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Institute of Circular Economy (INCIEN)

Policy Paper

Circularity and the life cycle of batteries and structural materials in the automotive industry as an opportunity for the Czech Republic

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The automotive industry in a time of major transformation

The EU automotive industry, with its long history of producing internal combustion engine vehicles (ICEVs), is facing a historic transformation towards electrification and decarbonisation. The main reasons for this are both the EU's target of zero CO2 exhaust emissions for new vehicles by 2035 and the growing competition from China, which already dominates the production of electric vehicles and their components. European car manufacturers are facing higher production costs and external dependence on critical raw materials. Mario Draghi's report for the European Commission on the future of European competitiveness highlights the need for a long-term industrial strategy encompassing all phases from research and development to recycling and raw material recovery, with a focus on small and affordable electric vehicles, autonomous vehicles and the circular economy.[1]

The Czech Automotive Industry Association (AutoSAP) also includes as the first priority for the new European legislative period "the creation of a coherent EU industrial strategy for a sustainable and competitive value chain of low-carbon economy, i.e. from research and development, through extraction and processing, to the production of components and final products," whereby "an important part must be the use of circular economy principles to ensure the maximum share of material self-sufficiency."[2] The automotive industry is a key sector of the Czech economy. It accounts for a quarter of industrial production and exports, 9% of GDP and 26% of the manufacturing sector;[3] in 2023, nearly 1.4 million passenger cars were produced in the country. It employs over 180,000 people directly in production and half a million in the supply chain.[4] The Czech Republic is the third largest car manufacturer in the EU and the second largest in the world per capita.[5] Given its high export share, the Czech automotive industry needs to respond strategically to global changes in the sector.

In relation to electrification and decarbonisation, two areas are key for the Czech automotive industry: **batteries and structural materials.**

1 https://www.europarl.europa.eu/thinktank/en/document/EPRS_ATA(2024)762419

2 https://autosap.cz/aktualita/priority-sdruzeni-automobiloveho-prumyslu-pro-nadchazejici-evropske-programove-obdobi-2024-2029/

3 https://www.czechinvest.org/cz/Technologicke-domeny/Mobilita

4 https://autosap.cz/zakladni-prehledy-automotive/obecne-zakladni-prehledy/

5 https://autosap.cz/zakladni-prehledy-automotive/rocni-prehledy-vyroby-a-odbytu-vozidel/

Batteries

Czechia is lagging behind in electromobility compared to other European countries. Despite the fact that 180,000 electric vehicles (battery and plug-in hybrids) are produced in the country every year,[6] the majority of them are exported and only tens of thousands are used on the roads here.

Meanwhile, the battery industry represents a fast-growing sector with a high added value. Not only the production itself, but also other parts of the battery value chain offer a significant economic opportunity – from the extraction and processing of critical raw materials, through synthesising electrode materials, manufacturing components, to the assembly of cells, battery modules and packs. Lithium batteries are then used both in electric cars and consumer electronics such as mobile phones, smart watches and laptops, and increasingly in stationary storage systems of renewable energy and for balancing the electricity grid. However, most of the growing demand for batteries is now driven by electric vehicles (EVs).[7]

The Czech battery industry is trailing behind compared to European and global competition. **Unlike its Central and Eastern European neighbours, the Czech Republic has not been able thus far to attract large-scale battery production in excess of 1GWh per year (i.e. a gigafactory).** It is the last of the Visegrad Four in that respect[8]. All the while, the Czech Republic has significant deposits of critical raw materials needed for battery

6 https://www.cistadoprava.cz/vyroba-elektrickych-vozidel-v-cr/

7 https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/FTI_July2021.pdf

8 https://www.mzp.cz/konference_cista_mobilita_2024/2_den/OPZP-2_18_19_20_Kazda_Zemanova_Blumtritt_Hodnotovy_retezec_baterii-20240531.pdf

production, a technically educated workforce, and it is also tightly integrated into automotive industry value chains.

Moreover, the lack of production also creates a barrier for **the recycling sector, where battery waste is an essential input.** Electromobility is developing only slowly in the Czech Republic and the long lifetime of batteries means that there are not enough batteries from end-of-life EVs for the Czech battery recycling ecosystem to develop. However, with a relatively high average age of the local car fleet, it is likely that many EVs will be ending their life cycle in the Czech Republic.

In order to harness the potential of this rapidly growing sector, the Czech Republic can take inspiration from other EU Member States, where the development of lithiumion battery recycling is well underway.

For setting the right conditions for the battery industry to flourish, this policy paper first presents the value chain of lithiumion battery production and recycling, before diving into the existing European and Czech legal frameworks in the field of batteries and especially the management of waste batteries. The paper concludes by offering concrete recommendations to policy makers.

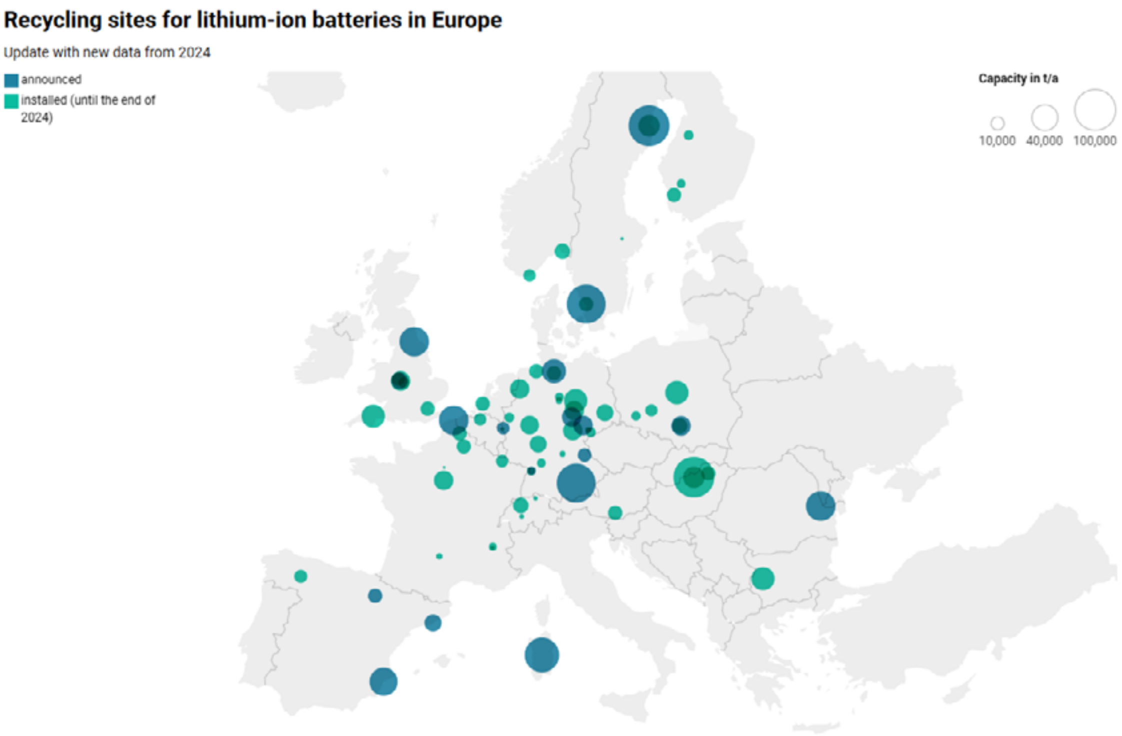


Figure 1: Lithium battery recycling in Europe, update 06/2024.[9]

9 https://www.isi.fraunhofer.de/en/blog/themen/batterie-update/lithium-ionen-batterie-recycling-europa-kapazitaeten-update-2024.html

Production and use of lithium batteries

The battery value chain starts with the extraction of raw materials such as lithium, cobalt, nickel, manganese, graphite and others. This is followed by processing and refining the materials to ensure the necessary level of purity and quality. Europe currently utilises limited sources of raw materials, with extraction distributed among relatively few countries outside Europe, and the vast majority of processing and refining taking place in China. **Although China does not possess significant deposits of critical raw materials for the production of cathode materials, it is dominant in the processing stage.** In the field of anode materials, on the other hand, China dominates both the mining of natural graphite (72% of world production) and the synthesis of artificial graphite (69%), as well as the production of spherical graphite for battery anodes (99%).[10] Today, 75% of global battery production and 57% of all electric cars sold come from China.[11]

Europe has been investing heavily in recent years in developing all parts of the battery value chain. **Europe's share of global battery production is expected to increase from around 6% in 2020 to around 8% in 2025.** While this does not sound like much, global battery production is expected to increase almost tenfold between 2020 and 2025 from 450 GWh to around 4 TWh.[12] Moreover, Europe has significant reserves of critical raw materials for the future that currently remain untapped. For example, European lithium reserves should be able to meet a significant part of current demand.[13]

Commercially available batteries today differ mainly in the composition of the cathode materials (e.g. LCO, LFP, LMO, NMC and NCA), **which affects their performance, capacity and safety.** The most widely used lithium batteries today are NMC (or older NCA) and LFP. NMC (nickel-manganese-cobalt) batteries achieve higher energy density, which reduces the amount of material needed

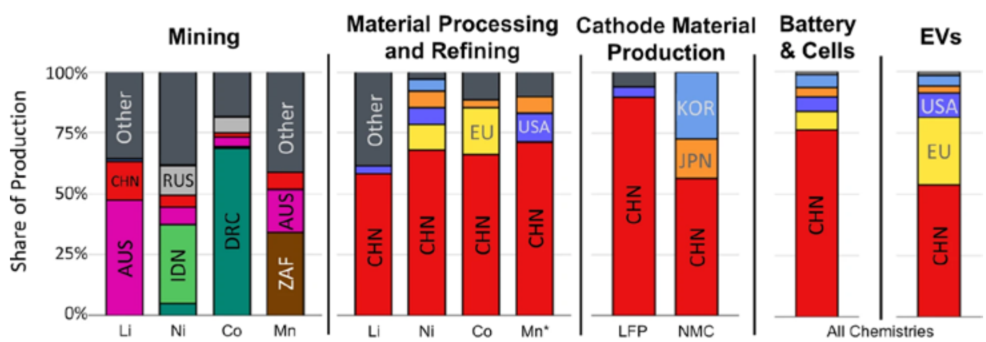


Figure 2: Geographical distribution of the battery and electric vehicle (EV) value chain.[14]

10 https://source.benchmarkminerals.com/article/infographic-china-controls-three-quarters-of-graphite-anode-supply-chain?mc_cid=fa15bb4f77&mc_eid=72d0981fff

11 https://gargantua.polytechnique.fr/siatel-web/app/linkto/TGhXT2JFSkpaQklwTWpaT3g2NDhkeVFqdWh1a1hJaDFVRXVjWllScUpKa1dzQlVoL2k2dHNjcW1yN3NESXdrQTZQSUZLak1vaGRFPQ?aw=1

12 https://www.iea.org/data-and-statistics/charts/lithium-ion-battery-manufacturing-capacity-2022-2030

13 https://www.transportenvironment.org/articles/unlocking-lithiums-potential-how-to-do-it-sustainably-in-europe

14 https://www.nature.com/articles/s41467-024-46418-1

to achieve the same capacity. They are being used more extensively by European car manufacturers, such as VW[15] or BMW,[16] but also by the American Tesla to achieve greater range. However, due to the presence of nickel and cobalt, they have a higher cost and environmental footprint associated with mining. On the other hand, it is worth recycling these batteries at the end of their life precisely because they contain more valuable minerals. The predecessor of this material, NCA (nickel-cobalt-aluminium), was used, for example, in older Tesla models.[17]

LFP batteries (lithium-iron-phosphorus) have a lower energy density and are more cost-effective and stable, but their lower energy density also means a lower range or the need for a larger battery. This chemistry is mainly used by Chinese companies such as CATL or BYD, which, thanks to massive investments in this technology, are able to achieve practically half the price of NMC batteries produced in Europe.[18] However, mining and processing of critical raw materials are energy intensive and, given the significant share of coal-fired power plants in China's energy mix, battery production in China has a significantly higher carbon footprint than in Europe.[19] In addition, LFP batteries are not worth recycling to such an extent as they contain a lower proportion of valuable materials.

Nowadays, many manufacturers guarantee the lifetime of batteries for electric vehicles to be at least 8 years or 160,000 km,[20] but in practice it can be many times higher. **With today's batteries, lifetimes**

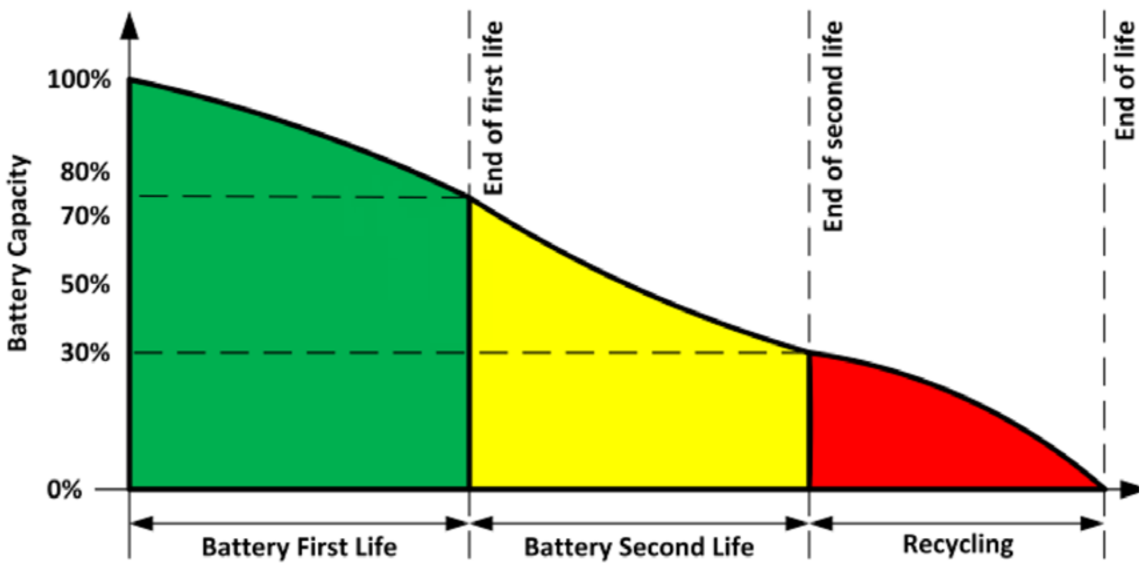


Figure 3: Battery usage with respect to remaining battery capacity.[21]

15 https://zpravy.aktualne.cz/ekonomika/auto/volkswagen-ve-stopach-tesly-baterie-si-bude-vyrabet-sam-mozn/r~ed465d9085a211ebb2f60cc47ab5f122/

16 https://www.bmwblog.com/2024/10/18/bmw-lfp-vs-nmc-batteries-ev-performance-sustainability/

17 https://www.shop4tesla.com/en/pages/tesla-unterschiede-der-batterie

18 https://www.transportenvironment.org/articles/boom-or-bust-europes-battery-dilemma

19 https://www.transportenvironment.org/articles/an-industrial-blueprint-for-batteries-in-europe

20 https://archiv.hn.cz/c1-66973780-kdyz-se-bori-legendy-a-myty-ktere-obestiraji-elektromobilitu

21 https://www.mdpi.com/1996-1073/16/2/953

of around 20 years or 500,000 km can be achieved. Once the battery capacity has fallen to around **70 % of its original capacity**, the the battery can be used in a **secondary use (second life)** in a range of applications, such as **renewable energy storage or industrial energy systems.** This approach extends the lifetime of batteries (projects in the Czech Republic, for example, envisage an additional lifetime extension of around 15 years[22]), but also reduces the environmental impact as the need to extract raw materials and produce new batteries is reduced. It is therefore desirable to set appropriate regulatory conditions in the Czech Republic for the secondary use of batteries after their first life cycle has ended.

Battery recycling

At the end of the battery life cycle is recycling, which enables the recovery of up to 90–95% of the raw materials that can then be reused for battery production. Recycling thus reduces not only the environmental footprint of primary mining, but also the dependence on the supply of critical raw materials. However, the development of battery recycling is being hampered in particular by the high **cost of mechanical processing**, but also **the different composition of cathode materials, rapidly changing dimensions and types of casings, often missing labelling** of the exact composition, and the associated **sorting and recycling costs.**[23, 24]

Due to hazards such as electric shock or the risk of fire or explosion of the used battery, a pre-treatment process including battery deactivation, disassembly and separation of materials is required prior to recycling. On an industrial scale, mechanical pre-treatment, which involves crushing and separation of materials, e.g. by sieving and flotation, is often used.[25] Mechanical crushing produces **black mass containing critical raw materials such as cobalt, nickel, lithium and manganese.** The pure materials are then recovered using recycling methods.[26]

Pyrometallurgy uses high-temperature melting in a furnace to recycle metals such as copper, cobalt and nickel. However, pyrometallurgical processes are not able to directly recycle lithium, aluminium and manganese. Graphite and plastics are incinerated and **the efficiency of recycling is usually less than 50 %**, making this method unsatisfactory in the future due to its low recycling efficiency.[27]

In the **hydrometallurgical** process, the batteries are crushed, the ferrous parts are removed by magnetic separation and the electrodes are isolated by a stream of air. Heating removes the binder and separates the individual parts. Graphite and copper or aluminium collectors are extracted using sieves and physicochemical processes. Lithium, cobalt, manganese and nickel are then gradually precipitated by leaching in mineral acids, particularly sulphuric acid. The main benefit is the yield of high purity materials, with the **most modern methods**

22 https://autosalon.tv/novinky/auto-profi/skoda-a-cez-pripravily-pro-vyslouzile-baterie-z-elektroaut-prijemny-duchod-15-let-prace-v-ulozisti

23 https://climate.mit.edu/ask-mit/how-well-can-electric-vehicle-batteries-be-recycled

24 https://europeum.org/data/articles/report-cirkularita-final.pdf

25 https://pubs.acs.org/doi/10.1021/acs.chemrev.9b00535

26 https://iopscience.iop.org/article/10.1149/2.0271701jes/meta

27 https://doi.org/10.1016/j.jclepro.2020.123585

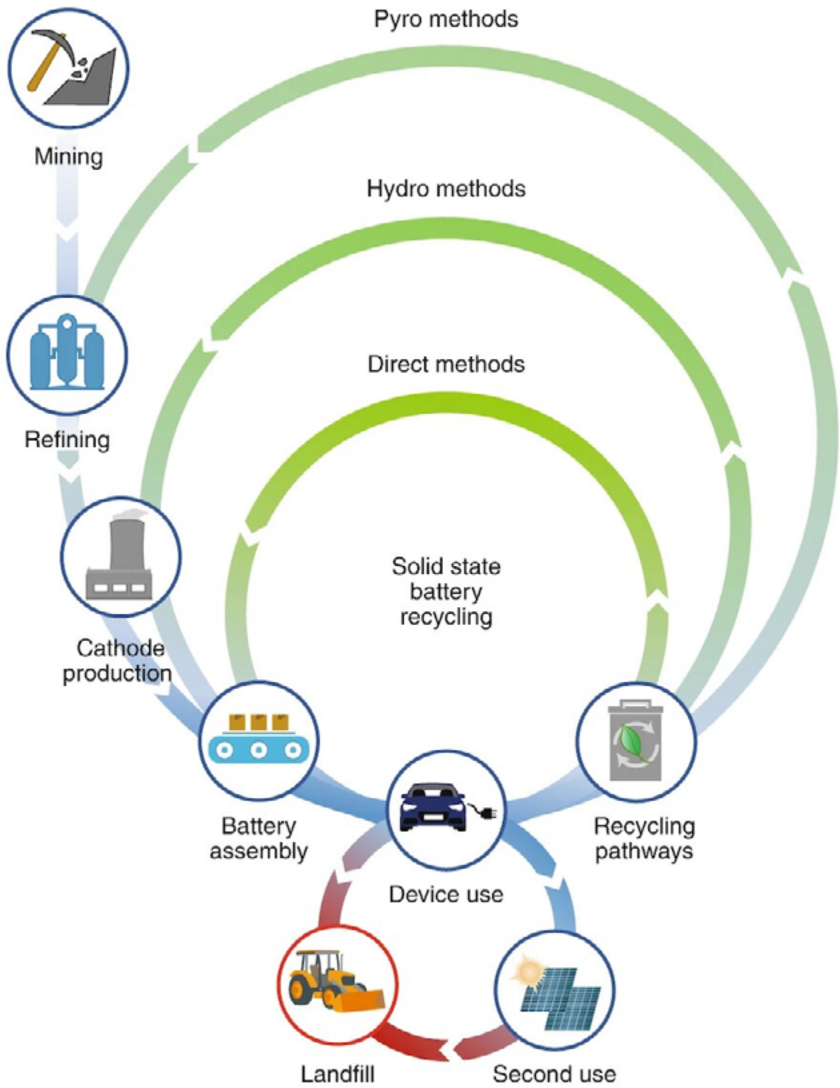


Figure 4: The battery value chain, including indicated recycling routes.[28]

reaching efficiency of up to 90–95% due to electrolyte and graphite recovery.[29]

Direct recycling is a technology that preserves the composition of electrode materials and prevents their breakdown into elemental substances without heavy dependence on strong acids or alkalis.[30] The aim of this method is to supply recycled electrode materials directly back to battery manufacturers. If the binders from the solvents used are also recycled, the **efficiency is between 90–100%**, but requires a rigorous pre-separation treatment and disassembly associated with electrode separation. For this reason, this technology is difficult to develop on an industrial scale.[31]

28 https://phys.org/news/2020-03-pathways-all-solid-state-batteries.html

29 https://pubs.rsc.org/en/content/articlelanding/2023/su/d3su00142c

30 https://www.sciencedirect.com/science/article/pii/S2405829722005153

31 https://www.aimspress.com/article/doi/10.3934/ctr.2021007?viewType=HTML

Today, the development of battery recycling is mainly hindered by the high financial cost of the technology. The cost of a new recycling plant, for example, is around EUR 24 million[32] and, with the uncertain prevalence of used batteries, it is a risky investment. In practice, to be sustainable, recycling projects supported by subsidy programmes are often forced to buy used batteries off the market, distorting their market price. Many of the technologies available are also built on single-source inputs and take a long time to re-set. Thus, it is not possible to use the technologies flexibly for waste batteries with different chemical compositions. Today, the inputs from collection are often contaminated by different types of batteries, which degrades the quality of the output products.[33] Batteries with different chemical compositions cannot be recycled together, so it is necessary to set up a collection and sorting system for waste batteries that will achieve the best possible quality of waste batteries at the input and thus the highest possible quality of the recyclate.

European legal framework

In order to promote raw material self-sufficiency and clean industry, the EU has adopted the **European Critical Raw Materials Act (CRMA)[34] and the Net Zero Industry Act (NZIA).[35]** The former sets EU critical raw material targets for 2030 to cover 10% of annual EU consumption from domestic extraction, 40% from domestic processing and 25% from recycling in the EU, while the supply of any one critical raw material should not be covered by a single non-EU country for more than 65%. The latter act sets a 2030 target of 40% of domestic demand for clean technologies to be produced in the EU, including batteries.

Deadline for achieving the target	Recycling efficiency from an average Li battery weight	Minimum rate for recovery of materials			
		Cobalt	Copper	Lithium	Nickel
Present	50 %	X	X	X	X
31.12.2025	65 %	X	X	X	X
31.12.2027	65 %	90 %	90 %	50 %	90 %
31.12.2030	70 %	90 %	90 %	70 %	90 %
31.12.2031	70 %	95 %	95 %	80 %	95 %

Table 1: Overview of recycling efficiency and material recovery rates.

32 https://cicenergigune.com/en/blog/battery-recycling-industry-europe

33 https://www.sciencedirect.com/science/article/pii/S2589004223021491

34 Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.

35 Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 on establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724.

Research, development and innovation support programmes are set up to achieve these goals, including the **Innovation Fund**[36] and the so-called **Important Projects of Common European Interest (IPCEI).**[37]

In addition, both acts introduce the designation of so-called **strategic projects**, which should speed up the permitting processes for the extraction and processing of critical raw materials as well as the production of clean technologies.

In addition, the EU has adopted **the Battery Regulation**,[38] which sets out new rules for the **entire battery life cycle – from design and production to take-back, reuse and recycling.** The Regulation gradually introduces mandatory labelling of batteries, which will help consumers make informed choices and ensure proper handling during disposal. From 2027, batteries will have to be labelled with a **'battery passport'** containing information on the battery model and specific data about the battery throughout its lifetime, including material composition, carbon footprint, origin of raw materials, recycled content, capacity, performance, lifetime, etc., as well as information to facilitate disassembly, repair or replacement, battery refurbishment, second-life and its recycling.

In order to improve the efficiency of waste battery collection, the Regulation strengthens the **Extended Producer Responsibility (EPR)**, which imposes operational and financial responsibility on companies for the collection, treatment and recycling. From 2025, EV battery producers will need to introduce a free take-back system for batteries from end-consumers and ensure their transport to processing plants. In order to promote the recycling and re-use of materials, it also sets targets for the recycled content of batteries and values for minimum recycling efficiency rates. They clearly show that pyrometallurgy, for example, will not be able to meet the necessary targets by the end of 2025.

The regulation also deals with the **transport of waste batteries.** The treatment of waste batteries may be carried out in other Member States or outside the EU, but the used batteries may be classified as hazardous waste, where the transport is governed by national legislation, possibly leading to different legal regimes or interpretation. In addition, the shipment of hazardous waste involves high costs of transport and storage and significant financial guarantees. The Regulation also allows for the control of the transport of used batteries.

The Regulation is complemented by a number of **'delegated acts'** which specify technical parameters, such as the calculation of the carbon footprint of batteries[39] and methodologies for calculating recycling efficiency or material recovery rates.[40] These additional pieces of legislation are currently being consulted with

36 https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en

37 https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis/batteries-value-chain_en

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

39 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13877-Batteries-for-electric-vehicles-carbon-footprint-methodology_en

40 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14265-Calculation-and-verification-methodology-of-rates-for-recycling-efficiency-and-recovery-of-materials-of-waste-batteries_en

stakeholders and it is desirable that representatives of the Czech automotive industry use this opportunity to clarify some of the requirements. These additional acts should not favour any specific type of battery, but maximise circularity and sustainability in line with the objectives of the Battery Regulation.

Czech legal framework

In addition to directly applicable European regulations, vehicle batteries in the Czech Republic are covered in particular by **Act No. 542/2020 Coll. on End-of-Life Products (ZVUŽ)**, which specifies the obligations for placing batteries on the market, their labelling, information for users, take-back and treatment of waste batteries. In the area of recycling, the law mandates the use of best available techniques in facilities achieving the required recycling efficiency and prohibits the incineration and landfilling of batteries. The Czech law, in particular **Act No. 541/2020 Coll. on waste**, also allows transport of waste batteries across borders for treatment and recycling in line with the relevant EU regulations. However, more detailed regulation on any of the end-of-life treatment routes for waste batteries, whether it be repair, refurbishment, reuse, repurposing or recycling, is still lacking. Harmonisation of Czech legislation with the EU Battery Regulation should be ensured by the forthcoming amendment to the ZVUŽ.[41]

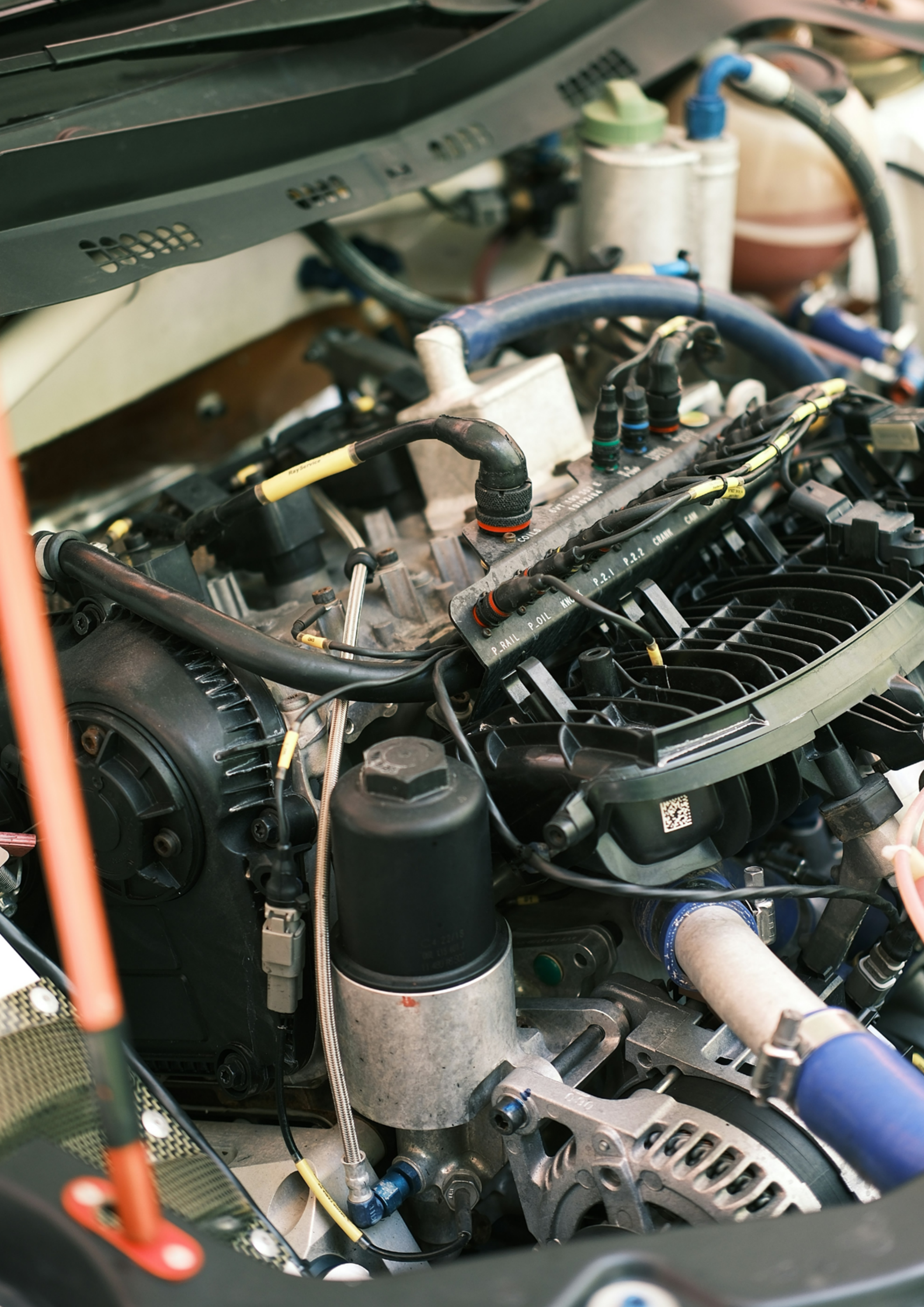
The update of the **National Action Plan for Clean Mobility (NAP CM)** published in autumn 2024[42] contains some measures to promote batteries, including support for second life and reuse, support for reverse logistics and battery recycling, and setting the conditions for the practical deployment of Vehicle to Grid (V2G) and Vehicle to Home (V2H) technologies, which should contribute to greater energy system flexibility and a higher share of electricity from renewable sources.

According to the NAP CM, support for second life, reuse, reverse logistics and recycling of batteries should be achieved by 2026, in particular by reducing the legislative requirements for battery energy storage systems, enabling their sharing within aggregation blocks, clarifying technical requirements, including mandatory battery testing, analysing the rules for storage and transport of batteries, and possibly creating a methodology for assessing batteries for reuse after emergencies such as car accidents. However, a more detailed description of the proposed measures is also still lacking.

The Czech Republic also **lacks a long-term automotive development strategy** that would focus on both supporting individual parts of the battery value chain and linking relevant actors across the chain. For example, close cooperation between manufacturers and recyclers is necessary in recycling issues, but is not systematically supported. The awareness of automotive actors of new measures, including extended producer responsibility, battery passports, financing opportunities from Czech or EU sources or other support programmes, is also still relatively low and information is often skewed in the public domain.

41 https://europeum.org/data/articles/zvuz-17-10-2024-mm.pdf

42 https://www.mpo.gov.cz/cz/rozcestnik/pro-media/tiskove-zpravy/cista-a-udrzitelna-doprava--vlada-schvalila-aktualizaci-narodniho-akcniho-planu-ciste-mobility---282792/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Structural materials

Materials in the context of automotive decarbonisation

The decarbonisation of vehicles has so far focused on operational emissions, but these are decreasing with electrification and the increasing share of renewable energy sources, which shifts the focus to emissions embedded in materials. Industrial production accounts for 21% of total CO2 emissions in the EU.[43] Two-thirds of these industrial emissions come from the production of four basic materials – **iron and steel, aluminium, cement and chemicals** (especially polymers). In this context, the automotive industry is the second largest consumer sector for these materials after construction (19% of steel consumption, 17% aluminium and 8% plastics). This sector in the Czech Republic imports most of its consumption of these three materials, and their embedded carbon from the entire supply chain in the Czech Republic and abroad (Scope 3) is estimated at roughly 5–6 million tonnes CO2-eq per annum. From a circularity perspective, the current end-of-life vehicle (ELV) treatment system in the EU is inefficient; metals are downcycled, less than 20% of plastic waste from ELVs is recycled (for other lower-value products) and only 5% of car parts are remanufactured.[44]

Decarbonising **steel** for the automotive industry involves switching to low-emission production processes such as direct reduction of iron with hydrogen and electric arc furnaces (EAF), but the quality of the recycled scrap plays a crucial role. Currently,

43 https://faktaoklimatu.cz/infografiky/emise-eu-detail

44 https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/754627/EPRS_BRI(2023)754627_EN.pdf

only 6% of steel scrap collected in the EU is ultimately used in new car production, highlighting the need to expand capacity for low-carbon steel and more efficient recycling.

Studies estimate that by 2030, low-carbon steel could cover 25–40% of consumption in the automotive industry.[45]

Aluminium is a key material for structural components, battery cases, cooling systems and other parts, accounting for 10–20% of the carbon footprint of electric vehicles (BEVs) and 20–30% for internal combustion engine vehicles (ICEVs).[46] Aluminium recycling, which can reduce emissions from aluminium production by more than 95%, plays a crucial role, but the challenge remains ensuring the purity of the recycled material and resolving contamination issues. Increasing demand, especially due to the trend towards lightweighting and the transition to electromobility, is expected to increase the weight share of aluminium in cars by over 25% by 2030. However, recycled aluminium will not cover the entire demand and will have to be combined with low-emission primary aluminium.

Thanks to their light weight and durability, plastics are used in many vehicle parts such as bumpers, dashboards, carpets and battery covers, helping to reduce vehicle weight and thus operational emissions. Approximately 75% of plastics in vehicles are made up of four types: polypropylene, polyurethane, polyamides and PVC. Mechanical recycling of plastics already offers up to 80% reduction in CO2 emissions compared to the production of virgin plastics, but faces challenges in mixing different plastics and preserving the properties of the materials. Chemical recycling technologies could solve these problems, but they are still technologically underdeveloped and their life-cycle environmental impact needs to be thoroughly assessed.[47]

In addition to reducing the carbon footprint of input materials, two other strategies play a critical role in decarbonising the vehicle material cycle: increasing material efficiency in vehicle design (lightweighting, vehicle downsizing, waste prevention); and slowing down material flows during the vehicle life cycle, extending the life of vehicles through circular design, remanufacturing and reuse of parts.

EU policy and legislative framework

Climate neutrality and decarbonisation of industry

The material transformation of the EU automotive industry is taking place in the wider context of the European Green Deal's climate commitment to achieving carbon neutrality by 2050 and the "Fit for 55" legislative package. As part of the updated regulation on strengthening CO2 emission performance standards for vehicles, a common EU methodology for life-cycle assessment (LCA) of CO2 emissions from passenger cars and vans placed on the EU market will be developed by the end of 2025, under which car manufacturers can voluntarily submit life-cycle CO2 emissions data for new vehicles from June

45 https://www.agora-industry.org/publications/creating-markets-for-climate-friendly-basic-materials

46 https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-race-to-decarbonize-electric-vehicle-batteries

47 https://op.europa.eu/en/publication-detail/-/publication/0980feaf-2146-11ee-94cb-01aa75ed71a1/language-en

2026.[48] The EU has also committed to reducing CO_2 emissions in energy-intensive sectors (EU ETS) by 62% compared to 2005, by 2030.[49]

This includes a new **Carbon Border Adjustment Mechanism** (CBAM),[50] which, from 2026, introduces an obligation to declare the carbon footprint of imported industrial materials and to surrender the corresponding certificates in parallel with a gradual reduction of the free allocation of emission allowances under the EU ETS.

Sustainable finance and non-financial reporting

The EU Taxonomy defines sustainability criteria for the production of vehicles, their components and the management of ELVs, creating a common standard for financing sustainable investment. However, the criteria for these activities are too general to create significant incentives to implement specific circular measures.[51] From the 2024 financial year, a first set of companies covered by the **CSRD** will be required to report activities in accordance with the Taxonomy, including shares of turnover, investments and costs. According to the European Sustainability Reporting Standards (ESRS), automotive companies will report on CO_2-eq emissions from the supply chain (Scope 3) and set policies, targets and measures for resource use and circular economy, thereby motivating them to reduce these emissions and increase material efficiency in production.[52]

Raw materials, materials and the circular economy

The new **Ecodesign for Sustainable Products Regulation** (ESPR) is key to setting environmental parameters for automotive input materials (including steel, aluminium, tyres, paints, lubricants, chemicals and energy-related products).[53] The regulation sets specific environmental parameters such as lifetime, repairability, recyclability or carbon footprint. Digital Product Passports (DPPs) will provide detailed product information for all participants in the value chain. **The Waste Shipment Regulation** tightens the rules for exporting waste outside the EU.[54] Exports to non-OECD countries will be banned unless they demonstrate their ability to manage waste sustainably. The EU is digitising procedures to better track waste shipments to boost recycling and speed up approval processes for certified facilities.

Vehicle circularity and end-of-life vehicles

In July 2023, the European Commission proposed a new **Regulation on Circularity Requirements for Vehicle Design and on Management of End-of-life Vehicles** (ELVR).[55] The aim is to promote the

48 https://eur-lex.europa.eu/legal-content/CS/TXT/?uri=CELEX%3A32023R0851

49 https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/what-eu-ets_en

50 https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

51 https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

52 https://eur-lex.europa.eu/legal-content/CS/TXT/?uri=CELEX%3A32022L2464

53 https://eur-lex.europa.eu/legal-content/CS/TXT/?uri=CELEX%3A32024R1781

54 https://eur-lex.europa.eu/legal-content/CS/TXT/?uri=CELEX%3A32024R1157

55 https://eur-lex.europa.eu/legal-content/CS/TXT/?uri=CELEX%3A52023PC0451

transition to a circular economy for vehicles in six areas: design, recycled content, efficient waste management, extended producer responsibility, increased and smarter collection of ELVs, and extension of the rules to other vehicle categories.

According to the European Commission's impact assessment, the proposed measures would potentially reduce annual CO2-eq emissions by 12.8 million tonnes by 2035 (from the higher valorisation of 5.4 million tonnes of materials and the collection and processing of up to 3.8 additional ELVs in the EU instead of exporting outside the EU), and 22,000 new jobs would be created in the recycling and service sector, of which 14,200 in SMEs. Preliminary positions of the Government, the Chamber of Deputies and the Senate of the Czech Republic acknowledge the overall objectives of the proposal, but stress the need for a fair distribution of responsibilities and an assessment of the feasibility of plastic recycling targets and implementation deadlines. Adoption of the new Regulation is expected by the end of 2025 or the first half of 2026.[56]

National policy framework

The issue of long-term development of the automotive industry, including the handling of materials and raw material security, is addressed in individual measures across several national strategy documents. The new **Economic Strategy of the Czech Republic** sets the direction of economic policy for the next 10–15 years, focusing on human capital, productivity and value added; strategic infrastructure; value-added industrialisation; and financing.[57] Emphasis is placed, inter alia, on manufacturing, in particular the automotive and semiconductor industries. The strategy emphasises the need for investment in recycling and the transition to low-carbon technologies. Key measures include green public procurement, tripling the circular use of materials by 2040 and strengthening research into new materials and technology. The implementation plan for the strategy will determine the monitoring mechanism and its interactions with the individual implementing ministerial strategies. The key documents for raw material security and the circular economy are the **Strategic Framework of the Circular Economy of the Czech Republic 2040**, the related **Action Plan** for the period 2022–2027[58] and the Update of **the Secondary Raw Materials Policy of the Czech Republic** (SRMP). The former includes support for the introduction of technologies for the recovery of secondary raw materials, circular industrial technologies and mapping the synergies between digitalisation, artificial intelligence and the circular economy (Industry 4.0 and 5.0). The SRMP is being updated this year and promotes the efficient use of secondary raw materials across sectors.

56 https://eur-lex.europa.eu/legal-content/CS/TXT/?uri=CELEX%3A52023SC0257

57 https://www.mpo.gov.cz/cz/rozcestnik/pro-media/tiskove-zpravy/hospodarska-strategie-ceske-republiky-ministr-vlcek-predstavil-cestu-do-top-10-zemi-evropske-unie--283601/

58 https://www.mzp.cz/cz/akcni_plan_cirkularni_cesko_2040


220

Conclusions and recommendations

Batteries

The Czech Republic possesses large deposits of critical raw materials needed for battery production, a technically educated workforce and it is **firmly integrated into automotive value chains.** The Czech Republic thus has a number of prerequisites for the growth of the battery sector, from production to recycling. In order to harness this potential, the Czech Republic can take inspiration from other European countries that are further ahead in this respect, such as Sweden, Norway or Finland, or geographically and economically closer Poland. These countries aim for a broad inclusion of stakeholders into creating integrated battery value chains and provide stable long-term support to the sector.

On the other hand, it is necessary to avoid creating a risky technological dependency, as in the case of Hungary, where Chinese investments in the battery industry are growing rapidly, but the battery assembly brings little added value with limited positive effect on the development of research, development or a technically educated workforce.[59] The European legal framework creates a stable and predictable environment while offering a range of tools to support it. However, there are a number of areas where clearer conditions are needed.

Broad cooperation and information dissemination

The development of the battery industry requires public and private actors to work together – from the state administration

59 https://www.gmfus.org/sites/default/files/2024-06/CEE%20Industrial%20Policy.pdf

to research organisations, companies and the public. Building a consensus can be helped by a **clear government policy with clear priorities and functional collaborative platforms.**

Long-term support for electromobility is important to provide stability, but effective policy must take into account all parts of the battery value chain.

We recommend **strengthening informa-tionand dissemination activities** at national level regarding the **obligations arising from the EU Battery Regulation** (extended producer responsibility, labelling obligations, incl. the battery passport, recycling efficiency targets, etc.), **financ-ing opportunities** from the Innovation Fund or IPCEI projects, but also, for exam-ple, the **designation of strategic projects** to help speed up the authorisation for strategic investment projects, including in the battery value chain, mining and processing of critical materials.

National strategy for the battery industry

In the development and implementation of the national battery strategy (e.g. as part of the implementation plan of **the Eco-nomic Strategy of the Czech Republic**), it is important to take advantage of the **opportunities arising from the presence of Czech actors on the EU single market and to contribute to the resilience of the economy by introducing circular practices** that help reduce dependence on external suppliers of raw materials. It is also advisable to avoid importing (incomplete) technologies from geopoliti-cally problematic countries and to set trade policy accordingly.

In the Czech legal system, the **prepara-tion of rules for the secondary use of batteries needs to be accelerated** in order to extend their lifetime, increase their economic value and reduce their environ-mental footprint. **The development of recycling and re-use should be sup-ported by public incentives.**

Among recycling methods, it is appropriate to favour those that meet the necessary recycling targets.

Clarification of European regulations on waste batteries and recycling

In the field of waste battery transport, European legislation needs to be clarified and harmonised. The current designation of waste batteries as hazard-ous waste complicates cross-border cooperation. In order to strengthen the resilience of the EU economy and reduce raw material dependency, strict recycling limits must not push the recycling of batteries outside Europe.

As part of the implementation of the Battery Regulation, **the methodology for calculating the carbon footprint needs to be clarified** early so that manufactur-ers can prepare for it. Similarly, it is essential to establish methodologies **for calculating recycling efficiency and material recovery targets that do not favour batteries with a certain chemical composition and do not lead to the landfilling of waste batteries.** In the calculation of material recovery rates, criteria of material purity must be intro-duced to support the functioning of closed-loop circular systems. In all discus-sions related to any outstanding imple-menting or delegated acts, Czech stakeholders should remain active.

Structural materials

Due to the complexity of this topic, we summarise below only the main areas of recommendations to support decarbonisation and higher circularity of structural materials in vehicles. In the accompanying INCIEN study ***"Decarbonisation and Circularity of Structural Materials in the Automotive Industry – Current Challenges and Opportunities for the Czech Republic"***, individual areas are analysed in detail and specific recommendations for the public administration in the Czech Republic as well as for stakeholders in the automotive industry are elaborated.

Support for innovation and development across the automotive value chain and implementation of the Czech Economic Strategy in relation to the automotive industry

As part of the implementation plan of the Economic Strategy of the Czech Republic, it is necessary on the one hand to include specific measures to address the insufficient network of technologically advanced recycling facilities providing secondary raw materials in the quality needed to replace primary raw materials in production processes. At the same time, requirements need to be adopted for the preferential use of secondary or other low-emission materials in public procurement procedures. Among other things, it will be crucial to strengthen research, development and innovation in the field of new materials, processes and technologies to ensure circularity and reduce material intensity in the automotive industry as one of the two strategic sectors targeted for "value-added industrialisation".

Introduction of vehicle life-cycle assessment

There is a need to establish clear rules for assessing the environmental performance of electric vehicles in particular and a European harmonised framework for the overall reduction of the carbon and energy footprint of vehicles, which Member States, businesses and consumers can use to compare, assess and allocate future support for electric and other low-emission vehicle models. Given the difficulty of implementing European or global standards and LCA methods for vehicles, there is also the possibility to apply simpler procedures as an intermediate step, which will take into account the most significant impacts of vehicles, both from their operational phase and the production and consumption of materials. For example, BEUC DUH, IMT (IDDRI) and T&E have proposed a so-called "eco-score", which focuses on the energy efficiency and carbon footprint of key components (batteries, steel, aluminium) and links with the CBAM and the Battery Regulation.[60] Such a system could provide more flexibility for manufacturers' industrial strategy, improved communication with consumers and a framework for environmental parameters of fiscal policy or fleet threshold values. The European Commission's current evaluation of the Car Labelling Directive also offers the opportunity to include more comprehensive information for new BEVs in the future, covering not only the energy efficiency of the vehicle, but also the impact of vehicle production on climate and resource use (e.g. by using the above-described "eco-score").

60 https://www.transportenvironment.org/articles/joint-call-for-an-eu-wide-vehicle-environmental-score-to-support-the-industrial-transition

Vehicle design and construction

The main opportunity to reduce the material intensity of new vehicles and increase the circularity of materials, structures and parts is in the vehicle design phase. **Circular design** includes modularity and designs that allow disassembly, remanufacturing and easy recycling of vehicle parts. The ELVR proposal introduces requirements for circular design and recycled content, and sets out rules for disassembly. To ensure that the requirements in Chapter II of the ELVR proposal take full advantage of this opportunity, it is essential to define sufficiently specific design criteria for the removability of parts and components and thus standardise design processes, minimise the need for specialised tools for service work, reduce development costs and the number of variants and the associated efforts and costs of suppliers and processing facilities. Further consideration should be given to the inclusion of additional parameters to extend the lifetime of key structural parts and vehicle components (e.g. durability requirements or longer warranty periods for new vehicles, parts and components, longer minimum availability periods for some spare parts and available software updates).

The **Digital Vehicle Passport** (DVP) concept promotes transparency of information about materials, components and their sustainability.[61] To ensure maximum benefit from the proposed Circularity Vehicle Passport (CVP) in the ELVR proposal, it will be important to: 1) effectively link and integrate the CVP with existing information systems (e.g. International Dismantling Information System – IDIS) and other planned instruments (DPP, battery passports, EVP under the Euro 7 Regulation); and 2) thereby expand the content of the CVP to include additional information on material composition, carbon and other environmental footprint, substances of concern (SoCs) and, where applicable, repairability or durability of the vehicle, parts and components. At the same time, consideration should be given to shortening the deadline for the introduction of the CVP from the proposed 7 years after the adoption of the Regulation, in coordination with the earlier introduction of the other digital passports mentioned.

Increased use of low-emission and secondary materials in new vehicles

Automakers face financial challenges in increasing the share of low-emission materials due to higher prices. The use of low-emission steel and aluminium or recycled plastics is technologically possible, but market conditions and the lack of business models prevent their wider use. A key problem is the inconsistent definition of low-carbon steel, which makes it difficult to compare and support its demand. Circular strategies focus on improving the quality of steel scrap but increase operating costs. It is therefore necessary to create premium markets where automakers would prefer high-quality recycled steel; set targets for recycled content; and provide tax reductions or subsidies.

In order to support the **low-carbon steel** market, it is important to establish uniform standards (for example, according to the IEA "sliding scale" method[62] and the new

61 https://www3.weforum.org/docs/WEF_Enabling%20Automotive_Circularity_through_Digital_Vehicle_Passports_2024.pdf

62 https://www.responsiblesteel.org/news/the-sliding-scale-setting-equitable-thresholds-to-drive-global-steel-decarbonisation

German LESS standard[63]) and to create certainty for investment in new capacity by entering into voluntary offtake agreements with steel producers for future sales, or by considering the introduction of mandatory targets for minimum low-emission steel content in vehicles as part of the ELVR proposal.

In addition, it is recommended to consider tax breaks and subsidies to encourage greater use of recycled steel in the automotive industry. In the case of **aluminium**, the carbon footprint of recycled aluminium is 90–95% lower than the EU average for aluminium production. 95% of aluminium from ELVs is currently being recycled, but for low-quality applications due to contamination. Higher recycling of aluminium for use in technically demanding applications, including automotive applications, would be facilitated by requirements to sort the aluminium fraction in ELVs into at least a few basic sub-fractions of alloys for recycling back into the same group, and to include information on metal alloys and body in white composition in the vehicle circularity passport.

The ELVR proposal already includes targets for 25% **recycled** content of post-consumer **plastic** waste in new vehicles within 6 years of adoption, of which at least 25% in a closed loop from ELVs.[64] Despite the understandable controversy that this measure has created in the supply chain and related efforts to reduce its ambition, a predictable environment should be ensured in the further negotiation of the proposal for planning and investment in research and development, innovation and expansion of recycling capacity, which has long been hampered by weak demand and low prices. In setting out eligible recycling technologies, it is crucial to clearly prioritise mechanical recycling given its lower environmental footprint, while chemical recycling will also play a significant role, considering the quality requirements of the automotive industry for plastics and subject to a thorough life-cycle impact assessment.

Extending the life of vehicles: Reuse, repair and refurbishment

Car manufacturers and key suppliers in the EU (e.g. Audi, BMW, Encory, Renault, Stellantis, Volvo, ZF Friedrichshafen) are already setting up circular centres for the repair, refurbishment and recycling of car parts. These vehicle life-cycle service models help to reduce dependence on external suppliers and secure material flows. Reusable components account for only 2% of the vehicle weight in the Czech Republic, as the majority of ELVs are obsolete models with low demand for spare parts.[65] Due to its extensive production network and related know-how, the Czech automotive industry has a great potential to become an important player in other phases of the life cycle such as **repair, remanufacturing and dismantling of vehicles**, in addition to being a major manufacturer, and thus strengthen its competitiveness. However, to do this, the current business model needs to be adapted to these strategies. International examples of practice show that a business model focusing not purely on sales but also on aftermarket services related to the whole vehicle life cycle can be economically viable, and large OEM groups secure

63 https://gmk.center/en/news/less-green-steel-standard-presented-in-germany/

64 https://eur-lex.europa.eu/legal-content/CS/TXT/?uri=CELEX%3A52023PC0451

65 https://incien.org/wp-content/uploads/2022/10/incien_study_CZ_DIGI.pdf

material flows for the future and reduce the risk of dependence on external suppliers. This will entail the introduction of appropriate measures (e.g. the obligation to offer repairs using used, remanufactured or refurbished spare parts and components or economic incentives, including reduced VAT rates) to support repair, refurbishment and reuse of parts and, based on a mapping of industry needs, determine the scope of support and define clear timelines for the completion of individual tasks.

Efficient and environmentally friendly treatment of ELVs

In the Czech Republic, between 155,000 and 180,000 ELVs are scrapped annually, which is approximately 2.5% of all ELVs in the EU.[66] The Czech Republic's share of total car production in the EU is up to four times greater than its share of the number of scrapped ELVs. To significantly increase the use of secondary materials from ELVs in car production in the Czech Republic, not only will much more efficient processing and recovery of materials be needed from ELVs on the Czech market, but also multiple times greater quantities of recycled materials will need to be sourced from ELVs scrapped and processed in other EU Member States.

To ensure the flow of materials back into production and parts for reuse, conditions must be created to connect and motivate vehicle manufacturers and scrap processors in this direction. At the same time, to make the system more efficient, it is necessary to reduce the number of permitted ELV processing facilities and to introduce a monitoring system that will guarantee the proper treatment of ELVs. An **Extended Producer Responsibility** (EPR) scheme, which, according to the ELVR proposal, will be introduced three years after the Regulation's entry into force, is expected to bring about a fundamental change in the functioning of the current system for the management of ELVs. Setting parameters for fee modulation under collective EPR schemes is another opportunity to encourage manufacturers to take into account a wider range of criteria for circular and ecological vehicle design.

Furthermore, the measures in the ELVR proposal for increased collection of ELVs are related to the efficient and environmentally friendly management of ELVs, and it will be crucial to ensure an effective monitoring system and enforcement of the measures (e.g. use of the Certificate of Destruction as a basis for the final removal of the vehicle from the register). Financial incentives for taking vehicles to authorised facilities and avoiding poor quality treatment (following the example of Denmark)[67] should also be considered. To avoid that large numbers of ELVs continue to be sent for recycling outside the EU and still count towards the ELVR recovery and recycling targets, the "equivalent" conditions for treatment of ELVs in third countries vis-à-vis the EU need to be properly defined.

For the **efficient processing** of steel, aluminium, plastics and other materials and parts made from ELVs, disassembly should be preferred to crushing and shredding of the wreck and then advanced automated technologies utilised to enable recognition of material composition and impurities. At the same time, it should be ensured that the mandatory removal of certain parts that are not suitable for reuse, refurbishment, or reconditioning or for which there

66 https://autovraky.mzp.cz/autovrak/overview/wrecks-in-region

67 https://www.weforum.org/publications/paving-the-way-eu-policy-action-for-automotive-circularity/

is no demand does not lead to additional costs and environmental impacts, or does not unduly weaken the incentive to introduce advanced post-shredding and recycling technologies. In particular, minimum guaranteed quality requirements should be set for material fractions obtained from ELVs with economic and/or strategic value, regardless of whether or not dismantling and disposal takes place prior to shredding (e.g. for flat steel or basic sub-fractions of aluminium alloys).


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Study
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