for a large-scale industrial recycling market. This needs to happen in close alignment with the life-cycle analysis and the set-up of new data infrastructure, and must account for pan-European differences in the recycling industries.

Improving the quality of recovered steel recyclates (in particular, by preventing copper contamination) would increase the recycled steel's value and reusability.[119] It could indirectly support investments in scrap-based EAFs which can be powered through renewable energy sources.[120] Leveraging vehicle recycling for green steel production also accelerates its adoption across industries, as the automotive industry's share of the global steel market (12%) provides a critical impulse to initiate market growth. For battery materials, high-value recycling is similarly important, as the mining of these critical raw materials is not only very resource- and energy-intensive but also prone to human right risks and geopolitical dependencies. Other materials, especially aluminium, would undergo similar effects if recovery rates are adapted according to material type and quality.

Current status

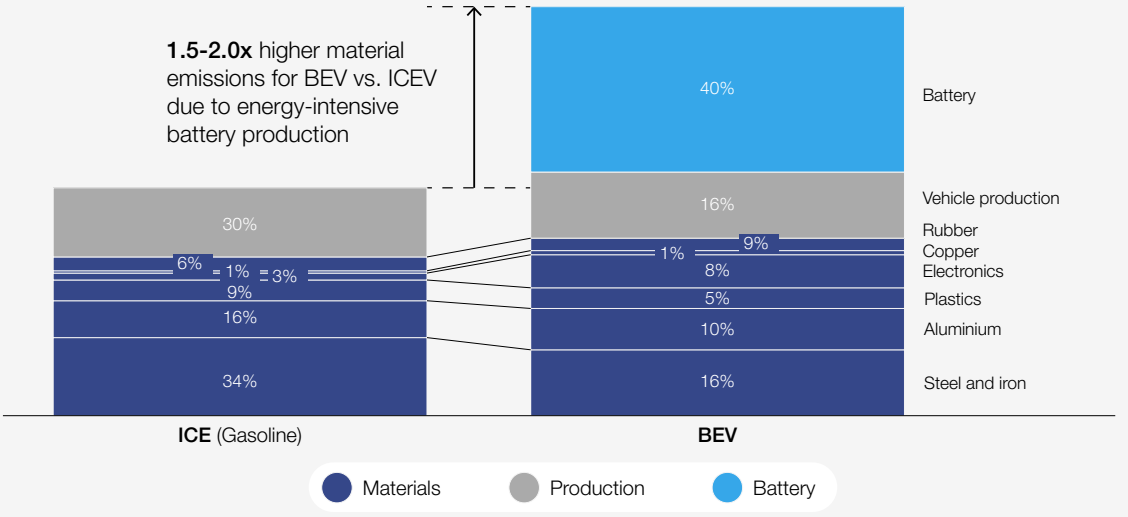
88% of the weight of a car's materials are currently recovered in Europe; of that, steel accounts for the biggest share, as it typically comprises 50-65% of the vehicle's weight.[121,122] However, due to pollution with copper and other materials, the recovered steel is mainly downcycled into lower value construction steel. As this cannot replace high-quality steel, greenhouse gas (GHG) emissions are not reduced when looking at the automotive industry individually, though there is a positive impact on the economy's overall CO_2 footprint. In addition, until the coming-in-force of the EU Battery Regulation, vehicle lithium-ion batteries are not covered by the Battery Directive's recycling requirement but are instead considered part of the vehicle under the ELV Directive. This lack of specific recovery targets for traction battery materials, steel, and other critical vehicle materials results in downcycling and loss of the most valuable materials.

Recommended policy action

The revision of the ELV Directive needs to link recovery quotas to material type (battery materials,[123] steel, aluminium, and plastic)[124] and specify the quality of recovered materials. The European Commission has set a blueprint for such regulation with the proposal of the new Battery Regulation which considers the whole life-cycle, plus environmental and human rights impacts, and already foresees the adoption of recovery rates differentiated by material types.[125] Even in the Commission's Battery Regulation draft, however, definitions and target requirements for the quality of recyclates are absent.[126] The recovery targets proposed by the draft Battery Regulation are ambitious for the most important battery materials, but for lithium they are below the industrially achievable and thermo-dynamically sensible rates. To address these shortcomings, the Circular Economy Initiative Deutschland (CEID) has proposed detailed definitions for scope and key terms related to battery recycling.[127] The Battery Regulation must be adopted with the proposed concepts, but with a focus on strengthening the recycling industry's capability to extract lithium and to achieve high qualities of recovered battery materials. The ELV Directive should follow a similar progressive path and include both recovery targets for important materials (steel, aluminium, plastic), as well as quality requirements for recyclates while reflecting pan-European differences in the structure of the recycling industry. This will enable material circularity for the complete vehicle and provide consistent policy-making across directives.

FIGURE 12 | **Material emissions in ICEVs and BEVs**

Material emissions



Source: World Economic Forum, 2021

Policy development principle
Circular, low-carbon materials

Recommendation 3.3

Set appropriate content quotas for selected recycled materials and require transparency of recyclates rates

Barrier
Virgin materials are used for most of the vehicle due to high prices of secondary materials and limited availability

EU policy options
ELV Directive, Battery Regulation

Stakeholders
Recycling facilities, tier 1–3 suppliers, OEMs

Rationale

The use of secondary materials for vehicle production is a fundamental pathway to avoid excessive use of finite natural resources. At the same time, it minimizes waste at the vehicles' end-of-life and, for many materials (especially metals, but less often hydrocarbons, i.e. plastics), emissions from their production, too. A transparent and well-developed market for recyclates could increase demand for quality recycled content. This would lead to additional investments into the recycling market, supporting the development of a stable, competitive market that supplies high-quality secondary materials to the manufacturing industries at scale.

Current status

While many OEMs (e.g. Daimler, BMW, Nissan) have set targets for the use of secondary materials, the industry is still far from operating in a closed-loop system, in the sense that significant amounts of materials are recovered at high qualities.[128, 129, 130] Several barriers hinder the use of secondary materials at scale: for example, they are often more expensive than virgin materials.[131] Moreover, the availability of high-quality recyclates is limited as steel and plastics, especially, are downcycled.[132] Only 30% of plastics across industries are recycled and only 6% of demand is met through secondary plastic.[133] The recycling of critical battery materials suffers from low battery collection rates, insufficient recyclates quality, and uneconomic recovery processes.[134] The absence of sufficient volumes and qualities of recycling inputs increases the costs of recycling, and creates lower and varying output qualities which, in turn, lead to limited demand, creating a vicious circle.

> Recycled content quotas for cars can help to break the vicious circle of uneconomic material recovery processes, high prices, low quality of secondary materials, and limited demand.

Recommended policy action

In order to break this negative feedback loop, disclosure of the share of recyclates used in a product should be required and mandatory recycled content quotas for selected materials (focusing on battery materials, steel, aluminium, copper, and plastics) should be phased in carefully. This has been proposed in the EU commission's 2020 draft of the new EU Battery Regulation[135] and should be considered in analogue for the revision of the ELV Directive to cover all crucial materials. Continuous revision of the content quotas should be mandated. Recycled content mandates are currently rare in legislative pieces across the globe.[136] Examples of existing policies are the EU Battery Regulation proposal and laws for recycled content in plastic bottles in the EU.[137, 138] Critics note that recycled content mandates are difficult to implement and track due to the unavailability of secondary materials,[139] lack of distinguishability, and risk of international competition.[140, 141] However, current technological developments (such as machine learning, digital twins and distributed ledgers) in material tracking and the creation of standardized calculation methods for high-quality recycled content can mitigate these challenges. In addition, the combination of material-specific recovery targets and carefully defined recycled content mandates will help to avoid risks of insufficient secondary material supply.

Recommendation 3.4

Optimize end-of-life vehicle (de-)registration

Policy development principle
Circular, low-carbon materials; Reuse & remanufacture

Barrier
One-third of vehicles in the EU end up in unknown whereabouts, resulting in loss of valuable materials and potential hazards to public health and the environment

EU policy options
ELV Directive

Stakeholders
OEMs, remanufacturers, workshops, collectors, part dealers, dismantlers, shredding, separation and recycling facilities

Rationale

Minimizing the illegal and low-quality treatment of all end-of-life vehicles enables environmentally sound de-pollution and supports the formal recycling market's economics.[142] The automotive sector suffers from the high costs of environmentally sound de-pollution and recycling, and thus faces high competition from illegal end-of-life vehicle treatment facilities and illegal exports of end-of-life vehicles to other countries (see Appendix C). By reducing these activities, the sector will experience less economic pressure, which in turn reduces the risk of improper treatment and contributes to less environmental harm and resource use.[143]

Current status

Roughly **1/3** vehicles registered in the EU end up in unknown whereabouts[145]

Studies for the European Commission identified an annual gap of approximately 4 million vehicles with unknown whereabouts each year,[144, 145] accounting for roughly one-third of all end-of-life vehicles in the EU.[146] A substantial share of these vehicles is likely to be illegally treated or exported. End-of-life vehicles that are improperly handled can be hazardous to workers, the public, and the environment. Toxic materials from electronic waste treatment can cause neurological damage in humans and other organisms if they leak into the environment, and improper end-of-life treatment reduces the amount of available and high-quality circular materials.[147] Valuable materials are permanently lost if not collected, resulting in significant environmental and economic costs.[148] With the transition to BEVs, the importance of reducing the number of unknown vehicle whereabouts becomes even more critical: for example, the material circularity of batteries could reduce up to 20% of net cost over their life-cycle.[149] However, the current predominant business model of vehicle manufacturers and legislative frameworks do not sufficiently incentivize the tracing of vehicles' whereabouts, and the safe treatment thereof. BEVs have a higher end-of-life value and so the risk of missing vehicles may decrease if better battery tracking and new ownership structures are established.[150]

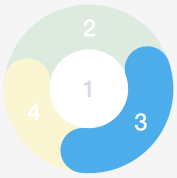
At the moment, the ELV Directive demands that a certificate of destruction (CoD) is presented to the relevant authorities when a vehicle has been treated at an end-of-life facility. However, the implementation of this differs between member states and is often not linked directly to the de-registration of vehicles.

Recommended policy action

Increase the effectiveness of vehicle (de-)registration frameworks, including linking them to financial incentives, as part of the ELV Directive to reduce the number of unknown whereabouts.[151] This should reliably direct all end-of-life vehicles to licensed treatment facilities[152] by ensuring their registration is only permanently cancelled if an adequate proof is provided (e.g. CoD, export or theft).[153] The ELV Directive must introduce strict, harmonized guidelines for (de-)registration procedures to prevent illegal treatment and disposal across the EU.[154] Ensuring that national registration systems are interlinked transnationally would increase the effectiveness and achieve equal environmental protection across countries.

Member states should be demanded to additionally introduce financial incentives as part of vehicle (de-)registration frameworks. While this applies across Europe, application is especially needed in states with higher-than-average shares of used vehicles, such as some Eastern European countries. Financial penalties, such as in Portugal, where a vehicle tax is collected until a CoD is presented, are a good example.[155] Denmark, in contrast, applies a pay-out to citizens who hand over an end-of-life vehicle to a licensed treatment facility, and the Netherlands applies a strict registration system where a CoD is a prerequisite to deregister a vehicle.[156]

Recommendation 3.5



Policy development principle
Reuse & remanufacturing

Improve certification systems and information access for reused, refurbished, and remanufactured parts

Barrier
Information asymmetry (quality certification and information access to vehicle parts repair) limits the widespread use of remanufactured vehicle parts

EU policy options
Regulation on access to vehicle repair and maintenance information, certification systems

Stakeholders
Remanufacturers, workshops, collectors, parts dealers, dismantlers, tier 1–3, OEMs

Rationale

Compared to new spare parts, remanufactured parts can result in cost savings of 20% and entail significant carbon and resource savings.[157] In a future circular scenario, remanufactured parts should be a common option for new vehicle production where possible, and regularly used for repair operations in workshops.[158] The right policy framework can pave the way towards such a scenario. Especially for BEVs, the relevance of remanufacturing and refurbishment will increase due to the importance of extending vehicles' lifetimes to distribute their environmental footprint (from production) across more kilometres. Extending the lifetime of ICEVs should not be a policy priority as most of these vehicles' emissions take place during use and transition to BEVs should be the focus.

Current status

Within the EU, 22 million remanufactured units are produced annually, with an approximate split between Tier 1, independent, and OEM remanufacturers of 38%, 48% and 14% respectively.[159] However, products are becoming increasingly complex and access to technical information to enable remanufacturing is a challenge. As shown in Figure 11, the market share of remanufactured vehicle parts still has significant potential to grow.

Recommended policy action

EU policy-makers should promote remanufacturing and refurbishment practices in two ways: by improving access to information; and supporting the ongoing development of harmonized global certification systems of remanufactured and refurbished parts.

Adapting information access for remanufacturers and customers is key. The regulation on *Access to vehicle repair and maintenance information* in the EU obliges OEMs to transfer vehicle repair and dismantling information using the International Dismantling Information System (IDIS) but the transfer of repair information is only mandatory for the vehicle as a whole, rather than its parts. This could be adapted to include refurbishment, remanufacturing, and repair-related information on a parts level. Moreover, accessing the information incurs a fee for dismantling and remanufacturing companies.[160] Improving this information access to facilitate the operations of dismantlers and remanufacturers is crucial.[161] Requiring workshops to offer customers a choice between a new spare part and a circular part is another policy option which has been implemented successfully in France, leading to a substantially increased demand for circular components, and this could be adopted by other EU member states.

EU policy-makers should also mandate and support the establishment of standardized, widely used certification systems of the environmental impact and quality of refurbished and remanufactured parts. This could improve customer awareness and trust to stimulate demand, and support the emergence of a scaled market for quality refurbished and remanufactured parts. Certification systems for remanufactured parts must be developed as stand-alone standards, assuring the safety, quality, functionality, and environmental benefits of the part. Existing fora, such as the World Forum for Harmonization of Vehicle Regulations (WP.29) of the UN (to which the EU actively participates and contributes) could be used as basis for such harmonized requirements, as is already the case for rethreaded tyres (in UN Regulations No.108 and 109 for light and heavy vehicles). Such standards or regulations should be designed without creating unnecessary market barriers by being excessively strict (for example, by requiring the identical functionality and performance requirements as newly produced parts). Improving certification systems for remanufactured parts is closely linked to the integration of value-retention processes and their definitions and targets in the revision of the ELV Directive. Relevant adjacent actors like industry consortia (e.g. for remanufactured parts) or insurance companies should be engaged to ensure applicability in practice.

Recommendation 3.6

Policy development principle
Utilization increase

Create harmonized legal frameworks and vehicle access regulations to support shared mobility

Barrier
Varying local conditions (legal frameworks and spatial planning) for shared mobility hinder profitability and scalability of business models

EU policy options
Urban Mobility Package

Stakeholders
Shared mobility providers, parking operators, consumers, OEMs

Rationale

Shared mobility (ride-sharing or car-sharing[162]) represents one of the main opportunities to enable low-emission road transport and material efficiency since it can reduce the total vehicle stock required to meet mobility demand.[163] According to the UN International Resource Panel (IRP), material cycle emissions could be reduced by 13% to 20% in the G7 if 25% of all rides were shared. Shared mobility offers can be designed to complement public transit offers, reduce empty trips and increase uptake of high-occupancy rides while providing an opportunity to lower structural lock-ins into individual mobility.[164] Thereby, they can charter a way to more intermodal, integrated mobility systems. These findings do not apply to ride-hailing which has recently been found to increase emissions and overall traffic volume, and rarely replaces individual car ownership.[165, 166]

Current status

The current operating framework for shared mobility providers is challenging. The conditions still vary widely depending on national and local conditions, as legal authority for policy decisions rests at city or member state level. This difficulty in decision and regulation sovereignty complicates the operations of shared mobility providers and hinders improved access. The most comprehensive policy tool on this topic at the EU level is the European Commission's Urban Mobility Package which provides supporting tools for urban areas by, for example, giving guidance and access to funding for the development of Sustainable Urban Mobility Plans.[167] The new EU mobility strategy foresees a revision of this initiative in 2021.[168] The impact assessment of the Urban Mobility Package concluded that, while funding and knowledge sharing was helpful and resulted in the adoption of sustainable urban mobility plans across Europe, the measures did not lead to the necessary changes in urban mobility emissions, air pollution, and road safety.[169] At the same time, various progressive cities have started to implement vehicle access approaches but these are predominantly focusing on low-emission vehicles and differ widely depending on the local context. To address this, the Horizon 2020 project ReVeAL supports a comprehensive approach to vehicle access regulation by aiming to standardize and disseminate these instruments to cities across Europe.[170]

Recommended policy action

Policy incentives to promote shared mobility through improved legal frameworks and vehicle access regulations should be specifically integrated in the new Urban Mobility Package by tackling the following facets through more binding measures:

First, EU-level policy-makers should support member states in implementing conducive legal frameworks for shared mobility by coordinating dialogues and creating best practice regulatory frameworks as guidance. The legislative frameworks in the member states are very diverse

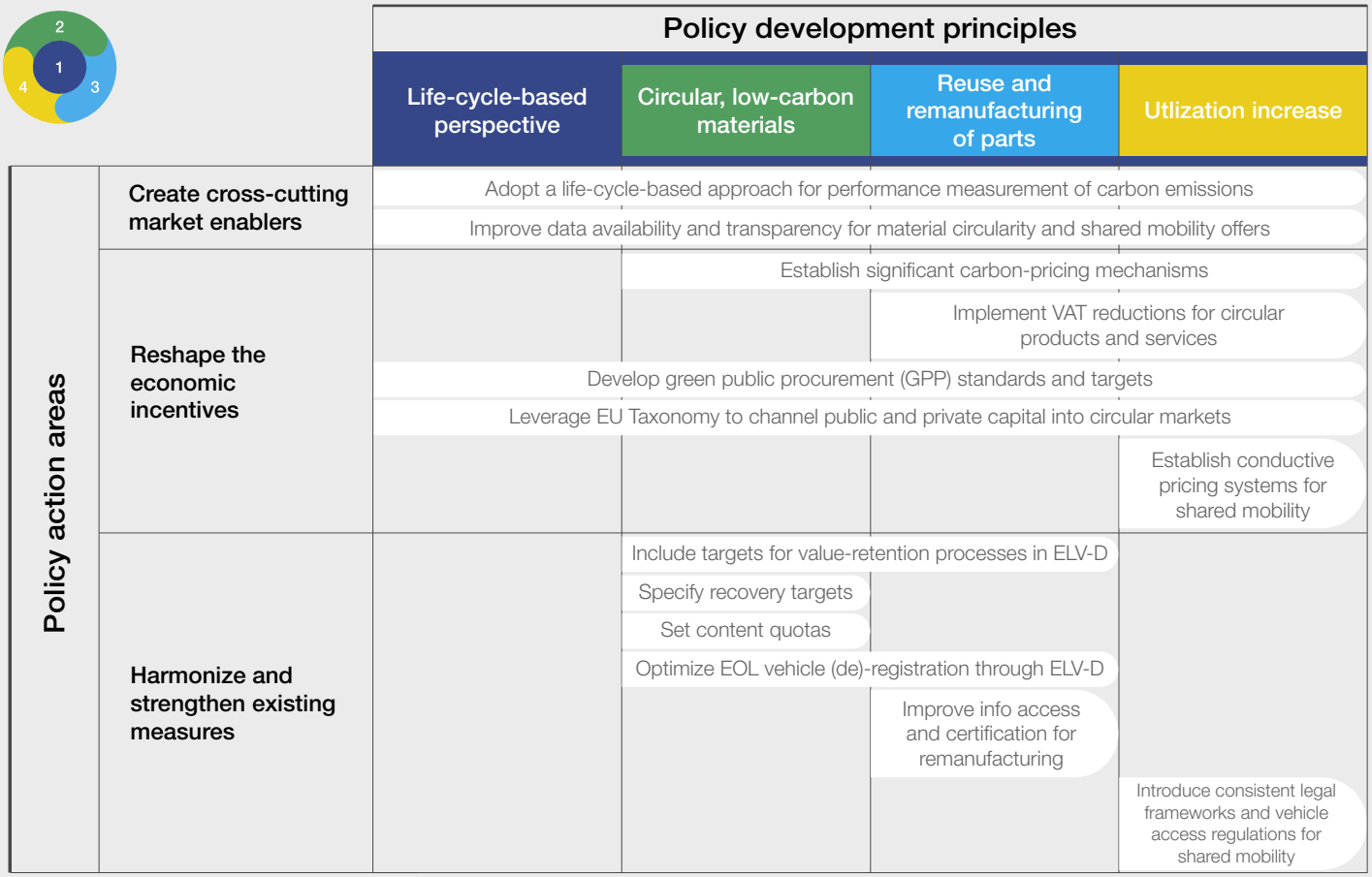
> A harmonized approach to support shared mobility across Europe must be fostered to unlock carbon and resource efficiency potentials of car-based mobility.

and mostly lack conducive mechanisms for shared mobility. An example of this is the revision of Germany's Passenger Transportation Act (PBefG). In the recently adopted act (March 2021), three different types of services (taxi, pooling and rental) are classified, which is a step that paves the way towards new, shared mobility providers. Pooling, for example, now has a defined legal form for the first time. However, ride-sharing providers are still obliged to return to their 'headquarters' when they have no customer requests which hinders potential efficiency gains from their technological solutions.[171] To act on the science-based facts of the CO_2 reduction potential of shared mobility, a level playing field between established mobility providers (e.g. taxis) and new, resource-efficient services must be created in member states through appropriate legal frameworks. This should avoid the establishment of counterproductive measures, such as 'back-to-garage' rules, which undermine business models based on innovative, efficient route optimization and create the need for unnecessary journeys. The social effects (especially regarding access to jobs) of such legislative revisions should be considered and minimized.

Secondly, the Urban Mobility Package should raise awareness and offer guidance and funding on vehicle access regulation for shared mobility. New spatial planning measures, such as high occupancy vehicle lanes,[172] parking spaces for shared vehicles, temporal and spatial access restrictions, and connections to mass transit in urban planning must be rolled-out across the EU, not just in several cities. Cities' ability to integrate such measures can be supported through funding (e.g. for access to legal assistance). The European Commission should orchestrate such favourable framework conditions for shared mobility and support cities with local implementation as part of the revised Urban Mobility Package. The Package could include targets in combination with funding access through Horizon Europe for cities and member states that adopt shared mobility incentives.

The recommendations presented here are meant as a complementary contribution to the work of other organizations that support the adoption of conducive policy tools for shared mobility: the Global New Mobility Coalition[173] amplifies the path towards shared, electric, and autonomous mobility by coordinating public and private actors, and promoting the adoption of a specific set of policy instruments. In the EU, POLIS[174] and the Covenant of Mayors for Climate and Energy Europe[175] exemplify the collective power of local and regional action to achieve European targets.

FIGURE 13 **Overview of policy recommendations**



Source: SYSTEMIQ

ELV-D = End-of-Life Vehicles Directive

5 Conclusion

The EU Policy Action Framework proposed in this paper supports decision-makers to accelerate automotive circularity.

A rethink of the role of policy among automotive value chain players is required: instead of holding up the status quo, policy must drive progressive interventions to pave the way for a low-carbon, resource-efficient future.

Using the European Green Deal and COVID-19 recovery momentum to reset the automotive industry requires a rethink of the role of policy among automotive players: instead of upholding the status quo, policy support must drive progressive dynamics on the road to a low-carbon, resource-efficient future. Automotive pioneers along the value chain are called upon to co-shape and drive these developments by advocating for the recommended policy measures with a united voice.

Considering the various current EU legislative revisions, recovery fund distributions, as well as this year's COP26 climate conference and G7 summit, and many other intervention points in 2021 and 2022, the current window of opportunity is extensive (see Figure 13) but will soon narrow. Missing this opportunity risks locking in legacy structures that will not be competitive in the emerging low-carbon economy and would lead to substantial write-downs and job-losses in the near future. Stakeholders across the ecosystem are thus called to steer the automotive industry onto a path that enables vehicles to be a part of a low-carbon, resource-efficient, intermodal mobility system – and thereby increase their chances to be ready for 21st century economic developments.

As a priority, EU and member state policy-makers must act now on the points in Table 1 to set the benefits of a circular automotive industry in motion. Five policy interventions are highlighted as priorities due to their high relevance for automotive circularity as well as urgency based on the EU's policy processes.

In summary, the policy recommendations outlined in this report charter a way towards the transition to a circular, low-carbon and resource-productive automotive sector, as part of a smart and sustainable mobility system. The CCI community calls on EU policy-makers to take bold action and is looking forward to collaborating with stakeholders and policy-makers across the value chain to support this.

TABLE 1 **Overview of EU Policy Action for Automotive Circularity**

EU policy tool	Lock-in moment	Recommendation summary
CO_2 emission performance standards	Revision of post-2021 targets Q2/2021	Ensure that the standards are revised in line with the updated EU climate targets, and require standardized vehicle LCA disclosure to prepare the legislation to incorporate full vehicle life-cycle emissions in the next revision (see recommendation 1.1).
Battery Regulation	Parliament and council adoption Q4/2021 – Q1/2022	Adopt the proposal in its ambitious form, in particular increasing ambition levels in the intended recovery quote for lithium and linking recovery quotas to clear definitions and system boundaries which reflect the physical closure of the metal loops. In addition, upholding the intended requirement for digital disclosure of location-specific product carbon footprint to kick-off life-cycle-based performance measurement in Extended Producer Responsibility (EPR) policies (see recommendation 1.1 and 3.2/3.3).
Urban Mobility Package	Revision Q3/2021	Support cities in maximizing the carbon and resource benefits of shared mobility options. Help member states to create and harmonize suitable conditions, such as national legal frameworks, vehicle access regulations (e.g. spatial planning instruments like high-occupancy vehicle lanes), and conducive pricing systems (see recommendation 2.5 and 3.6).
EU Taxonomy for Circular Economy	Q4/2021	Develop an ambitious EU Taxonomy for Circular Economy supporting high-value circularity processes to channel public and private capital into solutions for automotive circularity (see recommendation 2.4).
Green Public Procurement	2021	Develop Green Public Procurement standards for the public purchase of repaired, remanufactured, or refurbished vehicle parts, shared mobility packages for public sector employees and, in the long-term, procurement of vehicles with a certain quota of recycled materials (see recommendation 2.3).
EU Emissions Trading System and Carbon Border Adjustment Mechanism	2021/2022	Implement an effective Carbon Border Adjustment Mechanism including phased out free allowances to ensure that the EU Emissions Trading System effectively influences the uptake of circular materials and services (see recommendation 2.1).
End-of-Life Vehicles Directive	2021/2022	Revise to take a life-cycle perspective that enables circularity more effectively: including specific targets for additional value-retention processes (e.g. remanufacturing), material recovery targets by material type and quality, content quotas for the use of recycled materials in vehicles, and effective vehicle (de)-registration systems to reduce the number of missing vehicles (see recommendation 3.1-3.4).
European Green Deal and Mobility Data Space	Ongoing	Collaborate with all stakeholders to develop European (Mobility and European Green Deal) Data Spaces and product passports for better information availability for circularity and multi-modal mobility (see recommendation 1.2).
EU's Common System of Value Added Tax	Ongoing	Enable VAT reductions for repair services as well as remanufactured and refurbished products, spare parts with recycled content, and car- and ride-sharing.
Information Access and Certification for Re-manufacturing	Ongoing	EU policy-makers should promote remanufacturing and refurbishment by improving the access to information and further supporting the ongoing development of harmonized global certification systems of remanufactured and refurbished parts.

Priority policy interventions

Appendix

Appendix A: Summary of automotive circularity policy landscape

The recommendations of the CCI EU policy paper are based on an extensive analysis of the current policy landscape related to automotive circularity. Appendix A summarizes the main learnings from this analysis and Appendix D provides an overview on each of the evaluated policies.

Policy tools for automotive circularity

An optimal policy mix that creates conducive framework conditions for circular products and services entails fiscal measures, regulations and standards, public procurement and infrastructure aspects, public investments, collaboration platforms (such as public-private-partnerships and research projects), as well as educative and informative tools. These measures can be implemented on a mandatory or voluntary basis.[176]

Policy for automotive circularity covers all types of policy tools: some policy interventions are purely aimed at promoting automotive circularity, while others have only indirect effects (see Figure 14 for selected examples). Generally, policy tools to accelerate the clean energy and electromobility transition (such as subsidies, taxes, registration rights and urban policies) have already been used extensively. An overview of policy tools used in other mobility-related areas that could be adopted for automotive circularity can be found in the Circular Cars Initiative's policy research agenda.[177]

FIGURE 14 **Policy tool overview**

Instrument	Description	Example
Strategic	– Coordinated policy strategy – Specific targets	– Roadmaps, mobility strategies
Regulatory	– Statutory regulations and standards	– CO_2 emission performance assessment – End-of-Life Vehicles Directive
Economic	– Fiscal/economic measures	– Reduced VAT – Carbon pricing schemes
	– Public procurement and investment	– Investment in end-of-life infrastructure – Shared fleets
	– Research funding	– Horizon 2020, Horizon Europe
Information	– Material flow data, mobility data	– Collaboration platforms via public-private-partnerships – Integrated multi-modal mobility platforms
	– Educative and informative tools	– Information on emissions per trip taken – Transparency on recycled materials

Source: SYSTEMIQ based on van Ewijk 2018

A circular economy is increasingly part of national policy agendas

Policies for a circular economy span multiple sectors and simultaneously entail specific implications for diverse industries. A holistic, top-down circular economy framework can enable a systemic approach to sectoral policies. In this vein, a variety of local, national, and international circular economy policy frameworks have been

developed and established all over the world.[178] Various policy instruments, ranging from fiscal measures and regulations, to investment proposals and informative tools, are used. At the national level, countries such as China, Japan,[179] Denmark,[180] Finland,[181] France,[182] Greece,[183] Scotland,[184] and the Netherlands[185] have issued circular economy strategies.[186,187] China, for instance, has undertaken incremental steps to evolve early individual laws into the *Circular Economy Promotion Law*[188] in 2009 and the *Circular Economy Development Strategy and Immediate Plan of Action* 2013.[189] These resulted in the implementation of a more comprehensive set of circular economy policies in the respective five year plans.[190] In the European Union, circular economy is increasingly adopted in legislations subsumed under the new Circular Economy Action Plan 2020, which builds on the first Circular Economy Action Plan from 2015, as one of the main pillars of the European Green Deal.[191]

Circular economy roadmaps have implications for various topics and sectors. In the case of automotive circularity, these cross-topic influences particularly address industrial strategies and mobility systems. For example, the European Union Circular Economy Action Plan pinpoints batteries and vehicles as two key value chains. Moreover, automotive circularity entails implications for mobility strategies, as a circular approach to the automotive industry requires a stronger embedding of vehicles in a multi-modal mobility system. This interrelation is also mirrored in the uptake of circular economy topics in transport policy roadmaps, for example, in the EU's Sustainable and Smart Mobility Strategy.[192]

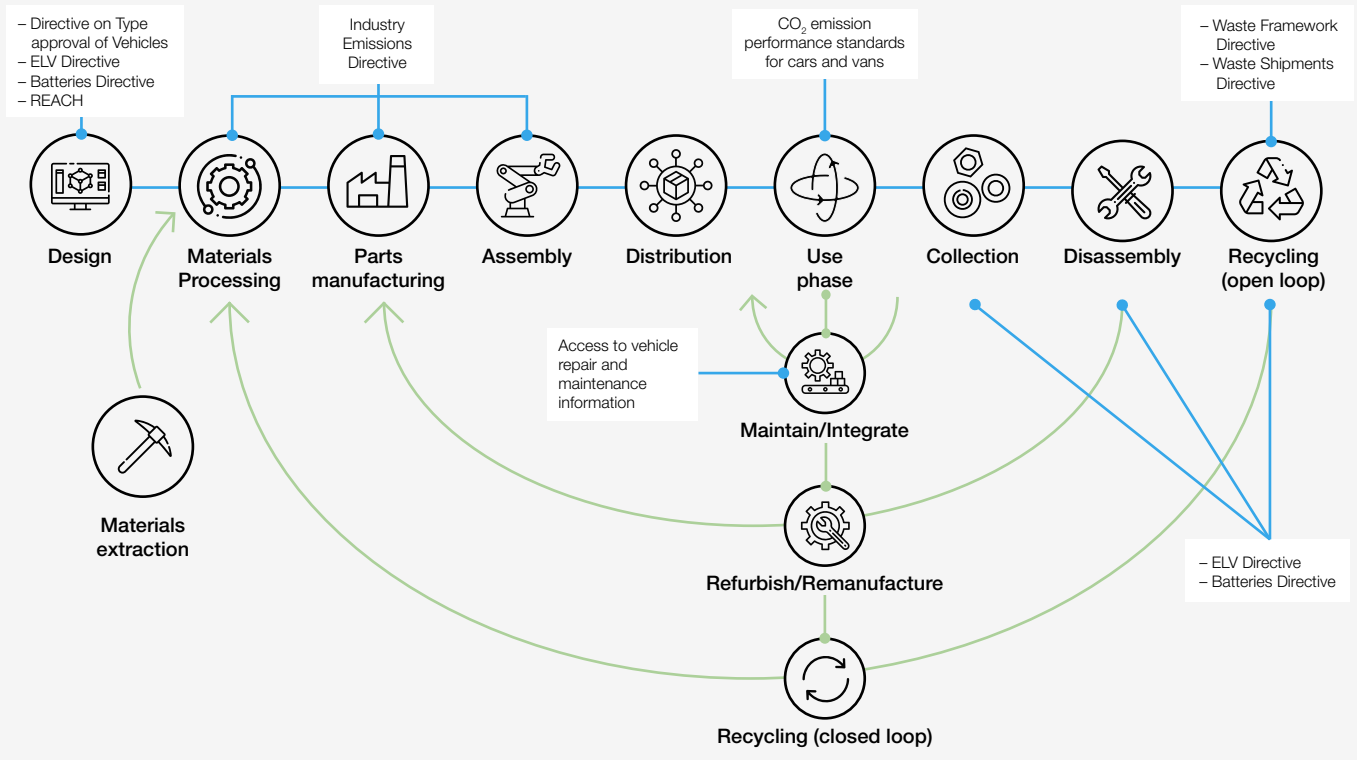
EU circular policy regulation for light-duty vehicles focuses on batteries and end-of-life vehicle management

Policy regulation for cars has originally focused on the safety of passenger vehicles. The climate change and resource depletion trajectories are shifting this focus to increased introduction of environmental policy. While the public focus of these policies resides on cars' emission performance, several policies address the extension of product lifetimes, reuse, and remanufacturing. China and EU member states are frontrunners in the adoption of circularity policies, not least due to their respective top-down circular economy strategies. An analysis of existing policies[193] shows that there is a dominant focus on recollection and recycling of batteries and end-of-life vehicles. Lifetime extension and utilization improvement are currently underrepresented. Moreover, regulatory policy tools are mainly utilized, while economic and informational instruments remain underexplored.

The EU's directives and member states' implementation act as blueprint for other countries

In the EU, several directives have been long present but are now investigated and adapted to improve their potential to foster circular activities among industry players. The most relevant legislative pieces for automotive circularity[194] are the Batteries Directive (currently being replaced by the Batteries Regulation) and the End-of-Life Vehicles Directive (ELV Directive).

FIGURE 15 **Overview of legislation for a Circular Car Value Chain (EU)**



Excluded in this figure: Directive on Waste Electrical and Electronic Equipment, Restriction of the use of certain hazardous substances in electrical and electronic equipment directive, Vehicle Registration Directive, Regulation on persistent organic pollutants, motor vehicle block exemption regulation

The ELV and Batteries Directive are complemented by the Waste Framework Directive, Waste Shipments Directive, the Industrial Emissions Directive, and the REACH Regulation on chemicals, among others. In addition, the CO_2 Emission Performance Standards for Cars and Vans might become more relevant to automotive circularity in the future, as the European Commission intends to evaluate if emissions beyond the use phase should be included. Figure 15 shows the main relevant regulation in the EU along a vehicle's life-cycle.

Global efforts for regulatory policies to support automotive circularity are increasing, by learning from the EU's past efforts

The EU is often described as a pioneer in progressive policy introduction. This can be observed through the increasing number of policies around the globe that emulate EU policies or underlying principles, highlighting the multiplicator role of the EU's policy-making. Vice versa, global policies can also shed light on aspirational practices that could improve EU policy.

In China, automotive-related policies are implemented within a broader framework to achieve resource efficiency. The *Technical Policy For The Recovery And Utilization Of Automobile Products* from 2006 establishes quotas for the recoverability (95%) and recyclability (85%) of end-of-life vehicles based on their weight, and provides guidelines on vehicle design, production, and dismantling.[195] These rules have been amended by encouraging companies to remanufacture core components instead of scrapping them.[196] Off the back of the uptake of BEVs, the Chinese government has implemented a series of regulations targeting end-of-life treatment of traction batteries. The respective policy measures set recovery rates for critical raw materials, establish Extended Producer Responsibility (EPR) schemes, install a traceability management system for traction batteries, and foster maintenance and service networks, as well as recycling infrastructure collaborations.[197]

Chile has introduced an extensive EPR law that obliges producers to ensure rubber tyre materials are recovered, by financing waste management and implementing circular design principles.[198] While circular economy policy measures for light-duty vehicles in the U.S. are still comparatively undeveloped,[199] a few legislative pieces have contributed to an increase in circular practices. For example, the Federal Vehicle Repair Cost Savings Act 2015 encourages the uptake of remanufactured parts in federal fleets.

The economic framework conditions still limit automotive circularity, however, as governments subsidise linear and individual mobility

In the EU, six out of 10 new vehicles are company cars. This is not without a reason: there are significant tax benefits involved for employers and employees engaging in company car schemes.[200] In addition, the automotive industry benefits from financial support from national and regional governments for purchase schemes (e.g. scrapping schemes), research and development, direct investments, and infrastructure-related investments. While this is an important aspect of government involvement, these expenditures mainly favour the traditional automotive industry's business model over other, more sustainable modes of transportation, or innovative business models and technologies additionally promoting the circularity of the industry, such as new mobility providers or the end-of-life market.

While economic measures with a pull effect of automotive circularity are still rare, there are some promising examples. For instance, carbon pricing mechanisms, such as the EU Emissions Trading System (ETS), or VAT reductions for circular activities, as implemented in China for organizations which re-tread tyres or produce tyre powder.[201] Green Public Procurement schemes are also increasingly considering circular business models. For example, several Swedish city governments promote car sharing through public contracts.[202]

Additionally, governments are starting to channel public investments into circular economy solutions. The European Union uses one of its major investment instruments, the European Investment Bank, to supply capital for circular projects. The European Investment Bank contributes to several funding programmes, such as the LIFE programme and the Joint Initiative on Circular Economy (JICE). The EU Horizon2020 and Horizon Europe programmes are also a global role model for circularity-related research financing.[203] Beyond European efforts, some funding programmes have been established on a national level. In Scotland, for example, SMEs with circular products or services can apply for financing from the Circular Economy Investment Fund and China subsidizes companies that remanufacture vehicles and batteries.[204]

At the same time, educational and informational policy measures on EU-level, and in local contexts to support circularity are growing

A prominent example of a shared information platform is the International Dismantling Information System (IDIS), which facilitates repair and recycling markets by providing compiled end-of-life treatment information from manufacturers across Europe, Japan, Korea, Malaysia, India, China, and the U.S. Other supportive information platforms (particularly aimed at mobility) include the European Smart Cities Information System and the Mobility Data Space concept from the German Federal Ministry of Transport and Digital Infrastructure. The European Smart Cities Information System functions as a knowledge hub for smart and sustainable city concepts, while the proposed Mobility Data Space is an aggregation platform for municipal mobility data that enables the development of smart mobility solutions. On a national level, Luxembourg has established the Fit4Circularity programme, which supports companies in the exploration of

circular business models. Initiatives such as the Global Battery Alliance's Battery Passport aim to foster circularity by increasing transparency on the sustainability of raw materials and the manufacturing process of batteries. Moreover, education on automotive circularity-related aspects, such as technical training on battery recycling, is starting to spread (e.g. EIT RawMaterials offers Junior Expert in Circular Economy training, and Delft University of Technology offers various circularity-related courses, in conjunction with the Ellen MacArthur Foundation).[205, 206]

While the emergence of educational, research and informative measures is picking up, particularly in the EU, these types of policy tools remain underrepresented compared to regulatory measures.

Public planning as a tool to support more productive mobility systems

Government action to accelerate shared mobility through spatial and urban planning is being tackled on a city-level. Cities around the globe are increasingly adopting innovative ways to limit individual car use. Preferential access areas (such as low emission zones or shared mobility lanes)[207,208] are accelerating, but the main focus is currently on vehicle electrification. Public-private partnerships to better connect public transport with shared mobility offers are also being leveraged. The German city of Hamburg, for example, now offers single-trip prices for multi-modal transport routes.[209] Moreover, during the COVID-19 pandemic, dedicated bike lanes were introduced in many cities. Other examples that incentivize the use of shared mobility include a reduction of toll fees for shared vehicles (as implemented in San Francisco) and the subsidy of the per-trip fees for pooled rides in New York.[210] Paris and Stockholm, among other cities, are well known for their progressive approach to urban planning. These approaches focus on decentralization through short proximities and the transformation of previously car-dominated spaces into social functions. As a result, shared mobility is increasingly promoted as an alternative to individual car ownership.

Appendix B: National circular economy monitoring frameworks and metrics

Measuring circular economy progress is a cornerstone of policy-making for automotive circularity. This appendix outlines the current status of national circularity metrics.

The evaluation of the progress and effectiveness of circular economy actions on a national level is crucial to steering the circular transition, including the automotive circularity transition. Since 2015, 13 countries across the globe, together with the EU, have implemented national circular economy policies, and pioneering countries like the Netherlands and Finland have set nationwide circularity targets.[211] Several monitoring frameworks for circular economy at national, EU, and international level are already applied in practice (i.e. China, the EU as a whole, France and Slovenia have national circular economy monitoring frameworks in place).[212, 213, 214]

However, an aligned and comparable set of circular economy metrics – one that supports policy-makers, businesses, and citizens to implement relevant circular processes – is still missing. While many metrics are in place to assess the national outcomes of a circular economy (e.g. national resource use, waste reduction, or share of secondary materials used), metrics that help to assess the transition process (e.g. such as remanufacturing, circular economy related jobs and investments) are still underrepresented, and many of these metrics require data from companies that are not yet readily available.[215, 216] In line with the systemic approach of the circular economy, national monitoring should assess effects on all three sustainability dimensions: social, economic and environmental.[217, 218, 219, 220] As impact metrics (e.g. water scarcity or biodiversity loss) are strongly underrepresented in current monitoring frameworks, it remains hard to reliably assess the extent to which circular activities lead to resource reduction and the expected decrease in negative environmental and socio-economic impacts (e.g. on health, quality of labour, and wellbeing).[221]

For nations to successfully measure and report on progress, circular economy data should be collectable, comparable, and reliable. Currently, several circular economy standards and waste standards, applicable to various industries, introduce concepts of circularity – see Figure 16 for selected examples.

By mandating circular economy reporting through a specific infrastructure or circular economy metrics, consistent data will be collected, enabling nations to measure progress. At the same time, circular processes of organizations will probably become more transparent, leading to incentives to increase efforts more generally.

With the advancement of technology, standardization of reporting and data collection should enhance accessibility, enabling nations to identify additional circular economy opportunities in specific industries. A multi-year journey lies ahead as countries collaborate and converge, however this process could be sped up by: (1) utilizing the key learnings from the implementation of the International Standard on Financial Reporting Scheme (IFRS) and (2) encouraging the EU to take the lead on driving the process forward on a global level.

FIGURE 16 **Selected examples of CE related standards on reporting and metrics**

Standard name	Institute	Status	Description
BS 8001: 2017 Circularity Standard	British Standards Institution (BSI)	Active (May 17)	A practical framework to help organizations consider and implement more circular and sustainable practices and link established business procedures with circular economy principles. Intended to help businesses of any size or location.
AFNOR XP X30-901	Francais de Normalisation	Active (Oct 18)	A project management tool to help organizations plan, implement, evaluate and improve CE projects.
ISO/TSC 323	International Organization for Standardization (ISO)	Not active (Early 2023)	To provide frameworks, guidance, supporting tools and requirements to standardize circular economy activities of all involved organizations. Expected to influence the development of the EU Taxonomy for Circular Economy.
GRI 306 Waste	Global Reporting Initiative (GRI)	Active (May 20)	Updated waste management standard introducing concepts of circularity and waste prevention. Includes reporting templates.

Source: Kick et al. 2021[222]

Appendix C: Evaluation of the ELV Directive and impact of vehicle exports

Appendix C provides a more detailed view on the current shortcomings of the ELV Directive and an introduction of the vehicle export issue, which is related to the number of missing vehicles in the EU.

The EU ELV Directive is a landmark policy to improve automotive material circularity and decrease waste. As outlined in Appendix A, it addresses various issues related to automotive circularity, with a current focus on reducing landfill. As part of the new Circular Economy Action Plan, the rules on end-of-life vehicles will be revised in 2021 (in Q2/2021 a public consultation will take place). The Directive has the potential to unlock automotive material circularity and lifetime extension if adapted accordingly.

Currently, the Directive has various shortcomings and, therefore, does not effectively enable high-quality material circularity. The main reasons are:

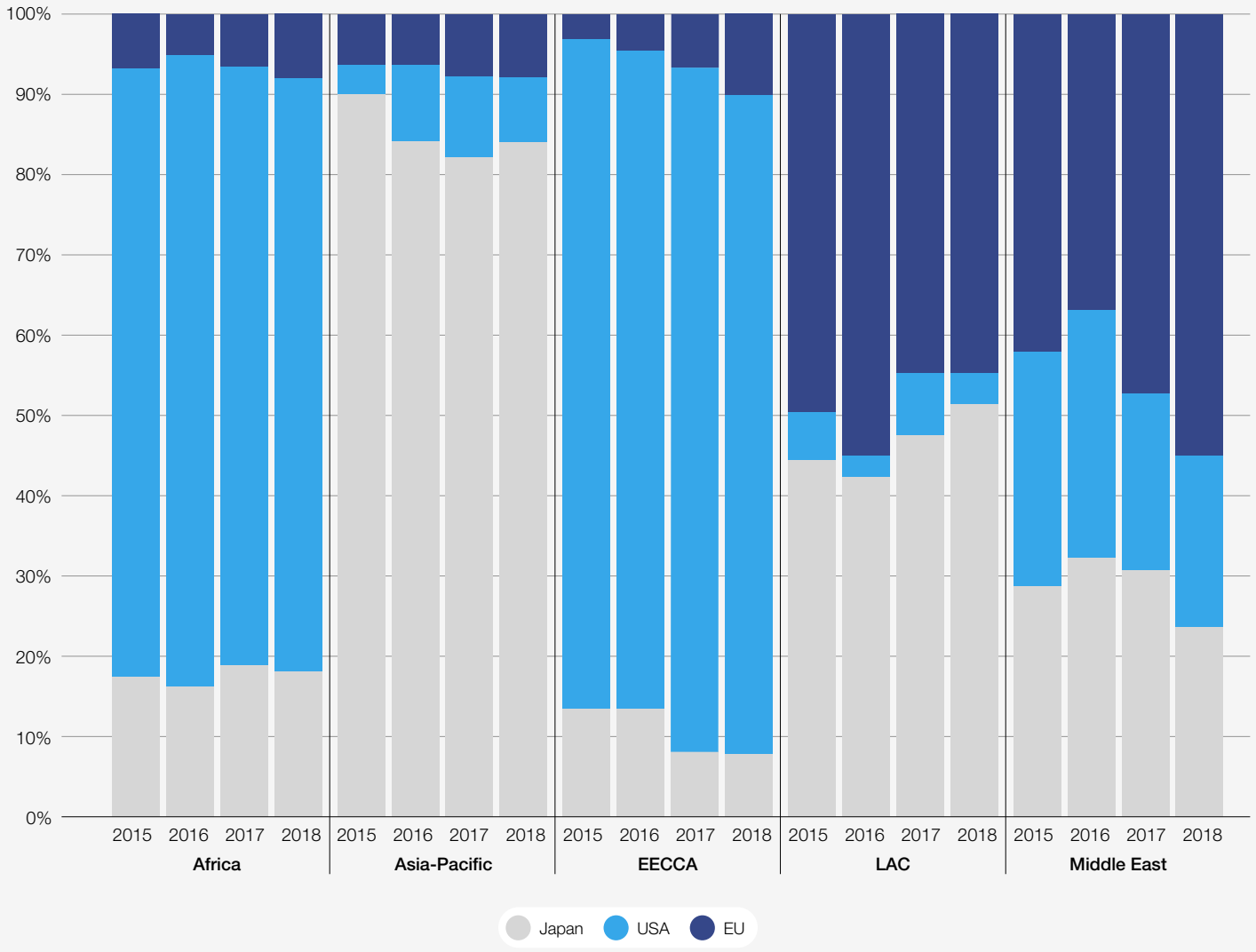
- **Unknown vehicle whereabouts:** 35% of vehicles in the EU end up in unknown whereabouts and are therefore not subject to the Directive's provisions.[223]
- **Low-value recycling:** The Directive's recycling and recovery targets are weight-based, leading to a focus on less complicated material recycling and into lower material value (e.g. construction steel).
- **Unaligned with the waste management hierarchy:** The Directive does not specifically include value-retention processes (e.g. reuse, refurbish, remanufacturing) as end-of-life activities, which leads to a prioritization of recycling over recovery strategies that retain more of the embedded energy of vehicle parts.
- **Uncertainty on waste vs. non-waste status:** Uncertainty exists as to a vehicle's waste status (e.g. differentiation between a used vehicle and an end-of-life vehicle).
- **Lack of support for recyclate use:** The Directive does not establish recycled content mandates which would create a step change in secondary material demand.
- **Insufficient adoption of extended producer responsibility:** The evaluation of the Directive has shown that while OEMs are obliged to pay for ELV treatments of vehicles, the implementation of this is currently not well-managed, as some Authorized Treatment Facilities (ATF) note that they bear the economic costs.[224]

Exports of end-of-life vehicles jeopardize human health and environmental protection

The high number of missing vehicles, especially, presents a challenge. These missing vehicles are mainly due to illegal exports and treatments. While illegal treatments can be solved with optimized (de-) registration systems, illegally exported vehicles especially jeopardize human health and environmental protection. Africa is the main destination for used car exports, accounting for over 30% of all shipments from Europe. In Africa, 8 out of 10 imported vehicles are used vehicles, primarily sourced from the U.S., Europe, Japan, and the Gulf States.[225]

The export of ELVs has significant impacts on importing countries: high emissions of particulate matter such as NOx and CO_2 increase environmental and human health risks.[226] In most African countries, an adequate structure for the disposal and treatment of ELVs is lacking. Uncontrolled treatment of vehicles during disposal leads to environmental and health damage. Soil contamination from lead battery manufacturing and recycling has been studied and proven in several African countries[227] and, in addition, valuable secondary raw materials are lost.

FIGURE 17 | **Share of used light-duty vehicles (LDV) exports from Japan, EU, and the USA to Africa, Asia-Pacific, Eastern European and Central Asian countries (EECA), Latin America and the Caribbean (LAC) and the Middle East, 2015-2018**



Source: UNEP, based on data from the Japanese International Auto Trade Association (iATA), the United States Department of Commerce, Bureau of the Census, Foreign Trade Division and the European Commission – Eurostat Comext Database, 2019

Regulation of vehicle exports can avoid negative consequences for communities and the environment

While regulatory action has long been lacking, government action to regulate the import market and improve air quality and road safety in Africa is increasing. Over-reliance on imported used cars is an obstacle to the further development of the African automotive sector, limiting the sale of new, pricier vehicles, as well as local production and assembly of vehicles.[228] To counteract extensive numbers of vehicle imports, 15 countries in West Africa (within the Economic Commission of West African States) have recently stipulated that all imported and newly registered vehicles must meet the Euro 4/IV emissions standard, and have set an age limit for imported vehicles (five years for light and 10 years for heavy-duty vehicles).[229] The introduction of regulations that lower the age of vehicles for import, while raising their price by increasing levies, encourages the sale of locally manufactured cars. Most importantly, exporting countries must ensure that export vehicles meet the standards set by the importing countries.[230]

Automotive material circularity requires collaborative, global action

Reducing the negative impact of exporting used cars requires close cooperation. Both exporting and importing countries will benefit from a reduction in the export of end-of-life vehicles, particularly given the accelerating electric fleet renewal.[231] In a future scenario, vehicles should be dismantled locally so that highly toxic materials can be properly treated, negative impacts on air/soil quality and human health can be avoided, and local automotive economies are boosted in less-developed countries.

Appendix D: Overview of selected circularity-related policies

The policy priorities outlined in this paper are based on an analysis of the current policy landscape of automotive circularity. Regulatory, economic, and informative policies were assessed, with a focus on selected policies established on an EU-level, underpinned by global examples. The table below provides an overview of the assessed policies, including the type of policy, the topic addressed, upcoming revisions (if relevant) and the affected circularity lever.

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Strategies, roadmaps	Circular economy	Circular Economy Action Plan *New plan published in 2020*	– Outlines key value chains for circular economy, including batteries and vehicles – Includes various action points to revise certain directives, establish recycled content mandates, VAT reductions for CE products and circular procurement – Various EU countries have developed their respective national circularity strategies, please see the study of the Circular Economy Initiative Germany for an overview	✓	✓	
	Mobility	Sustainable and Smart Mobility Strategy *Published in 2020*	– Lays the foundation for how the EU transport system can achieve its green and digital transformation – Includes over 80 actions the EU intends to take in coming years	✓		✓
	Data	European Data Strategy *Published in 2020*	– Highlights the future establishment of a European Green Deal and Mobility Data Space to enable data sharing for circular economy practices and integrated mobility systems	✓	✓	✓
Regulation	Vehicle emissions	Regulation 2019/631 CO_2-emission performance standards for cars and vans *Revision in Q2/2021*	– Regulates the tailpipe emission performance of new cars and vans in the EU (current fleet target is 95g CO_2/km for cars) – Currently several possibilities for free allowances exist (e.g. weight factor, buy and sell, supercredits/phase-ins)	✓		✓

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Regulation	ELV Directive (ELV)	ELV Directive 2000/53/EC *Revision in 2021/2022*	– Targets are based on the weight of a vehicle (minimum of 95% for reuse and recovery; 85% for reuse and recycling) – European automotive manufacturers are responsible for disposal/recycling costs – Aims at the set-up of treatment facilities – Imposes provisions on vehicle design (e.g. use of chemicals)	✓		
	Batteries	Directive 2006/66/EC on batteries and accumulators/ waste batteries and accumulators *Former Directive (see below for new proposal)*	– No explicit inclusion of lithium-ion batteries – Automotive, industrial and electric vehicle batteries are to be collected – Introduces specific reporting/labelling obligations – Prohibits marketing of batteries with specific hazardous substances – 50% recycling rate established by battery weight	✓		
		Proposal for New Battery Regulation *To be adopted Q4/2021*	– Minimum recycling efficiency rates are set to be 65% from 2025 onwards – Recovery rates for individual materials: cobalt 90% (95%), copper 90% (95%), nickel 90% (95%), lithium 35% (70%) – 2026 (2030) – Supported by information/labelling, carbon footprint targets, electronic exchange system and Battery Passport, Green Public Procurement	✓		
	Remanufacturing	Regulation (EU) No 461/2010 on motor vehicles – block exemption from EU competition law	– Fosters competitiveness of independent repairers – Supports information release from OEMs – Mitigates misuse of warranty terms		✓	

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Regulation	Remanufacturing	Regulation EC 715/2007 on type approval and access to vehicle repair and maintenance information (2007)	– Manufacturers must ensure that independent operators have easy, restriction-free, and standardized access to information on vehicle repair and maintenance – Discrimination with respect to authorized dealers and repair workshops is not allowed		✓	
	Waste	Waste Framework Directive 2008/98/EC on waste and repealing certain Directives (2008)	– Sets the framework and definitions related to waste management and circular economy – Explains the definition of waste (i.e. when does a product/part become waste?) – Establishes waste hierarchy	✓	✓	
		Basel Convention	– Multilateral environmental agreement on the cross-border transport of hazardous waste – Implemented through the Waste Shipment Regulation	✓		
		Regulation (EC) 1013/2006 on shipments of waste (2006)	– Implements provisions of the Basel Convention – Addresses uncontrolled transport of ELV vehicles classified as waste – Includes a ban on the export of hazardous wastes to non-OECD countries (Basel Convention) – Ban on the export of waste for disposal	✓		
	Data	EU General Data Protection Regulation 2016/679 – GDPR	– Data privacy and security law – Aims to unify regulations across the EU on data handling and control	✓	✓	✓

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Regulation	Data	Directive 2010/40 on Intelligent Transport Systems	– Legal framework for use of Intelligent Transport Systems – Particularly aimed at compatibility and interoperability across borders			✓
		Regulation on Data Governance *Currently drafted*	– Planned in the context of the EU Data Strategy and the plan to establish European data spaces – Aim is to improve data access for citizens and companies, and simultaneously provide more control	✓	✓	✓
	Other	Regulation (EC) 1907/2006 REACH (2006)	– Adopted to improve protection of human health and the environment from the risks posed by chemicals, while enhancing competitiveness of EU chemicals industry	✓		
		Restriction of Hazardous Substances Directive 2011/65	– Sets restrictions for the material contents of new electronic equipment	✓		
		Directive 2005/64/EC type approval for reusability, recyclability and recoverability	– Facilitates recycling and recovery of ELV parts by mandating manufacturers to incorporate recyclability into vehicle design	✓		
		Directive 2010/75/ EU Industrial Emissions Directive (2010)	– Regulates whole environmental performance of industrial plants – Uses the best available technologies (BAT) approach to set emission benchmarks	✓		
		Directive 2012/19 on Waste Electrical and Electronic Equipment (WEEE)	– Collection, recycling and recovery targets for electronic equipment (also relevant for equipment used in vehicles)	✓		

Policy type	Category	Name	Description	Circularity Lever		
				Material circularity	Lifetime extension	Utilization improvement
Regulation	Member state specific (Selected examples)	France: Anti-Waste Law	– Includes a measure to promote the use of spare parts – Obliges vehicle part dealers to offer customers alternative spare parts from the circular economy, e.g. re-used or remanufactured parts		✓	
		Passenger Transportation Act Germany *Revised in March 2021*	– Regulates the transportation service offering for passengers – Sets rules for taxi, car pooling, and rental			✓
		Portugal: Legal framework for passenger transport based on electronic platforms 45/2018	– Regulates digital transport activities, such as Uber, Cabify, etc. – Establishes a legal framework for passenger transport based on electronic platforms			✓
Economic measures	Tax incentives – Environment	Common System of Value-Added Taxes	– Establishes a common system for VAT across Europe – Determines certain minimum and maximum thresholds	✓	✓	✓
		Landfill or incineration tax across different European countries	– Tax on top of normal landfill or incineration fees – Aim is to incentivize recycling by increasing costs of landfilling vs. recovery – Exists in 23 EU member states	✓	✓	
		Environmental investment allowances (2020) – Netherlands	– Tax deduction for investments in environmentally friendly technologies – Companies can get a tax deduction of up to 36% of the investment	✓	✓	✓
	Tax incentives – Car-specific	Company car taxation across different European countries	– VAT deductions and depreciation write-offs for company cars (e.g. for OEMs, dealerships, short-term rentals, and true fleets) – Very common in Europe			✓

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Economic measures	Carbon pricing	EU Emissions Trading System *Revision 2021/2022*	– Greenhouse gas emission trading scheme established in the EU27 and Iceland, Norway, Liechtenstein, and the UK	✓	✓	✓
		Carbon Tax Germany	– Germany established an additional national carbon tax in 2021 – The tax covers heating and transportation fuels			✓
Investments, Green Public Procurement	Research funding	Horizon2020, HorizonEurope	– EU's flagship research and innovation funding programme	✓	✓	✓
	Public investment	European Green Deal Investment Plan	– The EGDIP is the investment pillar of the Green Deal – To achieve the goals set by the EGD, the plan will mobilize at least €1 trillion in sustainable investments over the next decade	✓	✓	✓
		European Investment Bank	– Publicly-owned financial institution, shareholders are EU member states – Aims at the support of policy goals by providing funding and credits	✓	✓	✓
		Next Generation EU (COVID Recovery Package)	– Supports the economic recovery following the COVID-19 pandemic – €750 billion in total, with the recovery and resilience facility at the core (€672.5 billion) for financial support for reforms/investments of member states	✓	✓	✓

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Investments, Green Public Procurement	Private investment	Joint Initiative on Circular Economy (JICE)	– A partnership between the European Union's largest national promotional banks and institutions and the European Investment Bank – Goal is to invest at least €10 billion in the circular economy by 2023	✓	✓	✓
		EU Taxonomy *Criteria for CE will be published by Q4/2021*	– EU Taxonomy is a classification system, establishing a list of environmentally sustainable economic activities – Important enabler to scale up sustainable investments from private and public sources	✓	✓	✓
	Green Public Procurement	Green Public Procurement DG Environment	– Public purchasing criteria specifically targeting eco-innovation and sustainably produced products	✓	✓	✓
		Clean Vehicles Directive	– Promotes low-emission mobility solutions for public purchasing – National targets are set and the Directive needs to be transposed into national law in 2021	N/A	N/A	N/A
Partnerships, education and information	Partnerships and education	European Battery Alliance	– Public-private alliance in partnership with EU states and EIB – Goal is to create a competitive and sustainable battery cell manufacturing value chain	✓	✓	
		European Circular Economy Stakeholder Platform	– Joint initiative by European Commission and European Economic and Social Committee – Cross-sector initiatives and networks to foster the circular economy transition	✓	✓	✓

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Partnerships, education and information	Partnerships and education	EU Smart Cities Information System (SCIS)	– Knowledge platform connecting various stakeholders across Europe – Focused on enabling the development of smart cities, e.g. through best practice sharing and data collection			✓
		ReVeAL (Horizon2020 Project)	– Supports a European-wide, harmonized approach to vehicle access regulation, with a focus on zero-emission zones, spatial interventions, pricing, and new tools			✓
		CarE-Service (Horizon2020 Project)	– Research and knowledge sharing on reuse, remanufacturing and recycling of hybrid and electric vehicles	✓	✓	
	Information	International Dismantling Information System (IDIS)	– IDIS provides information for dismantlers on environmentally-sound treatment of end-of-life vehicles – Today, 23 car manufactures from Europe, Japan, Korea and the U.S. are represented	✓	✓	
		Gaia-X	– Strategic infrastructure project for data spaces initiated by the French and German government – Aims at data sovereignty of Europe	✓	✓	✓
Vehicle access regulation/ pricing for shared mobility	Information	High-occupancy vehicle lanes (HOV lanes)	– Specific lanes of roadways that restrict the lane use to promote ride-pooling – Examples in Europe are scarce, but the U.S. has established HOV lanes in multiple cities (e.g. San Francisco, Houston) – In Europe, low emission zones are spreading			✓

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Vehicle access regulation/ pricing for shared mobility		Parking Spaces / Car-Sharing Stations	– Parking space conversion to allow for car-sharing parking and pick-up and drop-off for ride-sharing – Established in various European cities, (e.g. Berlin, Munich)			✓
Global policies (selected examples)	Strategies	China: Circular Economy Promotion Law (2009)	– Top-down circularity policy roadmap – Applies the 3-R (reduce, reuse, recycle) principles – 5-year action plans are established	✓	✓	
	ELV Legislation	China: Technical Policy for the Recovery & Utilization of Automobile Products (2006)	– Establishes rules on recovery and end-of-life management of vehicles – Specifically aimed at resource efficiency	✓	✓	
		Japan: End-of-Life Vehicles Recycling Law	– Establishes ELV recycling fee – 95% target for recycling rate	✓		
		USA/California: AB-1509 Solid waste – lithium-ion batteries (2019)	– Recycling law for lithium-ion batteries in California – Proper disposal of the batteries must be ensured to reduce hazards	✓		
	Ride-sharing legislation/taxes	New York: Cap of license issues to ride-hailing drivers	– City of New York halted the issuance of licenses for for-hire vehicles to stop influx of new drivers			✓
		USA (Washington): Reduction of Taxes for Car Sharing	– In Washington, tax credits are provided to employers who offer access to car-sharing			✓

Policy type	Category	Name	Description	Circularity lever		
				Material circularity	Lifetime extension	Utilization improvement
Global policies (selected examples)	Emission standards	USA: Corporate Average Fuel Economy Standards (2009)	– Regulates fuel economy of cars and light trucks sold in the U.S. – Average fuel economy is calculated for each manufacturer – Credits can be traded or carried from previous years/other fleet categories	N/A	N/A	N/A
	Carbon pricing	Chinese National ETS (2021)	– First only covers power sector – To enable roll-out to other sectors, monitoring/reporting/ verification obligations are being established	✓		
	Green Public Procurement	Canada Federal Carbon Pricing (2016)	– Pan-Canadian approach to carbon pricing demands provinces and territories to establish a carbon pricing initiative or implement the federal system	✓		
		Federal Vehicle Repair Cost Savings Act (2015)	– Encourages the use of remanufactured vehicle parts in federal agencies if it reduces the cost of maintenance		✓	
		USA (Massachusetts): Car Sharing for State-Owned Fleets	– Public-private collaboration between Massachusetts's Department of Transportation and Zipcar to offer state employees access to car sharing			✓
	Partnerships / Information	Global Battery Alliance	– Public-private collaboration platform of over 70 organizations – Working towards a sustainable battery value chain, including circularity as a focus topic	✓		
		International Material Data System (IMD)	– Data system of the automotive industry, storing information on mate-rials used during manufacturing – especially valuable to reduce hazardous substances – IMDS has become a global standard used by OEMs globally	✓		

Acronyms

ATF	Authorized treatment facilities
BEV	Battery electric vehicle
CCI	Circular Cars Initiative
CoD	Certificate of destruction
ELV	End-of-life vehicle
EPR	Extended producer responsibility
ETS	(European) Emissions Trading System
EGD	European Green Deal
GHG	Greenhouse gas
ICEV	Internal combustion engine vehicle
IFRS	International Financial Reporting Standards
IMDS	International Material Data System
IDIS	International Dismantling Information System
LCA	Life-cycle assessment
OEM	Original equipment manufacturer
PEF	Product environmental footprint
VAT	Value-added tax

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Endnotes

1. "Transport could burn up the EU's entire carbon budget", *International Council on Clean Transportation*, 2021, https://theicct.org/blog/staff/eu-carbon-budget-apr2021.
2. "Transport could burn up the EU's entire carbon budget", *International Council on Clean Transportation*, 2021, https://theicct.org/blog/staff/eu-carbon-budget-apr2021.
3. World Economic Forum, *Forging Ahead: A Materials Roadmap for the Zero-Carbon Car*", 2021, https://www.weforum.org/reports/forging-ahead-a-materials-roadmap-for-the-zero-carbon-car.
4. Ibid.
5. "Automotive industry", *European Commission*, https://ec.europa.eu/growth/sectors/automotive_hu.
6. "Transport could burn up the EU's entire carbon budget", *International Council on Clean Transportation*, 2021, https://theicct.org/blog/staff/eu-carbon-budget-apr2021.
7. International Resource Panel, *Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.
8. "Automotive industry", *European Commission*, https://ec.europa.eu/growth/sectors/automotive_hu.
9. World Economic Forum, *Raising Ambitions – A new roadmap for the automotive circular economy*, December 2020, http://www3.weforum.org/docs/WEF_Raising_Ambitions_2020.pdf.
10. Not least as BEVs do not only offer an effective pathway for decarbonization, but also dematerialization of road transportation – ICEVs burn material (oil) 300 times greater in mass than is lost over the lifetime of a BEV. (See: Transport & Environment, *Batteries vs. Oil: A Systemic Comparison of Material Requirements*, 2021, https://www.transportenvironment.org/sites/te/files/publications/2021_02_Battery_raw_materials_report_final.pdf and "Fossil fuel cars make "hundreds of times" more waste than electric cars", *The Guardian*, 2021, https://www.theguardian.com/business/2021/mar/01/fossil-fuel-cars-make-hundreds-of-times-more-waste-than-electric-cars.)
11. World Economic Forum, *The Road Ahead: A Policy Research Agenda for Automotive Circularity*, 2020, http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf.
12. World Economic Forum, *A Vision for a Sustainable Battery Value Chain in 2030*, 2019, http://www3.weforum.org/docs/WEF_A_Vision_for_a_Sustainable_Battery_Value_Chain_in_2030_Report.pdf.
13. International Energy Agency, *Global EV Outlook 2021*, 2021, https://www.iea.org/reports/global-ev-outlook-2021.
14. While this holds true for the automotive industry worldwide, this report focuses on the European Union and respectively mentions EU car makers only.
15. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.
16. "Average Age of the EU Motor Vehicle Feet, by Vehicle Type", *European Automobile Manufacturers Association*, 2021, https://www.acea.be/statistics/article/average-age-of-the-eu-motor-vehicle-fleet-by-vehicle-type.
17. "Groupe Renault Creating First European Factory Dedicated to the Circular Economy of Mobility in Flins", *Green Car Congress*, 2020, https://www.greencarcongress.com/2020/11/20201126-renault.html.
18. Ellen MacArthur Foundation, *Growth within: A Circular Economy Vision for a Competitive Europe*, 2015, https://www.ellenmacarthurfoundation.org/publications/growth-within-a-circular-economy-vision-for-a-competitive-europe.
19. In 2017, 87% (on average) of end-of-life vehicles' materials in the EU were reused or recycled. (See: Eurostat, *End-of-Life Vehicle Statistics*, 2020, https://ec.europa.eu/eurostat/statistics-explained/pdfscache/24943.pdf). However, these materials were not fully used again for vehicle production, but rather downcycled into lower construction applications. For example, car bodies consist of approximately 25% recycled steel (See: "Recycling", *World Steel Association*, https://www.worldautosteel.org/life-cycle-thinking/recycling/). Recent studies have also forecast that demand for secondary steel in the construction sector will plateau before 2050, leading to an increased need for high-value steel recycling and related copper contamination management (See: Daehn, Katrin E, André Cabrera Serrenho and Julian M Allwood, "How Will Copper Contamination Constrain Future Global Steel Recycling?", *Environmental Science and Technology,* vol. 51, no. 11, 2017, pp. 6599-6606, https://doi.org/10.1021/acs.est.7b00997).
20. Barriers are partially based on: World Economic Forum, *Raising Ambitions – A new roadmap for the automotive circular economy*, December 2020, http://www3.weforum.org/docs/WEF_Raising_Ambitions_2020.pdf.
21. "Why shared mobility is poised to make a comeback after the crisis", *McKinsey & Company*, 2020, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/why-shared-mobility-is-poised-to-make-a-comeback-after-the-crisis.
22. See Appendices A, B and D for an overview of current policy tools for automotive circularity.
23. "Coronavirus / COVID-19", *European Automobile Manufacturers Association*, https://www.acea.be/industry-topics/tag/category/coronavirus-covid-19.
24. "Economic Recovery Packages in Response to COVID-19: Another Push for Electric Vehicles in Europe?", *International Council on Clean Transportation*, 2020, https://theicct.org/blog/staff/economic-recovery-covid-19-ev-europe-aug2020.

25. "Commitment to Net Zero Double in Less Than a Year", *United Nations Climate Change*, 2020, https://unfccc.int/news/commitments-to-net-zero-double-in-less-than-a-year.

26. "Securing a Green Recovery", *We Mean Business Coalition*, 2021, https://www.wemeanbusinesscoalition.org/build-back-better/.

27. International Energy Agency, *The Role of Critical Minerals in Clean Energy Transitions*, 2021, https://iea.blob.core.windows.net/assets/24d5dfbb-a77a-4647-abcc-667867207f74/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf.

28. Transport & Environment, *Batteries vs. Oil: A Systemic Comparison of Material Requirements*, 2021, https://www.transportenvironment.org/sites/te/files/publications/2021_02_Battery_raw_materials_report_final.pdf.

29. International Resource Panel, *Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.

30. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem (IPBES), *The Global Assessment Report on Biodiversity and Ecosystem Services: Summary for Policymakers*, 2019, https://ipbes.net/sites/default/files/inline/files/ipbes_global_assessment_report_summary_for_policymakers.pdf.

31. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 2015, https://epic.awi.de/id/eprint/37530/.

32. World Economic Forum, *Forging Ahead: A Materials Roadmap for the Zero-Carbon Car*, 2020, https://www.weforum.org/reports/forging-ahead-a-materials-roadmap-for-the-zero-carbon-car.

33. World Economic Forum, *Raising Ambitions: A New Roadmap for the Automotive Circular Economy*, 2020, http://www3.weforum.org/docs/WEF_Raising_Ambitions_2020.pdf.

34. International Resource Panel, *Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.

35. Depending on the age of the ICEV, the evaluation and decision might change. Life-cycle-based assessments are needed to determine when an ICEV's lifetime should not be extended.

36. World Economic Forum, *Forging Ahead: A Materials Roadmap for the Zero-Carbon Car*, 2020, https://www.weforum.org/reports/forging-ahead-a-materials-roadmap-for-the-zero-carbon-car.

37. Umwelt Bundesamt, *9 Principles for a Circular Economy*, 2020, https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020_10_23_leitlinie_kreislaufwirtschaft_englisch_bf.pdf.

38. World Economic Forum, *The Road Ahead: A Policy Research Agenda for Automotive Circularity*, 2020, http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf.

39. Trinomics, *The Effect of the Circular Economy on the Labour Market in Europe*, 2018, https://trinomics.eu/project/the-effect-of-the-circular-economy-on-employment-in-europe/.

40. European Parliamentary Research Service, *EU Policies – Delivering for Citizens*, 2019, https://www.what-europe-does-for-me.eu/data/pdf/focus/focus12_en.pdf.

41. See: Regulation (EU) 2019/631, eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0631.

42. World Economic Forum, *The Road Ahead: A Policy Research Agenda for Automotive Circularity*, 2020, http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf.

43. Lehmann, Annekatrin, Matthias Finkbeiner, Clare Broadbent and Russ T. Balzer, "Policy Options for Life Cycle Assessment Deployment in Legislation", *Life Cycle Management*, pp213-224, Springer Netherlands, 2015. https://doi.org/10.1007/978-94-017-7221-1_15.

44. Bothe, David and Christoph Sieberg, *Crediting System for Renewable Fuels in EU Emission Standards for Road Transport*, 2020, https://www.bmwi.de/Redaktion/DE/Downloads/C-D/crediting-system-for-renewable-fuels.pdf?__blob=publicationFile&v=4.

45. The proposal aims to mandate the declaration of a battery's carbon footprint by 2024. From 2026 onwards, these will have to be labelled according to their carbon intensity performance and by 2027 maximum carbon footprint targets are planned to be established.

46. The CO_2 performance standards for cars and vans are of utmost importance for the acceleration of EV sales. The standards are under revision in 2021 and, while various methodological changes are recommended (e.g. adjusting the mass target), it is now crucial that the focus remains on tailpipe emissions, and other important topics are addressed in separate legislation until BEVs have taken a firm foothold in automotive sales. Shifting to an LCA-approach right away would already favour EVs over combustion cars today, but the relative incentive to shift would be lowered temporarily. (See: Ricardo Energy & Environment, *Determining the Environmental Impacts of Conventional and Alternatively Fuelled Vehicles through LCA*, 2020, https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/2020_study_main_report_en.pdf.) Please also see the position paper of Transport and Environment on the revision of the CO_2 performance standards.

47. Allowing for accrediting of low carbon fuels (aka "synfuels") is not found to be an optimal decarbonization strategy since ICEVs combusting synfuels require five times more energy per kilometre than equivalent BEVs, leading to higher lifetime environmental footprints and costs (See: Transport & Environment, *Electrofuels: What Role in EU Transport Decarbonisation?*, 2017, https://www.transportenvironment.org/sites/te/files/publications/2017_11_Briefing_electrofuels_final.pdf).

48. Kendall, Alissa, Hanjiro Ambrose, Erik Maroney and Huijing Deng, *Program for Vehicle Regulatory Reform: Assessing Life Cycle-Based Greenhouse Gas Standards*, National Centre for Sustainable Transportation, 2018, https://escholarship.org/uc/item/49g4h212#page=40.
49. Circular Economy Initiative Deutschland, *Resource-Efficient Battery Life Cycles – Driving Electric Mobility with the Circular Economy*, 2020, https://en.acatech.de/publication/resource-efficient-battery-life-cycles/.
50. Measures must be developed taking into account the ethical implications (e.g. due to person-specific data), the quality of data (e.g. source assurance), and the consequences and feasibility of traceability.
51. World Economic Forum, *Raising Ambitions: A New Roadmap for the Automotive Circular Economy*, 2021, http://www3.weforum.org/docs/WEF_Raising_Ambitions_2020.pdf.
52. European Commission, *A European Strategy for Data*, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0066&from=EN.
53. European Parliament, *Directive 2005/64/EC of the European Parliament and of the Council of 26 October 2005 on the type-approval of motor vehicles with regard to their reusability, recyclability and recoverability and amending Council Directive 70/156/EEC*, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32005L0064.
54. Spearheaded by Germany and France. See: "Questions and answers about the GAIA-X project", *Federal Ministry for Economic Affairs and Energy*, https://www.bmwi.de/Redaktion/DE/FAQ/Dateninfrastruktur/faq-projekt-gaia-x.html.
55. "Mobility – Data Interoperability and Data Sovereignty", *Federal Ministry for Economic Affairs and Energy*, https://www.bmwi.de/Redaktion/EN/Artikel/Digital-World/GAIA-X-Use-Cases/mobility-data-interoperability-and-data-sovereignty.html.
56. Jelbi, *Berlin's entire public transport and sharing services in just one app*, 2021, https://www.jelbi.de/.
57. WBCSD, *Enabling Data-Sharing: Emerging Principles for Transforming Urban Mobility*, 2020, https://docs.wbcsd.org/2020/01/WBCSD_Enabling_data_sharing_Emerging_principles_for_transforming_urban_mobility.pdf.
58. MaaS Alliance, *MaaS Market Playbook*, 2020, https://maas-alliance.eu/wp-content/uploads/sites/7/2021/03/05-MaaS-Alliance-Playbook-FINAL.pdf.
59. bitkom, *European Strategy for a Sustainable and Smart Mobility – towards a Data Driven European Transport and Mobility Ecosystem*, 2020, https://www.bitkom.org/sites/default/files/2020-09/200923_pp_european-transport-mobility-ecosystem.pdf.
60. dpa, *Autobranche baut digitales Informations-Netzwerk aus*, 2 March 2021, https://www.idowa.de/inhalt.initiative-catena-x-autobranche-baut-digitales-informations-netzwerk-aus.ac4404cd-6e77-491a-a5e3-55e7980e66d3.html.
61. World Bank Group; Gesellschaft für Internationale Zusammenarbeit (GIZ); wbcsd; International Road Federation, *Sustainable Mobility: Policy Making for Data Sharing*, 2021, https://www.wbcsd.org/contentwbc/download/11663/176259/1.
62. ISO, *ISO 22628:2002: Road Vehicles – Recyclability and Recoverability – Calculation Method*, 2002, https://www.iso.org/standard/35061.html.
63. European Commission, *The Environmental Footprint Pilots*, https://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm.
64. IDIS, *The International Dismantling Information System*, 2021, https://www.idis2.com/.
65. IMDS, *Welcome to the International Material Data System*, 2021, https://www.mdsystem.com/.
66. GS1 in Europe, *Welcome to GS1 in Europe*, 2021, https://www.gs1.eu/.
67. International Data Spaces Association, *International Data Spaces*, https://internationaldataspaces.org/.
68. FIWARE, *Developers – FIWARE*, 2021, https://www.fiware.org/developers/.
69. bitkom, *European Strategy for a Sustainable and Smart Mobility – towards a Data Driven European Transport and Mobility Ecosystem*, 2020, https://www.bitkom.org/sites/default/files/2020-09/200923_pp_european-transport-mobility-ecosystem.pdf.
70. Fraunhofer, *Mobility Data Space*, 2020, https://www.ivi.fraunhofer.de/content/dam/ivi/en/documents/brochure/Mobility_Data_Space_2020_EN_neu.pdf.
71. World Bank Group; Gesellschaft für Internationale Zusammenarbeit (GIZ); WBCSD; International Road Federation, *Sustainable Mobility: Policy Making for Data Sharing*, 2021, https://www.wbcsd.org/contentwbc/download/11663/176259/1.
72. bitkom, *European Strategy for a Sustainable and Smart Mobility – towards a Data Driven European Transport and Mobility Ecosystem*, 2020, https://www.bitkom.org/sites/default/files/2020-09/200923_pp_european-transport-mobility-ecosystem.pdf.
73. Reiter, Julius, "Warum wir ein Mobilitätsdaten-Gesetz brauchen", *Tagesspiegel Background*, 28 April 2021, https://background.tagesspiegel.de/mobilitaet/warum-wir-ein-mobilitaetsdaten-gesetz-brauchen?utm_source=bgmt+vorschau&utm_medium=email.
74. European Commission, *EU Data Governance Act Proposal*, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0767&from=EN.
75. Ibid.
76. MaaS Alliance, *MaaS Market Playbook*, 2020, https://maas-alliance.eu/wp-content/uploads/sites/7/2021/03/05-MaaS-Alliance-Playbook-FINAL.pdf.

77. Circular Economy Initiative Deutschland, *Resource-Efficient Battery Life Cycles – Driving Electric Mobility with the Circular Economy*, 2020, https://en.acatech.de/publication/resource-efficient-battery-life-cycles/.

78. Oosterhuis, FH, M. Rayment, A. Varma, et al., *The Use of Differential VAT Rates to Promote Changes in Consumption and Innovation*, Vrije Universiteit Amsterdam, 2008, https://research.vu.nl/en/publications/the-use-of-differential-vat-rates-to-promote-changes-in-consumpti.

79. SYSTEMIQ; Ellen MacArthur Foundation, *Achieving Growth Within*, 2017, https://www.systemiq.earth/resource-category/achieving-growth-within/.

80. Carbon Border Adjustment Mechanism implementation will also include discussions on the methodology of assessing product-level carbon emissions. This relates back to aspects of LCA methodology and requires further refinement of available methodologies.

81. Stede, Jan, Stefan Pauliuk, Gilang Hardadi, Karsten Neuhoff, *Carbon Pricing of Basic Materials: Incentives and Risks for the Value Chain and Consumers*, 2021, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3806327.

82. World Economic Forum, Raising Ambitions: A New Roadmap for the Automotive Circular Economy, 2021, http://www3.weforum.org/docs/WEF_Raising_Ambitions_2020.pdf.

83. World Economic Forum, *Forging Ahead: A Materials Roadmap for the Zero-Carbon Car*, 2021, https://www.weforum.org/reports/forging-ahead-a-materials-roadmap-for-the-zero-carbon-car.

84. "EU-Industriestrategie: Chancen zur Dekarbonisierung der deutschen Wirtschaft?", *EURACTIV*, 2020, https://www.euractiv.de/section/energie-und-umwelt/news/eu-industriestrategie-unklarheit-um-die-dekarbonisierung-der-deutschen-wirtschaft/.

85. Low-carbon steel making can be achieved by hydrogen-based, direct reduced iron and electric arc furnaces, carbon valorization, storage of traditional, or blast oxygen furnace production routes. Scrap-based steelmaking is especially conducted on the former, meaning that decarbonization of steel making will not automatically result in higher recycling rates.

86. European Environment Agency, *Trends and Projections in the EU ETS in 2020*, 2020, https://www.eionet.europa.eu/etcs/etc-cme/products/etc-cme-reports/etc-cme-report-3-2020-trends-and-projections-in-the-eu-ets-in-2020/@@download/file/Report_ETS_03_2020_20201218.pdf.

87. European Climate Foundation, *Decarbonising European Transport and Heating Fuels Is the EU ETS the Right Tool?*, 2020, https://europeanclimate.org/wp-content/uploads/2020/06/01-07-2020-decarbonising-european-transport-and-heating-fuels-full-report.pdf.

88. "Sweden is Paying People to Fix their Belongings instead of Throwing them Away", *World Economic Forum*, 2016, https://www.weforum.org/agenda/2016/10/sweden-is-tackling-its-throwaway-culture-with-tax-breaks-on-repairs-will-it-work/.

89. Statista, *Plug-in Electric Vehicles as a Share of New Vehicle Sales in Selected Markets in 1st Half 2020*, 2021, https://www.statista.com/statistics/267162/world-plug-in-hybrid-vehicle-sales-by-region/.

90. Rodenbach, Johannes, Bram Seeuws and Jeffrey Matthijs, Shared Mobility Opportunities and Challenges for European Cities, 2018, http://stars-h2020.eu/about-stars-deliverables/.

91. Ashworth, Elisabeth and Etienne Cox, "INSIGHT: Using VAT as a Tool to Fight Climate Change?", *Bloomberg Tax*, 14 April 2020, https://news.bloombergtax.com/daily-tax-report-international/insight-using-vat-as-a-tool-to-fight-climate-change.

92. European Commission, *EU Circular Economy Action Plan: A new Circular Economy Action Plan for a Cleaner and More Competitive Europe*, 2020, https://ec.europa.eu/environment/circular-economy/.

93. European Commission, *Public Procurement Indicators*, 2017, https://ec.europa.eu/docsroom/documents/38003.

94. United States Congress, *Federal Vehicle Repair Cost Savings Act 2015*, 2015, https://www.cbo.gov/publication/50038.

95. European Commission, *Public Procurement for a Circular Economy*, 2017, https://ec.europa.eu/environment/gpp/pdf/Public_procurement_circular_economy_brochure.pdf.

96. Bocken, Nancy, Alexandra Jonca, Karolina Södergren and Jenny Palm, "Emergence of Carsharing Business Models and Sustainability Impacts in Swedish Cities", *Sustainability*, vol. 12, no. 4, 2020, https://www.mdpi.com/2071-1050/12/4/1594.

97. European Commission, *Clean Vehicles Directive*, https://ec.europa.eu/transport/themes/urban/clean-vehicles-directive_en.

98. Rijkswaterstaat Ministry of Infrastructure and the Environment, *Sustainable Procurement Using DuboCalc and the CO_2 Performance Ladder*, 2014, https://gpp2020.eu/fileadmin/files/Training_materials/Training_reports_photos_etc/Sustainable-procurement-using-DuboCalc-and-the-CO_2-performance-ladder_lr....pdf.

99. SYSTEMIQ; Ellen MacArthur Foundation, *Achieving Growth Within*, 2017, https://www.systemiq.earth/resource-category/achieving-growth-within.

100. Ibid.

101. Climate Action Network Europe, *Phase-out 2020 Monitoring Europe's Fossil Fuel Subsidies*, 2017, https://odi.org/en/publications/phase-out-2020-monitoring-europes-fossil-fuel-subsidies/.

102. European Investment Bank, *The Joint Initiative on Circular Economy*, 2019, https://www.eib.org/de/publications/joint-initiative-on-circular-economy.

103. EU Technical Expert Group on Sustainable Finance, *Taxonomy: Final Report of the Technical Expert Group on Sustainable Finance*, 2020, https://knowledge4policy.ec.europa.eu/publication/sustainable-finance-teg-final-report-eu-taxonomy_en.

104. ISO, *STANDARDS BY ISO/TC 323 Circular economy*, https://www.iso.org/committee/7203984/x/catalogue/p/0/u/1/w/0/d/0.

105. European Commission, *Categorisation System for the Circular Economy – a Contribution to the Future EU Taxonomy,* 2020, https://circulareconomy.europa.eu/platform/en/measuring-circular-economy/categorisation-system-circular-economy-contribution-future-eu-taxonomy.

106. EU Technical Expert Group on Sustainable Finance, *Taxonomy: Final Report of the Technical Expert Group on Sustainable Finance,* 2020, https://knowledge4policy.ec.europa.eu/publication/sustainable-finance-teg-final-report-eu-taxonomy_en.

107. ECOS; Zero Waste Europe; European Environmental Bureau, *ECOS, EEB & Zero Waste Europe Joint Comments to the European Commission Report: Categorisation System for the Circular Economy A Sector-Agnostic Categorisation System for Activities Substantially Contributing to the Circular Economy,* 2020, https://ecostandard.org/wp-content/uploads/2020/05/ECOS-EEB-ZWE_Comments-on-Circular-Economy-Sustainable-Finance-Report_23.4.20.pdf.

108. International Resource Panel, *Resource Efficiency and Climate Change – Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.

109. Internationales Verkehrswesen, *Studie zeigt: Autobesitzer unterschätzen Fahrzeugkosten massiv*, 2020, https://www.internationales-verkehrswesen.de/studie-zeigt-autobesitzer-unterschaetzen-fahrzeugkosten-massiv/.

110. "Wird Anwohnerparken bald teurer?", *Autozeitung*, 2020, https://www.autozeitung.de/anwohnerparken-beantragen-kosten-strafe-197894.html.

111. World Economic Forum, *Shared, Electric and Automated Mobility (SEAM) Governance Framework, 2019*, http://www3.weforum.org/docs/WEF_Governance_Framework_US_UE_Prototype.pdf.

112. International Resource Panel, *Redefining Value: Manufacturing Revolution*, 2018, https://www.resourcepanel.org/reports/re-defining-value-manufacturing-revolution.

113. Ibid.

114. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.

115. Paterson, David A, Chih Chuan Kao, Winifred L. Ijom, James FC Windmill, *Incorporating Remanufacturing into the End-of-Life Vehicles Directive: Current Presence and the Waste Problem*, Journal of Remanufacturing, vol. 8, no. 1-2, pp. 23-37, 2018, https://doi.org/10.1007/s13243-018-0043-0.

116. The Waste Shipment Regulation includes guidelines on the shipment of waste vehicles (See: European Commission, *Waste Shipments*, https://ec.europa.eu/environment/topics/waste-and-recycling/waste-shipments_en).

    Such guidelines should further be improved and made compulsory to engage EU MSs in ensuring a better monitoring of vehicle and vehicle parts exports outside of the EU. The WSR also complies with the Basel Convention which regulates the movement of waste among countries. Especially for vehicle batteries, further expansion of circular processes will require the ability to move products (batteries and spare parts) for repair, reuse, and recycling across borders. Such amendments to the agreement are currently under discussion (See: The National Law Review, *Proposals to Expand Basel Convention Controls on Circular Economy Trade*, 2021, https://www.natlawreview.com/article/proposals-to-expand-basel-convention-controls-circular-economy-trade).

    The World Economic Forum's Global Battery Alliance, together with White & Case and SYSTEMIQ, published a position on the matter, making recommendations for potential solutions based on legal and sector expert analysis (See: World Economic Forum, *A Framework for the Safe and Efficient Global Movement of Batteries*, 2021, https://www.weforum.org/whitepapers/a-framework-for-the-safe-and-efficient-global-movement-of-batteries).

117. European Commission, *Waste Prevention and Management*, https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index_en.htm.

118. Targets for higher-value-retention processes should not undercut recycling targets. It is also worth noting that remanufactured parts should be of high value and combine environmental impacts with reasonable remanufacturing efforts. There is currently no clear agreement on the key parts suitable for remanufacturing, as various industry associations lay out different scopes and parts (See: European Remanufacturing Network, *Remanufacturing Market Study*, 2015, https://www.remanufacturing.eu/assets/pdfs/remanufacturing-market-study.pdf).

119. Daehn, Katrin, André Cabrera Serrenho, Julian M. Allwood, "How Will Copper Contamination Constrain Future Global Steel Recycling?", *Environmental Science and Technology*, vol. 51, no. 11, 2017, pp. 6599-6606, https://doi.org/10.1021/acs.est.7b00997.

120. World Economic Forum, *Forging Ahead: A Materials Roadmap for the Zero-Carbon Car*, 2021, https://www.weforum.org/reports/forging-ahead-a-materials-roadmap-for-the-zero-carbon-car.

121. Ibid.

122. Eurostat, *End-of-Life Vehicle Statistics*, 2020, https://ec.europa.eu/eurostat/statistics-explained/pdfscache/24943.pdf.

123. As covered in EU Battery Regulation proposal.

124. As the number of electronic devices in modern vehicles is increasing, addressing their recycling becomes ever more important. While the recycling of these materials is complex, it remains crucial to address the recyclability of electronic components' materials to reduce upstream and downstream emissions, as well as other negative impacts on the environment and human health. Additional legal measures beyond the current scope of the ELV Directive need to be considered and implemented in compatibility with ELV legislation.

125. European Commission, *Proposal for a Regulation of the European Parliament and of the Council concerning Batteries and Waste Batteries, Repealing Directive 2006/66/EC and Amending Regulation (EU) No 2019/1020,* 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020PC0798.

126. See Annex XII of COM(2020) 798/3 and Annex I of Commission Regulation (EU) No 493/2012.

127. See the report on traction batteries of the Circular Economy Initiative Germany for thorough recommendations on this topic: https://www.circular-economy-initiative.de/s/TB_Gesamtbericht-EN.pdf.

128. Daimler, *Resource Conservation, Recycling, and Reuse*, 2021, https://sustainabilityreport.daimler.com/2019/strategy/resource-conservation.html.

129. Nissan Motor Corporation, *Resource Dependency*, https://www.nissan-global.com/EN/SUSTAINABILITY/REPORT/ENVIRONMENTAL/RESOURCES/.

130. "BMW will use more Recycled Materials in its Cars by 2030", *BMWBLOG*, 2020, https://www.bmwblog.com/2020/07/28/bmw-recycled-materials-cars-2030/.

131. International Resource Panel, *Resource Efficiency and Climate Change. Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.

132. Ibid.

133. European Parliament, *Plastic Waste and Recycling in the EU: Facts and Figures*, 2018, https://www.europarl.europa.eu/news/en/headlines/society/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures.

134. Circular Economy Initiative Deutschland, *Resource-Efficient Battery Life Cycles – Driving Electric Mobility with the Circular Economy*, 2020, https://en.acatech.de/publication/resource-efficient-battery-life-cycles/.

135. European Commission, *Proposal for a Regulation of the European Parliament and of the Council concerning Batteries and Waste Batteries, Repealing Directive 2006/66/EC and Amending Regulation (EU) No 2019/1020*, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020PC0798.

136. International Resource Panel, *Resource Efficiency and Climate Change. Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.

137. Ibid.

138. Arthur, Rachel, *"California Makes Recycled Content in Plastic Bottles Mandatory with 'World's Strongest Recycled Content Standards'"*, 2020, https://www.beveragedaily.com/Article/2020/09/28/California-mandates-50-recycled-content-rPET-in-plastic-bottles.

139. The exponential uptake of BEVs will result in a booming demand for critical raw materials. Satisfying significant shares of this demand through recycled materials is expected to take several decades. Therefore, optimizing carbon and other environmental footprints of primary raw material extraction and production remains crucial.

140. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.

141. Eurobat, *EUROBAT Position Paper on the Batteries Regulation: Recommendations to Policy-Makers*, 2020, https://www.eurobat.org/news-publications/position-papers/461-eurobat-position-paper-on-the-batteries-regulation-recommendations-to-policy-makers.

142. Umwelt Bundesamt, *Effectively Tackling the Issue of Millions of Vehicles with Unknown Whereabouts*, 2020, https://www.umweltbundesamt.de/en/publikationen/effectively-tackling-the-issue-of-millions-of.

143. Ibid.

144. European Commission; Oeko-Institut e.V, *Assessment of the implementation of Directive 2000/53/EU on end-of-life vehicles (the ELV Directive) with emphasis on the end of life vehicles of unknown whereabouts*, 2018, https://doi.org/10.2779/446025.

145. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.

146. Umwelt Bundesamt, *Effectively Tackling the Issue of Millions of Vehicles with Unknown Whereabouts*, 2020, https://www.umweltbundesamt.de/en/publikationen/effectively-tackling-the-issue-of-millions-of.

147. Nathanson, Jerry, "Hazardous-Waste Management", *Encyclopedia Britannica*, 2020, https://www.britannica.com/technology/hazardous-waste-management.

148. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.

149. Circular Economy Initiative Deutschland, *Resource-Efficient Battery Life Cycles – Driving Electric Mobility with the Circular Economy*, 2020, https://en.acatech.de/publication/resource-efficient-battery-life-cycles/.

150. The Chinese car manufacturer Nio, for example, operates a 'battery-as-a-service' model where vehicle owners do not own, but rent, swappable traction batteries (See: Nio, *Vehicle-Battery Separation*, 2021, https://www.nio.com/de_DE/baas). Such business model changes could lead to reduced numbers of unknown vehicle whereabouts as car manufacturers have better control over the location of vehicle and battery.

151. Umwelt Bundesamt, *Effectively Tackling the Issue of Millions of Vehicles with Unknown Whereabouts*, 2020, https://www.umweltbundesamt.de/en/publikationen/effectively-tackling-the-issue-of-millions-of.

152. Ibid.

153. Nathanson, Jerry, "Hazardous-Waste Management", *Encyclopedia Britannica*, 2020, https://www.britannica.com/technology/hazardous-waste-management.

154. Umwelt Bundesamt, *Effectively Tackling the Issue of Millions of Vehicles with Unknown Whereabouts*, 2020, https://www.umweltbundesamt.de/en/publikationen/effectively-tackling-the-issue-of-millions-of.

155. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.

156. European Commission; Oeko-Institut e.V, *Assessment of the Implementation of the ELV Directive with Emphasis on ELVs Unknown Whereabouts*, 2018, https://doi.org/10.2779/446025.

157. International Resource Panel, *Redefining Value: Manufacturing Revolution*, 2018, https://www.resourcepanel.org/reports/re-defining-value-manufacturing-revolution.

158. World Economic Forum, *Raising Ambitions: A New Roadmap for the Automotive Circular Economy*, 2021, http://www3.weforum.org/docs/WEF_Raising_Ambitions_2020.pdf.

159. European Remanufacturing Network, *Remanufacturing Market Study*, 2015, https://www.remanufacturing.eu/assets/pdfs/remanufacturing-market-study.pdf.

160. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.

161. Saidani, Michael, Alissa Kendall, Bernard Yannou, Yann Leroy and François Cluzel, "Management of the End-of-Life of Light and Heavy Vehicles in the U.S.: Comparison with the European Union in a Circular Economy Perspective", *Journal of Material Cycles and Waste Management*, vol. 21, no. 6, 2019, pp. 1449-1461, http://link.springer.com/10.1007/s10163-019-00897-3.

162. Ride-hailing is not included in this definition, aligned with the UN IRP report on climate change and resource efficiency. Car-sharing includes centralized, free-floating, and peer-to-peer models. Ride-sharing focuses on car- and van-pooling (See: International Resource Panel, *Resource Efficiency and Climate Change. Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change).

163. International Resource Panel, *Resource Efficiency and Climate Change. Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.

164. OECD International Transport Forum, *ITF Transport Outlook 2019*, 2019, https://www.oecd-ilibrary.org/sites/transp_outlook-en-2019-en/1/2/3/index.html?itemId=/content/publication/transp_outlook-en-2019-en&_csp_=1b3375008054c148f41fef71cd42b552&itemIGO=oecd&itemContentType=book.

165. World Economic Forum, *The Road Ahead: A Policy Research Agenda for Automotive Circularity*, 2020, http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf.

166. OECD International Transport Forum, *Good to Go? Assessing the Environmental Performance of New Mobility*, 2020, https://www.itf-oecd.org/sites/default/files/docs/environmental-performance-new-mobility.pdf.

167. Eltis, *The SUMP Concept*, 2020, https://www.eltis.org/mobility-plans/sump-concept.

168. European Commission, *Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future*, 2020, https://eur-lex.europa.eu/resource.html?uri=cellar:5e601657-3b06-11eb-b27b-01aa75ed71a1.0001.02/DOC_2&format=PDF.

169. European Commission, *Evaluation of the 2013 Urban Mobility Package*, 2021, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52021SC0047.

170. ReVeAL, 2021, https://civitas-reveal.eu.

171. Mohnke, Thomas, "Mietwagen am Abgrund", *Tagesspiegel Background,* February 23 2021, https://background.tagesspiegel.de/mobilitaet/mietwagen-am-abgrund.

172. World Economic Forum, *Shared, Electric and Automated Mobility (SEAM) Governance Framework*, 2019, http://www3.weforum.org/docs/WEF_Governance_Framework_US_UE_Prototype.pdf.

173. Global New Mobility Coalition, https://www.weforum.org/projects/global-new-mobility-coalition.

174. POLIS, https://www.polisnetwork.eu/.

175. Covenant of Mayors for Climate & Energy Europe, https://www.covenantofmayors.eu/.

176. Van Ewijk, Stijn, UCL Institute for Sustainable Resources, *Resource Efficiency and the Circular Economy: Concepts, Economic Benefits, Barriers, and Policies*, 2018. https://www.researchgate.net/publication/327868697_Resource_efficiency_and_the_circular_economy_Concepts_economic_benefits_barriers_and_policies.

177. World Economic Forum, *The Road Ahead: A Policy Research Agenda for Automotive Circularity,* 2020. http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf.

178. Organization for Economic Cooperation and Development, *Improving Resource Efficiency and the Circularity of Economies for a Greener World* 2020. https://www.oecd-ilibrary.org/docserver/1b38a38f-en.pdf?expires=1606820050&id=id&accname=guest&checksum=A1EE294D97BD07F6B348ABB27587A06D.

179. Gov base, "Circular Economy Vision", *Ministry of Economy, Trade and Industry*, 2020, https://www.gov-base.info/en/2020/05/22/119119.

180. European Union, *Danish Strategy for Circular Economy*, 2018, https://circulareconomy.europa.eu/platform/en/strategies/danish-strategy-circular-economy.

181. European Union, *Leading the cycle – Finnish road map to a circular economy*, 2016, https://circulareconomy.europa.eu/platform/en/strategies/leading-cycle-finnish-road-map-circular-economy-2016-2025.

182. European Union, *Circular Economy roadmap of France: 50 measures for a 100% circular economy*, 2018, https://circulareconomy.europa.eu/platform/en/strategies/circular-economy-roadmap-france-50-measures-100-circular-economy.

183. European Union, *National Action Plan on Circular Economy*, 2018, https://circulareconomy.europa.eu/platform/en/strategies/national-action-plan-circular-economy.

184. Scottish Government, *Making Things Last: a circular economy strategy for Scotland*, 2016, https://www.gov.scot/publications/making-things-last-circular-economy-strategy-scotland/.

185. Circular Economy, *A Circular Economy in the Netherlands by 2050*, 2016, https://circulareconomy.europa.eu/platform/sites/default/files/17037circulaireeconomie_en.pdf.

186. Organization for Economic Cooperation and Development, *Improving Resource Efficiency and the Circularity of Economies for a Greener World*, 2020, https://www.oecd-ilibrary.org/docserver/1b38a38f-en.pdf?expires=1606820050&id=id&accname=guest&checksum=A1EE294D97BD07F6B348ABB27587A06D.

187. Weber, Thomas and Martin Stuchtey, *Pathways towards a German Circular Economy. Lessons from European Strategies Preliminary Study,* Circular Economy Initiative Deutschland, 2019, https://static1.squarespace.com/static/5b52037e4611a0606973bc79/t/5d678660d3c92c0001a0f712/1567065698846/Circular_Economy_engl_Freigabe.pdf.

188. The Central People's Government of the People's Republic of China, *The Circular Economy Promotion Law of the People's Republic of China*, 2008, http://www.gov.cn/flfg/2008-08/29/content_1084355.htm.

189. The Central People's Government of the People's Republic of China, *Circular Economy Development Strategy and Short-term Action Plan*, 2013, http://www.gov.cn/zwgk/2013-02/05/content_2327562.htm.

190. Zhu, Junming Zhu, Chengming Fan, Haijia Shi and Lei Shi, "Efforts for a Circular Economy in China: A Comprehensive Review of Policies", *Journal of Industrial Ecology,* vol. 23, no.1, 2019, pp. 110-118, https://doi.org/10.1111/jiec.12754.

191. European Commission, *EU Circular Economy Action Plan: A new Circular Economy Action Plan for a Cleaner and More Competitive Europe*, 2020, https://ec.europa.eu/environment/circular-economy/.

192. The new EU mobility strategy highlights important steps to enable a 90% reduction in transport sector emissions (e.g. data spaces, charging infrastructure rollout). However, it still lacks a clear path to implementing other necessary changes, such as well-coordinated city action for shared mobility and a shift in the CO_2 measuring approach of vehicles (See: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), *The Sustainable and Smart Mobility Strategy of the European Commission – A Critical Assessment*, 2021).

193. Please see Appendix D for an analysis of the most important policies on automotive circularity.

194. For circularity in general, the EU's Ecodesign Directive regulates the environmental performance for many products (e.g. by setting requirements for the energy efficiency across the life-cycle). Automotive vehicles and vehicle parts, however, are excluded from the Ecodesign Directive (See: European Parliamentary Research Service, *The Ecodesign Directive (2009/125/EC)*, 2017, https://www.europarl.europa.eu/RegData/etudes/STUD/2017/611015/EPRS_STU(2017)611015_EN.pdf).

195. AsianLII, *The Technical Policy for the Recovery and Utilization of Automobile Products*, 2006, (Accessed December 4 2020), http://www.asianlii.org/cn/legis/cen/laws/ttpftrauoap730/.

196. "Investors encouraged to enter Scrap Vehicle Sector", *The People's Republic of China State Council*, 2019, http://english.www.gov.cn/news/policy_briefings/2019/02/23/content_281476534533038.htm.

197. Cao, James, Ying Dai and Toby Green, "China Plans to Come From Behind to Win the Global Battery Recycling Industry, Thanks to New Policies", *CRU*, 2019, https://www.crugroup.com/knowledge-and-insights/insights/2019/china-plans-to-come-from-behind-to-win-the-global-battery-recycling-industry-thanks-to-new-policies/.

198. UNEP Finance Initiative, *Financing Circularity: Demystifying Finance for Circular Economies*, 2020, https://www.unepfi.org/publications/general-publications/financing-circularity/.

199. Saidani M., A. Kendall, B. Yannou, Y. Leroy, F. Cluzel, "Management of the End-of-Life of Light and Heavy Vehicles in the U.S.: Comparison with the European Union in a Circular Economy Perspective", *Journal of Material Cycles and Waste Management*, vol. 21, no. 6, 2019, pp.1449-1461, https://doi.org/10.1007/s10163-019-00897-3.

200. Transport & Environment, *Company Cars: How European Governments Are Subsidising Pollution and Climate Change*, 2020, https://www.transportenvironment.org/sites/te/files/publications/2020_10_Company_cars_briefing.pdf.

201. Ibid.

202. Bocken, N., A. Jonca, K. Södergren and J. Palm, "Emergence of Carsharing Business Models and Sustainability Impacts in Swedish Cities", *Sustainability,* vol. 12, no. 4, p.1594, 2020, https://www.mdpi.com/2071-1050/12/4/1594/htm.

203. Fachagentur Nachwachsende Rohstoffe e.V, *EU Green Deal – Horizon Europe*, 2020, https://international.fnr.de/get-in-touch/funding-opportunities/horizon-2020.

204. Ibid.

205. TU Delft, *Circular Economy*, https://ocw.tudelft.nl/courses/circular-economy/.

206. eit RawMaterials, *Junior Expert in Circular Economy,* 2021, https://www.studycirculareconomy.com/.

207. World Economic Forum, *The Road Ahead: A Policy Research Agenda for Automotive Circularity,* 2020, http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf.

208. World Economic Forum, *Shared, Electric and Automated Mobility (SEAM) Governance Framework,* 2019, http://www3.weforum.org/docs/WEF_Governance_Framework_US_UE_Prototype.pdf.

209. Mobilität auf neuen Wegen, *hvv, Vernetzt,* 2021, https://www.hvv.de/de/ueber-uns/aufgaben-und-projekte/vernetzt-mobilitaet-auf-neuen-wegen.

210. International Resource Panel, *Resource Efficiency and Climate Change, Material Efficiency Strategies for a Low-Carbon Future*, 2020, https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change.

211. circulareconomy.earth, *How the Circular Economy Can Help Realize the Sustainable Development Goals*, 2020, https://circulareconomy.earth/?policy=cep&year=2015.

212. European Commission, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a Monitoring Framework for the Circular Economy*, 2018, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614.

213. Geng, Y., J. Fu, J. Sarkis and B. Xue, Towards a National Circular Economy Indicator System in China: an Evaluation and Critical Analysis, *Journal of Cleaner Production*, vol. 23, no. 1, 2012, pp. 216-224, https://doi.org/10.1016/j.jclepro.2011.07.005.

214. Ministry of the Environment Energy and Marine Affairs Change (France), *10 Key Indicators for Monitoring the Circular Economy,* 2017, http://temis.documentation.developpement-durable.gouv.fr/docs/Temis/0086/Temis-0086452/22978_2017_ENG.pdf.

215. Ellen MacArthur Foundation, *Resources – The Tools to Guide you Through your Circulytics® Journey*, 2020, https://www.ellenmacarthurfoundation.org/resources/apply/circulytics-measuring-circularity/resources.

216. PBL Netherlands Environmental Assessment Agency, *Circular Economy: What We Want to Know and Can Measure,* 2018, https://www.pbl.nl/sites/default/files/downloads/pbl-2018-circular-economy-what-we-want-to-know-and-can-measure-3217.pdf.

217. Corona, B., L. Shen, D. Reike, J. Rosales Carreón and E. Worrell, Towards Sustainable Development through the Circular Economy – A Review and Critical Assessment on Current Circularity Metrics. *Resources, Conservation and Recycling*, 2019, https://doi.org/10.1016/j.resconrec.2019.104498.

218. Wageningen University and Research, *Methodologies for Measuring the Macroeconomic and Societal Impacts of the Circular Economy,* 2018, https://circular-impacts.eu/sites/default/files/D2.3v2_Measuring-macroeconomic-%26-societal-impacts_FINAL.pdf.

219. Kristensen, H.S. and M.A. Mosgaard, A Review of Micro Level Indicators for a Circular Economy – Moving Away From the Three Dimensions of Sustainability?, *Journal of Cleaner Production,* 2020, https://doi.org/10.1016/j.jclepro.2019.118531.

220. European Commission, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Closing the Loop – An EU Action Plan for the Circular Economy*, 2015, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614).

221. Helander, H., A. Petit-Boix, S. Leipold, and S. Bringezu , How to Monitor Environmental Pressures of a Circular Economy: An Assessment of Indicators, *Journal of Industrial Ecology*, vol. 23, no. 5, pp.1278-1291, 2019, https://doi.org/10.1111/jiec.12924

222. Kick, M., S. Kadner, K. Greiff, et al., *Making Circular Economy Count – What You Can't Measure, You Can't Manage*. 2021, https://www.systemiq.earth/wp-content/uploads/2021/04/CE-Metrics-Report-1404.pdf.

223. Trinomics, *Supporting the Evaluation of the Directive 2000/53/EC on End-of-Life Vehicles*, 2020, https://www.elv-evaluation.eu/fileadmin/elv-evaluation/user_upload/elvd_evaluation_final_report_aug2020.pdf.

224. Ibid.

225. Ibid.

226. Netherlands Human Environment and Transport Inspectorate, *Used Vehicles Exported to Africa*, 2020, https://www.ilent.nl/binaries/ilt/documenten/rapporten/2020/10/26/rapport--used-vehicles-exported-to-africa/RAPPORT-+Used+vehicles+exported+to+Africa.pdf/

227. Gottesfeld P., F.H. Were, L. Adogame, et al., Soil Contamination from Lead Battery Manufacturing and Recycling in Seven African Countries. *Environmental Research*, vol. 161, pp. 609-614, 2019, https://doi.org/10.1016/j.envres.2017.11.055.

228. Edinger, H., M. Davies, K. McDonald, S. Schaefr and T. Schiller, Africa Automotive Insights Navigating the African Automotive Sector: Ethiopia, Kenya and Nigeria, *Deloitte,* 2018, pp. 1-52.

229. Netherlands Human Environment and Transport Inspectorate, *Used Vehicles Exported to Africa*, 2020, https://www.ilent.nl/binaries/ilt/documenten/rapporten/2020/10/26/rapport--used-vehicles-exported-to-africa/RAPPORT-+Used+vehicles+exported+to+Africa.pdf/

230. Edinger, H., M. Davies, K. McDonald, S. Schaefr and T. Schiller, Africa Automotive Insights Navigating the African Automotive Sector: Ethiopia, Kenya and Nigeria, *Deloitte,* 2018, pp. 1-52.

231. Gottesfeld P., F.H. Were, L. Adogame, et al., Soil Contamination from Lead Battery Manufacturing and Recycling in Seven African Countries. *Environmental Research*, vol. 161, 2019, pp. 609-614, https://doi.org/10.1016/j.envres.2017.11.055.

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