

Decarbonising Road Transport Beyond Mining-Intensive Pathways

October 2026

On behalf of the Centre for Research on Multinational Corporations (SOMO), Seas At Risk (SAR), and PowerShift.



Decarbonising Road Transport Beyond Mining-Intensive Pathways (Research Report)

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List of Abbreviations

BAU	Business as usual
BEV	Battery-electric vehicle
CRM	Critical raw materials
DRC	Democratic Republic of Congo
EU	European Union
EoL	End of life
EPR	Extended producer responsibility
ETS	Emissions trading system
GHG	Greenhouse gas
LFP	Lithium iron phosphate
LIB	Lithium-ion battery
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
SUMP	Sustainable urban mobility plan
UK	United Kingdom
WHO	World Health Organisation

Summary

The transition to battery-electric passenger cars in the European Union (EU) is expected to increase the demand for critical battery raw materials such as cobalt, lithium, manganese, nickel, and copper in current demand scenarios. This study identifies and prioritises EU measures that can reduce demand for these materials beyond mining-intensive pathways. Based on a literature review and expert interviews five priority measures were selected for an in-depth analysis at the EU level.

Recycling (measure 1) reduces the demand for primary raw materials—though not total material volumes—and strengthens the EU's supply resilience and recycling expertise. Depending on the source, primary demand savings could range up to ~50% for lithium, ~50% for nickel, and ~70% for cobalt in 2040. The Batteries Regulation and the Critical Raw Materials Act are the central EU-policy entry points.

Downsizing (measure 2) and **energy efficiency** (measure 3) reduce material demand per vehicle. Ambitious downsizing scenarios project reductions of roughly 17%-23% for key battery materials by 2035-2050. Efficiency improvements alone could cut cumulative demand by around a quarter by 2050. The Automotive Omnibus, with a proposal of a new small-vehicle type-approval category (M1E) and the revision of the CO₂ Emissions Performance Standard and car label are near-term EU entry points. However, Member State fiscal instruments, such as size-based bonus-malus systems, remain essential complements.

Modal shift (measure 4) and **travel avoidance** (measure 5) have a wide range of estimated savings (roughly 7–36%). Successful modal shift or travel avoidance may not automatically reduce the size of the vehicle fleet but could reduce the average mileage per vehicle, with fleet-size occurring over the long term. The EU's role is comparatively limited and mostly indirect. It includes co-financing (Multiannual Financial Framework), requirements for Sustainable Urban Mobility Plans, the Emissions Trading Scheme II for road transport and buildings and a non-binding telework/right-to-disconnect consultation. Most concrete levers, such as public transportation infrastructure and service quality, congestion pricing, parking policy, urban and spatial planning, and speed limits, are under the control of Member States and local/regional authorities.

Ultimately, this report demonstrates that **demand can be significantly influenced by policy choices**: Europe can respond to rising material needs by using resources more efficiently. The measures assessed in this study show that reducing demand can be a deliberate policy strategy for limiting the pressure to expand mining, whether on land or at sea. Reducing demand for critical raw materials (CRM) can both reduce environmental and social impacts and can effectively ensure supply security and resilience for the EU.

1 Introduction: Why is this study relevant and what is its focus?

The electrification of road transport is key for the decarbonisation of the transport sector. The large-scale deployment of battery electric vehicles (BEVs) will therefore play a central role in future mobility systems, with BEVs already accounting for a fifth of all new passenger cars in the EU in the first half of 2026 (BEO 2026).

This transition is accompanied by a substantial increase in demand for critical raw materials (CRM)¹, thereby intensifying concerns regarding social, climate and environmental impacts, resource availability and supply security. In addition, electromobility is associated with growing demand for materials used in charging infrastructure.

This study was commissioned by SOMO, Seas at Risk and PowerShift with the objective of identifying effective strategies for reducing the CRM demand in passenger vehicles and assessing policy entry points at the EU level. The analysis focuses on the battery materials cobalt, lithium, manganese, nickel, and copper—all considered critical and strategic raw materials by the EU (European Commission 2024). The primary production of these materials is concentrated outside Europe, resulting in significant import dependencies and supply risks. Furthermore, their extraction and processing are frequently associated with negative environmental impacts, social challenges and ongoing debates regarding future resource frontiers such as deep-sea mining.

The table below provides an overview of the global distribution of primary production, reserves and major supplying countries relevant to the EU. For each criterion, the three leading countries and their respective shares are reported. The data reveals a high degree of concentration in global raw material supply chains. For lithium, cobalt, nickel, and manganese, the three largest producing countries account for more than 70% of global production. Supply concentration is particularly pronounced for cobalt, where the Democratic Republic of the Congo (DRC) accounts for approximately 74% of global production, and for nickel, where Indonesia contributes approximately 67%. Such concentration patterns highlight the vulnerability of global battery material supply chains to geopolitical, economic, social and environmental risks and highlight the importance of reducing primary CRM demand.

¹ CRMs are raw materials of high importance to the EU economy and of high risk associated with their supply. (see https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en)

Table 1-1: Major global primary production countries, reserves and EU suppliers of the materials in focus (for 2025)

	Main primary producers in 2025	Main suppliers for Europe in 2025 (value)	Main reserves in 2025
Lithium	Australia (32%) China (21%) Chile (19%)	Chile (56%) Argentina (10%) Unites States (9%)	Chile (25%) Australia (23%) China (12%)
Cobalt	DR Congo (74%) Indonesia (14%) Russia (2%)	China (70%) United Kingdom (22%) Brazil (5%)	DR Congo (50%) Australia (14%) Russia (7%)
Nickel	Indonesia (67%) Philippines (7%) Russia (5%)	Canada (46%) Brazil (32%) Zambia (13%)	Indonesia (44%) Australia (18%) Brazil (11%)
Manganese	South Africa (38%) Gabon (25%) Ghana (10%)	South Africa (48%) Gabon (38%) Brazil (6%)	Australia (32%) South Africa (31%) Brazil (17%)
Copper	Chile (23%) DR Congo (14%) Peru (12%)	Brazil (28%) Chile (21%) Peru (18%)	Chile (18%) Australia (10%) Peru (9%)
Sources	USGS 2026	Eurostat COMEXT	USGS 2026

Source: Oeko-Institut Consult gGmbH; compilation based on USGS 2026 for main producers and main reserves, without US data for lithium, manganese (<https://pubs.usgs.gov/periodicals/mcs2026/mcs2026.pdf>); main supplier based on Eurostat COMEXT database <https://ec.europa.eu/eurostat/comext/newxtweb/submitresultsextraction.do> data refer to CN codes: nickel: 26040000; cobalt: 28220000 + 26050000; manganese: 26020000; lithium: 28252000 + 28369100; copper: 26030000)

The increasing demand for these materials is further amplified by prevailing trends in the automotive sector, notably the continuing increase in vehicle ownership and growing market share of larger vehicles. Also, most existing and planned EU policy measures focus on increasing the supply of CRMs.

To address these challenges, the present study examines selected measures to reduce the demand for battery raw materials from two complementary perspectives. Firstly, measures that address the vehicles themselves and aim to reduce the material intensity of batteries are analysed. These include battery downsizing, improvements in vehicle energy efficiency, and the increased use of secondary raw materials. Secondly, the study considers strategies and measures that address more structural mobility patterns, aiming to reduce vehicle kilometres travelled and the overall demand for passenger cars by avoiding travel and encouraging the use of more sustainable modes of transport. For each selected measure, potential policy options are assessed with a particular focus on policy entry points at the EU level.

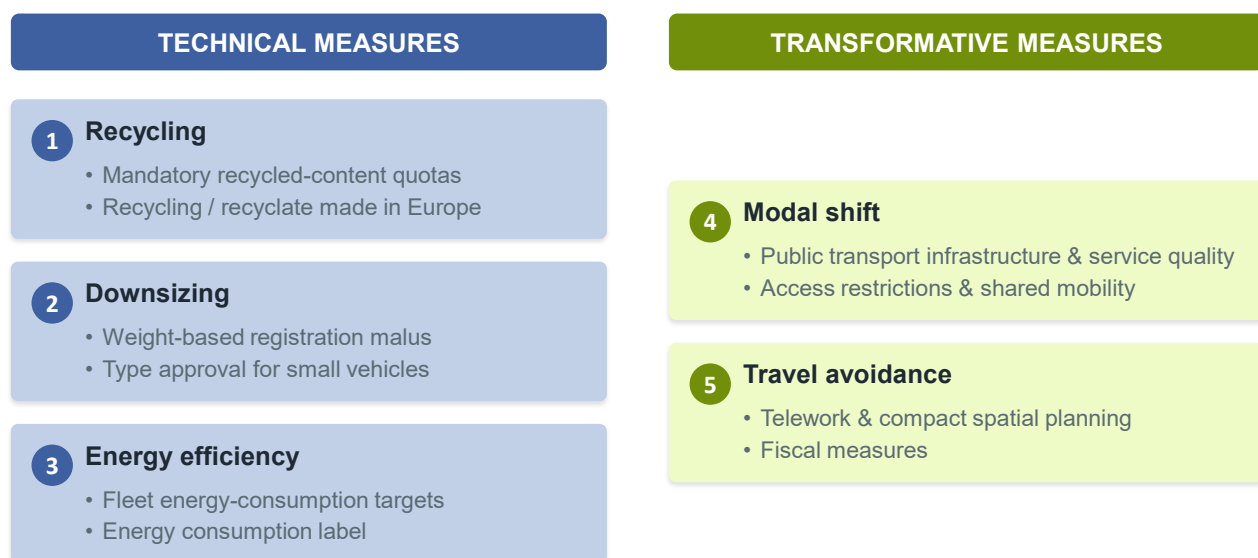
2 Overview of the identified measures and prioritisation

A multi-step methodology was employed to identify promising measures for reducing the use of CRMs in passenger car batteries. A literature review aimed to compile a long list of potential measures and their potential CRM reduction capabilities (see the Annex 6.2 for sources). The following criteria were used for the preliminary prioritisation:

- the CRM saving potential;
- an assessment of the feasibility and effectiveness of the potential measures; and
- relevant co-benefits and risks.

As part of the literature review, we distinguished between measures that address the vehicle itself and are predominantly technical in nature and measures that address vehicle use or mobility patterns and are more transformative. Recycling, downsizing, and energy efficiency were identified as the most relevant technical measures (blue in the following figure). Among the transformative measures (green), modal shift and travel avoidance were deemed relevant, while shared mobility was considered a sub-measure of these strategies. Transformative measures are underpinned by sub-measures, which are detailed in the Annex.

Figure 2-1: Selected technical and transformative measures



Selected sub-measures (examples, not exhaustive)

Source: Oeko-Institut Consult gGmbH

The following table summarises the five measures and their respective saving potentials, co-benefits and relevant risks. Details are provided in the corresponding sub-chapters in Chapter 3. The reviewed sources do not report battery-specific estimates of copper savings for lithium-ion-batteries (LIBs). Available figures are only provided in a broader context (e.g., the vehicle as a whole).

Table 2-1: List of measures and their CRM reduction potential

Measure		Feasibility	Co-benefits and risks	Comment
Recycling 		Technically feasible; regulations in place	Resilience, less import dependency; reduced negative impacts from mining	No reduction in overall demand
Recycling Saving potential (up to 69%)	Li	2035: 11% (8); 8 kt**	2040: 52% (1)(3); 36 kt**	2045: 33% (2)
	Ni	2035: 16% (8); 79 kt**	2040: 50% (1)(3); 250 kt**	2045: 40% (2)
	Co	2035: 40% (8); 29 kt**	2040: 69% (1)(3); 51 kt**	2045: 46% (2)
	Mn	2035: 10% (8); 6 kt**	2040: 19% (8);	
Downsizing 		Technically feasible; safety requirements	Less parking/land use, lower energy demand; Risk: additional second car	Uncertainties in acceptance and implementation
Downsizing Saving potential (up to 23%)	Li	2035: 17% (2); 12 kt**	2045: 18% (2)	2050 cum: 13-22% (4)(5)
	Ni	2035: 17% (2); 84 kt**	2045: 19% (2)	2050 cum: 14-21% (4)(5)
	Co	2035: 17% (2); 12 kt**	2045: 21% (2)	2050 cum: 12-19% (4)(5)
	Mn			2050 cum: 12-23% (4)(5)
Energy efficiency 		Technically feasible; established engineering measures	Reduced electricity demand; Risk: rebound (range increase instead of battery mineral reductions)	EU battery-capacity target needed; Sub-measures needed; acceptance and implementation uncertain
Energy efficiency Saving potential (up to 29%)	Li	2035: 14% (6); 10 kt**		2050 cum: 28% (4)
	Ni	2035: 14% (6); 69 kt**		2050 cum: 29% (4)
	Co	2035: 14% (6); 10 kt**		2050 cum: 25% (4)
	Mn	2035: 14% (6); 8 kt**		2050 cum: 25% (4)
Modal shift***		Feasible; challenges in rural areas; requires investment	Improved social inclusion (public transport expansion); revenue stream (fiscal measures)	Addressed on national and local level; long-term measure (2050)
Travel avoidance***		Urban planning; various sub-measures necessary	Less congestion/emissions; Risk: equity concerns, no guaranteed reduction in fleet size spatial planning has to be thought completely new	Relevant long-term measure (2050)
Modal shift & travel avoidance Saving potential	Li	2035: 10% (7)*; 9 kt**		2050: ~36% (7)*
	Ni	2035: 10% (7)*; 49 kt**		2050: ~36% (7)*
	Co	2035: 10% (7)*; 7 kt**		2050: ~36% (7)*
	Battery Capacity		2040:17% (7)	

Source: Oeko-Institut Consult gGmbH; green portions of the pie charts graphically present the potential of (primary) material demand reduction

(1) Tang et al. 2025, (2) Sutter et al. 2026, (3) Buchert et al. 2026, (4) Morfeldt et al. 2025, (5) Racu 2023, (6) Seibert et al. 2026, (7) ICCT 2024 *(including LCV and HDV); (8) Poliscanova, J. and Gimbert, Y. 2024;

** Calculation of the saving potential based on the assumptions and scenarios considered in the supporting studies of EC's impact assessments of the ELV Regulation and the Batteries Regulation (Stahl et al. 2021, Baron et al. 2023). The reported saving potentials in percentage terms and absolute tonnes (*in italics*) originate from various studies, each employing different methodological approaches, different temporal scopes, assessment horizons and assumptions. As a result, these estimates should not be interpreted as directly equivalent nor comparable, given the variation in system boundaries, baseline scenarios, and calculation methodologies across studies;

*** The saving potentials of modal shift and travel avoidance are reported in aggregated form. Consequently, the corresponding potentials is considered jointly.

Although **material substitution** is not considered within the scope of the detailed assessment, it is important to note its benefits.

Battery technologies have undergone chemical innovations in recent decades, and further developments are expected in the future. Currently, nickel-rich lithium-ion batteries such as NMC811, lithium iron phosphate (LFP) and sodium-ion batteries are among the most prominent chemistries. For instance, NMC811 batteries offer a higher energy density than earlier NMC generations, enabling battery weight reductions while reducing the use of CRMs such as cobalt. In contrast, LFP batteries do not require cobalt or nickel; however, their lower energy density compared with NMC811 can result in higher overall material requirements (Sutter et al. 2026).

Battery manufacturers and original equipment manufacturers (OEMs) actively invest in research, development and innovation activities aimed at advancing cell chemistries. In addition, policy frameworks like the forthcoming **Advanced Materials Act** (EC 2025) can influence future developments. Public research and innovation funding at the European level, as well as differentiated Extended Producer Responsibility (EPR) requirements for specific battery chemistries, may further shape the direction and pace of technological development.

Additional measures identified but not examined in detail are presented in the Annex. These include vehicle lightweighting, lifetime extension of batteries through repair and second-life applications, as well as shared mobility concepts.

3 The selected five measures

The following sub-chapters present a comprehensive analysis of the five selected measures, covering their background and rationale, potential rebound effects, key stakeholder groups, and the corresponding EU-policy entry points.

3.1 Measure 1: Recycling—for less primary material demand

Measure	Increase the recycling of lithium-ion batteries (LIB).
Benefits	Less primary material demand.
Feasibility	Technical feasibility; different cell chemistries require tailored recycling processes to ensure efficient recovery of CRMs; scale-up constrained by investment costs and feedstock uncertainty.
Sub-measures	Mandatory recycled content of materials in LIBs, LIB and recycled material in Europe; Circular economy partnerships including technology transfer with Global South partners.
Main policy entry points	EU Batteries Regulation, Critical Raw Materials Act.
Stakeholder acceptance	Different perspectives: shredder/black-mass exporters benefit from the current export model; hydrometallurgical recyclers and OEMs need regulatory certainty to invest.

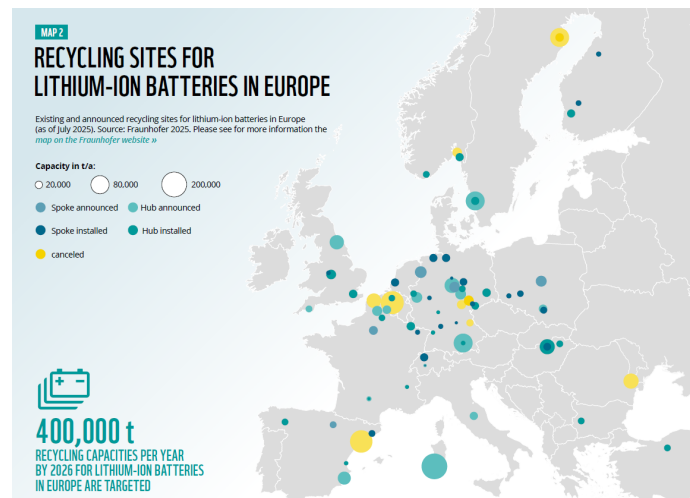
Explanation of the measure

The goal of recycling is to reduce the need for primary CRM demand by using secondary raw materials. As BEV uptake grows, production capacities for primary raw materials for LIBs will need to expand considerably to meet demand in mainstream scenarios (Buchert et al. 2026). Using recycled materials (recyclate) in battery cell production lowers the increase in primary material demand, though the total material volume required for batteries remains unchanged.

Sourcing CRMs from EU recycling facilities in battery-grade quality reduces import dependencies and strengthens supply resilience. With the growing BEV fleet end-of-life (EoL) battery volumes will rise sharply over the coming decades, making it important to build and retain recycling expertise—and ideally the wider value chain (anode, precursor, cathode, cell production)—within the EU.

Recycling in this context involves two stages according to a simplified scheme: pre-treatment ('spoke' sites, where battery cells are shredded into an intermediate material known as black mass) and refining ('hub' sites, where metals are recovered from the black mass in battery-grade quality). Hub capacity within the EU is essential to recover relevant materials in battery grade quality; pre-treatment alone is not sufficient to retain material value in the EU.² According to a map of installed, planned and cancelled recycling sites in Europe, several announced projects have already been cancelled, reflecting high investment requirements, feedstock uncertainty and challenges in securing local acceptance. (WWF Germany 2026)

Figure 3-1: Installed, announced and cancelled recycling sites in Europe



Source: WWF Germany 2026

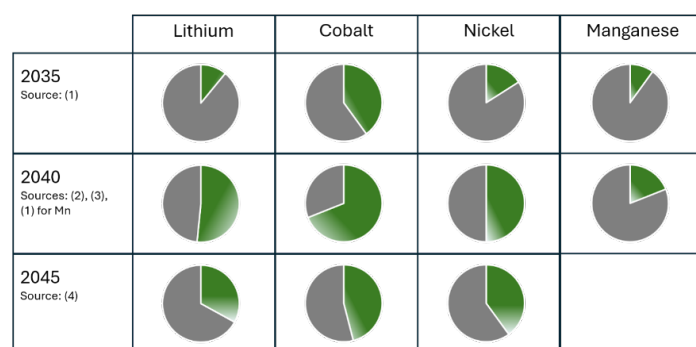
In November 2026, waste lithium-ion batteries and black mass will be classified as hazardous waste (EU 2025/935). Consequently, their export to non-OECD countries will be prohibited, thereby promoting the development of European recycling capacities.

What effect does this measure have?

Recent studies estimate that by roughly 2040-2045 secondary materials from recycling can significantly reduce the demand for primary raw materials—e.g., lithium by 25%-50%, cobalt by 60%-70%, and nickel by 35%-50%. (Tang et al. 2025; Buchert et al. 2026; Sutter et al. 2026)³

There are **uncertainties** and different assumptions in the modelling such as the speed of ramp-up of recycling facilities in Europe, the take back mechanisms of used LIB and keeping the EoL batteries in Europe,

Figure 3-2: Recycling saving potential of primary material demand for LIBs



Source: own compilation Oeko-Institut Consult gGmbH. In green: saving potential of primary material through the use of recycled material (1) Poliscanova and Gimbert 2024, (2) Buchert et al. 2026, (3) Tang et al. 2025, (4) Sutter et al. 2026

² Scaling up recycling production site e.g., cylib, recovering lithium from black mass (see <https://www.cylib.de/>)

³ For manganese and copper no comparable information was available. Given the limited availability of specific data for manganese, its relevance and potential savings can be assume to be broadly analogous to those identified for cobalt (Sutter et al. 2026).

the quality of the recycled materials, the timeframes for changing in cell chemistries and, battery size.

Beyond mitigating land use, pollution, and waste generation, recycling has the potential to reduce greenhouse gas (GHG) emissions by 17% to 61%, depending on the recycling technology, cell chemistries and process applied in case of lithium. (Asad et al. 2025; WWF Germany 2024)

Who are the key actors?

Shredder and black-mass producers currently benefit from exporting black mass from Europe⁴, while **hydrometallurgical recyclers**⁵—which recover battery-grade lithium, cobalt, and nickel—require support and investment in both pre-treatment and refining technologies. To justify investment, recyclers need clearer information on incoming battery volumes, chemistries, and material specifications, potentially via the battery passport. They also need assurance that automotive and battery producers will actually purchase the recycled output.

Battery and automotive producers may resist stronger recycling requirements because of administrative work and need for financing. However, EPR frameworks already require producers to account for future recycling obligations, making more efficient recycling financially relevant.⁶ Producers also need reliable access to secondary materials of the right quality, with predictable quantities and prices.

Where are possible EU-policy entry points?

Batteries Regulation

The EU [Batteries Regulation](#)⁷ sets clear regulatory requirements along the entire battery life cycle, from production to disposal. Explicit requirements are made for mandatory recycled-content targets (see Article 8) for lithium (6% by 2031; 12% by 2036), cobalt (16% by 2031; 26% by 2036) and nickel (6% by 2031; 15% by 2036), among other materials and recycling efficiency requirements (Article 71, Annex 12). Targets for copper recovery are given in Annex XII Part C. Furthermore, the Regulation introduces the battery passport, covering cell chemistry, state of health, dismantling and material composition.

Key recommendations for the Batteries Regulation:

In 2028, a revision will reassess the recycled content targets based on raw-material availability.

- The objective should be to preserve the currently ambitious recycled content targets.

⁴ E.g., South Korea; see <https://institut-mobilites-en-transition.org/wp-content/uploads/2026/07/The-circularity-potential-of-the-European-battery-industry.pdf>

⁵ Hydrometallurgical recycling of black mass is important to win lithium, cobalt and nickel compounds in battery grade.

⁶ See also Hautsch, Marine; Hermine, Jean-Philippe: A circular battery plan for Europe. Policy Brief. No.1, July 2026; <https://institut-mobilites-en-transition.org/wp-content/uploads/2026/07/The-circularity-potential-of-the-European-battery-industry.pdf>

⁷ See <https://eur-lex.europa.eu/eli/reg/2023/1542/oj/eng>

A further review of the Batteries Regulation is due by mid-2031, and it can be expected that an assessment will start in 2030, potentially including further materials:

- Manganese and graphite should be incorporated within the scope of the Regulation to ensure that their recycling is equally prioritised.
- Recycled content should be defined as material recovered through closed-loop recycling processes involving LIB production scrap and EoL LIBs. This measure would strengthen investment incentives for EU battery-recycling infrastructure and mitigate the risk of reallocating secondary raw materials from other sectors to the battery sector.

Critical Raw Materials Act (CRMA)

The [CRMA](#)⁸ focusses on the materials in scope of this study as critical and strategic raw materials among other materials (see Annex I and II of the Regulation). Article 5 of the CRMA sets benchmarks for strengthening the EU's strategic raw materials value chain. By 2030, EU recycling capacity should be capable of supplying at least 25% of the EU's annual consumption of strategic raw materials.

By 1 January 2027 delegated acts shall be adopted to express recycling capacity benchmarks of the strategic materials available in relevant waste streams (in Article 5, paragraph 3). Currently the stakeholder consultation is running.⁹ The implementing regulation (2026/1116)¹⁰ prioritizes batteries having relevant CRM recovery potential.

Recommendations for the CRMA:

- Specific targets for CRMs should be assessed for recycling capacities.

The list of strategic and critical raw materials will be reviewed by May 2027 and every three years thereafter (Article 3 and 4).

- As efforts to enhance recycling and resource circularity continue to advance, it is essential that battery raw materials remain on the CRM list to ensure their continued prioritisation within recovery and recycling strategies.

According to Article 26.1 the Member States shall implement national programmes, which are already overdue.

- The EC should promote ambitious measures to increase the collection, recycling and incorporation of recycled battery materials into the battery value chains.

⁸ See <http://data.europa.eu/eli/reg/2024/1252/oj/eng>

⁹ See <https://www.euwid-recycling.com/news/policy/eu-consultation-on-recycling-capacities-for-strategic-raw-materials-140726/>

¹⁰ See <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32026R1116>

One relevant step under the CRMA is European support of strategic projects in mining and recycling in the EU as well as projects in processing and substitution. Here, it is necessary that recycling and substitution projects remain in the focus of prioritisation.

In December 2025 the EU published the **RESourceEU Action Plan**¹¹ to reduce CRM dependencies and strengthen economic security through financing, supply diversification and international partnerships. The value chain of battery raw materials is in focus, with recycling playing a notable role. The Battery Booster will be designed to find CRMs projects crucial to the battery value chain, especially lithium, cobalt, nickel, manganese and graphite.

The following legislation can further support battery recycling:

- **Industrial Accelerator Act (IAA):** The proposal for the IAA (2026/0068) was published in March 2026.¹² Strengthening the resilience of European supply chains for strategic raw materials requires that recycling capacities and production processes be established and expanded within Europe. Public procurement can serve as a key policy instrument and entry point for promoting such market development.
- **Clean Industrial Deal:** The Clean Industrial Deal¹³ presents measures with the focus on the clean-tech sector as well as circularity, among other topics. The Clean Industrial Deal aims to mobilize over 100 billion Euro to support EU-made clean manufacturing.
- **Circular Economy Act (CEA):** The CEA is expected to be adopted in 2027 (the draft will be presented by the EC at the end of 2026) and aims to establish a market for secondary raw materials, increase the supply of high-quality recycling materials and stimulate demand for these materials within the EU. The CEA will support other legislation with detailed benchmarks like the Batteries Regulation.
- **Net-Zero Industry Act (NZIA)**¹⁴: The NZIA from 2023 aims to scale-up the manufacturing of clean technologies in Europe and is one pillar of the European Green Deal, with batteries as one of the key technologies covered.
- **ELV Regulation:** The ELV Regulation, which entered into force in August 2026, does not focus on automotive batteries; reference is made to the Batteries Regulation. The ELV Regulation addresses, among other issues, the situation of missing vehicles and therefore the potential for recycling of LIBs.
- **Ecodesign for Sustainable Products Regulation (ESPR)**¹⁵: The ESPR¹⁵ (2024/1781) has been in force since July 2024, and among other aspects, it strengthens the circular economy. In the current version, vehicles are excluded; however, a review will be carried out in 2030 to determine whether this should remain the case in the future.

¹¹ See <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52025DC0945>

¹² See https://single-market-economy.ec.europa.eu/document/download/9bc8eb85-4d43-4025-be7b-c86b9f3648ec_en?filename=Proposal%20establishing%20measures%20for%20industrial%20capacity%20and%20decarbonisation%20in%20strategic%20sectors%20.pdf

¹³ See <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0085>

¹⁴ See https://commission.europa.eu/topics/competitiveness/green-deal-industrial-plan/net-zero-industry-act_en

¹⁵ See <https://eur-lex.europa.eu/eli/reg/2024/1781/oj/eng>

3.2 Measure 2: Downsizing—for less battery material per vehicle

Measure	Reducing battery size in BEV.
Benefits	Less primary and secondary material demand per battery.
Feasibility	Technically proven.
Sub-measures	Political measures: type approval of small vehicles, threshold for energy consumption of vehicles in use phase. Economic measures: introduction of a registration tax with a bonus/malus system based on car size and battery size, insurance premiums depending on battery size; expansion of (speed) charging infrastructure, parking costs related to car size. Public procurement requirements.
Main policy entry points	EU type approval (Automotive Omnibus).
Stakeholder acceptance	Downsizing is not merely a technical challenge but also requires a fundamental shift in mindset. OEMs pursue higher profit margins through the sale of larger vehicles, while some consumers perceive spacious, highly equipped vehicles as symbols of social status. There can be conflicting interests, from e.g., countries like Germany with OEMs producing large vehicles, or countries like France with OEMs producing small vehicles. Potential rebound effect: increased vehicle ownership if smaller cars supplement rather than replace existing vehicles.

Explanation of the measure

The aim of downsizing is to reduce the size of vehicles and, as a result, the necessary battery size and thereby less CRM needed per car. There has been a continuous increase in average weight¹⁶ and size of new passenger cars sold and further weight increases can be expected. While increasingly stringent safety requirements constitute an important driver of vehicle weight increase, rising consumer demand for larger vehicle sizes has also contributed significantly to this trend.¹⁷ Thus, downsizing to a smaller vehicle entails not only technological adaptations but also changes in business models and consumer preferences. (Sutter et al. 2026, Morfeldt et al. 2025)

¹⁶ The measure ‘downsizing’ focuses on the vehicle size and not on lightweight construction measures.

¹⁷ Causes of increasing average vehicle weight can be summarized: 30% safety; 25% legislation; 22% comfort; 15% interior; 8% quality (Sutter et al. 2026).

There are already countries taking steps towards promoting smaller vehicles/batteries and offer good-practice examples:

- Japan's **Kei cars** show how targeted tax and regulatory incentives can make smaller, lower-cost vehicles an attractive mobility option. Their success, with these vehicles accounting for almost 40% of Japan's vehicle fleet in 2016, is supported by lower taxes, tolls and parking costs, while still offering modern features and comfort. (Geiger 2019) The limited uptake of comparable L7e¹⁸ microcars in Europe shows that EU safety, emissions and vehicle standards currently make it difficult for smaller vehicles to compete with conventional cars. (Sutter et al. 2026)
- **French bonus/malus system of first-registration tax on CO₂ emissions and in terms of vehicle weight:** In 2008 France implemented a bonus-malus system¹⁹ in terms of CO₂ emissions (IEA 2024). This regulation has evolved, and the thresholds have become more ambitious over time (Directorate for Legal and Administrative Information France 2025). Although the regulation focuses on vehicle weight and exempt BEVs, this serves as a good example of how the size of a vehicle/battery can be considered.

There is a risk that consumers do not replace larger vehicles with cheaper, smaller cars but instead increase their personal vehicle fleet with a smaller vehicle for short-distance transport. This **rebound effect** needs to be considered when developing and implementing measures.

The level of **acceptance** of a transition towards smaller vehicles and lower battery capacities varies among stakeholders. Countries like Germany, with OEMs producing large vehicles, and countries like France, with OEMs producing small vehicles, may have different perspectives on downsizing. Some car companies may oppose the shift to smaller vehicles. Also, changes in consumer behaviour and preferences may take time.

What effect does this measure have?

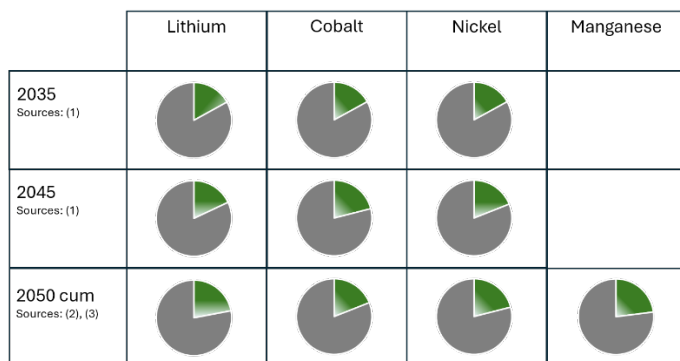
A shift from larger vehicles towards smaller vehicle concepts has the potential to significantly reduce material requirements. Under ambitious downsizing scenarios, the demand for battery materials could be markedly lower than in a transition pathway dominated by larger vehicles.

¹⁸ Four-wheeled light motor vehicles have a maximum weight of 450 kg (600 kg for vehicles for the carriage of goods), not including batteries of electric vehicles. This vehicle class was regulated by EC Directive 2007/46/EC and EU Regulation 2011/678/EU. The engine power is limited to 15 kW (maximum) with a maximum speed of 45-90 km/h. Regarding safety, Japan's Kei cars only meet minimal standards: airbags, ABS or comprehensive stability systems are usually not available; usually with only two seats and reduced additional comforts.

¹⁹ High malus for new vehicles with high specific CO₂ emissions. In France the tax is based on the vehicle's weight. Currently BEVs are excepted from weights malus. (CO₂ emissions are only relevant for vehicles with internal combustion engines and do not apply to BEVs.)

Several studies²⁰ indicate that an ambitious transition from large passenger vehicles to microcars could substantially reduce CRM demand. Such a transition could decrease the demand for key battery materials, including lithium, cobalt, nickel, and manganese²¹: by 2035 approximately 17% overall; by 2045 projected reductions ca. 20% for lithium, 19% for nickel, and 21% for cobalt. (Sutter et al. 2026). These assumptions are also set out in IEA (2023) on a similar scale (18% for 2030, 20% for 2050) across all EV battery materials.

Figure 3-3: Downsizing saving potential of material demand for LIBs



Source: own compilation Oeko-Institut Consult gGmbH; In green: saving potential of material in comparison to BAU

(1) Sutter et al. 2026, (2) Racu 2023, (3) Morfeldt et al. 2025

The potential savings are assumed to be attributable to downsizing interventions when benchmarked against a business-as-usual scenario (BAU) in which existing structures and practices remain unchanged. Similarly, Morfeldt et al. (2025) and Racu (2023) report considerable cumulative material savings by 2050 compared with a BAU scenario. Depending on the scenario assumptions, foreseen reductions range from 12% to 23% for manganese, 13% to 22% for lithium, 14% to 21% for nickel, and 12% to 19% for cobalt.

Beyond material savings, smaller vehicles and batteries reduce land requirements for parking and energy use per kilometre travelled.

Who are the key actors?

The **automotive sector**, particularly OEMs, plays a central role, as larger vehicles typically generate higher profit margins.

Consumer vehicle choices are strongly influenced by social norms, identity and emotional factors. Therefore, economic incentives alone may be insufficient to drive a transition towards smaller vehicles. In addition, efforts are needed to establish a positive cultural narrative in which compact vehicles are perceived as attractive, innovative and aspirational.

Where are possible EU-policy entry points?

EU legislation is needed to facilitate the market uptake of small BEVs. Currently, a regulatory gap exists between microcars classified under the L7e category, which are governed by Regulation (EU) No 168/2013, and conventional passenger vehicles classified as M1, which are regulated under Regulation (EU) 2018/858. Addressing this gap through the introduction of dedicated vehicle classes

²⁰ E.g., Sutter et al. (2026), Racu (2023), Riofrancos et al. (2023), Morfeldt et al. (2025), ICCT (2024), IEA (2023), IFEU (2024)

²¹ Availability of specific data for manganese is limited. Its relevance and potential savings can be assumed to be broadly analogous to those identified for cobalt (Sutter et al. 2026).

or tailored regulatory requirements would support the wider adoption of smaller and more resource-efficient electric vehicles.²²

The Automotive Omnibus aims at increasing the uptake of small affordable BEVs. For this, the type approval of a M1E car needs to be categorized as a new vehicle subcategory under the **Regulation 2018/858** (Type-approval Framework Regulation). Vehicle-size considerations (in the proposal with a maximum length of 4.2 m), together with benefits such as super-credits under CO₂ emission standards and potential incentives at the national and local levels, are already part of ongoing policy discussions for future regulatory amendments (Council of the European Union 2026). In this context, the Automotive Omnibus Package, published in December 2025, has initiated further debate on promoting more resource-efficient vehicle concepts.

Recommendations for downsizing batteries under the Automotive Omnibus:

- For small batteries, the car length of M1E should be reduced to a maximum of 4.0 meters (as a comparison: length of a VW ID.3 is 4.261 m²³; length of a Renault Twingo 3.79 m²⁴)

The EU can further recommend and provide guidance to Member States to support downsizing of BEVs:

- Taxation based on vehicle size with a bonus/malus system. The tax on the purchase of a vehicle should be based on the size of the vehicle and should also take energy consumption kWh/km into account.
- Size-based parking price structure (TEN-T and SUMP) (see further information on TEN-T measure 4)
- Subsidies for the purchase of BEVs could be differentiated according to vehicle size, thereby creating incentives for the adoption of smaller and more energy-efficient models.

²² Furthermore, battery capacity and vehicle energy consumption could be more explicitly integrated into future EU legislation. Energy consumption, measured in kWh per kilometre, reflects the overall energy requirements arising from various vehicle functions and characteristics, including propulsion, rolling resistance, auxiliary systems, and comfort-related features. In contrast to indicators based solely on battery material demand, energy consumption provides a more comprehensive measure of vehicle efficiency throughout the use phase. Consequently, regulatory approaches that incorporate energy demand as a key performance parameter could incentivise the development of lightweight, energy-efficient vehicle designs, irrespective of the specific raw-material composition of the battery system.

²³ See <https://www.volkswagen-automobile-berlin.de/blog/volkswagen/id3-technische-daten>

²⁴ See <https://www.renault.de/elektromodelle/twingo-e-tech-elektrisch/abmessungen-und-innenraum.html>

3.3 Measure 3: Energy efficiency (same range with smaller batteries)—for less material per battery

Measure	Improving energy efficiency of BEVs by reducing energy consumption.
Benefits	Higher energy efficiency in electric cars leads to reduced energy consumption, which may result in smaller batteries and therefore less material demand per battery. Furthermore, energy efficiency results in co-benefits like lower vehicle prices, less environmental impacts, less energy demand in the production.
Feasibility	No significant technical barriers have been identified.
Sub-measures (examples)	Technical measures include vehicle aerodynamics, tyre resistance, drivetrain efficiency, vehicle lightweighting, additional energy consumers, speed limit, and energy consumption targets for fleets. Political measures can cover energy consumption labels and energy consumption targets. Widespread deployment of charging infrastructure constitutes a fundamental prerequisite.
Main policy entry points	EU type approval (Automotive Omnibus), CO ₂ Emissions Performance Standard, Car Labelling Directive.
Stakeholder acceptance	Broad support in increasing energy efficiency of BEVs (vehicle manufacturers, consumers). Rebound effects (longer driving range, higher battery capacity, more comfort, larger and numerous vehicles) need to be considered.

Explanation of the measure

This measure seeks to improve the energy efficiency of BEVs, as reflected by their specific energy consumption per kilometre travelled (excluding charging losses). Improved energy efficiency reduces the battery capacity required to achieve a given driving range, thereby lowering the demand for battery materials.

The energy demand of a BEV is determined by a range of interrelated factors. These include vehicle mass²⁵, vehicle size, aerodynamics, rolling resistance, and driving behaviour, including factors influenced by speed limits. Measures aimed at improving BEV efficiency can be implemented across various technological domains, including vehicle lightweighting, aerodynamic optimization, low-

²⁵ Due to the significant challenge associated with recycling composite materials, which are frequently used in lightweight construction, this aspect will not be examined in further detail.

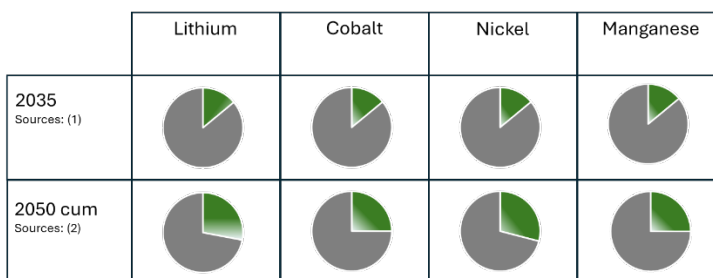
resistance tyres, more efficient powertrain architectures, and enhanced regenerative braking systems.

What effect does this measure have?

Various studies analyse energy efficiency potentials with different geographical scope, time frame and technological aspects, e.g., Wesselkämper et al. (2024), Morfeldt et al. (2025), Seibert et al. (2026).

The potential impact of increased energy efficiency is large. Measures aimed at reducing battery capacity can generate substantial savings in battery material demand with varying degrees of intensity: from 14% in 2035 (Seibert et al. 2026) to cumulative 2050 of 28% for lithium, 29% for nickel, 25% for cobalt, and 25% for manganese (Morfeldt et al. 2025) in comparison with BAU scenarios.

Figure 3-4: Material demand saving potential for LIBs through energy efficiency



Source: own compilation Oeko-Institut Consult gGmbH; In green: saving potential of material in comparison to BAU
(1) Seibert et al. 2026, (2) Morfeldt et al. 2025

Potential **rebound effects** must be taken into consideration. To maximise the benefits of improved energy efficiency—and to prevent those gains from being offset by larger or more numerous vehicles—this measure should be combined with complementary strategies aimed at reducing vehicle size, battery capacity and development of charging infrastructure. In particular, vehicle downsizing helps ensure that efficiency gains are translated into absolute reductions in demand and overall resource consumption rather than being absorbed by increasing vehicle dimensions or performance characteristics.

Who are the key actors?

The **automotive industry** represents the major stakeholder in implementing measures aimed at reducing vehicle energy demand and battery capacity requirements. Vehicle manufacturers can influence several key determinants of energy efficiency. However, efficiency gains do not necessarily translate into smaller or fewer batteries, as OEMs may instead prioritise increased driving range, improved vehicle performance, or higher levels of comfort.

Achieving lower battery capacities and reduced range requirements depends on the availability of **adequate public charging infrastructure**. A dense and reliable high-speed charging network can increase consumer acceptance of vehicles with less material-demanding batteries by reducing concerns related to driving range and charging accessibility. It should be noted, however, that the expansion of charging infrastructure requires additional material and resource inputs.

Consumers also represent a crucial stakeholder group. Transparent and accessible information about vehicle energy consumption can support more informed purchasing decisions and increase awareness of the economic benefits associated with highly energy-efficient vehicles. Given that travel behaviour, vehicle preferences and perceptions of acceptable driving range are deeply

embedded in societal norms and practices, behavioural change is unlikely to occur in the short term and likely requires sustained efforts over an extended period.

Where are possible EU-policy entry points?

At present, no legal incentives for vehicle manufacturers to improve the energy efficiency of BEVs exist in the EU, although the measure is broadly supported across stakeholders. In January 2026 the first energy consumption standard for BEV came into force in China, establishing requirements for electricity consumption by pure electric passenger vehicles. (TechNode 2025), (ICCT 2026)

European legislation plays a pivotal role in promoting vehicle energy efficiency by incorporating energy-demand-related criteria into regulatory frameworks. Potential instruments include vehicle type-approval procedures, fleet-average performance standards and other measures that explicitly address energy consumption during the vehicle use-phase.

CO₂ Emissions Performance Standard 2019/631²⁶ has been tightened with Regulation 2023/851²⁷. Currently the Automotive Package proposes to weaken CO₂ standards. The existing Regulation is predominantly centred on CO₂ emissions, while BEVs are exempt from the performance requirements due to their lack of tailpipe emissions. As a result, vehicle energy consumption is not currently addressed as a key regulatory parameter. Incorporating energy-efficiency indicators into the CO₂ performance standard framework would enable a more comprehensive assessment of the environmental performance of BEVs and create incentives for reducing energy demand during the use phase. The European Commission's review proposal, published in December 2025 and currently under negotiation, provides a potential opportunity for such incorporation.²⁸

Recommendations for the CO₂ Emissions Performance Standard 2019/631:

- Assess the impact of establishing a minimum energy-efficiency threshold for zero-emission vehicles (Article 15) in the short-term
- Integrate a minimum energy-efficiency threshold in the next review of the Standard (long-term)

Euro 7 Regulation (EU) 2024/1257²⁹ primarily targets exhaust and non-exhaust pollutant emissions, so its relevance to BEV energy efficiency is currently limited. While it includes provisions on tyre and brake wear and foresees future reviews, introducing minimum energy consumption requirements appears unlikely.

The **Car Labelling Directive** (EU COM 1999) entered into force in January 2000 with associated recommendations 2017/948 (European Union 2017). This Directive is expected to undergo further review, creating an opportunity to incorporate additional information on vehicle energy

²⁶ See <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0631>

²⁷ See <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0851>

²⁸ See <https://observatory.clean-hydrogen.europa.eu/eu-policy/co2-emission-performance-standards-passenger-cars-and-light-commercial-vehicles>

²⁹ See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401257

consumption.³⁰ In particular, energy-efficiency classifications ranging from A to G could be introduced.³¹ The inclusion of such information would enhance transparency for consumers, facilitate comparisons between vehicles based on their energy performance, and potentially strengthen incentives for the development and uptake of more energy-efficient vehicle technologies. In 2025, the European Commission announced its intention to review the Car Labelling Directive in 2026.³²

The **Ecodesign for Sustainable Products Regulation (ESPR)** (2024/1781)³³ establishes a framework for ecodesign requirements for products placed on the EU market. Although motor vehicles are excluded, relevant products such as tyres and charging infrastructure fall within its scope. Through delegated acts, the ESPR enables product-specific sustainability, resource-efficiency, performance and information requirements, which may indirectly reduce energy demand of electric mobility. The first evaluation is scheduled for July 2030.

The forthcoming **Advanced Materials Act** (EC 2025) represents a key European legislative initiative intended to support the development, scale-up and deployment of advanced materials, with batteries constituting one of the most important application areas. It is essential to ensure that the Act is designed in a way that directs R&I (research and innovation) and industrial support towards recycling, downsizing, energy efficiency and substitution.

The EU can further recommend and provide guidance to Member States to support energy efficiency of BEVs using various tools.

- **Fiscal instruments** can influence the energy consumption of the vehicle fleet through vehicle taxation schemes that account for vehicle energy efficiency. Registration or purchase taxes could be linked to specific energy consumption (e.g., kWh/km), thereby providing economic incentives for purchasing energy-efficient vehicles.
- **Speed regulation:** Member States are responsible for determining speed limits on their road networks, including motorways. Since vehicle energy consumption increases disproportionately at higher speeds due to greater aerodynamic drag, speed limits can significantly affect the energy demand of the vehicle fleet.
- **Financial incentives for BEVs with energy consumption requirements:** Subsidies for the purchase of BEVs could be differentiated according to vehicle energy consumption, thereby creating incentives for adopting smaller and more energy-efficient models.

³⁰ Automotive Omnibus published a proposal. While the first draft of the EC included a (small, indicative) second energy consumption rating for BEV, this provision was not retained in the revised proposal after stakeholder consultation. (Seibert et al. 2026)

³¹ See <https://www.gesetze-im-internet.de/pkw-envkv/BJNR103700004.html>

³² See https://climate.ec.europa.eu/news-other-reads/news/eu-evaluates-car-labelling-directive-drive-digitalisation-and-uptake-zero-emission-vehicles-2025-06-11_en; https://transport.ec.europa.eu/document/download/89b3143e-09b6-4ae6-a826-932b90ed0816_en?filename=Communication%20-%20Action%20Plan.pdf

³³ See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401781

3.4 Measure 4: Modal shift—for less car use

Measure	Shifting existing trips from private cars to public transport, cycling, walking or shared modes of transport.
Benefits	Lower passenger-car mileage and a smaller vehicle fleet result in lower demand for new BEV; co-benefits for reduced congestion, emissions, land use, accessibility and public health.
Feasibility	No technical barriers; depends on the availability and quality of alternatives, which is mainly a local/regional competence. Infrastructure investment and public transport operating costs especially in low utilisation areas are needed; changes in mobility patterns are a long-term process and uncertainties remain regarding the level of the vehicle fleet reduction.
Sub-measures (examples)	Infrastructure for public transport and active mobility; public transport service quality and affordability, restrictions and fiscal measures that make alternatives to passenger cars more attractive, shared mobility; (partly overlapping with travel avoidance, see sub-chapter 3.5).
Main policy entry points	EU funding of public transport (infrastructure): MFF 2028-2034 currently in negotiations, targeted for agreement by the end of 2026. SUMP requirements in TEN-T Regulation Art. 41/42 in the long term, increasingly encompassing land-use and transport integration. Other entry points mostly on the level of Member States or local/ regional legislation.
Stakeholder acceptance	Dependent on the underlying sub-measure. Resistance to restrictive measures such as driving bans or financial burdens resulting from higher taxes and fees possible; high acceptance of supply-side measures, though this may not extend to the associated costs.

Explanation of the measure

‘Modal shift’ refers to the strategy of moving existing trips from private cars to public transport, cycling, walking or shared modes of transport without necessarily changing whether or how far people travel overall.³⁴ Implementing a modal shift reduces demand for new passenger cars and therefore for BEV batteries and CRM.

‘Modal shift’ is an umbrella term for several (sub-)measures that can address quite different leverage points. On the supply side, this means creating attractive alternatives to car use (‘pull’ measures e.g., improved public transport frequency, cycling infrastructure and mobility services for commuters). On the demand side, ‘push’ measures make car use less attractive, either by restricting it or by raising its cost (e.g., congestion charges, parking fees or limited traffic zones). No single

³⁴ ‘Modal shift’ is distinct from ‘travel avoidance’ (sub-chapter 3.5), which reduces the need to travel in the first place. The transport-decarbonisation literature commonly treats these as two distinct pillars of a wider avoid-shift-improve framework (ITF 2023, ICCT 2024)

measure can be assigned to a concrete target; rather, a combination of measures creates the conditions for individuals to shift away from, or avoid adopting, car-dependant mobility. Individual mobility behaviour tends to be stable and is often only revisited at specific life junctures such as moving house, marriage, or having children.

The demand for car ownership depends not only on accessibility, household and life-cycle characteristics, but also strongly on economic resources and spatial structure. Cars do not serve transport purposes alone but can also function as status symbols. Nevertheless, even without a change in the car ownership rate, a reduction in average yearly mileage per car could reduce demand for new vehicles if the total mileage driven over a vehicle's lifetime remains unchanged. In this case, vehicles would remain in the vehicle stock longer before reaching end of life.

Sub-measures

Building infrastructure for public transport and active mobility covers the physical assets needed for any modal shift to materialise, since alternatives to the car can only be used if the underlying infrastructure exists. It includes developing safe cycling and walking networks and dedicated bus priority lanes and investing in expansion of rail infrastructure. Building and maintaining this infrastructure is mainly a local, regional and national responsibility, especially for urban and regional transport. However, the EU financially contributes to this infrastructure through co-financing and funding programmes such as the European Regional Development Fund (ERDF)³⁵, the Cohesion Fund (CF)³⁶ or Connecting Europe Facility (CEF)³⁷.

Improving public transport service quality addresses the frequency, coverage and reliability of services and integrated ticketing across different transport modes and operators, which lowers the practical barrier to switching from car use to public transport. Unlike infrastructure, these are largely ongoing operational and organisational decisions rather than one-off investments. Responsibility sits almost entirely at the local, regional and Member-State levels.

Fiscal measures can aim at making car use relatively more expensive compared with public transport, cycling, walking and shared mobility, thereby encouraging a shift towards these alternatives. Examples include congestion charges, parking charges, distance-based tolls, the taxation of vehicle purchase or registration, reduced VAT on bike-sharing services, and energy and CO₂ levies on fuel. Another approach is to provide greater subsidies to lower public-transportation ticket prices, thereby making public transit more attractive.

Regulatory and access restriction measures make car use less convenient or less viable, thereby encouraging a shift towards public transport, cycling and walking. Examples include Low Traffic Neighbourhoods and Urban Vehicle Access Regulations that restrict entry for certain vehicles or times of day, stricter urban speed limits that reduce the time advantage of driving, and urban planning choices that reduce parking-space availability or reallocate road space away from cars towards public transport, cycling and walking infrastructure. As with fiscal measures, these restrictions often act on both modal shift and travel avoidance simultaneously. Responsibility for these measures lies almost entirely with local and regional authorities.

³⁵ See https://ec.europa.eu/regional_policy/funding/erdf_en

³⁶ See https://commission.europa.eu/funding-and-tenders/find-funding/eu-funding-programmes/cohesion-fund-cf_en

³⁷ See https://cinea.ec.europa.eu/programmes/connecting-europe-facility_en

Shared mobility complements public transport and active mobility by offering bikesharing, carsharing (station-based or free-floating) and ride-pooling/carpooling as intermediate alternatives to private vehicle use. It is treated here as a complementary rather than a primary lever.

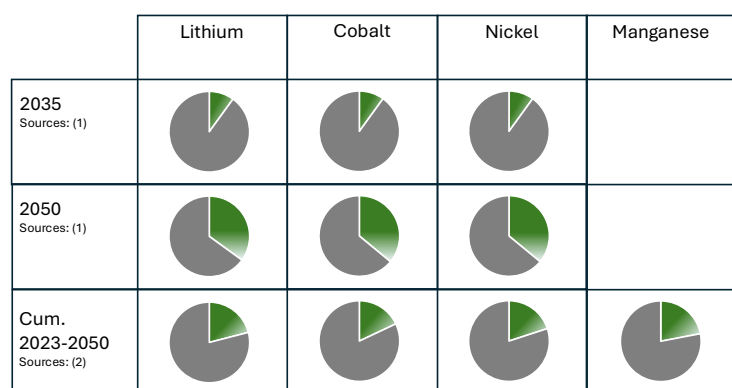
What effect does this measure have?

Several studies have quantified the CRM savings potential that could be achieved through transformative measures, including modal shift. They often present combined results for modal shift and travel avoidance. Racu (2023) assumes a reduction in car kilometres travelled due to modal shift of up to 15%-30% by 2050, while Morfeldt et al. (2025) assume a 24% reduction in per capita car travel demand by 2050, 10 percentage points of which are specifically attributed to modal shift, alongside travel avoidance. In contrast, modelling by the ITF (2023) for European cities yields more moderate outcomes: under the High Ambition scenario, the urban passenger-car mode share by 2050 is foreseen to fall by around 10 percentage points, accompanied by a 14% reduction in trip length.

ICCT (2024) present a 29% reduction in new passenger car sales by 2050 with Avoid-and-Shift measures, reducing material demand by 9%-10% in 2035 and 29%-36% in 2050.

In terms of cumulated material savings, Morfeldt et al. (2025) model shows reductions of 16%-17% by 2030 and 27%-30% by 2050 across the considered materials due to modal shift and travel avoidance, whereas Racu (2023) reports savings of 7%-9% in the Accelerated scenario and 18%-22% in a more ambitious scenario by 2050.

Figure 3-5: Combined material saving potential of modal shift and travel avoidance



Source: own compilation Oeko-Institut Consult gGmbH; In green: saving potential of material in comparison to baseline- (1) or BAU-scenario (2)
(1) ICCT 2024, (2) Racu 2023

According to WWF France (2023), a modal shift could lead to a 14% reduction in demand for battery metals by 2035 compared to a business-as-usual scenario.

The results presented above are subject to considerable uncertainty, since most of them are based on optimistic assumptions and do not analyse the relationship between modal shift or reduced car use and the reduction in new car sales.

Measures supporting modal shift can generate substantial co-benefits, even if car ownership declines by less than the assumptions the above studies. These include improved air quality, public health, accessibility, equity, reduced congestion and more liveable cities. Even modest shifts can free space for housing, green areas and infrastructure for active mobility.

Who are the key actors?

Congestion charging, parking policy, Limited Traffic Zones, speed limits and land-use planning are typically decided and enforced by **local and regional governments** (Kuss and Nicholas 2022; ITF 2023). Their interest generally aligns with reduced congestion, better air quality and more liveable urban space, but they must balance this against local political resistance and revenue/budget constraints for financing alternatives.

Public transport operators' and infrastructure providers' capacities and service quality directly determine the extent to which modal shift is realistically achievable. Several sources note that pricing/restriction measures only work if adequate public-transport or active-mobility alternatives already exist (ITF 2023). They benefit from increased ridership but require sustained public investment to expand capacity ahead of demand.

Shared mobility providers (e.g., bike- and carsharing, ridepooling) shape the availability and cost of private car alternatives through their own commercial decisions on pricing, fleet size and service area.

As the ultimate users of any alternative mode, **citizens** constitute a further key actor group whose acceptance determines whether a measure succeeds in practice. Several sources flag equity concerns in this context: people without access to alternatives e.g., in rural or low-income settings, are disproportionately affected by restrictive measures, making perceived fairness a recurring precondition for public buy-in.

Where are possible EU-policy entry points?

In the current **EU funding** period, which runs until 2027, responsibilities are clearly divided across instruments. This division may shift under the proposed post-2027 arrangements. Funding for local public transport has historically relied primarily on the EU Structural and Cohesion Funds (ERDF & Cohesion Fund (restricted to lower-income Member States), Regulation (EU) 2021/1058). The Connecting Europe Facility (CEF Transport, Regulation (EU) 2021/1153) primarily finances cross-border missing links, long-distance corridors on the TEN-T network, and major rail nodes.

The EU's Multiannual Financial Framework³⁸ (MFF) for 2028-2034 is under negotiation, aiming to conclude before the end of 2026, 'which would allow for the adoption of legislative acts in 2027 and thereby ensure that EU funding reaches beneficiaries from January 2028.'³⁹ The Commission proposes folding the existing Structural and Cohesion Funds into consolidated 'National and Regional Partnership Plans' (NRPPs). For urban public transport, this means Member States would need to prioritise public transport projects within their national plans rather than relying on fixed, ring-fenced allocations for regional infrastructure. This creates a risk that local public transport will compete with other national flagship projects for the same pool of funds. The Commission's draft for CEF 2028-2034 proposes a substantial budget increase for transport infrastructure.

In its position paper, UITP calls for a stronger transport budget in the next EU financial framework. It advocates the explicit recognition of urban nodes and multimodal hubs as projects of common

³⁸ Under the MFF 2028–2034, NRPPs and CEF III are most relevant for infrastructure and vehicles.

³⁹ See <https://www.consilium.europa.eu/en/policies/the-eu-s-long-term-budget-2028-2034/timeline-eu-long-term-budget-2028-2034/>

European interest under the CEF Regulation, to unlock investment beyond TEN-T corridors. UITP further proposes a dedicated ‘urban and local mobility envelope’ within the National and Regional Partnership Plans, to guarantee predictable and direct investment in clean, affordable, and resilient public transport systems. (UITP 2026)

Recommendations for securing funding for public transport and active mobility:

- Establish binding minimum spending requirements for local and regional public transport within NRPPs to mitigate competition with other national investment priorities.
- Include a dedicated operating-cost eligibility line within NRPPs or a successor instrument, since NRPPs, CEF III, and the ECF do not currently cover recurring public transport operating costs.

The revised **TEN-T Regulation (EU) 2024/1679**⁴⁰, in force since 18 July 2024, sets out binding requirements for urban nodes in Article 41. By **31 December 2027**, Member States must ensure that each urban node has adopted and is monitoring a SUMP covering measures to integrate transport modes and shift towards sustainable mobility, reduce air and noise pollution, and, where appropriate, assess accessibility. Also, **urban mobility data** needs to be collected and submitted to the Commission on sustainability, safety and accessibility (Article 41(1)(b)).

Article 42 additionally sets qualitative priorities for urban-node projects of common interest like first/last-mile connections, seamless multimodal interconnection, and increased modal share of public transport and active modes but does not define further binding deadlines.

Recommendations for the TEN-T Regulation:

- Analyse SUMPs (and their implementation) and mobility data across the EU to identify successful examples and measures and promote them, aligned with the recommendations by the European Court of Auditors. (ECA 2026)

The TEN-T Regulation primarily regulates infrastructure outputs (e.g., route kilometres, technical standards) but not the desired outcomes (e.g., modal shift or GHG reduction).

- Transform the TEN-T into an output-oriented regulatory framework with binding performance indicators such as modal split, accessibility of sustainable modes of transport and expansion of active mobility.

⁴⁰ See <https://eur-lex.europa.eu/eli/reg/2024/1679/oj/eng>

3.5 Measure 5: Travel avoidance

Measure	Reducing the need to travel and discouraging travel cutting overall passenger-kilometres (trip number and/or length). Linked to modal shift (sub-chapter 3.4).
Benefits	Lower passenger-car mileage and reduction of the vehicle fleet result in lower demand for new BEVs; co-benefits off reducing emissions and, congestion, and improving health and wellbeing (telework), and if paired with green infrastructure quality of life and social equity in urban areas.
Feasibility	No technical barriers; depends on policies to influence individual/household decisions. Urban/spatial planning changes are slow, long-term processes tied to existing building stock; telework uptake depends on job type and employer policy, not solely on regulation. Long-term, low-certainty effect on vehicle fleet size, similar to modal shift.
Sub-measures (examples)	Teleworking and digitalisation of services; compact, mixed-use urban and spatial planning; fiscal and regulatory/access restrictions already covered under modal shift (sub-chapter 3.4), which reduce trips as well as shift mode.
Main policy entry points	Quality Jobs Act is expected to be proposed by the end of 2026. ETS2: 2028 start date and price-stabilisation mechanism largely settled; near-term entry point is shaping national Social Climate Plans for targeted fund disbursement. SUMP requirements under TEN-T Regulation Art. 41/42 (see sub-chapter 3.4). Urban/spatial planning: not an EU competence; entry points mostly at Member State / local-regional level.
Stakeholder acceptance	Mixed: telework measures (right to disconnect, fair conditions) generally have high acceptance among employees, but employer resistance to binding standards is possible. Urban densification/containment measures can face local resistance (e.g., housing cost concerns) despite broad support for the underlying sustainability goals. Fiscal/regulatory sub-measures shared with modal shift carry the same acceptance risks as in sub-chapter 3.4.

Explanation of the measure

Travel avoidance refers to strategies that reduce the total number or length of trips made with passenger cars. The link to CRM demand runs via the same mechanism as modal shift. Fewer and shorter trips reduce cumulative vehicle-kilometres travelled, which can translate into a smaller or more slowly growing car fleet and therefore lowers the number of new BEVs that need to be produced.

As with modal shift, travel avoidance is best understood as a long-term strategy rather than a single measure, since it depends on policies that influence individual and household decisions (e.g., whether to work from home, where to live in relation to workplaces, and whether to take long-distance leisure trips). These decisions are influenced by the political framework, such as taxation, subsidies as well as urban and regional planning.

Sub-measures

Remote work arrangements and **digital access to public and commercial services** reduce the need for commuting and business trips, thereby avoiding vehicle use and, in return, the need for private cars. Uptake depends on job type, employer policy and digital infrastructure like broadband access.

Compact, mixed-use **urban and regional planning**—such as the ‘15-minute city’ concept, with short distances to shops, healthcare, everyday services, and accessible green space for recreation—reduces the need for long trips and therefore avoids travel. It is interlinked with modal shift (see sub-chapter 3.4) by making walking and cycling viable for daily needs and improving the catchment and viability of public transport. This encompasses both redesigning existing urban areas and urban densification instead of developing new land on city outskirts.

Beyond these sub-measures, **fiscal measures and regulatory/access restrictions**, which are already discussed in more detail under modal shift (sub-chapter 3.4) also reduce total travel, not only the choice of mode. Raising the cost of car use (e.g., with increased congestion and cordon pricing, fuel and CO₂ levies and distance-based tolls) or making it less convenient (e.g., reduced speed limits, parking restrictions and access regulations) can lead individuals to avoid or forgo trips altogether rather than merely switching transport mode.

What effect does this measure have?

WWF France (2023) models a 9% reduction in demand for battery metals by 2035 compared with a business-as-usual scenario that would result from travel avoidance. Several of the studies already mentioned in sub-chapter 3.4 analyse material savings from travel avoidance and modal shift jointly and are therefore not considered again here.

When it comes to assumptions about travel avoidance, the reviewed studies rely on rather optimistic assumptions. For example, Morfeldt et al. (2025) assume that half of all commuters work from home two days a week, which would correspond to a 5% reduction in car travel per capita, as well as a shift away from or avoidance of long-distance leisure trips (-9%). Chiarotti et al. (2026) also consider travel avoidance, assuming a 26% reduction in passenger kilometres travelled per capita compared to a 2050 baseline scenario.

The sub-measures addressing travel avoidance discussed in this chapter, however, can have **additional effects** beyond material savings, which are outlined below. A literature review of the environmental and social effects of remote work finds reduced traffic volume and air pollutant levels associated with telework uptake, alongside co-benefits for health and satisfaction: reduced commuting time, greater autonomy, and healthier lifestyles. These benefits are unevenly distributed and accompanied by new stressors such as isolation and stress. (Kelmali et al. 2024)

An EU Urban Agenda assessment on compact cities lists positive effects, including increased GDP, reduced traffic pollution and greater social equity through lower car dependency, shorter commute

times and reduced social segregation. However, compact cities can also have negative impacts, such as higher housing costs, increased traffic congestion and loss of green space, unless paired with green infrastructure. (KaturiĆ 2025)

Who are the key actors?

Regional and local authorities are the primary implementing actors for urban and spatial planning measures (e.g., densification, containment, mixed-use zoning, SUMP), since binding land-use and infrastructure decisions are made at this level.

Member States hold formal competence for spatial/urban planning and, where applicable, national telework or right-to-disconnect legislation; they also set the regulatory context (e.g., building codes, zoning law) within which local authorities act.

Employers determine the extent and conditions of telework uptake through internal policy.

Private individuals directly influence travel avoidance through their everyday choices, such as where to live in relation to work and services, whether to work remotely and whether to take long-distance trips, such as for holidays.

Where are possible EU-policy entry points?

No binding EU legal framework for **telework** currently exists. The 2002 Framework Agreement on Telework⁴¹ remains the only EU-level reference but is non-binding and unevenly implemented. Following a failed attempt by EU social partners to renegotiate the agreement in 2022-2023, the Commission launched a two-stage consultation in 2024 and 2025 on possible minimum EU standards for the right to disconnect and to fair teleworking conditions. This track has since been folded into the Commission's Quality Jobs Act, which names the right to disconnect among its priority areas and is expected to be proposed by the end of 2026.⁴²

It remains unclear at this stage whether the EU-level initiative will result in a binding or non-binding instrument. Some Member States have already implemented binding rules, e.g., the Netherlands gives employees a statutory right to request home working for eligible jobs (Llave et al. 2022).

Once a proposal is brought forward, the key institutional entry points would be the European Parliament's Committee on Employment and Social Affairs (EMPL) and the Council configuration for Employment, Social Policy, Health and Consumer Affairs (EPSCO), composed of the relevant national ministers.

Recommendations for a binding Directive for telework:

- Support translation of the current consultation into a binding Directive.

⁴¹ See <https://www.etuc.org/en/framework-agreement-telework>

⁴² See https://employment-social-affairs.ec.europa.eu/policies-and-activities/rights-work/quality-jobs-companies-and-workers-europe_en

The **EU Emissions Trading System for Buildings and Road Transport⁴³ (ETS2)** was adopted in 2023 as part of the ETS Directive revision. It establishes a separate cap-and-trade carbon price on fuel suppliers for road transport and building emissions, distinct from the existing EU ETS for power and industry. Allowances are distributed exclusively via auctioning, with a price containment mechanism releasing additional allowances if prices exceed roughly €45/tCO₂ (in 2020 prices).

The system was originally due to start in 2027 but was postponed by one year to 2028. Early auctioning of allowances is foreseen from January 2027. Revenues finance the Social Climate Fund (SCF), already active since 2026 and expected to mobilise up to €65 billion between 2026 and 2032 plus additional 25% from the Member States, to cushion cost impacts on vulnerable households and small enterprises⁴⁴.

The fund will support measures and investments to reduce emissions in the road transport and building sectors. It will also reduce costs for vulnerable households, micro-enterprises, and transport users who are particularly affected by ETS2. The fund will also provide temporary direct income support for vulnerable households and transport users.

Recommendations for the ETS2 and the SCF:

- Ensure that ETS2 starts in 2028 as planned and avoid further delays. A predictable regulatory signal is important for investments.
- Within the Social Climate Fund, prioritise investment in energy efficiency, public transport, active mobility, shared mobility and zero-emission vehicles and infrastructure over direct income compensation.
- Where targeted income support is used, it should be limited in time to the period before affected groups can access alternatives to private car use. The most effective way to prevent lock-in to car dependency is to support long-term investments in alternatives and changes in behaviour rather than providing recurring compensation payments.

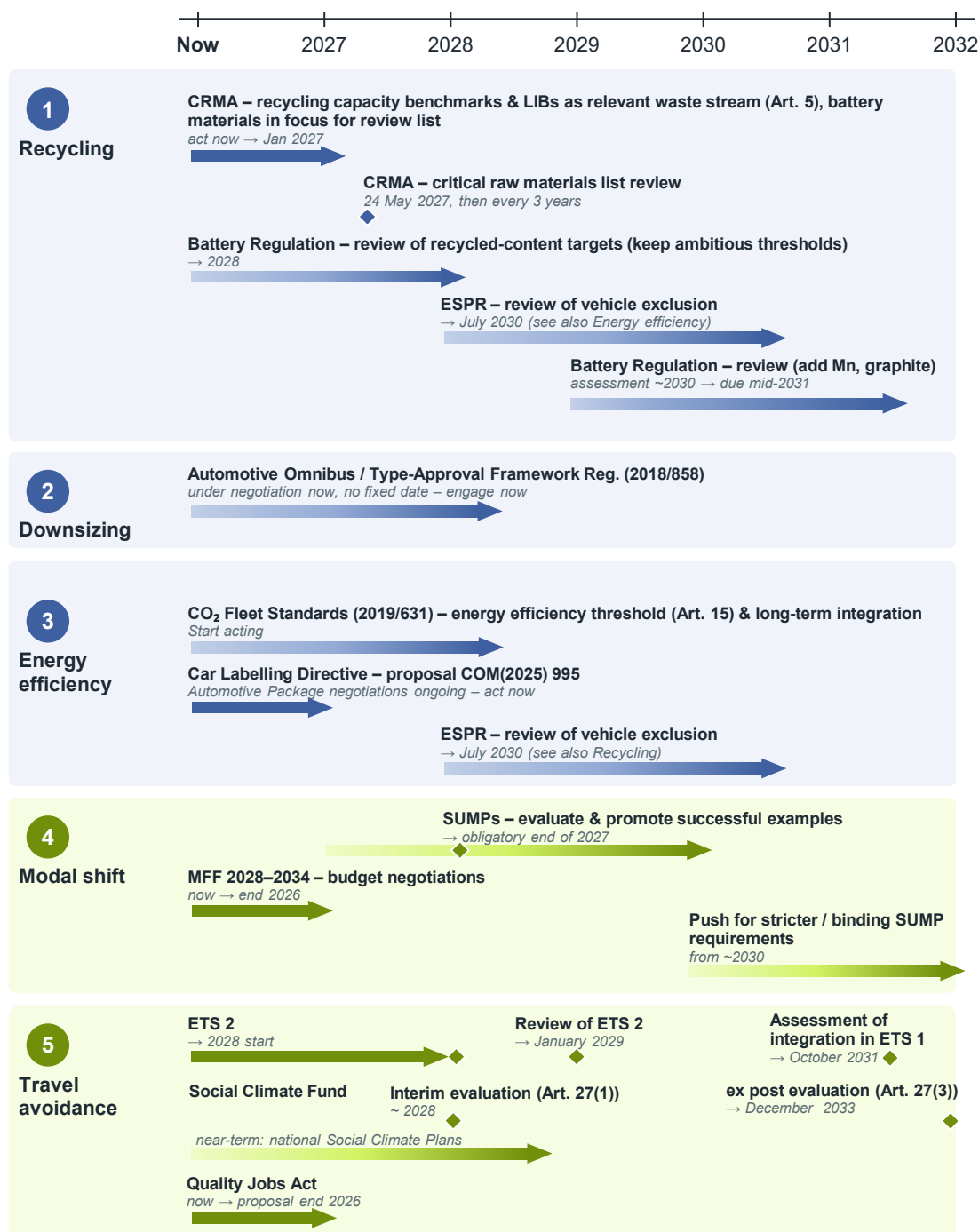
⁴³ See https://climate.ec.europa.eu/areas-action/carbon-markets/ets2-buildings-road-transport-and-additional-sectors_en

⁴⁴ See <https://eur-lex.europa.eu/EN/legal-content/summary/social-climate-fund.html?fromSummary=20>

4 Timeline of the entry points for the selected 5 measures

The following figure illustrates the timeline of European policy entry points discussed above. National and regional/local-policy entry points, as well as supporting financial instruments, are not included in the figure but are discussed in the corresponding sub-chapters of chapter 3.

Figure 4-1: EU-level policy entry points: when activity is required



Note: SUMP requirements under TEN-T Regulation Art. 41/42 are shared between modal shift and travel avoidance (see lane 4).
Source: Oeko-Institut Consult gGmbH, own compilation

5 Recommendations

The preceding chapters have outlined the background to the selected measures and discussed individual policy options. Building on this analysis, several cross-cutting themes emerge as particularly relevant for facilitating decarbonizing road transport beyond mining-intensive pathways:

- **Expanding the recycling of battery raw materials within the EU** is essential to reduce dependence on imports of primary raw materials. Strengthening European recycling capacities can enhance supply security, lower the environmental impacts associated with primary resource extraction, and contribute to a more sustainable and circular use of CRMs. (see sub-chapter 3.1 on recycling)
- **Energy consumption should become a central criterion for vehicle use, classification and support schemes.** Aligning regulatory frameworks and incentive structures with vehicle energy consumption would strengthen the environmental effectiveness of transport policies. (see sub-chapter 3.2 on downsizing and sub-chapter 3.3 on energy efficiency)
- **Public procurement criteria for vehicles should incorporate energy consumption and recycled content requirements,** including energy consumption thresholds and minimum shares of secondary materials. Such criteria enable public authorities to leverage their purchasing power—and the recycled-content benchmarks already set out in the Batteries Regulation—to support energy-efficient and circular vehicles via requirements for public procurement. (See sub-chapters 3.1 and 3.2 on recycling and downsizing.)
- **Financial incentives should be redesigned towards less resource intensive decarbonisation pathways.** Modal shift and travel avoidance together could contribute substantially to CRM savings. Public funds through the Multiannual Financial Framework 2028-2034 and Social Climate Fund should be allocated in a manner that prioritise sustainable mobility solutions and public transport services, ensuring that scarce financial resources generate long-term societal and environmental benefits rather than primarily financing compensatory payments. (See sub-chapters 3.4 and 3.5)
- European targeted **funding for research and innovation** should be prioritized to support the development of advanced battery materials for battery downsizing and drive improvements in energy efficiency. Ensuring recyclability should be a central objective in the development of advanced materials. (See sub-chapter 3.3)
- **Existing policy frameworks should be reviewed for potentially conflicting incentives.** In particular, measures that may inadvertently encourage car dependency or increased transport demand should be assessed with regard to their compatibility with climate and sustainability objectives. (See sub-chapter 3.4 on modal shift and 3.5 on travel avoidance.)

Taken together, **the measures outlined in this report show that a less mining-intensive pathway is already technically feasible, credible and available now.** Pursuing it decisively, rather than treating supply gaps primarily as a problem to be solved through new extraction, offers a more competitive and secure route to Europe's modernisation.

6 Annex

6.1 Methodology

A multi-step methodology was employed to identify promising measures for reducing the use of (CRMs) in electric passenger car batteries and to identify policy entry points at the EU level. In a first step, a literature analysis was conducted to identify measures that can contribute to reducing primary CRM demand in the EU. As specified by the commissioning client, this was to cover both technical measures addressing the vehicle itself and transformative measures addressing mobility patterns, which can indirectly reduce demand for passenger cars. The literature review drew on publications provided by the client, publications identified by the authors through independent research, own publications by Oeko-Institut (including some still unpublished), and publications referred to by interview partners. The literature was evaluated per measure or measure package with support of machine assistance (Claude chatbot by Anthropic), with regard to:

- Main findings (saving potential)
- Impact pathway
- (Sub-)measures
- Methodology
- Assumptions
- Time frame
- Geographic scope
- Relevant EU measures
- Conflicts/conflicting trends and
- Co-benefits.

It should be noted that the review included both studies quantifying concrete CRM savings and other publications focused on transport demand, quantifying reductions in passenger car kilometres travelled and similar metrics.

In a second step, the results of this evaluation were compiled per measure into a long list, where possible. Several publications report findings for measure packages rather than individual measures, so in these cases the effects could not be directly disaggregated in the compilation. This compilation constitutes the long list, comprising, for technical measures: recycling, downsizing, substitution of materials in cell chemistry, lightweighting, extended battery lifetime (reuse/repair) and energy efficiency. For transformative measures, the long list comprises modal shift, travel avoidance and shared mobility. All measures ultimately share the goal of reducing car use and, in turn, reducing demand for new passenger cars. The transformative measures listed are best understood as strategies that need to be operationalised through a range of sub-measures. These sub-measures also overlap across categories. For example, fiscal measures that increase the cost of car use can incentivise both a shift to other modes and the avoidance of less essential trips or residential location choices, thereby contributing to both travel avoidance and modal shift.

On the basis of this long list, an initial prioritisation was carried out separately for technical measures addressing the vehicle and for transformative measures aimed at reducing car demand. The aim of the prioritisation was to identify those measures to be examined in further depth with regard to policy

entry points in the subsequent analysis. For this purpose, each measure was scored on a scale of 0 to 3, with higher values indicating better performance, with regard to:

- (Theoretical) CRM saving potential
- An assessment of the feasibility and effectiveness of the potential measures
- Relevant co-benefits
- Risks

A ranking was derived from the sum of the individual scores.

In a next step, two guided expert interviews were conducted with IMT and T&E/Clean Cities Campaign. Interview partners were provided with the matrix in advance. During the interviews, the self-derived ranking of measures was verified and challenged. Among the transformative measures, one interview yielded a differing assessment as to whether travel avoidance, rather than modal shift, should rank first. The prioritisation was then discussed and agreed with the clients.

On this basis, the top five measures were identified for further in-depth examination with regard to policy entry points. In addition to the interviews and the initial literature review, further research was conducted to substantiate possible entry points. The resulting rating is presented in the table below.

Table 6-1: Rating of measures

Measure	Potential	Feasibility and effectiveness	Co-benefits	Risks	Rating
Recycling	2	3	2	2	9
Downsizing	2	2	1	2	7
Energy efficiency	2	2	2	1	7
Substitution of materials	2	2	1	2	7
Extend battery lifetime (reuse/repair)	1	3	1	1	6
Lightweighting	2	2	1	0	5
Modal shift	2	2	2	2	8
Travel avoidance	2	1	2	1	6
Shared mobility	1	1	1	2	5

Source: Oeko-Institut Consult gGmbH

Calculation of reduction potential in Table 2-1

The saving potentials reported in the literature are derived using different methodological approaches and underlying assumptions. For the present analysis, the percentage reduction potentials reported in the respective sources were adopted, while absolute savings (in tonnes) were calculated using a harmonised set of scenario assumptions. As a result, the absolute reduction potentials presented in this study may differ from the values reported in the original sources.

The calculations of the saving potentials are based on the assumptions and scenarios considered in the supporting studies of EC's impact assessments of the ELV Regulation and the Batteries Regulation (Stahl et al. 2021, Baron et al. 2023). As the underlying data are only available up to 2040, it is not possible to quantify additional savings potentials in absolute terms beyond this time horizon.

Furthermore, the reported saving potentials in percentage terms and absolute tonnes in Table 2-1 originate from various studies, each employing different methodological approaches, different temporal scopes, assessment horizons and assumptions. As a result, these estimates should not be interpreted as directly equivalent or comparable, given the variation in system boundaries, baseline scenarios and calculation methodologies across studies.

These inconsistencies in the underlying datasets, combined with broader data limitations, hinder the standardisation of results and prevent a fully harmonised comparison across the examined measures.

6.2 Background research results on raw material effects from measures

A matrix of sources used for estimating CRM savings potentials can be found in a separate Excel document where the report is uploaded.

6.3 Background research results on policy options for transformative measures

The following tables provide a matrix of policy options for the transformative measures identified in this study.

Table 6-2: Modal shift sub-measures

Concrete sub-measure	Description/ Example	Source(s)
Free/subsidised public-transport passes and shuttle services	For commuters	Kuss and Nicholas 2022
Workplace travel planning	Employer-led incentives/information promoting alternatives to driving	Kuss and Nicholas 2022
University travel plans	For staff and students	Kuss and Nicholas 2022
School travel planning	Walking buses, safe routes to school	Kuss and Nicholas 2022
Gamification / app-based competitions	Smartphone app competition promoting sustainable mobility choices	Kuss and Nicholas 2022
Expansion of cycling/walking infrastructure, bus priority lanes, integrated ticketing	Infrastructure expansion combined with fare integration	ITF 2023
Rail investment/electrification, high-speed rail, short-haul flight bans	Shifting air/road travel to rail	ITF 2023

Source: Compilation of Oeko-Institut gConsult GmbH

Table 6-3: Travel avoidance sub-measures

Concrete sub-measure	Description/ Example	Source(s)
Congestion/ cordon pricing	City-centre road pricing	Kuss and Nicholas 2022; ITF 2023
Parking pricing/ parking-space restrictions	Workplace parking charges, removal of parking space	Kuss and Nicholas 2022; ITF 2023
Limited Traffic Zones/ urban access restrictions	Restricted-access zones, combined with public-transport funding	Kuss and Nicholas 2022; ITF 2023
CO ₂ / carbon pricing (urban and non-urban)	Pricing of transport emissions	ITF 2023
Speed limits	Reduction of urban speed limits	ITF 2023
Remote work/ teleworking / video conferencing	Avoiding commuting and business travel	Pigneur et al. 2024; ITF 2023; Chiarotti et al. 2026
Relocating residence/ holidays closer to work	Reduction of long-distance trips	Pigneur et al. 2024
Individualised/ personalised travel planning	Personalised travel advice for residents	Kuss and Nicholas 2022
Integrated land-use/ transport planning, transit-oriented development	Urban design avoiding the need for travel	ITF 2023

Source: Compilation of Oeko-Institut gConsult GmbH

Table 6-4: Shared Mobility sub-measures

Concrete sub-measure	Description/ Example	Source(s)
Car-sharing (station-based / free-floating)	Cambio, Stadtmobil, Flinkster (Station based Germany); Miles, Free now, Bold, Sixt (freefloating Germany) as a real-world example	Kuss and Nicholas 2022; Hülsmann et al. 2018
Ride-sourcing / ride-hailing	Uber/Lyft-type on-demand services	Dominish et al. 2024
Ride-pooling / carpooling	Bundling multiple passengers into one trip; digital platforms with real-time matching	Vercalsteren et al. 2026; Pigneur et al. 2024; Chiarotti et al. 2026; ITF 2023
Autonomous shared-vehicle concept	One autonomous-shared-vehicle replaces several private cars	Morfeldt et al. 2025
Battery-sharing (leasing / swapping)	Battery-leasing/swapping schemes as an alternative to vehicle ownership	Dominish et al. 2024
Bike- / micro-mobility sharing fleets	Shared bikes, scooters etc. as part of an integrated sharing offer	Vercalsteren et al. 2026
Coach-sharing / ridesharing for intercity travel	Incentives for coach travel and ridesharing on long-distance/regional trips	ITF 2023
Mobility-as-a-Service (MaaS)	Digital platforms bundling/integrating shared-mobility offers	ITF 2023
Increased vehicle occupancy	Target values for persons per vehicle	Racu 2023; Chiarotti et al. 2026

Source: Compilation of Oeko-Institut gConsult GmbH

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