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Reuse of batteries through characterisation, smart logistics, automated pack and module dismantling and repackaging and a blockchain enabled marketplace

Mapping the EU battery circularity landscape: a regulatory and standardisation review

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1 Executive Summary

A complex landscape of policies and standards influence battery circularity in the European Union (EU), featuring multifaceted challenges and enablers for the battery supply chain.

The EU has developed an extensive regulatory framework addressing batteries across their life cycle, including both regulations and soft policy instruments. At the centre of this framework is the EU Batteries Regulation (Regulation (EU) 2023/1542), which aims to ensure the sustainable production, use, and end-of-life management of batteries while supporting the functioning of the internal market.

Beyond the Batteries Regulation, several additional EU policies affect the battery life cycle. The largest cluster of relevant policies focuses on the manufacturing stage, spanning domains such as industrial emissions, vehicles, critical raw materials, product safety, and eco-design. Other EU regulations address battery-related transport, while a growing number of measures target the end-of-life management of batteries, particularly through waste legislation. Together, these policies shape the regulatory environment for battery manufacturing, logistics, and end-of-life treatment. For example, waste legislation and extended producer responsibility schemes play an important role in ensuring the collection and proper treatment of used batteries, while transport regulations address the safety risks associated with moving lithium-ion batteries and battery waste.

Standards constitute another critical pillar supporting the implementation of EU battery policy. While standards are generally voluntary, those referenced in EU legislation can become harmonised standards, providing a presumption of conformity with regulatory requirements. Existing standards for batteries cover several aspects of the supply chain, including life cycle assessment methodologies, product performance, safety, labelling, environmental impacts, and recycling practices. There are additional manufacturing standards in specific sectors (such as medical devices, robotics and aviation) that do not focus exclusively on lithium batteries, but whose application has significant implications for battery manufacturers. It is important to note that most standards currently focus on the manufacturing stage, particularly on battery safety and performance, while comparatively fewer standards address reuse, repurposing, and recycling.

Insights from stakeholder interviews and complementary desk research conducted within the project provide additional perspectives on the challenges to improve battery circularity in the EU.

While stakeholders from across different parts of the supply chain broadly recognise the Batteries Regulation as a key policy enabler, they also identified several barriers to achieving battery circularity in the EU. A key challenge is the limited availability of standards for battery end-of-life management, such as those on battery classification, dismantling, battery design to support automated disassembly. Stakeholders noted that while some standards exist, navigating the fragmented and complex landscape remains difficult. Additional policy shortcomings identified include limitations on the lifetime of battery passports and a lack of incentives to retain recycled battery materials within Europe throughout the recycling and subsequent manufacturing process.

Technological challenges also remain significant. These include safety concerns associated with handling and repurposing used batteries and the diversity of battery chemistries and formats which complicates routinised disassembly. Balancing the demands between designing batteries which are safe and durable (i.e. batteries must withstand vehicle vibrations, shocks and exposure to moisture) and assuring standardised disassembly presents an additional technological challenge.

Economic factors further affect the development of circular battery systems. Recycling and repurposing operations often face high operational costs, uncertain supply of end-of-life batteries, and fluctuating

prices for recovered materials. It is costly and uncertain to warrant that second-life batteries continue to meet performance and health and safety requirements, particularly because of technological challenges related to testing and the unpredictability of battery aging. At the same time, non-EU manufacturers produce high volumes of new, higher-performing batteries at increasingly lower costs each year. These economic challenges can reduce incentives for investment in circular solutions and slow the scaling of recycling and second-life applications in the EU.

Overall, the analysis shows that while the EU has made significant progress in establishing a comprehensive regulatory framework and standards for batteries, further efforts are needed to fully enable circularity in the battery supply chain. In particular, stakeholders require better support and guidance to navigate and apply existing policies and standards, alongside the development of new standards for areas such as battery reuse, repurposing, and recycling. Addressing knowledge gaps through research and improved data is also important, as is providing economic incentives to strengthen the European battery industry and promote circular practices. Finally, digital battery passport requirements should be clarified through stakeholder consultation to ensure they effectively support lifecycle transparency and second-life battery applications.

2 Introduction

Produced in the context of the EU-funded RECIRCULATE project–which aims to extend battery lifespans and transform battery reuse across Europe–this report delves into the complex landscape of policies and standards influencing battery supply chains, as well as the multifaceted challenges and enablers for battery supply chain circularity in the EU. Based on an inventory of relevant policies and standards and interviews with stakeholders spanning the supply chain, it provides recommendations for improved circularity. The remainder of the report is structured as follows. Section 3 details the extensive policy framework governing the battery supply chain in the EU. Section 4 then similarly details the network of standards covering the battery supply chain. Section 5 explores insights into challenges and enablers for building circular battery supply chains in the EU. Section 6 concludes with key policy recommendations to improve battery supply chain circularity in the EU.

3 The EU batteries policy framework

This section briefly characterises policies for the purpose of this study and describes the research approach used to inventory the policies relevant to battery supply chains in the EU, before providing a description of the EU batteries policy framework based on this inventory (see Appendix I and Appendix II). The framework includes both regulations and soft policy instruments spanning the various parts of the product life cycle but is particularly clustered around the manufacturing stage, transport, and end-of-life and waste handling. Additionally, several policies relate to all or multiple stages of the product life cycle. This section is organised in terms of these five clusters. The policies in the inventory also feature various types of policy tools, which will be mentioned throughout this section when relevant. These policy tools include targets; compulsory standards; economic tools such as taxes, charges, fees, and incentives; informational rules and obligations such as labelling requirements and mandatory disclosures; and a residual category of other rules and requirements.

In terms of scope, the policies inventory focuses on two policy categories: EU-level regulations and EU-level soft policy instruments. Regarding EU-level regulations, the inventory includes instances of EU Directives, EU Regulations, and European Commission Decisions–all of which are binding regulatory instruments. EU Directives set binding objectives on EU member states to achieve a certain result but leave Member States free to choose how to achieve these objectives through adoption of measures

which incorporate the Directive into national law (this is called transposition). Regulations are also binding, but they are directly and uniformly applicable to all EU Member States as soon as they enter into force (meaning they do not need to be transposed into national law). Decisions are in their entirety binding, but only on the specific addressees of a given decision where specified. Although the three types of instruments have different characteristics and uses, all three types of EU regulatory instruments are referred to as regulations for the purposes of this study as they all regulate various aspects of lithium batteries throughout the parts of the life cycle. For the most part, the regulations included in the inventory are currently in force. In addition to EU-level regulations, the inventory also includes EU soft policy instruments which set more general policy priorities and objectives, such as Action Plans and Strategies. Finally, while the focus of the inventory is EU-level regulations and soft policy instruments, the inventory also exceptionally includes a few results at the international level in cases when international instruments are referenced in key EU-level regulations and so are critical to understanding the EU-level regulations in the inventory.

In terms of method, we combined desk research of both more general sources and of official EU sources. Regarding the more general sources, we began with a variety of EU-funded project publications and webpages, as well as consultancy websites and similar sources. In this way we were able to provisionally identify a range of potentially relevant regulations and soft policy instruments. Then, from the items in this provisional list, we serially identified additional regulations and soft policies through textual cross-references. We were ultimately able to identify a network of regulations and soft policies through these cross-references. Regarding official EU sources, we referred to the Official Journal of the EU–the official gazette of record for EU legal acts, official information from EU institutions, etc. In this context we searched the Official Journal for all legal acts relating to lithium batteries. We were also able to leverage data collected in the context of CEPS' work on other EU-funded projects to contribute to our provisional list of potentially relevant regulations and soft policies. This approach resulted in the provisional review of several hundred policies–particularly from our search in the Official Journal of the European Union (OJEU)–and the identification of 28 policies for inclusion in the inventory.

3.1 Policies relating to all stages of the product life cycle

EU-level soft policy instruments such as the European Green Deal, the European Industrial Strategy, the Clean Industrial Deal, the Circular Economy Action Plan, the European Battery Alliance (EBA), and the Strategic Action Plan on Batteries span the stages of the battery life cycle.

At the level of the EU economy as a whole, the **European Green Deal** is a broad initiative aimed at modernising and transforming the EU into a competitive, resource-efficient economy. It aims to ensure zero net greenhouse gas emissions by 2050 and to achieve decoupling of economic growth from resource use. The European Commission has adopted a set of proposals to align the EU's climate, energy, industry, and policies in other domains with the objectives of the Green Deal.

In terms of industry, the **European Industrial Strategy** aims to support the twin transition to a green and digital economy in order to make the EU more competitive globally and enhance Europe's open strategic autonomy. Relatedly, **the Clean Industrial Deal** focuses on accelerating the EU's transition to a green, competitive, and sustainable industrial economy. Key elements include support to encourage the development and scaling of green technologies in order to boost industrial decarbonization; support to enable industrial transformation of sectors like energy, steel, cement, and chemicals to reduce emissions and adopt sustainable practices; frameworks and funding to stimulate private investment and innovation in clean industry through regulatory and financial support; support to ensure that the workforce is equipped with the skills necessary for a green economy. The Clean Industrial Deal also promotes

circularity through promotion of efficient resource use, waste reduction through recycling and reuse, and sustainable production.

Building on this circularity focus, the **Circular Economy Action Plan**–a key pillar of the European Green Deal–provides an agenda for accelerating the transition required by the European Green Deal while building on circular economy principles. It introduces a series of legislative and non-legislative measures to establish a strong and coherent product policy framework. The Plan comprises 35 actions and identifies 7 key product value chains to be addressed as a matter of priority, including batteries and vehicles. Building on this plan, the upcoming **Circular Economy Act** is set to become a cornerstone of European industrial policy by addressing structural barriers to circularity across high-impact sectors.

Moving to batteries specifically as a strategic part of the transition to a clean, digital, and competitive Europe, the European Commission launched the **European Battery Alliance (EBA)** in 2017 to develop an innovative, competitive, and sustainable battery value chain in Europe. In line with the European Green Deal, the Circular Economy Action Plan, and the European Industrial Strategy, the EBA focuses on bringing together stakeholders through the battery value chain in order to secure the priorities of the **Strategic Action Plan for Batteries**: access to raw materials for batteries, support European battery cell manufacturing and other investments; strengthen industrial leadership through accelerated research and innovation programmes; secure a highly skilled workforce along the whole value chain; support a sustainable EU battery cell manufacturing industry; and ensure consistency with broader frameworks. In the strategic action plan, these priorities are supported by a comprehensive framework of regulatory and non-regulatory measures targeting all parts of the battery value chain.

In addition to these EU-level soft policy instruments, regulations such as the new **Batteries Regulation** and the replaced **Batteries Directive** also target the entire battery life cycle. The Batteries Regulation aims to ensure that, in the future, batteries have a low carbon footprint, use minimal harmful substances, need fewer raw materials from non-EU countries and are collected, reused and recycled to a high degree within the EU. It applies to all batteries and sets out rules covering the entire life cycle of batteries. It includes binding battery waste collection targets for certain battery types; binding substance recovery targets for lithium, cobalt, copper, lead, and nickel from waste batteries for recyclers; binding minimum recycled content thresholds for cobalt, lead, lithium, and nickel; binding recycling efficiency targets; optional Member State incentive schemes for economic operators that achieve higher recovery rates than the targets; battery due diligence obligations; information and labelling requirements concerning battery components and recycled content; safety requirements for waste and used batteries; mandatory carbon footprint information requirements; and QR code and battery passport requirements.

3.2 Policies relating to manufacturing

The largest cluster of relevant policies focus on the manufacturing part of the battery life cycle and spans policy domains covering industrial emissions, vehicles, critical raw materials, product safety, and ecodesign.

For example, the **Industrial Emissions Directive (IED)** lays down rules on integrated prevention and control of pollution arising from industrial activities. It also lays down rules designed to prevent or, where that is not practicable, to continuously reduce emissions into air, water and land, to prevent the generation of waste, improve resource efficiency, and to promote the circular economy and decarbonisation, in order to achieve a high level of protection of human health and the environment taken as a whole (Article 1). The Directive applies to certain industrial activities giving rise to pollution, including battery manufacturing, other than exclusively assembling, with a production capacity of 15.000 tonnes of

battery cells (cathode, anode, electrolyte, separator, capsule) or more per year (Annex I). Requirements for these activities include permitting, installation operation, and information exchange requirements (Chapter II). The Directive does not apply to research activities, development activities or the testing of new products and processes.

In the automotive sector, the **Industrial Action Plan for the European automotive sector**, for example, provides a comprehensive framework of policies, measures, and funding and incentive opportunities in order to ramp up European industrial capacities, including for batteries and their components. The plan aims to make electric vehicle battery cells and components produced in the EU cost-competitive in the short term. The plan includes several key measures, such as a comprehensive "Battery Booster" package, which aims to support the production of battery cells and components through direct funding, non-price criteria for components and competitive loans. Upcoming legislation will specify the local content requirements for batteries and their components. The plan also aims to provide more support for recycling, including funding for recycling facilities. The Commission will also provide additional support to enhance cooperation in battery recycling amongst industry. Furthermore, measures will be taken to improve the health and repairability of electric vehicle batteries. The **Euro 7 Regulation**, which also covers the automotive sector, sets various requirements for vehicles. Relevant for electric vehicle batteries, the Regulation sets requirements for electric vehicle battery performance and durability. Electric vehicle batteries must comply with minimum performance requirements for electric vehicle battery durability (Article 6, Annex II). Notably, because the Euro 7 Regulation sets performance and durability requirements for electric vehicle batteries, the new Batteries Regulation sets only information requirements for electric vehicle performance and durability. Also an automotive sector regulation, the **Commission Regulation on vehicle type approval requirements (Regulation (EU) 2019/2144)** contains battery safety requirements which continue to be applicable for repaired electric vehicle batteries (Batteries Regulation, Recital 40).

When it comes to material inputs for battery manufacturing, the **Critical Raw Materials Act** identifies several battery-relevant substances as strategic raw materials–including lithium–based on strategic importance, forecasted demand growth and difficulty of increasing production (Article 3, Annex I). It also identifies several battery-relevant substances as critical raw materials based on supply risk and economic importance (Article 4, Annex II). In terms of incentives and support programs, the Regulation requires Member States and the European Commission to undertake efforts to incentivise and promote critical raw material circularity (Article 5, Article 26). In terms of requirements, the Regulation sets risk preparedness information disclosure requirements for large companies that use strategic raw materials to manufacture batteries for traction motors, among other uses (Article 24). In terms of substances used in batteries, the registration, evaluation, authorisation and restriction of chemicals **(REACH)** regulation provides a comprehensive legislative framework for chemicals that are manufactured and used in Europe. It includes substance restrictions, including use restrictions and concentration limits for battery-relevant substances such as lead, nickel, mercury, lithium and cobalt. It also includes mandatory substance registration requirements and mandatory information disclosure and reporting requirements.

Also relevant to the manufacturing part of the life cycle, the General Product Safety Regulation (GPSR) and the Ecodesign for Sustainable Products Regulation (ESPR) are general product regulations which may cover aspects of batteries insofar as they are not covered by more specific regulations such as the Batteries Regulation. The **GSPR** ensures that manufactured products such as batteries are safe for consumers. The Regulation lays down essential rules on the safety of consumer products placed or made available on the market (Article 1), including a general safety requirement (Article 5), rules for the presumption that products conforming with European standards satisfy the general safety requirement (Article 7), various obligations on economic actors related to risk analysis, technical documentation, internal

processes for product safety, etc. (Chapter III). It also includes informational obligations for economic operators in the case of distance sales (Article 19) and notification obligations of economic operators in the case of accidents related to safety of products (Article 20). However, the GSPR is a general regulation which covers aspects of products covered by sector-specific Union harmonising legislation such as the Batteries Regulation only insofar as those aspects are not covered by the sector-specific legislation (Article 2). The **ESPR**–which replaced the Ecodesign Directive in 2024–aims to significantly improve the circularity, energy performance and other environmental sustainability aspects of products. It is the basis for assessing and setting ecodesign requirements via delegated acts, set either for a specific product group or horizontally (more than one product group). Ecodesign requirements will improve product aspects such as durability, reusability, repairability, recycled content, etc. Ecodesign requirements will be set first for priority product groups. Batteries are not a priority product group for the development of ecodesign requirements (Article 18), though the Batteries Regulation already contains some requirements for batteries, such as recycled content requirements. The Regulation also introduces the digital product passport (DPP) and includes by reference battery passports under the new Batteries Regulation.

3.3 Policies relating to battery transport

Regulations covering battery-relevant transport include the Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) and the EU Inland Transport of Dangerous Goods Directive.

At the international level, the **ADR** regulates safe transport of dangerous goods by road. According to Art. 2, dangerous goods may be carried internationally provided they comply with conditions laid down in Annex A (general provisions and provisions concerning dangerous articles and substances) and Annex B (provisions concerning transport equipment and transport operations). The requirements for the transport of lithium batteries are listed under Art. 2.2.9.1.7. Depending on battery conditions and life cycle phase, safety rules may vary. All lithium-ion batteries are labelled as Class 9 (miscellaneous dangerous substances and articles). For all shipments, it is required that all personnel involved in the preparation and transport of batteries receive adequate instruction on these requirements or Dangerous Goods training. Additionally, the ADR in turn requires lithium batteries to comply with the requirements set by sub-section 38.3 of the UN Manual of Tests and Criteria. **UN 38.3** is a set of international standards for the transportation of lithium-ion batteries. The standards are designed to ensure the safe transport of lithium-ion batteries by air, land, and sea. The UN 38.3 standards cover a wide range of topics, including: packaging requirements, labelling requirements, testing procedures, and safety requirements.

At the EU level, the **Inland Transport of Dangerous Goods Directive** lays down common rules for the safe and secure transport of dangerous goods within and between EU countries by road, rail or inland waterway. It also covers aspects such as loading and unloading, the transfer to and from another mode of transport, as well as the stops in the course of the transport process. It extends the application of international rules (including under the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)) to national transport of dangerous goods.

3.4 Policies relating to end-of-life and waste handling

There are a number of regulations in the domain of waste policy which relate to the handling of batteries once they have reached end-of-life.

Addressing waste at a high level, **Waste Framework Directive (WFD)** establishes a legal framework for treating waste in the EU which is designed to protect the environment and human health by emphasising the importance of proper waste management, recovery and recycling techniques to reduce pressure on resources and improve their use. As a framework directive, it lays down basic waste management principles and establishes a number of high-level requirements and options for Member States to promote

proper waste management and circularity. The Directive establishes the waste hierarchy (prevention; preparing for re-use; recycling; other recovery, e.g. energy recovery; and disposal) and requires that Member States take into account the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts. The Directive also confirms the 'polluter-pays principle' whereby the original waste producer must pay for the costs of waste management and introduces the concept of 'extended producer responsibility' (EPR) including minimum requirements for EPR schemes.

In the context of waste shipments, the **new Waste Shipment Regulation** (Regulation (EU) 2024/1157) lays down the rules for procedures and controls on waste shipments which will gradually replace those under the **old Waste Shipment Regulation** (Regulation (EU) 1013/2006) through 2027. The regulation incorporates into EU law the provisions of the **Basel Convention on the control of transboundary movements of hazardous wastes and their disposal** and the **decision of the Council of the Organisation for Economic Co-operation and Development (OECD) on the control of transboundary movements of wastes destined for recovery operations**. The regulation applies to shipments between EU Member States, exports and imports to and from non-EU countries, and waste transiting through the EU. Under the Regulation, there are various informational, shipment bans, and other rules and requirements depending on the type of waste contained in a given shipment (hazardous according to the EU LoW, non-hazardous, etc.), the destiny of the shipped waste (disposal, recovery), and the shipment route (intra-EU, exports from the EU, imports to the EU). The Regulation also requires waste producers, notifiers, shippers and others involved in waste recovery or disposal not to endanger human health and to apply good environmental practices throughout the entire process. The Regulation also imposes take-back obligations and allocates associated costs when a waste shipment cannot be completed as intended or when a shipment is illegal. The Regulation provides for a financial guarantee for shipments for which prior notification is required.

Additionally, the **European List of Waste (LoW)** is a key instrument for managing waste in the EU and controlling waste shipments within and outside the EU. The LoW provides common terminology for classifying waste across the EU. Specifically, it identifies and classifies all different types of waste, including hazardous waste, which can be harmful to human health and the environment. Established in 2000, this list has been revised a number of times, and as of March 2025, the LoW now includes new battery-related waste codes corresponding to different parts of the battery life cycle. These include codes for lithium-based batteries, as well as codes for waste from battery manufacturing, waste from post-consumer batteries, and intermediate fractions from battery recycling ("black masss"). Black mass, lithium-based, nickel-based, and zinc-based waste batteries, and sodium sulphur and alkaline waste batteries are also now classed as hazardous. A new hazardous code for lithium-based batteries for separately collected municipal waste has also been added. The classification of battery-related waste streams impacts the extent to which they are subject to applicable waste rules such as waste shipment rules in accordance with the Waste Shipment Regulation.

In the automotive sector, the **End-of-Life Vehicles Directive** sets out measures to prevent and limit waste from end-of-life vehicles (ELVs) and their components by ensuring their reuse, recycling and recovery. It also aims to improve the environmental performance of all economic operators involved in the lifecycle of the vehicles. It sets targets for the reuse, recycling and recovery of end-of-life vehicles and their components and prohibits the use of hazardous substances in their manufacturing, including lead, mercury, cadmium or hexavalent chromium except as provided in Annex II (Article 4(2)). It also allocates the responsibility for ELV collection systems to manufacturers, importers, and distributors; and allocates the costs involved in delivery of ELV to authorised waste treatment facilities to manufacturers.

It requires that ELVs are first stripped, including the removal of batteries, before further treatment takes place (Article 6(1) and Annex I).

4 Standards covering the battery supply chain

4.1 Standard systems in the EU

Standardisation defines technical and quality specifications which products, processes and services may voluntarily comply with. The EU uses standards as a tool for ensuring conformity of products on the internal market, boosting competitiveness of its enterprises, facilitating international trade, protecting the well-being and safety of citizens, and minimising environmental impacts. European standards are adopted by three standardisation organisations, namely the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunications Standards Institute (ETSI). Battery-related standards are particularly adopted by CEN and CENELEC. CEN and CENELEC adopt standards based on national representation i.e. national standardisation bodies represent their country's stakeholders and send delegates to CEN and CENELEC committees.[1]

The EU can publish a harmonised standard in OJEU. As defined in Article 2, point (1)(c), of Regulation (EU) No 1025/2012, 'harmonised standard' means 'a European standard adopted on the basis of a request made by the Commission for the application of Union harmonisation legislation". Therefore, conformity with an EU harmonised standard means conformity with the respective EU regulation which makes a reference to it. An example of European harmonised standards impacting lithium batteries is the ISO 14040:2006 standard on life cycle assessment, which has a reference in the Batteries Regulation regarding the definition of the 'life cycle' and 'reference flow' concepts – used in the calculation of the carbon footprint of batteries.

From EU to national level, an EU standard undergoes five main following steps to be implemented in Member States.[2]

- Ratification: the Technical Board of CEN/CENELEC notes the approval of an EN standard.
- Availability: the definitive text in the official language versions of an approved CEN/CENELEC publication is distributed by the Central Secretariat of CEN/CENELEC.
- Announcement : the existence of an EN standard is announced at national level.
- Publication: an EN standard is implemented at national level by publication of an identical national standard or by endorsement.
- Withdrawal: national standards conflicting with an EN standard have to be withdrawn.

[1] Regulation EU 2025/2015 on standardisation: https://eur-lex.europa.eu/eli/reg/2012/1025/oj/eng

[2] Source: CEN5 procedure: https://standards.cencenelec.eu/dyn/www/f?p=CEN:110:0::::FSP_PROJECT:78721&cs=1E6207B1C0C7AC41376C4153950A90B5F

4.2 Standards for lithium batteries throughout the life cycle

This section provides an inventory of standards on lithium batteries (see Appendix III). They are categorised based on stages of the battery life cycle. While some standards cover all or multiple life-cycle stages, many others focus on one phase (e.g., manufacturing).

4.2.1 Standards covering all stages of battery life cycle

The **ISO 14040 and ISO 14044** standards provide a comprehensive framework for conducting Life Cycle Assessment (LCA), which are critical tools for evaluating the environmental impacts of lithium batteries throughout their entire life cycle, from the extraction of raw material to end-of-life disposal or recycling.

ISO 14040:2006 and its 2020 amendment establish the *principles and framework* for LCA, providing a foundation for consistent and transparent studies. It outlines the four major stages of LCA: defining goal and scope, conducting a life cycle inventory (LCI) analysis, carrying out a life cycle impact assessment (LCIA), and interpretating the results. For lithium batteries, these principles help to structure environmental assessments that consider aspects such as the mining of lithium, energy use during manufacturing, emissions during use, and the environmental impacts of disposal or recycling.

ISO 14044:2006 and its 2017 and 2020 amendments, on the other hand, provide detailed *requirements and methodological guidance* for implementing the LCA framework defined in ISO 14040. This includes guidance on handling data quality, system boundaries, allocation methods, and impact categories - all of which are critical issues in the assessment of complex supply chains, such as those for lithium-ion batteries. Given the energy-intensive nature of battery production and the global sourcing of materials (e.g., lithium, cobalt and nickel), ISO 14044 ensures that assessments are methodologically robust and comparable.

Both standards are essential in the context of EU regulations. For example, the EU Batteries Regulation (2023/1542) uses ISO 14040 to define terms such as 'life cycle' and 'reference flow'. These concepts are used, for example, in calculating the carbon footprint of batteries under Article 7 of the Regulation.

In addition to cross-sectoral standards such as ISO 14040 and ISO 14044, in the building and construction sector, **ISO 15686-5:2017** provides requirements and guidelines for conducting life-cycle cost (LCC) analyses of buildings and constructed assets and their components.

4.2.2 Standards impacting the manufacturing stage

The majority of standards for the manufacturing stages provide test procedures and requirements for the essential performance, safety and reliability characteristics of lithium batteries. Some also specify requirements for the markings, designations and dimensions.

Lithium batteries are used in a wide range of applications, from industrial applications to road vehicles, railway traction to portable equipment. Lithium batteries, cells and packs must meet different requirements to ensure their performance, safety and reliability in each application. The following standards reflect this feature through their diverse requirements for lithium batteries in **specific applications**:

- Industrial applications: IEC 62619:2022 and EN IEC 62619:202; IEC 62620:2014+AMD1:2023 and EN 62620:2015+A1:2023. Examples of applications utilising cells and batteries for industrial application include those for stationary applications (e.g. telecom, uninterruptible power supplies, electrical energy storage system, utility switching, emergency power) and motive applications (e.g. forklift trucks, golf carts, automated guided vehicles, railway vehicles and marine vehicles, excluding road vehicles).
- Rolling stock types (e.g. light rail vehicles, tramways, streetcars, metros, commuter trains, regional trains, high-speed trains and locomotives): IEC 62973-5:2023.

- Railway traction applications: IEC 62928:2017 and EN IEC 62928:2018, and IEC 62973-5:2023.
- Electrically propelled mopeds and motorcycles: ISO 18243:2017 + AMD 1:2020 and EN ISO 18243:2019
- Road vehicles not for propulsion (e.g. power source for the starting of internal combustion engines, lighting, stop-start functions, on-board auxiliary equipment and energy absorption for regeneration from braking): IEC 63118-1:2024 and EN IEC 63118-1:2024.
- Traction batteries of or for electrically propelled road vehicles: EN 50604-1:2016 and amendments
- Stationary lithium-ion batteries (e.g. batteries for industrial applications that are installed in separate closed buildings or housings as well as stationary batteries that are installed in public buildings, offices and private residences): IEC 62485-5:2020 and EN IEC 62485-5:2021 and amendments.
- Electric off-road vehicles: IEC 62485-6:2021 and EN IEC 62485-6:2021.
- Propulsion of electric vehicles (EV), including battery electric vehicles (BEV) and hybrid electric vehicles (HEV): IEC 62660-3:2022 and EN IEC 62660-3:2022
- Electrically propelled road vehicles: ISO 12405-4:2018
- Electrical Energy Storage Systems: IEC 63056:2020 and EN IEC 63056:2020
- Road vehicles not for propulsion: IEC 63057:2020 and EN IEC 63057:2020. Examples of typical applications: a power source for the starting of internal combustion engines, lighting, on-board auxiliary equipment, and energy absorption for regeneration from braking.
- Portable application (hand-held equipment, transportable equipment and movable equipment): IEC 61960-3:2017 and EN 61960-3:2017.
- Coin secondary lithium cells and batteries for portable applications and backup power supply such as memory backup application: IEC 61960-4:2024 and EN IEC 61960-4:2020.

Additionally, a number of standards set out test methods and requirements to ensure the safety of lithium batteries during **transport and operation**, *regardless of their intended use*. In the context of *transport safety*, IEC 62281:2019 (including amendments in 2021 and 2023) and EN IEC 62281:2019 (including an amendment in 2023) set out the test methods and requirements for the safe transport of both primary and secondary lithium cells and batteries (excluding those intended for recycling or disposal).

In terms of *operation safety*, the IEC 60086-4:2025 and its European equivalent, EN IEC 60086-4, set out the safety requirements and testing procedures for the safe operation of primary lithium batteries. This ensures that they perform correctly under both intended use and reasonably foreseeable misuse. Similarly, for secondary (rechargeable) lithium cells and batteries, IEC 62133-2:2017 (amended in 2021) and EN 62133-2:2017 (amended in 2021) specify the safety and testing criteria for portable sealed batteries containing non-acid electrolytes.

Finally, there are additional **manufacturing standards in specific sectors** (such as medical devices, robotics and aviation) that do **not focus exclusively on lithium batteries**, but whose application has significant implications for battery manufacturers. Some of the most notable standards in the EU context are listed below.

In the field of **medical devices, IEC 60601-1** sets out the general requirements for the basic safety and essential performance of medical electrical equipment. Medical devices operating near or within the human body must deliver uninterrupted and reliable performance. Consequently, the safety and

reliability of the batteries powering these devices of critical importance. This standard contains specific sections (e.g., Clause 15 and Annex A) that address internal power sources, including lithium batteries. The standard also makes *normative reference to IEC 60086-4* (a battery-focused standard for tests and requirements for primary lithium batteries to ensure their safe operation) and *IEC 62133* (which specifies requirements and tests for the safe operation of portable sealed secondary lithium cells and batteries containing non-acid electrolyte, listed above). Accordingly, devices with non-rechargeable batteries certified to IEC 60601-1 must comply with IEC 60086-4 , and devices with rechargeable batteries certified to IEC 60601-1 must comply with IEC 62133.

Also in the medical device area, **ISO 13485:2016** and **EN ISO 13485** focuses on the *quality management systems* in the design and manufacture of medical devices. They outline specific requirements to ensure consistent design, development, production, and delivery of medical devices that are safe for their intended purpose. Important to note that these standards are cited in *the EU Medical Device Regulation* (2017/745) and the *EU In-Vitro Diagnostic Medical Device Regulation* (2017/746) and their supporting Commission Implementing Decision. Accordingly, batteries used for medical devices and in-vitro medical devices must be designed and manufactured in accordance with a quality management system that meets the requirements of these standards.

In the field of **robotics**, **ISO/DIS 13482** sets out the safety requirements for service robots. This standard makes *normative references* to two other standards: IEC 62619:2022 (a battery-focused standard on requirements and tests for the safe operation of secondary lithium cells and batteries used in industrial applications) and IEC 62133-2:2017 (which sets out the requirements and tests for the safe operation of portable sealed secondary lithium cells and batteries containing non-acid electrolyte). Therefore, the application of IEC 62619:2022 and IEC 62133-2:2017 is mandatory where lithium batteries are used in compliance with ISO/DIS 13482.

In the field of **electric vehicles**, **ISO/SAE 12906:2024** has a significant impact on batteries. This standard provides test procedures for determining the charging performance of electric vehicles. *Tests on batteries* are included in the articles on rechargeable energy storage systems and battery thermal preconditioning functions.

In the field of **aviation**, **RTCA DO-311A** (developed by the Radio Technical Commission for Aeronautics) is a notable standard for battery manufacturers. The standard is aimed at designers and manufacturers of rechargeable lithium batteries and battery systems, as well as aircraft manufacturers, equipment installers, and other aviation stakeholders. It stipulates that aerospace manufacturers must ensure that batteries incorporated into their systems adhere to aviation safety regulations. Adherence to the standard helps guarantee that batteries and battery systems can perform their intended functions safely under the operational conditions typical of aviation environments.

4.2.3 Standards impacting other life cycle stages

While most standards focus on the manufacturing stage of lithium batteries, a few others address other stages of the life cycle.

At the **handling** stage, ISO 23625:2025 and EN ISO 23625:2025 set out the requirements and recommendations for *selecting and installing* lithium-ion batteries in boats. The standards apply to lithium-ion batteries and battery systems with a capacity greater than 600 Wh, installed on small craft to provide power for general electrical loads and/or to electric propulsion systems. The standard is primarily intended for manufacturers and battery installers.

Regarding **end-of-life management**, the following standards apply for the **recycling** stage:

- IEC 63218:2021 and EN IEC 63218:2021 provide guidance and recommendations on the *collection, recycling and environmental impact assessment*, including design, manufacturing, transportation, storage and disposal of secondary lithium, nickel cadmium and nickel-metal hydride cells and batteries for portable applications. The standards aim to promote environmental sustainability by providing the following: a) basic considerations and information relating to the environmental aspects and environmental impact of secondary cells and batteries; b) basic guidance for the collection and recycling of secondary cells and batteries; c) basic guidance for environmental impact assessments across all stages of life cycle of secondary cells and batteries during design and manufacturing; and d) useful information for interested parties regarding regulations on secondary cells and batteries.
- IEC 62902:2025 and EN IEC 62902 specifies *marking symbols* for the identification of secondary cells and batteries prevailing the market, including lead acid, nickel cadmium, nickel metal and lithium-ion batteries. The standard includes optional use of the recycling symbol ISO 7000-1135, to indicate that the marked item or its material is part of a recovery or recycling process.
- IEC 63218 and EN IEC 63218 offer guidance to improve the *environmental sustainability* of secondary batteries. The standards contain specific measures to improve the efficiency and safety of the collection and recycling of secondary cells and batteries. They require batteries be marked using the recycling symbol to improve sorting and recycling efficiency. Furthermore, they provide the calculation method to evaluate the efficiency of battery recycling.

In addition, several international standards address the **reuse and repurposing** of batteries, notably the following IEC standards. As of the drafting date of this report, no official EU equivalents of these standards have been published.

- IEC 63330-1 provides general requirements for repurposing of secondary batteries. It particularly specifies the procedure to evaluate the *performance and safety* of used secondary batteries and battery systems for repurposing. It also offers general requirements for application of repurposed batteries. While IEC 63338:2024 (above) provides relatively high-level requirements (environmental aspects, safety risk awareness, traceability, general recommendations) for the reuse/repurposing of cells & batteries, IEC 63330-1 offers detailed evaluation procedure for performance and safety, application requirements of repurposed product.
- IEC 62933 (Part 4-4) provides *environmental requirements* for *battery-based energy storage systems* (BESS) with reused batteries, e.g. from other electric energy storage installations or electric vehicles. The standard specifies requirements for identifying and preventing environmental issues throughout the life cycle of reused batteries in a BESS, from the design to the disassembly.
- IEC 63330-1:2024 provides general requirements for repurposing of secondary cells, modules, battery packs and battery systems that are originally manufactured for other applications such as electric vehicles. The standard provides the procedure to evaluate the *performance and safety* of batteries for repurposing. It particularly targets secondary lithium ion batteries and battery technologies with data traceability.
- IEC 63338:2024 provides general guidance on the reuse and repurposing of secondary lithium ion and nickel-metal hydride cells and batteries. It addresses aspects related to the reusing and repurposing of secondary cells and batteries including *environmental aspects, safety risks*, *suitability for reuse or repurposing* based on battery lifetime traceability data, and manufacturer warning notice on the applicability of a product for reuse or repurposing. For reuse or repurposed application manufacturers particularly, the standard recommends the removal of original cell or battery label and markings, and affixation of label or marking specifying the reuse or repurposing of batteries in the products.

While mainly covering the manufacturing stage, these following standards also include element relating to **packaging, handling, storage, transport and disposal**: IEC 60086-4:2025 and EN IEC 60086-4; IEC 62133-2:2017+AMD1:2021 and EN 62133-2:2017+A1:2021, IEC 62281:2019+AMD1:2021+AMD2:2023 and EN IEC 62281:2019+A2:2023; IEC 62485-5:2020 and EN IEC 62485-5:2021 & amendments, IEC 62485-6:2021 and EN IEC 62485-6:2021; and IEC 62619:2022 and EN IEC 62619:2022.

4.3 Standard systems under the EU Batteries Regulation

The EU Batteries Regulation aims to support the efficient functioning of the internal market while minimising the environmental and health risks associated with batteries. As described in Section 3 of this report, to be placed on the EU market, batteries must meet the sustainability, safety, labelling and information requirements set out in Articles 6-13 of the Regulation.

The Regulation uses standards as one of the key measures to ensure the above. The text of the Regulation explicitly includes only two groups of standards.

- First, Recital (44) requires that batteries should be labelled with information available by means of QR code in conformity with the standard ISO/IEC 18004:2015, giving access to the battery passport. Article 77 further specifies that the battery passport shall be accessible through the QR code which links to a unique identifier that the economic operator placing the battery on the market shall attribute to it. The QR code and the unique identifier shall comply with the ISO/IEC standards 15459-1:2014, 15459-2:2015, 15459-3:2014, 15459-4:2014, 15459-5:2014 and 15459-6:2014 or their equivalent. All information included in the battery passport shall be based on open standards.
- Second, Annex II also refers to ISO 14040:2006 or an equivalent standard when defining the concepts of 'life cycle' and 'reference flow' – these elements are essential in the calculation of the carbon footprint of batteries under Article 7.

Recital (47) and Article 15 clarifies that reference to other harmonised standards on performance, durability, repurposing and safety will be published in the Official Journal of the European Union (in accordance with Regulation EU 1025/2012). In case no standard exists in a specific field, the Commission can ask European standardisation organisations to draft one (Article 16).

- Recital (34): mentions the need for harmonised standards or common specifications to test battery performances and durability of batteries for energy storage, because existing measurement methods are deemed insufficient.
    - Article 9: by 18 August 2027, the Commission will adopt a delegated act on minimum values for the electrochemical performance and durability of *portable batteries of general use* (excluding button cells), taking into consideration relevant international standards and labelling schemes. These values will be applied from 18 August 2028 or 24 months after the date of entry into force of the delegated act.
    - Article 10: From 18 August 2024, *rechargeable industrial batteries with a capacity greater than 2 kWh, LMT batteries and electric vehicle batteries* shall be accompanied by a document containing values for the electrochemical performance and durability parameters set out in Part A of Annex IV. Such a document shall contain an explanation

of the technical specifications, standards and conditions used to measure, calculate or estimate the values for the electrochemical performance and durability parameters.

- Recital (38): consumer safety during the removal of portable batteries should be in line with Union safety standards.
- Recital (41): requires the Commission to assess the introduction of harmonised standards for common chargers for LMT batteries and rechargeable batteries in specific electrical and electronic equipment.
- Recital (42): requires the Commission to encourage the development of standards that facilitate the maintenance, repair and repurposing of SLI batteries and electric vehicle batteries.
- Recital (43): considers laying down parameters and applicable standards on safety test to ensure no risk of stationary battery energy storage systems to human health or the safety of persons, property or the environment.
- Recital (126): requires the Commission to publish harmonised standards (with reference in the OJEU) or common specifications to ensure the effective, dynamic and market-driven implementation of the battery passport.
- Finally, Article 94 states that by 1 January 2025, the Commission shall assess how best to introduce harmonised standards for a common charger for, respectively, rechargeable batteries designed for light means of transport, as well as for rechargeable batteries incorporated into specific categories of electrical and electronic equipment covered by Directive 2012/19/EU. Charging devices for categories and classes of radio equipment under Article 3(4) of Directive 2014/53/EU shall be excluded from the scope of that assessment.

Importantly, Recital (47) also mentions that if no standards are available at the time of the application of a given requirement in the Regulation, or the standard developed by the European standardisation organisations is unsatisfactory, the Commission can adopt its own common specification through implementing act.

The Regulation also acknowledges sub-optimal involvement of the Commission and the Member States in the work of international standardisation committees and calls for more active engagement in the development of international standards to enhance European voice in global standardisation and the competitiveness of its companies (Recital 48).

The Regulation also requires the involvement of different stakeholder to ensure the product's adherence to the standards: conformity assessment bodies to carry out conformity assessment tasks (Article 25), notified bodies to assess that products meet the Regulation requirements in corresponding to the harmonised standards referred to by the Regulation (Article 33), battery manufacturers to ensure the production process be in conformity with the harmonised standards (Article 38), and economic operators to incorporate in its battery due diligence policy standards that are consistent with the standards set out in the internationally recognised due diligence instruments listed in Annex X (point 4) of the Regulation.

For manufacturers specifically, Annex VIII (Part A) further requires that they draw up technical documentation to show the battery's conformity with the requirements of the Regulation. Such a document shall contain, among others, the list of the harmonised standards referred to in Article 15, applied in full or in part, including an indication of which parts have been applied. Where the harmonised standards have not been applied or are not available, the document must describe the solutions adopted to meet the applicable requirements.

5 Stakeholder insights into improving battery circularity in the EU

This section explores challenges and enablers for improving battery circularity in the EU based on consultations conducted in October and November 2025 with stakeholders from across the battery supply chain. In total, 18 stakeholders working across the battery supply chain – from manufacturing to transport and handling – were interviewed (see Appendix IV). The interviews were semi-structured in terms of their format. A set of guiding questions focused either on both policies and standards or only standards (see Appendix V and Appendix VI, respectively) was shared with the stakeholders prior to the interviews to provide a framework for discussion. The aim of this approach was to facilitate a series of open discussions covering real-world insights spanning the battery supply chain, with questions tailored to stakeholders' experiences; the questionnaire focused on standards guided the interviews with stakeholders from standards organisations while the questionnaire focused on both policies and standards guided the remaining interviews. Additional desk research was conducted to complement the issues raised by stakeholders. This section summarises these insights, which will inform policy recommendations to improve battery supply chain circularity in the EU in the final section of this report.

5.1 Policy enablers and shortcomings

Stakeholders from across different parts of the supply chain broadly recognise the Batteries Regulation as a key policy, enabling for example significant progress on battery passports and overall traceability. The battery passport could for the first time allow economic actors working on disassembly and remanufacturing of batteries to add value through information added to the passport at these stages of the value chain, for example. Stakeholders also noted recycled content targets as a concrete circularity gain enabled by the Batteries Regulation.

However, while existing policies have generally prompted investment in recycling facilities and research and provided a concrete point of departure for focused discussions on battery circularity, there are also a number of policy shortcomings under current battery regulations. As discussed in the following sections, stakeholders pointed to several areas where the absence of rules contributes to difficulty in building supply chains for second-life battery applications, while also emphasising that regulatory complexity and overregulation could also hinder innovation and the development of viable second-life battery markets. They also raised concerns about particular regulatory issues which are those related to battery passport and standards.

5.1.1 Gaps in regulation and guidance

Stakeholders highlighted several regulatory gaps that hinder the development of second-life battery supply chains and broader circularity in the European battery value chain.

Classification is made challenging by a lack of common regulatory standards and definitions, such as regarding whether a battery is suited for second-life applications. Building second-life battery supply chains however requires reliably estimating and predicting volumes of second-life batteries, which is itself a challenge due to ambiguity regarding regulatory requirements for second-life classification. This leads to implementation variation and mischaracterisation of used batteries, as waste for example. Further, because used batteries often must be transported to centralised diagnostic facilities to be tested and classified as waste or batteries destined for second-life applications, classifying used batteries upon collection to better estimate second-life volumes is a challenge. When transporting used batteries to

centralised testing facilities requires cross-border shipment, shipping rules which require pre-shipment testing and documentation also present an obstacle.

There is also a lack of guidance and standards to support consistent lifecycle assessments across manufacturers and a lack of guidance on battery dismantling. For example, implementing standardized processes for separating anode and cathode materials prior to delamination could yield purer recovered materials and reduce the complexity of downstream recycling operations (Harper et al., 2023).

And although current regulations do establish recycled content targets, stakeholders pointed out that incentives to keep recycled battery materials within Europe for the entire recycling and subsequent manufacturing process are lacking. This means that recycling may take place outside of Europe and recycled content may be sourced from outside of Europe, ultimately limiting the overall circularity of the European battery value chain. Moreover, stakeholders pointed to an overall lack of incentives, requirements, and support to promote circularity and the waste hierarchy, emphasizing that policies should focus on promoting reuse before recycling.

5.1.2 Regulatory complexity and overregulation

While stakeholders identified a number of areas where policy is insufficient or lacking, they also cautioned that overregulation may pose a challenge for second-life battery use. The requirements, standards and technical specifications established under the EU Batteries Regulation are considered among the most stringent globally (Győrffy, 2024).

Stakeholders highlighted an overarching lack of clarity under existing policies due to various types of complexity. This includes regulatory complexity, with rules depending on place in the supply chain and location, among other things. According to stakeholders, it is difficult to understand what is required depending on whether they are a big battery manufacturer, whether other supply chains such as raw material supply chains are involved, and whether operations are inside or outside of the EU. This complexity also means that even actors specialising in DPPs may struggle to advise on implementation of battery passport requirements, for example. Stakeholders also pointed to the lack of harmonised regulations for battery waste transport and storage as a challenge, which is currently left to a complex web of local regulations.

The complexity is further compounded by upcoming technical thresholds, standards, and specifications under the EU Batteries Regulation, which the Commission will define through delegated acts. For instance, since 2024, the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI) have been developing eight European standards to support the implementation of a digital product passport system (TÜV SÜD, 2024).

Additionally, although less topically focused than the Batteries Regulation, stakeholders also identified regulations aimed at health and safety, safe transport, logistics, and other goals as critical to understanding the complete battery value chain. In this context, the 3 cubic meter limit for large packages in the ADR was highlighted as an obstacle, as the use of a container for such transports is not permitted.

5.1.3 Battery passport

Stakeholder identified remarkable challenges related to the implementation of the battery passport under the Batteries Regulation.

They first highlighted a lack of information in the battery passport to support characterising batteries for second-life use. This includes information related to voltage and current anomalies during a battery's lifetime and degradation, for example. This concern aligns with the findings of Harper et al. (2023) and

Rufino Júnior et al (2024), who noted information asymmetries across battery, vehicle, and second-life manufacturers: battery manufacturers may possess comprehensive data about the batteries but are often unaware of their secondary applications, whereas second-life manufacturers typically lack information about specific phenomena occurring during the batteries' first life. Similarly, Rizos & Urban (2024) emphasised that challenges in implementing the battery passport under the EU Batteries Regulation are compounded by the absence of harmonised standards for consolidating battery data across value-chain actors. Additional questions were raised regarding the reliability of data collected from different stakeholders. Serna-Guerrero et al. (2022) also identified inconsistencies in data formats throughout battery supply chain, underscoring the need for standardised data collection to improve transparency and enable circularity. It was also suggested that in the future and as metrics about the battery's state of safety (SoS) evolve, the inclusion of such indicators in the battery passport could further support second-life characterisation.

Relatedly, stakeholders highlighted a lack of incentives or strict requirements to ensure manufacturers disclose essential information–information concerning safety of disassembly, for example–for second-life battery uses in the battery passport, though they acknowledged that clear rules on how to disclose this information may alleviate some of manufacturers' confidentiality concerns and minimise resistance to making disclosures of unencrypted battery management system data. The risks of disclosures are also mitigated with respect to recyclers processing end-of-life batteries, as battery technologies quickly become outdated. This leaves the possibility that disclosures are made more freely to end-of-life recyclers. At the same time, stakeholders cautioned that regulations favouring confidentiality through exceptions undermine transparency and that interpreting these exceptions introduces additional complexity in navigating an already complex regulatory landscape.

For the above reasons, stakeholders emphasised that clear and detailed information or standards are needed on how these characterisation parameters should be measured and reported, which is lacking at present due to technical complexity. Overall, the lack of clarity makes compliance difficult and makes it difficult for companies–particularly SMEs–to invest in establishing protocols, business models, and standards for circularity in the battery supply chain.

Stakeholders also suggested that consulting with industry actors is an important first step for realistically clarifying the real-world operation of battery regulations, including what roles are envisioned for different actors throughout the value chain and how tools such as the battery passport can serve their differing needs. Stakeholders also suggested that there is a need for guidance to navigate this complex regulatory landscape. This is particularly important for companies that lack the time and resources to navigate existing regulations independently.

In addition, stakeholders identified rules limiting the lifetime of battery passports as a policy shortcoming. Because the battery passport is tied to the battery as a complete, undismantled product, the passport 'dies' when the battery is stripped. The problem with this is that valuable historic information about the battery components is lost with the death of the passport making it difficult to track multiple lifecycles as required for circularity.

Finally, stakeholders also pointed to the absence of clear methodologies and standards for calculating key circularity parameters related to carbon footprint, service and repair costs. Accordingly, it may lower barriers to performing these complex calculations to encourage development and use of standardised secondary data sets as the basis of these calculations. While this approach would admittedly be less accurate than calculations performed on the basis of unique data collected for individual products, it would make calculating key parameters more manageable for smaller companies. And although economic actors often see circularity as a question of regulatory compliance or as a basic economic balance

focused on revenue and profitability, this access to lifecycle information may actually shift the calculus in favour of greater circularity through better insight into costs throughout the lifecycle.

5.1.4 Standards

Stakeholders highlighted challenges in identifying, applying, and navigating relevant standards. As discussed above, while stakeholders identified the absence of certain standards altogether, at the same time they acknowledged the existence of many applicable standards but emphasised that it is challenging to navigate them all. In this context they noted a lack of guidance to apply existing standards referred to in key regulations, as well as an absence of clear and explicit links between existing standards and regulatory requirements and tools. This makes identifying and applying the many existing standards challenging, particularly for startups and SMEs who may lack the necessary resources and expertise. Stakeholders pointed out that even Member State market surveillance authorities may lack necessary expertise to ensure products comply with existing standards. Stakeholders identified incorporating existing standards into regulations by reference wherever possible as an effective yet accessible first step. They also suggested that there is an important role for accredited test labs in this regard.

And while stakeholders highlighted challenges in complying with existing standards, they also emphasized the importance of a structured approach to developing new standards that complements current ones and addresses gaps without creating additional uncertainty. In order to encourage investment in standard-setting, progressive incorporation of standards should be planned for and flexibility should remain for actors to improve on existing standards. It should be kept in mind that regulatory delays and changes can introduce added uncertainty for stakeholders. For this reason, stakeholders advised that experts with knowledge on existing standards and how possible new standards could interface with existing standards should be consulted early in the standardisation process to determine what is necessary, practical and safe.

5.2 Technological challenges

Stakeholders identified a number of technological challenges that must be negotiated before circular supply chains can be established in the European battery industry.

5.2.1 Automated handling and disassembly

Stakeholders emphasised the hazardous nature of battery disassembly in particular, suggesting that automation may present an opportunity to reduce health and safety risks by replacing human workers in high-risk operations. At the same time, automation solutions represent a significant technological challenge. A number of stakeholders lamented that without standards for battery architecture and design, disassembly is difficult to routinize and therefore to automate for safe and efficient disassembly across battery brands and models. The wide variety of battery pack designs, geometries, and shapes, combined with limited information about their prior use, further complicates the development of standardized processes for recycling and reusing lithium-ion batteries (Rizos & Urban, 2024). In contrast, OEMs may benefit from this lack of standardisation, as it allows them greater flexibility and prevents them from being constrained to standardised battery designs and components (Prenner et al., 2024).

At the same time, balancing the demands of challenging operation conditions for batteries such as EV batteries with the demands of disassembly presents an additional technological challenge. Safe and durable EV batteries must withstand vehicle vibrations, shocks, exposure to moisture, and more, but they must also be easy to disassemble if battery supply chains are to be circular. This is a significant design challenge and a challenge for standardisation, according to stakeholders. Indeed, stakeholders noted that there is a lack of key knowledge for implementing a circular battery supply chain in Europe, and

that closing these knowledge gaps must precede standardisation processes. Moreover, there is a need to balance any potential need for standards related to battery design for second-life with the key principle that standards are meant to capture performance specifications rather than design specifications and with manufacturers' interest in protecting their intellectual property.

There will be large volumes of used batteries produced in the near future as batteries reach end-of-life, and it will require flexibility to identify ways to manage these batteries effectively, particularly through burgeoning automation rather than through labour-intensive manual processes. For instance, some stakeholders suggested a need for greater flexibility for limited battery handling in research contexts, though others emphasised the hazardous nature of batteries and therefore the need for strict safety rules. Research into automated handling and disassembly of used batteries is particularly important for striking a balance between these two viewpoints because manual disassembly presents health and safety concerns and is more costly due to added time and labour requirements. However, stakeholders have seen limited coverage of their automation work in key policies.

5.2.2 Testing for second-life uses

Stakeholders also identified testing battery cells for second-life use as a technological barrier to circularising battery supply chains. Some stakeholders highlighted a lack of standards for second-life testing of lithium-ion batteries. The EU Batteries Regulation, as well as IEC 63330 and IEC 63338, acknowledge this gap, specifying that the safety of second-life battery is assessed using battery management system (BMS) data from their first life. The lack of dedicated second-life safety testing, combined with OEM's reluctance from sharing battery management system data (often citing intellectual property concerns), may affect market confidence in the safety and quality of second-life batteries (Harper et al., 2023; Prenner et al., 2024).

In this context, one stakeholder suggested that characterisation methods developed in projects such as RECIRCULATE, could provide guidance on how characterisation could be implemented directly within BMSs, with key battery data (SoH, SoC, SoP, SoE, SoS) made accessible to second-life actors. Other stakeholders emphasised instead that applying the typical battery sample testing approaches to second-life batteries made up of used battery cells is inappropriate. Unlike with new, complete battery packs which can be sample tested and then safely used and repurposed in their entirety until end-of-life, it may not be possible to properly test second-life batteries made from used cells for safety and performance. This is because individual testing tends to be either partially damaging or totally destructive, but batteries may be too variable for sample testing to produce representative results. For this reason, some stakeholders suggested that reuse and repurposing of complete battery packs should be prioritised, followed by deep discharging for material recycling.

Stakeholders also explained that the variable and unpredictable nature of battery aging is a barrier to circularising battery supply chains because it makes reusing batteries challenging. According to stakeholders, used battery cells may have aged differently from one another. This makes it difficult to safely manage the cells together in second-life battery packs, introducing overcharging and fire risks, as well as challenges monitoring safety parameters such as internal temperature. The situation is made more challenging by the fact that degradation is currently expressed in terms of state of health (SOH)–a simple measure that compares current capacity to initial capacity but does not adequately capture degradation pathways, or ultimately performance and safety of second-life batteries. Moreover, predicting battery cell aging is a significant technological challenge because it requires long term aging data but cannot be determined empirically under accelerated operating conditions. This makes it yet more difficult to obtain the aging information necessary to manage packs of second-life cells and to predict remaining battery life, particularly as models change from year-to-year. In this context, it was suggested that the provision standardised ageing datasets by battery manufacturers would be beneficial.

5.3 Economic challenges

Stakeholders highlighted a challenging economic landscape as a barrier to building circular battery supply chains in Europe. While existing policies have prompted investment in circular battery supply chains–in recycling facilities, for example–competitiveness and economic feasibility present a major challenge for European battery manufacturers, second-life processors, and recyclers looking to invest in circular battery business models.

5.3.1 Costs of second-life batteries

Processing batteries for second-life use is costly, requiring significant time and labour to carry out safely and in compliance with existing standards and regulations. Stakeholders suggested that automation may help to lower this economic barrier, though automation itself represents a technological challenge which will require an incremental approach and considerable investment to overcome, as discussed above. At the same time, stakeholders pointed to the risks of such investments: there is a possibility that EV manufacturers undertake dismantling processes themselves after the investment is made; there is a possibility that manufacturers produce batteries which are more difficult to disassemble via newly developed automation methods; and there is the possibility that completely different vehicle technologies emerge. According to stakeholders, the investment landscape is particularly risky with respect to the latter possibility because the future of EV incentives is uncertain and the initial market shift from conventional vehicles to EVs has already occurred, likely lowering barriers to further technological shifts.

Stakeholders also pointed out that the hazardous nature of batteries presents challenges for handling and transporting used batteries at scale; managing the risks of transporting and handling used batteries according to existing standards and regulations introduces extra costs and efforts for industry players, ultimately undermining competitiveness of European undertakings adopting circular business models. This is especially so when transport and handling are done without access to battery management systems.

Meanwhile, at present, foreign manufacturers produce high volumes of new, higher performing batteries ever more cheaply year-over-year, meaning there is limited economic incentive to invest in circularity. The raw materials necessary for battery manufacturing also largely originate outside of Europe, meaning that the economic viability of circular battery value chains in Europe depends on policy outside the EU and resulting raw material price fluctuations. This is why stakeholders emphasised that as a first step the EU should focus on establishing competitive European battery manufacturing, heavily promoting circularity in the industry only once capable large undertakings are established and their products ultimately reach end-of-life. According to stakeholders, this could be done using a combination of tariffs, support programs, and incentives such as subsidies. The benefit of such an approach would be to bring more battery manufacturing under the influence of European policies and regulations aimed at boosting circularity. Stakeholders also noted that clear standards defining European origin would be required under such an approach, raising the possibility that abundant foreign batteries–and the raw materials they contain–could be leveraged by treating second-life batteries as European for the purpose of any incentives targeting European battery manufacturing.

5.3.2 Performance and safety of second-life batteries

Stakeholders also noted that the commercial feasibility of second-life batteries is limited partly because it is uncertain to warrant that second-life batteries continue to meet performance and health and safety requirements–particularly because of technological challenges related to testing and the unpredictability of battery aging. For instance, numerous fire incidents involving battery-powered vehicles have been documented, and safety risks are considered higher for repurposed batteries compared to new ones. These concerns underscore the need for stringent standards or regulations to guarantee the

performance and safety of second-life batteries (Rufino Júnior et al., 2024). Moreover, as the many economic actors involved in battery supply chains aim to minimise liability, challenges warranting second-life battery quality make it difficult to establish cooperative supply chain relation ships.

6 Policy recommendations for achieving circularity in the European battery supply chain

Based on our analysis a number of policy recommendations can be drawn:

R1. Support the application of existing standards and regulations.

Navigating the complex network of standards and regulations required to transform the battery supply chain can be challenging for European companies. This is especially true when developing circular business models in a competitive battery market. To address this, European undertakings should receive practical support in identifying and applying relevant standards and regulations. This support could include guidance documents, practical guides, and digital tools. In addition, regulations should provide clearer and more detailed references to existing standards, making it easier for companies to understand which standards apply and how to implement them. Finally, the use of accredited testing laboratories by Member State market surveillance authorities should be explored to verify that products comply with applicable standards and regulations.

R2. Development of new standards for battery recycling, reuse and repurposing.

The EU should develop its standards for battery repurposing, taking into consideration existing international standards in this area. In areas where standards are currently lacking (such as battery design to facilitate disassembly, consolidation of battery data for battery passport, second-life testing, classification for second-life applications, and battery dismantling), the EU should develop new standards or contribute to the development of international standards. To support this process, the EU should closely consult with international and European standardisation experts, original equipment manufacturers (OEMs), research institutes, and stakeholders involved in battery end-of-life management in order to assess the need for new standards. Given the rapid pace of technological developments in the lithium-ion battery sector, the European Commission and standardisation organisations should continuously monitor emerging battery technologies and adapt the regulatory and standardisation framework accordingly.

R3. Close key knowledge gaps related to circular battery business models.

The technological complexity of building circular battery supply chains calls for programs and support to close key knowledge gaps surrounding automation of battery processing for second-life use, battery aging, and safety and performance testing of second-life battery cells–for example, to explore the limits of second-life cell sample testing. This support could take the form of research funding or regulatory flexibility for battery handling and transport in low-volume research cases–as long as safety is kept front of mind. In addition, support is needed for the development of secondary data sets that can underpin the calculation of important life-cycle assessment (LCA) circularity metrics, such as carbon footprint and service and repair costs. Although this approach may be less precise at the individual product level, it can significantly reduce barriers to conducting complex lifecycle assessments and promote broader adoption of lifecycle thinking in the battery sector.

R4. Provide circularity-boosting incentives to build the European battery industry.

Given the challenging economic conditions, targeted incentives are necessary to help build a competitive European battery industry and to encourage investment in circular battery business models among European undertakings. Origin-based incentives could help improve the competitiveness of European manufacturers and ensure that a larger share of battery manufacturing operates under the umbrella of European regulations and standards. To boost circular performance while still allowing room for technological innovation, output incentives should also be introduced. These incentives should prioritise, in order: i) reuse and repurposing of complete battery packs, ii) Reuse of battery cells, where batches are sufficiently similar for sample testing results to be representative and iii) deep discharging and material recycling. Financial incentives could include tax relief or similar economic measures for companies producing second-life batteries and recovering battery materials.

R5. Consult with stakeholders to clarify and refine DPP requirements.

To fully realise the potential of battery passports to enable circular business models throughout the battery supply chain, DPP rules should be clarified and refined in close consultation with stakeholders throughout the battery supply chain. Clarifying and refining rules regarding passport lifespan, what information must be disclosed, and to whom information should be disclosed, for example, would ensure that battery passports meet the varied needs and concerns of all stakeholders. Special attention should also be given to inclusion of lifecycle information and information for characterising batteries for second-life use as technical developments are made in these areas.

R6. Traceability and Battery Passport scope

In the future, as supply chains mature in meeting traceability requirements, the possibility of expanding traceability requirements beyond the current Battery Passport scope (currently limited to electric vehicle batteries and batteries larger than 2 kWh) should be assessed. This would help ensure that smaller batteries and individual cells are not left outside the regulatory system. A harmonized labeling or QR-based regime should cover products that will otherwise remain information-poor at end of life. In addition, as safety metrics develop, their inclusion in the battery passport framework could also be considered.

R7. Design for disassembly

Design-for-disassembly principles should be encouraged, focusing on achieving safe, efficient, and economically viable recovery at end-of-life by future battery and packs. The provision of guidance documents on disassembly and features such as modularity, accessible connectors and clearly marked safe cutting points would also support safer and faster recovery. The inclusion of machine-readable dismantling information in battery documentation would also be valuable. Pack architecture, joining methods, safe handling steps, disassembly instructions, and similar data should be available in a format that supports both manual operations and robotic or digital-twin-based dismantling.

R8. Transition governance

It should be recognised that there will be a long transition period in which batteries with passports, batteries without passports and individual cells will coexist in the same waste and reuse streams. Legislators could consider supporting a framework of bridging rules that works under mixed-market conditions, acknowledging that a fully standardized ecosystem does not yet exist. International coordination, standardisation efforts and targeted innovation funding for scalable diagnostics, safer transport, interoperable data systems and automated disassembly could further support this transition.

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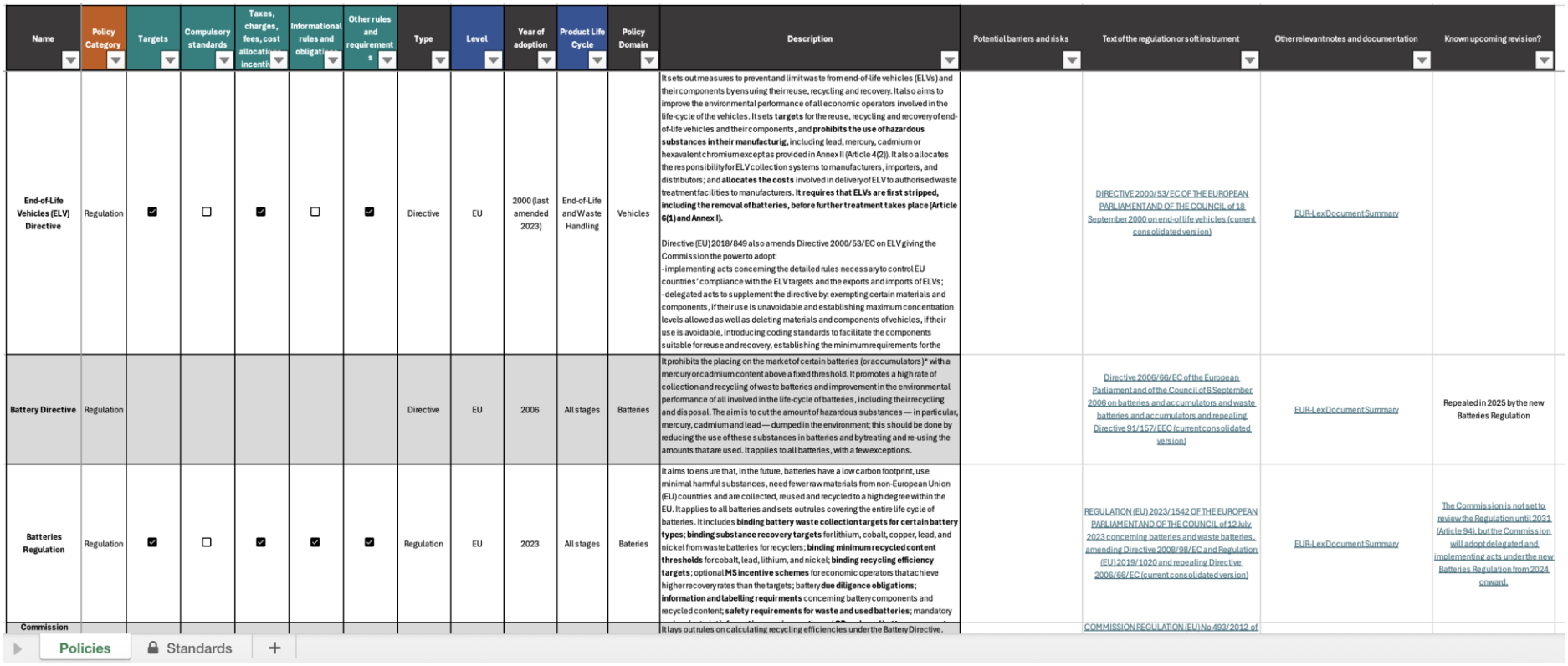
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8 Appendix I: Inventory tool

As part of the deliverable, an inventory was created in Excel, as shown below. This was shared online with the consortium, which was invited to provide feedback. The inventory consists of two tabs—one each for policies and standards—with filtering options.



Name	Policy Category	Targets	Compulsory standards	Taxes, charges, fees, cost allocati incenti	Informational rules and obligati	Other rules and requirement s	Type	Level	Year of adoption	Product Life Cycle	Policy Domain	Description	Potential barriers and risks	Text of the regulation or soft instrument	Other relevant notes and documentation	Known upcoming revision?
End-of-Life Vehicles (ELV) Directive	Regulation	☑	☐	☑	☐	☑	Directive	EU	2000 (last amended 2023)	End-of-Life and Waste Handling	Vehicles	It sets out measures to prevent and limit waste from end-of-life vehicles (ELVs) and their components by ensuring their reuse, recycling and recovery. It also aims to improve the environmental performance of all economic operators involved in the life-cycle of the vehicles. It sets **targets** for the reuse, recycling and recovery of end-of-life vehicles and their components, and **prohibits the use of hazardous substances in their manufacturig,** including lead, mercury, cadmium or hexavalent chromium except as provided in Annex II (Article 4(2)). It also allocates the responsibility for ELV collection systems to manufacturers, importers, and distributors; and **allocates the costs** involved in delivery of ELV to authorised waste treatment facilities to manufacturers. **It requires that ELVs are first stripped, including the removal of batteries, before further treatment takes place (Article 6(1) and Annex I).** Directive (EU) 2018/849 also amends Directive 2000/53/EC on ELV giving the Commission the power to adopt: - implementing acts concerning the detailed rules necessary to control EU countries' compliance with the ELV targets and the exports and imports of ELVs; - delegated acts to supplement the directive by: exempting certain materials and components, if their use is unavoidable and establishing maximum concentration levels allowed as well as deleting materials and components of vehicles, if their use is avoidable, introducing coding standards to facilitate the components suitable for reuse and recovery, establishing the minimum requirements for the		DIRECTIVE 2000/53/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 September 2000 on end-of life vehicles (current consolidated version)	EUR-Lex Document Summary	
Battery Directive	Regulation						Directive	EU	2006	All stages	Batteries	It prohibits the placing on the market of certain batteries (or accumulators)* with a mercury or cadmium content above a fixed threshold. It promotes a high rate of collection and recycling of waste batteries and improvement in the environmental performance of all involved in the life-cycle of batteries, including their recycling and disposal. The aim is to cut the amount of hazardous substances — in particular, mercury, cadmium and lead — dumped in the environment; this should be done by reducing the use of these substances in batteries and by treating and re-using the amounts that are used. It applies to all batteries, with a few exceptions.		Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC (current consolidated version)	EUR-Lex Document Summary	Repealed in 2025 by the new Batteries Regulation
Batteries Regulation	Regulation	☑	☐	☑	☑	☑	Regulation	EU	2023	All stages	Batteries	It aims to ensure that, in the future, batteries have a low carbon footprint, use minimal harmful substances, need fewer raw materials from non-European Union (EU) countries and are collected, reused and recycled to a high degree within the EU. It applies to all batteries and sets out rules covering the entire life cycle of batteries. It includes **binding battery waste collection targets for certain battery types**; **binding substance recovery targets** for lithium, cobalt, copper, lead, and nickel from waste batteries for recyclers; **binding minimum recycled content thresholds** for cobalt, lead, lithium, and nickel; **binding recycling efficiency targets**; optional **MS incentive schemes** for economic operators that achieve higher recovery rates than the targets; battery **due diligence obligations**; **information and labelling requirments** concerning battery components and recycled content; **safety requirements for waste and used batteries**; mandatory		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 (current consolidated version)	EUR-Lex Document Summary	The Commission is not set to review the Regulation until 2031 (Article 94), but the Commission will adopt delegated and implementing acts under the new Batteries Regulation from 2024 onward.
Commission												It lays out rules on calculating recycling efficiencies under the Battery Directive.		COMMISSION REGULATION (EU) No 493/2012 of		

Policies | Standards | +

Group	Name	Type	Level	Citation in the Official Journal of the EU	Status*	Year	Product Life Cycl	Scope of the standard	Text of the standard	Known upcoming revision	Remarks
1 (LCA)	ISO 14040:2006 + AMD2020 [Amendment 2020]	Standard	International	The EU Batteries Regulation contains the definition of ''life cycle' and 'reference flow' based on ISO 14040:2006 or equivalent standards. These concepts are used e.g. in the calculation of the carbon footprint of batteries (Article	Publication	2006	All LCA stages	**Principles and framework** for **life cycle assessment** (LCA), including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements. This standard covers life cycle assessment (LCA) studies and life cycle inventory (LCI) studies.	https://www.iso.org/standard/37456.html		ISO 14040 and ISO 14044 go together. ISO 14040 defines the general principles, framework, and key steps of LCA (it's a a high-level guideline). ISO 14044 provides detailed requirements and methodological guidelines to
2 (safety)	IEC 62281:2019+AMD1:2021+AMD2:2023 (consolidated version)	Standard	International	The standard is mentionned in the Commission SWD Impact Assessment Report accompanying the proposal for the Batteries Regulation, under 'Safety>transport', focusing on the transport of used batteries for	Publication	2023	Manufacturing, packaging, handling, storage, transport	Test methods and requirements for primary and secondary (rechargeable) lithium cells and batteries to ensure their **safety** during **transport** other than for recycling or disposal	https://webstore.iec.ch/publication/83426		
2 (safety)	IEC 62485-6:2021	Standard	International	The standard is mentioned in the Impact Assessment Report of the Batteries Regulation (2020): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0335&qid=1744043840000. It mentions that 'Measures for	Publication	2021	Manufacturing, packing, storage, transport, EoL	**Safety requirements** for **secondary** batteries and battery installations. This standards applies to battery installations used for **electric off-road vehicles**; it does not cover the design of such vehicles. Examples of the main applications are: industrial cleaning machines; trucks for material handling e.g. lift trucks, tow trucks, automatic guided vehicles; electrically propulsed lifting platforms; electric powered boats and ships	https://webstore.iec.ch/publication/32955		
2 (safety)	IEC 62619:2022 CMV [commented version]	Standard	International	Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries. Article 12 stipulates rules on the safety of stationary battery energy storage systems during their	Publication	2022	Manufacturing, packaging, transport	Requirements and tests for the **safe operation** of secondary lithium cells and batteries used in **industrial applications**, including **stationary applications**. The following are some examples of applications that utilize cells and batteries under the scope of this document: • Stationary applications: telecom, uninterruptible power supplies (UPS), electrical energy storage system, utility switching, emergency power, and similar applications; • Motive applications: forklift truck, golf cart, automated guided vehicle (AGV), railway vehicles, and marine vehicles, with the exception of road vehicles.	https://webstore.iec.ch/publication/76174		This standard is normatively referenced in the **ISO/DIS 13482** standard on "Robotics — Safety requirements for service robots". The application of IEC 62619:2022 is therefore mandatory where lithium batteries are used in
2 (safety)	IEC 62660-3:2022 RLV [Redline version]	Standard	International	The standard is mentionned in the Commission SWD Impact Assessment Report accompanying the proposal for the Batteries Regulation, under section on "the safety of batteries for electro-mobility applications", focusing on	Publication	2022	Manufacturing	This part of IEC 62660 specifies test procedures and the acceptance criteria for **safety performance** of secondary lithium-ion cells and cell blocks used for the **propulsion of electric vehicles** (EV) including battery electric vehicles (BEV) and hybrid electric vehicles (HEV). The evaluation of the safety of cells during transport and storage is not covered by this standard	https://webstore.iec.ch/en/publication/74669		
4 (performance)	ISO 12405-4:2018	Standard	International	COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT REPORT Accompanying the document Proposal for the EU Batteries Regulation: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A5	Published	2018	Manufacturing	Test procedures for the basic characteristics of performance, reliability and electrical functionality for the battery packs and systems for either high-power or high-energy application of **electrically propelled road vehicles**	https://www.iso.org/standard/71407.html		
2 (safety)	IEC 63056:2020	Standard	International	The standard is mentionned in the Commission SWD Impact Assessment Report accompanying the proposal for the Batteries Regulation: https://eur-	Publication	2020	Manufacturing, packaging	This document covers **safety requirements** for secondary lithium cells and batteries for use in **Electrical Energy Storage Systems** and is under the umbrella standard IEC 62619. It specifies requirements and tests for the product safety of secondary lithium cells and batteries used in electrical energy storage systems (Figure 2) with a maximum DC voltage of 1 500 V (nominal).	https://webstore.iec.ch/en/publication/29224		

Policies | Standards | +

9 Appendix II: Full list of identified policies

Name	Policy Category	Type	Level	Year of adoption	Product Life Cycle	Policy Domain	Description
End-of-Life Vehicles (ELV) Directive	Regulation	Directive	EU	2000 (last amended 2023)	End-of-Life and Waste Handling	Vehicles	It sets out measures to prevent and limit waste from end-of-life vehicles (ELVs) and their components by ensuring their reuse, recycling and recovery. It also aims to improve the environmental performance of all economic operators involved in the life-cycle of the vehicles. It sets targets for the reuse, recycling and recovery of end-of-life vehicles and their components, and prohibits the use of hazardous substances in their manufacturig, including lead, mercury, cadmium or hexavalent chromium except as provided in Annex II (Article 4(2)). It also allocates the responsibility for ELV collection systems to manufacturers, importers, and distributors; and allocates the costs involved in delivery of ELV to authorised waste treatment facilities to manufacturers. It requires that ELVs are first stripped, including the removal of batteries, before further treatment takes place

							(Article 6(1) and Annex I). Directive (EU) 2018/849 also amends Directive 2000/53/EC on ELV giving the Commission the power to adopt: - implementing acts concerning the detailed rules necessary to control EU countries' compliance with the ELV targets and the exports and imports of ELVs; - delegated acts to supplement the directive by: exempting certain materials and components, if their use is unavoidable and establishing maximum concentration levels allowed as well as deleting materials and components of vehicles, if their use is avoidable, introducing coding standards to facilitate the components suitable for reuse and recovery, establishing the minimum requirements for the certificates of destruction, establishing minimum requirements for the treatment of ELVs.

Battery Directive	Regulation	Directive	EU	2006	All stages	Batteries	It prohibits the placing on the market of certain batteries (or accumulators)* with a mercury or cadmium content above a fixed threshold. It promotes a high rate of collection and recycling of waste batteries and improvement in the environmental performance of all involved in the life-cycle of batteries, including their recycling and disposal. The aim is to cut the amount of hazardous substances – in particular, mercury, cadmium and lead – dumped in the environment; this should be done by reducing the use of these substances in batteries and by treating and re-using the amounts that are used. It applies to all batteries, with a few exceptions.

Batteries Regulation	Regulation	Regulation	EU	2023	All stages	Bateries	It aims to ensure that, in the future, batteries have a low carbon footprint, use minimal harmful substances, need fewer raw materials from non-European Union (EU) countries and are collected, reused and recycled to a high degree within the EU. It applies to all batteries and sets out rules covering the entire life cycle of batteries. It includes binding battery waste collection targets for certain battery types; binding substance recovery targets for lithium, cobalt, copper, lead, and nickel from waste batteries for recyclers; binding minimum recycled content thresholds for cobalt, lead, lithium, and nickel; binding recycling efficiency targets; optional MS incentive schemes for economic operators that achieve higher recovery rates than the targets; battery due diligence obligations; information and labelling requirments concerning battery components and recycled content; safety requirements for waste and used batteries; mandatory carbon footprint information requirements; and

							QR code and battery passport requirements.
Commission Regulation on calculating recycling efficiencies under the Battery Directive	Regulation	Regulation	EU	2012	End-of-Life and Waste Handling	Batteries	It lays out rules on calculating recycling efficiencies under the Battery Directive.
Commission Regulation on capacity labelling under the Battery Directive	Regulation	Regulation	EU	2010	Production/ Manufacturing	Batteries	The Regulation lays out rules for capacity labelling under the Battery Directive.
REACH Regulation	Regulation	Regulation	EU	2006 (last amended 2024)	Production/ Manufacturing	Chemicals	The registration, evaluation, authorisation and restriction of chemicals (REACH) regulation provides a comprehensive legislative framework for chemicals that are manufactured and used in Europe. It includes

							substance restrictions, including use restrictions and concentration limits for battery-relevant substances such as lead, nickel, mercury, lithium and cobalt, etc. It also includes mandatory substance registration requirements and mandatory information disclosure and reporting requirements.
Ecodesign Directive	Regulation	Directive	EU	2009 (last amended 2012)	Production/ Manufacturing		Sets out a framework for the European Commission to lay down harmonised ecodesign minimum requirements for energy-related products that are sold in the European Union (EU). It did not apply to means of transport used to carry people or goods. Ecodesign requirements under the Directive could cover all stages of a product's life cycle and the repair and recycling at end of life. Products that satisfied the requirements bore the CE marking and could be sold anywhere in the EU. By means of implementing acts adopted under the directive, the Commission established ecodesign requirements for the placing on the market of various categories of goods, none of which included electric

							vehicle batteries. The Ecodesign Directive was repealed in 2024 by Regulation (EU) 2024/1781 (ESPR).
Ecodesign for Sustainable Products Regulation (ESPR)	Regulation	Regulation	EU	2024	Production/ Manufacturing		The Regulation aims to significantly improve the circularity, energy performance and other environmental sustainability aspects of products. It is the basis for assessing and setting ecodesign requirements via delegated acts, set either for a specific product group or horizontally (more than one product group). Ecodesign requirements will improve product aspects such as durability, reusability, repairability, recycled content, etc. Ecodesign requirements will be set first for priority product groups. Batteries are not a priority product group for the development of ecodesign requirements (Article 18), though the Batteries Regulation already contains

							some requirements for batteries, such as recycled content requirements. The Regulation also introduces the digital product passport (DPP) and includes by reference battery passports under the new Batteries Regulation.
Euro 7 Regulation	Regulation	Regulation	EU	2024	Production/ Manufacturing	Vehicles	The Regulation sets various requirements for vehicles. Relevant for electric vehicle batteries, the Regulation sets requirements for electric vehicle battery performance and durability. Electric vehicle batteries must comply with minimum performance requirements for electric vehicle battery durability (Article 6, Annex II). Because the Euro 7 Regulation sets performance and durability requirements for electric vehicle batteries, the new Batteries Regulation sets only information requirements for electric vehicle performance and durability.

Commission Regulation on vehicle type approval requirements	Regulation	Regulation	EU	2019 (last amended 2023)	Production/ Manufacturing	Vehicles	The Regulation contains safety requirements which continue to be applicable for repaired electric vehicle batteries (Batteries Regulation, Recital 40).
Critical Raw Materials Act	Regulation	Regulation	EU	2024	Production/ Manufacturing	Critical Raw Materials	The Regulation identifies several battery-relevant substances as strategic raw materials–including lithium–based on strategic importance, forecasted demand growth and difficulty of increasing production (Article 3, Annex I). It also identifies several battery-relevant substances as critical raw materials based on supply risk and economic importance (Article 4, Annex II). In terms of incentives and support programs, the Regulation requires MS and the Commission to undertake efforts to incentivise and promote critical raw material circularity (Article 5, Article 26). In terms of requirements, the Regulation sets risk preparedness information disclosure requirements for large companies that use strategic raw materials to manufacture batteries for traction motors, among other uses (Article 24).

European List of Waste (LoW)	Regulation	Commission Decision	EU	2000 (last updated 2023, but currently undergo-ing an up-date)	End-of-Life and Waste Handling	Waste	The European List of Waste (LoW) is a key instrument for managing waste in the EU and controlling waste shipments within and outside the EU. The LoW provides common termi-nology for classifying waste across the EU. Specifically, it identifies and classifies all dif-ferent types of waste, including hazardous waste, which can be harmful to human health and the environment. Established in 2000, this list has been revised a number of times, and as of March 2025, the LoW now in-cludes new battery-related waste codes corresponding to different parts of the battery life cycle. These include codes for lithium-based batteries, as well as codes for waste from battery manufacturing, waste from post-consumer batteries, and intermediate fractions from battery recycling ("black masss"). Black mass, lithium-based, nickel-based, and zinc-based waste batteries, and so-dium sulphur and alkaline waste batteries are also now classed as hazardous. A new hazardous code for lithium-based batteries for separately

							collected municipal waste has also been added. The classification of battery-related waste streams impacts the extent to which they are subject to applicable waste rules such as waste shipment rules in accordance with the Waste Shipment Regulation.

(old) Waste Shipment Regulation	Regulation	Regulation	EU	2006 (last amended 2024)	End-of-Life and Waste Handling	Waste	The European Union (EU) has a system to supervise and control shipments of waste within its borders and with the countries of the European Free Trade Association (EFTA), the Organisation for Economic Cooperation and Development (OECD) and non-EU countries that have signed the Basel Convention. This Regulation contains rules controlling waste shipments. It covers almost all types of waste and applies to shipments of waste between EU countries, imported into the EU, exported from the EU, and in transit through the EU. The Regulation establishes the following control procedures: a procedure of prior written notification and consent for shipments of waste and general information requirements. These procedures apply depending on waste type, shipment route (within EU or into or out of the EU), and destiny of the waste (e.g., disposal or recovery). The Regulation also imposes take-back obligations and allocates associated costs when a waste shipment cannot be completed as intended or when a shipment is

							illegal. The Regulation provides for a financial guarantee for shipments for which prior notification is required. The Regulation also includes EU export bans for all wastes for disposal and for certain wastes for recovery, except to certain countries. The Regulation also includes import bans for wastes for disposal and wastes for recovery, except from certain countries. The Regulation also imposes an environmental protection obligation on undertakings involved in a shipment of waste and/or its recovery or disposal to ensure waste is managed in an environmentally sound manner throughout the period of shipment and during recovery and disposal.

(new) Waste Shipment Regulation	Regulation	Regulation	EU	2024	End-of-Life and Waste Handling	Waste	Regulation (EU) 2024/1157 lays down the rules for procedures and controls on waste shipments. The regulation incorporates into European Union (EU) law the provisions of the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal and the decision of the Council of the Organisation for Economic Co-operation and Development (OECD) on the control of transboundary movements of wastes destined for recovery operations. The regulation applies to shipments between EU Member States, exports and imports to and from non-EU countries, and waste transiting through the EU. Under the Regulation, there are various informational, shipment bans, and other rules and requirements depending on the type of waste contained in a given shipment (hazardous according to the EU LoW, non-hazardous, etc.), the destiny of the shipped waste (disposal, recovery), and the shipment route (intra-EU, exports from the EU, imports to the EU). The Regulation also requires that

							waste producers, notifiers, shippers and others involved in waste recovery or disposal not to endanger human health and to apply good environmental practices throughout the entire process. The Regulation also imposes take-back obligations and allocates associated costs when a waste shipment cannot be completed as intended or when a shipment is illegal. The Regulation provides for a financial guarantee for shipments for which prior notification is required.

Waste Framework Directive (WFD)	Regulation	Directive	EU	2008 (last amended 2023)	End-of-Life and Waste Handling	Waste	The WFD establishes a legal framework for treating waste in the EU which is designed to protect the environment and human health by emphasising the importance of proper waste management, recovery and recycling techniques to reduce pressure on resources and improve their use. As a framework directive, it lays down basic waste management principles and establishes a number of high-level requirements and options for Member States to promote proper waste management and circularity. The Directive establishes the waste hierarchy (prevention; preparing for re-use; recycling; other recovery, e.g. energy recovery; and disposal) and requires that Member States take into account the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts. The Directive also confirms the 'polluter-pays principle' whereby the original waste

							producer must pay for the costs of waste management and introduces the concept of 'extended producer responsibility' (EPR) including minimum requirements for EPR schemes.
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes	Regulation	International agreement	International	1989	End-of-Life and Waste Handling	International trade/ transport	The Convention aims to protect human health and the environment against the adverse effects of hazardous wastes. It covers wastes defined as "hazardous wastes" based on their origin and/or composition and their characteristics, as well as two types of wastes defined as "other wastes" - household waste and incinerator ash. Based on the concept of prior informed consent, the Convention requires that, before an export may take place, the authorities of the State of export notify the authorities of the

							prospective States of import and transit, providing them with detailed information on the intended movement. The movement may only proceed if and when all States concerned have given their written consent
OECD decision establishing a control system for waste shipments for recovery within OECD area	Regulation	International agreement	International	2001	End-of-Life and Waste Handling	International trade/ transport	The OECD Control System for waste recovery aims at facilitating trade of recyclables in an environmentally sound and economically efficient manner by using a simplified procedure as well as a risk-based approach to assess the necessary level of control for materials. Wastes exported outside the OECD area, whether for recovery or final disposal, do not benefit from this simplified control procedure. The OECD Control System is based on two types of control procedures: 1. Green Control Procedure: for wastes presenting low risk for human health and the environment and, therefore, are not subject to any other controls

							than those normally applied in commercial transactions 2. Amber Control Procedure: for wastes presenting sufficient risk to justify their control.
Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)	Regulation	International agreement	Interna-tional	1957	Transport	International trade/ transport	United Nations treaty dreafted in 1957, entered into force 1968 and regularly amended ever since. According to Art. 2, dangerous goods may be car-ried out internationally pro-vided they comply with condi-tions laid down in Annex A (general provisions and provi-sions concerning dangerous ar-ticles and substances) and An-nex B (provisions concerning transport equipment and transport operations). The requirements for the transport of lithium batteries are listed under Art. 2.2.9.1.7. Depending on battery condi-tions and life cycle phase, safety rules may vary. All

							lithium-ion batteries are labelled as Class 9 (miscellaneous dangerous substances and articles). For all shipments, it is required that all personnel involved in the preparation and transport of batteries receive adequate instruction on these requirements or Dangerous Goods training. Additionally, the ADR in turn requires lithium batteries to comply with the requirements set by sub-section 38.3 of the UN Manual of Tests and Criteria. UN 38.3 is a set of international standards for the transportation of lithium-ion batteries. The standards are designed to ensure the safe transport of lithium-ion batteries by air, land, and sea. The UN 38.3 standards cover a wide range of topics, including: Packaging requirements, Labeling requirements, Testing procedures, Safety requirements.

General Product Safety Regulation (GPSR)	Regulation	Regulation	EU	2023	Production/ Manufacturing	Product safety	The GPSR aims to ensure the health and safety of consumers and the functioning of the internal market as regards products intended for consumers. This regulation provides obligations for the relevant economic operators and providers of online marketplaces and also clarifies market surveillance rules and the powers of national authorities. The Regulation lays down essential rules on the safety of consumer products placed or made available on the market (Article 1), including a general safety requirement (Article 5), rules for the presumption that products conforming with European standards satisfy the general safety requirement (Article 7), various obligations on economic actors related to risk analysis, technical documentation, internal processes for product safety, etc. (Chapter III). It also includes informational obligations for economic operators in the case of distance sales (Article 19) and notification obligations of economic operators in the case of

							accidents related to safety of products (Article 20). However, the GSPR is a general regulation which covers aspects of products covered by sector-specific Union harmonising legislation such as the Batteries Regulation only insofar as those aspects are not covered by the sector-specific legislation (Article 2). This means that for the various battery-related issues covered by Union harmonising legislation such as the Batteries Regulation, the GPSR effectively does not apply.
Inland Transport of Dangerous Goods Directive	Regulation	Directive	EU	2008 (last amended 2025)	Transport	Transportation	The Directive lays down common rules for the safe and secure transport of dangerous goods within and between EU countries by road, rail or inland waterway. It also covers aspects such as loading and unloading, the transfer to and from another mode of transport, as well as the stops in the course of the transport process. It extends the application of international rules (including under

							the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)) to national transport of dangerous goods.
Industrial Emissions Directive (IED)	Regulation	Directive	EU	2010 (last amended 2024)	Production/ Manufacturing	Industrial	This Directive lays down rules on integrated prevention and control of pollution arising from industrial activities. It also lays down rules designed to prevent or, where that is not practicable, to continuously reduce emissions into air, water and land, to prevent the generation of waste, improve resource efficiency, and to promote the circular economy and decarbonisation, in order to achieve a high level of protection of human health and the environment taken as a whole (Article 1). The Directive applies to certain industrial activities giving rise to pollution, including battery manufacturing, other than exclusively assembling, with a production capacity of 15 000 tonnes of battery cells (cathode, anode, electrolyte, separator, capsule) or more per year (Annex I). Requirements for these activities

							include permitting, installation operation, and information exchange requirements (Chapter II). The Directive does not apply to research activities, development activities or the testing of new products and processes.
European Green Deal	Soft policy instrument	Strategy	EU	2019	All stages	Industrial	The European Green Deal is aimed to transform the EU into a modern, resource-efficient and competititve economy, ensuring: - No net emissions of greenhouse gases by 2050 - Economic growth decoupled from resource use - No person and no place left behind Within the Green Deal, the European Commission adopted a set of proposals to make the EU's climate, energy, transport, and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.

European Industrial Strategy	Soft policy instrument	Strategy	EU	2020	All stages	Industrial	The European Industrial Strategy, set up by the EU Commission, should support the twin transition to a green and digital economy. It should make the EU industry more competetive globallty and enhance Europe's open strategic autonomy. As a primary vehicle of innovation in the various ecosystems, small and medium enterprises (SMEs) need to be borne in mind in all actions under this Strategy. This is reflected in a horizontal manner by increased attention to regulatory burdens for SMEs. New actions will strongly benefit SMEs and start-ups, whether it be from a strengthened Single Market, reduced supply dependencies or the accelerated green and digital transitions. The Strategy also includes some measures dedicated to SMEs such as on increased resilience, combating late payments, and supporting solvency.

Circular Economy Action Plan	Soft policy instrument	Action Plan	EU	2020	All stages	Circularity	One of the key pillars of the European Green Deal (EGD), it provides an agenda for accelerating the transition required by the EGD while building on circular economy principles. It introduces a series of legislative and non-legislative measures to establish a strong and coherent product policy framework. The Plan comprises 35 actions and identifies 7 key product value chain to be adressed as a matter of priority, including batteries and vehicels. Within this domain, the Plan envisages the proposal new regulatory framework for batteries (see below).

Clean Industrial Deal	Soft policy instrument	Strategy	EU	2025	All stages	Industry	The Clean Industrial Deal focuses on accelerating the EU's transition to a green, competitive, and sustainable industrial economy. Key elements include: Support for Clean Technologies: Encouraging the development and scaling of green technologies, boosting industrial decarbonization. Industry Transformation: Aimed at enabling sectors like energy, steel, cement, and chemicals to reduce emissions and adopt sustainable practices. Regulatory and Financial Support: Proposing frameworks and funding to stimulate private investment and innovation in clean industry. Skills and Employment: Ensuring that the workforce is equipped with the skills necessary for a green economy. The initiative promotes cooperation between stakeholders to achieve a carbon-neutral economy by 2050.

Strategic Action Plan on Batteries	Soft policy instrument	Action Plan	EU	2018	All stages	Batteries	Action plan was developed in the context of the "Europe on the Move" communication of the European Commission. It sets a series of targeted measures to 'make Europe a global leader in sustainable battery production and use, in the context of the circular economy'. The Action Plan provides context and justification for the Batteries Regulation (Recital 7). Key dimensions of the Action Plan include the following. Sustainability Focus: The plan emphasises sustainability throughout the battery lifecycle, from raw material extraction to recycling and disposal. Value Chain Integration: It promotes a cross-border and integrated approach, covering all stages of the battery ecosystem. Innovation and Competitiveness: The plan aims to boost innovation and competitiveness in the European battery industry, ensuring it can compete globally. Circular Economy: It supports

							the principles of a circular economy, encouraging the re-use and recycling of batteries to minimise environmental impact.
European Battery Alliance (EBA)	Soft policy instrument	Knowledge and capacity building instrument	EU	2017	All stages	Batteries	Collaborative network supported by the European Commission and the EIB that brings together EU national authorities, regions, industry research institutes and other stakeholders in the battery value chain.

Industrial Action Plan for the European automotive sector	Soft policy instrument	Action Plan	EU	proposed 2025	Production/ Manufacturing	Industry	The proposed plan provides a comprehensive framework of policies, measures, and funding and incentive opportunities in order to ramp up European industrial capacities, including for batteries and their components. The proposed plan aims to make electric vehicle battery cells and components produced in the EU cost-competitive in the short term. The plan includes several key measures, such as a comprehensive "Battery Booster" package, which aims to support the production of battery cells and components through direct funding, non-price criteria for components and competitive loans. Legislation to be introduced later in 2025 will specify the local content requirements for batteries and their components. The plan also aims to provide more support for recycling, including funding for recycling facilities. The Commission will also provide additional support to enhance cooperation in battery recycling amongst industry. Furthermore, measures will be taken to improve the health and

							repairability of electric vehicle batteries.

10 Appendix III: Full list of identified standards

Group	Name	Level	Citation in the Official Journal of the EU	Status*	Year	Product Life Cycle	Scope of the standard
1 (LCA)	ISO 14040:2006 + AMD2020 [Amendment 2020]	International	The EU Batteries Regulation contains the definition of ''life cycle' and 'reference flow' based on ISO 14040:2006 or equivalent standards. These concepts are used e.g. in the calculation of the carbon footprint of batteries (Article 7 of the Regulation). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1542&qid=1744967857232	Publication	2006	All LCA stages	Principles and framework for life cycle assessment (LCA), including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.This standard covers life cycle assessment (LCA) studies and life cycle inventory (LCI) studies.
2 (safety)	IEC 62281:2019 +AMD1:2021+AMD2:2023 (consolidated version)	International	The standard is mentionned in the Commission SWD Impact Assessment Report accompanying the proposal for the Batteries	Publication	2023	Manufacturing, packaging, handling, storage, transport	Test methods and requirements for primary and secondary (rechargeable) lithium cells and batteries to ensure their safety during transport other than for recycling or disposal

			Regulation, under 'Safety>ttransport' , focusing on the transport of used batteries for secondary use or recycling: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0335&qid=1743520207999				
2 (safety)	IEC 62485-6:2021	International	The standard is mentioned in the Impact Assessment Report of the Batteries Regulation (2020): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0335&qid=1744043840000. It mentions that 'Measures for protections during normal operation conditions and under fault conditions will be available in the future standard IEC	Publication	2021	Manufacturing, packing, storage, transport, EoL	Safety requirements for secondary batteries and battery installations. This standards applies to battery installations used for electric off-road vehicles; it does not cover the design of such vehicles. Examples of the main applications are: industrial cleaning machines; trucks for material handling e.g. lift trucks, tow trucks, automatic guided vehicles; electrically propulsed lifting platforms; electric powered boats and ships

			62485-6, which is under preparation by IEC/TC 21.'				
2 (safety)	IEC 62619:2022 CMV [commented version]	International	Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries. Article 12 stipulates rules on the safety of stationary battery energy storage systems during their normal operation and use, referring to Annex V on the safety parameters. IEC 62619 is mentioned in this annex, under the section on the test for the safety parameter about 'thermal abuse': "During this test,	Publication	2022	Manufacturing, packaging, transport	Requirements and tests for the safe operation of secondary lithium cells and batteries used in industrial applications, including stationary applications. The following are some examples of applications that utilize cells and batteries under the scope of this document: • Stationary applications: telecom, uninterruptible power supplies (UPS), electrical energy storage system, utility switching, emergency power, and similar applications; • Motive applications: forklift truck, golf cart, automated guided vehicle (AGV), railway vehicles, and marine vehicles, with the exception of road vehicles.

			the battery shall be exposed to elevated temperatures (in IEC 62619 the temperature is 85 °C) which can trigger exothermal decomposition reactions and lead to a thermal runaway in the cell"				
2 (safety)	IEC 62660-3:2022 RLV [Redline version]	International	The standard is mentionned in the Commission SWD Impact Assessment Report accompanying the proposal for the Batteries Regulation, under section on"the safety of batteries for electro-mobility applications", focusing on the transport of used batteries for secondary use or recycling: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0335&qid=1743777464969.	Publication	2022	Manufacturing	This part of IEC 62660 specifies test procedures and the acceptance criteria for safety performance of secondary lithium-ion cells and cell blocks used for the propulsion of electric vehicles (EV) including battery electric vehicles (BEV) and hybrid electric vehicles (HEV). The evaluation of the safety of cells during transport and storage is not covered by this standard

			"In addition to this global regulatory framework, the safety of batteries for electro-mobility application is also covered by a number of international standards: ·IEC 62660-2 on reliability and abuse testing of secondary lithium-ion cells for EV ·IEC 62660-3 on safety requirements of secondary lithium-ion cells for EV"				
4 (performance)	ISO 12405-4:2018	International	COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT REPORT Accompanying the document Proposal for the EU Batteries Regulation: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020S	Published	2018	Manufacturing	Test procedures for the basic characteristics of performance, reliability and electrical functionality for the battery packs and systems for either high-power or high-energy application of electrically propelled road vehicles

			C0335&qid=1748701573335				
2 (safety)	IEC 63056:2020	International	The standard is mentioned in the Commission SWD Impact Assessment Report accompanying the proposal for the Batteries Regulation: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0335&qid=1744021333092. Under the 'Enabler: Safety' section, the SWD mentions that "A recent standard dedicated to safety of lithium-ion batteries used in electrical energy storage systems is IEC 63056:2020. While	Publication	2020	Manufacturing, packaging	This document covers safety requirements for secondary lithium cells and batteries for use in Electrical Energy Storage Systems and is under the umbrella standard IEC 62619. It specifies requirements and tests for the product safety of secondary lithium cells and batteries used in electrical energy storage systems (Figure 2) with a maximum DC voltage of 1 500 V (nominal).

			basic safety requirements for industrial applications are contained in IEC 62619, this new document provides specific requirements for electrical energy storage systems used for example for telecommunications, stationary engine starting, photovoltaic systems, residential energy storage systems, and large energy storage, both for on- and off-grid. A comparative analysis by the JRC 83 of all this existing international standards for battery safety in energy storage applications concluded that in order to set safety criteria for normal and abnormal operation of				

			lithium ion batteries, gaps would need to be covered and a harmonization process would be required. Provisionally, testing provisions in existing standards would allow imposing the following safety requirements: vibration, thermal shock and cycling, external short circuit protection, over-charge protection, over-discharge protection, over-temperature protection, overcurrent protection, thermal propagation, drop, impact, internal short circuit and thermal abuse, with proper considerations to the risk of toxic gases emitted from non-aqueous electrolytes."				

4 (performance)	IEC 61960-3:2017	International	Commission Regulation (EU) No 1103/2010 of 29 November 2010 establishing rules as regards capacity labelling of portable secondary (rechargeable) and automotive batteries and accumulators Text with EEA relevance: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010R1103&qid=1748700026790 Commission Delegated Regulation (EU) 2023/1669 of 16 June 2023 with regard to the energy labelling of smartphones and slate tablets: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1669&qid=1748700026790	Publication	2017	Manufacturing	This standar specifies performance tests, designations, markings, dimensions and other requirements for secondary lithium single cells and batteries for portable applications. The objective is to provide the purchasers and users of secondary lithium cells and batteries with a set of criteria with which they can judge the performance of secondary lithium cells and batteries offered by various manufacturers. Portable applications comprise hand-held equipment, transportable equipment and movable equipment.

			Commission Regulation (EU) 2023/1670 of 16 June 2023 laying down ecodesign requirements for smartphones, mobile phones other than smartphones, cordless phones and slate tablets: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1670&qid=1748700026790				
4 (performance)	EN 61960-3:2017	EU	1. Commission Regulation (EU) 2023/1670 of 16 June 2023 laying down ecodesign requirements for smartphones, mobile phones other than smartphones, cordless phones and slate tablets: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1670&qid=1743759871967. The	Withdrawal	2020	Manufacturing	Specification of performance tests, designations, markings, dimensions and other requirements for secondary lithium single cells and batteries for portable applications.

			Regulation establishes ecodesign requirements for the placing on the market of smartphones, other mobile phones, cordless phones and slate tablets. It includes the EC EN 61960-3:2017 to provide testing method to measure battery endurance for mobile phones, cordless phones and slate tablets (Annex IIIa) 2. Commission Delegated Regulation (EU) 2023/1669 of 16 June 2023 with regard to the energy labelling of smartphones and slate tablets: https://eur-lex.europa.eu/search.html?scope=EURLEX&text=61960&lang=en&type=quick&qid=174375987				

			1967&page=1. This Regulation establishes requirements for the labelling of smartphones and slate tablets, and the provision of supplementary product information on smartphones and slate tablets. It includes the EC EN 61960-3:2017 to provide testing method to measure battery endurance for mobile phones, cordless phones and slate tablets (Annex Iva). 3. Commission Regulation (EU) No 1103/2010 of 29 November 2010 establishing rules as regards capacity labelling of portable secondary (rechargeable) and automotive batteries and accumulators:				

			https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1669&qid=1743759871967. Similar to (2), it also includes the EC EN 61960-3:2017 to provide testing method to measure battery endurance for mobile phones, cordless phones and slate tablets (Annex Iva).				
4 (performance)	EN IEC 61960-4:2020	EU	Commission Regulation (EU) No 1103/2010 of 29 November 2010 establishing rules as regards capacity labelling of portable secondary (rechargeable) and automotive batteries and accumulators: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010R1103&qid=1743773825735. The	Publication	2020	Manufacturing	This part of IEC 61960 specifies performance tests, designations, markings, dimensions and other requirements for coin secondary lithium cells and batteries for portable applications and backup power supply such as memory backup applications. The objective of this document is to provide the purchasers and users of coin secondary lithium cells and batteries with a set of criteria with which they can assess the performance of coin secondary

			Regulation includes the IEC EN 61960 to provide the requirement for information on capacity labels for portable lithium batteries and its level of correctness.				lithium cells and batteries offered by various manufacturers.
Safety and perfomance	ISO 13485:2016 and EN ISO 13485	International	European Medical Device Regulation (Regulation (EU) 2017/745) (Article 8 and 10 (9): https://eur-lex.europa.eu/eli/reg/2017/745/oj/eng Europen In-Vitro Diagnostic Medical Device Regulation (Regulation (EU) 2017/746) (Article 8 and 10(8)): https://eur-lex.europa.eu/eli/reg/2017/746/oj/eng The 2017/745 regulation is supported by the Commission Implementing Decision (EU)			Manufacturing	Standard for quality management systems in the design and manufacture of medical devices. It outlines specific requirements that help organizations ensure their medical devices meet both customer and regulatory demands for safety and efficacy. ISO 13485 is crucial for manufacturers and suppliers of medical devices as it establishes a framework to ensure consistent design, development, production, and delivery of medical devices that are safe for their intended purpose. It aids in meeting rigorous regulatory requirements and managing risk, while ensuring best practices in the manufacture of medical

			2021/1182 of 16 July 2021 on the harmonised standards for medical devices, which requires EN ISO 13485 for quality management systems of medical devices: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02021D1182-20241009&qid=1748696677681 The 2017/746 regulation is supported by the Commission Implementing Decision (EU) 2021/1195 of 19 July 2021 : https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02021D1195-20241009&qid=1748698130925				devices. This standard not only facilitates market access across different countries but also enhances trust among stakeholders through demonstrated commitment to safety and quality

11 Appendix IV: Interviewees' affiliations and positions

Interview Number	Affiliation	Interviewee Position	Questionnaire
1	Research institute	Researcher	Policy and standards
2	Research institute	Technician	Policy and standards
3	Research institute	Researcher	Policy and standards
4	Academia	Principal lecturer	Policy and standards
5	Academia	R&D and innovation coordinator	Policy and standards
6	Traceability company	Executive	Policy and standards
7	Traceability company	Associate	Policy and standards
8	Robotics company	Executive	Policy and standards
9	Research institute	Engineer	Policy and standards
10	Research institute	Engineer	Policy and standards
11	Research institute	Product manager	Policy and standards
12	Automobile manufacturer	Engineer	Policy and standards
13	Automobile manufacturer	Engineer	Policy and standards
14	Automobile manufacturer	Engineer	Policy and standards
15	Logistics company	Executive	Policy and standards
16	Logistics company	Manager	Policy and standards
17	Standardisation organisation	Battery expert	Standards
18	Standardisation organisation	Project manager	Standards

12 Appendix V: Policy and standards questionnaire

1. In your experience, which are the key policies that affect the circularity of your work in the battery supply chain in terms of battery recycling and battery reuse? Which are the key policies that affect the overall circularity of the lithium battery supply chain in Europe?

2. In your view, what circularity gains have been enabled so far in the lithium battery supply chain under existing policies?

3. What opportunities do you think remain to be exploited for increased circularity in the lithium battery supply chain under existing policies?

4. What circularity challenges have you encountered or observed in your work in the lithium battery supply chain under existing policies (e.g., challenges related to policy predictability, competitiveness, innovation, etc.)?

5. Do you foresee any future risks (e.g., related to technologies, economics, etc.) in the longer term for achieving circularity under current policies?

6. What key policy changes or improvements would you like to see to reinforce progress toward circularity in the lithium battery supply chain and to address the challenges and potential risks you've identified?

7. Are there any areas that currently lack adequate international or European standards (e.g., related to specific stages of the lithium battery life cycle including manufacturing, handling, storage, transport, and end-of-life management such as reuse, recycling and disposal; to new or potential future battery technologies; to specific industrial sectors using lithium batteries, etc.)? Which aspects specifically are lacking?

8. Are there any existing EU standards on lithium batteries that are difficult to apply in practice due to ambiguity, cost, or lack of alignment with industrial processes? What support should the European Commission and Member States provide to facilitate compliance with current and upcoming standards (e.g., under the Batteries Regulation)?

9. Looking ahead 5–10 years, what do you see as the top priorities for new or revised standards to support sustainable, safe, and competitive lithium battery value chains in Europe?

13 Appendix VI: Standards questionnaire

1. Which stages of the lithium battery life cycle (e.g., manufacturing, handling, storage, transport, end-of-life management including reuse, recycling and disposal) lack adequate international or European standards today? Which aspects specifically are lacking?

2. Relating to the reuse and recycling phase specifically, do you see any challenges or gaps in existing EU standards?

3. Are there new or potential future battery technologies that current standards do not adequately address?

4. Are there industrial sectors using lithium batteries (e.g. robotics, medical device, transport, etc.) that lack adequate international or European standards?

5. Are there any existing EU standards on lithium batteries that are difficult to apply in practice due to ambiguity, cost, or lack of alignment with industrial processes?

6. What support should the European Commission and Member States provide to facilitate compliance with current standards and development of new standards under the Batteries Regulation?

7. Looking ahead 5–10 years, what do you see as the top priorities for new or revised standards to support sustainable, safe, and competitive lithium battery value chains in Europe?