GLOBAL BATTERY ALLIANCE

BATTERIES POWERING SUSTAINABLE DEVELOPMENT

GBA BATTERY PASSPORT

Circular Design Rulebook

ABOUT THIS INTERIM DRAFT FOR BATTERY PASSPORT PILOTS

The GBA battery passport rulebooks and corresponding data collection templates are interim versions released in June 2024 by the Global Battery Alliance. This version has been developed by the GBA's multistakeholder Environment, Social & Governance working groups for the purpose of Battery Passport piloting, whilst recognising that there remain selected substantive and editorial comments to be resolved together with feedback collected from the pilots. The Battery Passport pilots aim to test reporting against the performance indicators, as well as elements of data verification, aggregation and calculation of the GBA's ESG score for batteries. Following the piloting, the GBA will be hosting a structured public consultation phase on the indicator framework. Based on the feedback from the pilots and that gathered from thematic experts and other stakeholders, the rulebooks and data collection templates will be finalised and re-published in 2025.

Please find more information about the GBA's Battery Passport and the pilots here. If you would like to take part in the evolution of the GBA Battery Passport and future rulebooks across salient ESG issues, please join the GBA or contact us secretariat@globalbattery.org.

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Acknowledgements

GBA member organisations and external partners actively participated in the elaboration of the performance expectations in this rulebook.

1 Introduction

1.1 GBA overview

The Global Battery Alliance (GBA) is a public-private collaboration platform founded in 2017 at the World Economic Forum to help establish a sustainable battery value chain by 2030.

The GBA brings together over 160 leading international organizations, NGOs, industry actors, academic institutions, and multiple governments to align collectively in a pre-competitive approach and to drive systemic change along the entire value chain. Action Partnerships provide a collaborative platform for members to pool their expertise to achieve the shared goals of circularity, environmental protection, and sustainable development. Members of the Alliance collaborate to achieve the goals set out in the GBA 2030 Vision and agree to the GBA's Ten Guiding Principles. The GBA's multi-stakeholder governance structure aims to ensure inclusivity in decision-making and strategic focus.

1.2 The GBA vision

The GBA aims for batteries to be catalysts of sustainable development, striving for a circular battery value chain to meet the Paris Agreement goals, fostering a low-carbon economy to generate economic growth and employment, and upholding human rights in line with the UN Sustainable Development Goals.

The GBA's mission is to set trusted criteria and benchmarks for battery sustainability, mobilize collective action to improve the battery value chain's ESG footprint, and to communicate with one voice and strong media visibility to enhance the industry's public profile and accountability.

1.3 The GBA Battery Passport

Based on this foundation, the GBA envisions to accelerate the scaling of sustainable, responsible, and circular battery value chains by

- Establishing a global battery passport ecosystem, including harmonized sustainability performance expectations for batteries
- Making company efforts measurable, trusted and comparable
- Tracking and rewarding improvement actions across the value chain with a comprehensive ESG score for consumers

The GBA conceptualized the Battery Passport as a framework to increase transparency across the battery value chain. It establishes a digital twin of the physical battery that conveys information about all applicable sustainability and lifecycle requirements based on a comprehensive definition of a sustainable battery. In scope are EV batteries at initial stage; the Battery Passport is chemistry-agnostic and encompasses all major types of EV batteries present on the market.

The GBA's Battery Passport is unique as it is a key instrument is data-based, standardized, comparable, and auditable. Its ultimate goal is to provide end-users with a quality seal based on the battery's sustainability performance, according to reporting rules agreed upon by stakeholders from industry, academia, non-governmental organizations (NGOs) and government.

With the Battery Passport and the underlying rulebooks, the GBA aims to define a comprehensive set of sustainability indicators to create global and credible performance expectations with other relevant global players in the battery value chain. GBA multi-stakeholder working groups play an essential role in raising and validating the key sustainability performance expectations captured in the indicator framework.

The Battery Passport will both certify compliance with sustainability and societal expectations and clearly differentiate more valuable batteries in the market based on their sourcing impact and performance.

To implement the vision of the Battery Passport, the GBA collaborates with several key external stakeholders: standard setters, regulators/ policy makers, track & trace/ data verifying agencies, other initiatives with similar targets, corporate organizations, the financial community, non-corporate and public organizations, and end-users of vehicles/ batteries.

1.4 About the rulebooks

The objective of the rulebooks is to set globally harmonized rules that define which indicators and requirements are to be tracked within the battery passport which feeds into the sustainability score of the GBA Battery Passport. The rulebooks aim to provide a sound set of performance expectations for batteries and are intended to be applicable to all types of battery value chain members, regardless of where they operate or do business.

Development of the rulebook has taken place in the GBA's multistakeholder Working Groups, which were set up to define what stakeholders expect from sustainable performance and overseen by the Steering Committee which sets the high-level principles upon which the ESG issues of the GBA Battery Passport are to be developed. The rulebooks were created through a robust, intensive collaborative process based on drafts building on regulatory requirements and international standards. In online Working Group sessions, GBA members reviewed the content of this rulebook, debated key performance expectations, and agreed upon commonly acceptable positions. *Member organizations can choose not to agree on elements of the final rulebook in case consensus cannot be found. External stakeholders and groups representing affected people are consulted and their feedback on the requirements collected and included according to the working group's decision.*

2 Issue definition

In the face of growing global environmental challenges, there is a rising demand for products that are both efficient and sustainable, thereby reducing energy and resource consumption.[1] This shift reflects a broader recognition of the urgent need to address ecological concerns and the increasing consumer preference for environmentally responsible products. As the world's population nears 8 billion, the urgency for a sustainable approach in production and consumption becomes even more critical. Circular design, which integrates environmental protection criteria at every phase of the product lifecycle, emerges as a pivotal response to this demand.[2] It plays a crucial role, offering a framework for producing goods that meet ecological and economic requirements, thereby reducing the overall environmental footprint of products throughout their entire value chain.

2.1 Circular design

Circular design refers to incorporating environmental considerations into every stage of product lifecycle by aligning sustainability concerns with economic and quality requirements. This approach aims to create products with minimized aggregated environmental footprint throughout their entire value chain. For this rulebook, circular design focuses on reducing ecological impacts from the initial design stage to the end of the battery`s lifetime, including several steps of the product lifecycle:

- Design and manufacturing: Applying circular design methods for increasing resource productivity throughout the entire lifecycle.
- Product lifetime: Ensuring options for repair and reuse for improved product lifetime.
- End-of-life: Facilitating material recovery through disassembly and recycling strategies.

The main objective of circular design is to minimize environmental impact throughout the entire battery life cycle while maintaining product functionality, safety, and quality. This includes the consideration of relevant trade-off decisions while implementing circular design methods. For example, some circular design requirements may contradict the principles of lightweight design. Therefor it is crucial to take a full lifecycle perspective to avoid negative environmental outcomes. For this purpose, the focus is on improving battery durability and reliability, ensuring options for repair, disassembly, and remanufacturing, ensuring that products are easily recyclable at the end of their life cycle, and providing relevant information with focus on circular design to all relevant stakeholders along the battery value chain.

Circular design is increasingly recognized for its numerous benefits to both manufacturers and society, playing a crucial role in steering towards sustainable production and consumption practices. This approach minimizes environmental impact by incorporating environmental protection criteria throughout the product development process, from conception to recycling. Circular design principles will apply very differently from sector to sector and entail industrial challenges and trade-offs, particularly for clean technology products needed globally. While the overarching goal remains the same - to minimize environmental impact and promote sustainable practices - the specific implementation will vary depending on the industry and its unique requirements. Despite these challenges, embracing circular design principles offers immense benefits. It not only helps companies reduce costs and minimize waste but also opens new revenue opportunities by tapping into the growing market demand for sustainable products and services.[2]

It's worth noting that while circular design principles are integral to the development of this rulebook, specific indicators and requirements related to materials, such as the use of recycled content or critical materials, are addressed within the issue of "material consumption and usage" under the umbrella of Environmental, Social, and Governance (ESG). This broad ESG approach ensures a comprehensive approach to sustainability that encompasses not only circular design but also other key aspects of responsible resource management and environmental stewardship.

[1] https://single-market-economy.ec.europa.eu/industry/sustainability/sustainable-product-policy-ecodesign_en
[2] https://hbr.org/sponsored/2023/07/how-ecodesign-can-help-the-environment-and-your-bottom-line

2.2 Circular design and other ESG issues

The 25 ESG issues addressed by the GBA do not stand on their own. They are interlinked and somehow related under the E, S, G, pillars of the respective framework (Environmental, Social, Governance). While the individual issues can be delimited and defined for themselves, they may build on each other, may exacerbate, or improve each other. Issues under the same pillar are usually closer intertwined than with ones from other pillars. Nevertheless, issues from Environmental pillar may also be connected to issues from the Social pillar, Governance pillar, or other Environmental issues, and vice versa.

In examining the intricate relationship between circular design and various ESG issues within the battery value chain for electric vehicles, our focus will lie on those aspects where the correlation is especially high. This targeted exploration will provide a nuanced understanding of how circular design not only addresses environmental concerns but also makes substantial contributions to social and governance dimensions, thereby fostering sustainable and responsible practices within the electric vehicle industry.

Figure 1: Overview of GBA ESG issue list (as of June 2024)

Pollution (Environmental)[3]

Circular design's correlation with pollution reduction is profound. By prioritizing sustainable material choices, eco-friendly manufacturing processes, and considerations for responsible product disposal, circular design actively addresses and mitigates pollution concerns throughout the battery value chain. Its emphasis on e.g., minimizing the use of hazardous substances not only aligns with environmental regulations but also fosters a cleaner, more sustainable production process, showcasing circular design as a key driver for reducing pollution impacts.

Greenhouse gas emissions (Environmental)[4]

Circular design's high correlation with reducing greenhouse gas emissions stems from its advocacy for energy-efficient manufacturing processes and the selection of materials with lower carbon footprints. By incorporating a low-carbon approach, circular design can significantly contribute to mitigating the carbon impact of the battery value chain. This emphasis on environmental sustainability positions circular design as a strategic tool for addressing climate change concerns within several industries.

Waste management (Environmental)[5]

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[3] Charter, M., & Tischner, U. (2001). Sustainable Product Innovation: A Brief Review of Current Academic Research. Journal of Cleaner Production, 9(5), 429-441

[4] Kang, J. M., & Lee, H. K. (2018). Eco-design strategies and life cycle assessment of lithium-ion batteries for electric vehicles. Sustainability, 10(10), 3535

[5] European Commission. (2018). Study on Eco-design Requirements of Batteries and Accumulators

Circular design's robust correlation with waste management is evident in its emphasis on the entire lifecycle of products. By designing products with recyclability and responsible disposal in mind, circular design contributes significantly to efficient waste management practices within the battery value chain. This approach not only reduces the environmental impact of product disposal but also fosters a circular economy, reinforcing circular design as a cornerstone for sustainable waste management.

Material consumption / usage (Environmental)[6]

Circular design's correlation with material consumption and usage is evident in sustainable practices, particularly through the utilization of recycled and renewable materials, the management of critical resources, and adherence to policies promoting renewable and recyclable resources. Circular design principles prioritize environmentally conscious material choices throughout a product's life cycle, fostering a positive link with recycled and renewable materials. Challenges include balancing material efficiency and durability. Policies supporting renewables and recyclables, coupled with consumer demand for sustainability, drive this correlation. The complex interplay involves technological advances, policy frameworks, market dynamics, and industry commitments to sustainability. Ongoing research further refines our understanding of these relationships.

Worker's health and safety (Social)[7]

Circular design's impact on worker health and safety is notable, primarily through the promotion of materials and manufacturing processes prioritizing human well-being. By minimizing the use of hazardous substances, circular design actively contributes to creating a safer working environment in the battery production chain. This commitment to social responsibility aligns with broader efforts to ensure worker welfare, positioning circular design as a driver for positive social outcomes in several industries.

Product quality and safety (Social)[8]

Circular design enhances product quality and safety across industries by prioritizing sustainable product creation and manufacturing practices. This approach reduces harmful elements and ensures that stringent safety standards are met. The focus on longevity aligns with enhanced safety, as circularly designed products withstand wear and tear, minimizing malfunctions and hazards. This commitment benefits the environment and assures consumers of product safety and durability. Circular design cultivates accountability, prompting companies to address safety concerns throughout the product life cycle. The emphasis on sustainability resonates from material sourcing to manufacturing, positively impacting product quality. As a catalyst for ESG standards, circular design promotes environmental sustainability and ensures high-quality, safe products for consumers.

2.3 Circular design in the battery value chain

The escalating demand for batteries across various industries, including electric vehicles, renewable energy storage, and consumer electronics and appliances, necessitates a re-evaluation of the environmental impact associated with battery production, usage, and disposal, emphasizing the pivotal concept of circular design in the battery value chain. This transition towards sustainable battery production, underscored by the European Commission, prioritizes creating batteries characterized by sustainability, efficiency, and safety throughout their lifetime.[9]

According to the European Commission and built into the EU battery regulation, batteries placed on the European Union (EU) market must be produced with minimal environmental impact, utilizing materials obtained in a manner that fully respects human rights and adheres to social and ecological norms. The emphasis is on durability and safety, with a clear mandate that, at the end of their useful life, batteries must be reused, remanufactured, or recycled, thereby recovering valuable materials for the economy. It is a holistic

[6] European Commission. (2018). Study on Eco-design Requirements of Batteries and Accumulators
[7] McDonough, W., & Braungart, M. (2002). Cradle to Cradle: Remaking the Way We Make Things. North Point Press
[8] European Commission. (2018). Study on Eco-design Requirements of Batteries and Accumulators
[9] European Commission. "Study on Batteries – Revision of EU Batteries Legislation."

approach that addresses the entire life cycle of batteries, from production to disposal, reinforcing the need for a sustainable and responsible battery industry.[10]

Crucially, achieving these objectives requires the establishment of circular design practices and their continuous improvement to minimize environmental impact across the entire battery life cycle, emphasizing product functionality and quality. These practices are fundamental for the realization of a sustainable and responsible battery industry, aligning with global sustainability goals. In line with these objectives, the role of circular design becomes increasingly significant. Understanding the crucial role of circular design in sustainable battery production leads to a deeper examination of the battery value chain. Each step, from raw material extraction to manufacturing, use, and end-of-life management, presents unique challenges and opportunities for conducting due diligence and for implementing circular design principles. As the industry navigates these challenges, it is imperative to integrate circular design not only as a principle but as a guiding philosophy that shapes every facet of the battery value chain, contributing to a greener and more responsible future for the evolving energy landscape.

1. Design and manufacturing of batteries

During battery production, environmental considerations should be a key element during the design stage of battery production. Circular design at this stage is very important as it determines up to 80% of the environmental impact of a product.[11] By integrating ecological considerations into battery design, manufacturers can significantly reduce resource consumption, increase recyclability, improve energy efficiency, and extend product lifetime. This approach not only meets consumer needs and environmental responsibilities but is also in line with economic feasibility. This promotes sustainability and circular economy by ensuring that the entire life cycle of the battery, from inception to disposal, is considered.[12]

2. Use / repair / reuse

In the circular design framework for batteries, the use/repair/reuse phase plays a critical role in ensuring sustainability. This phase is characterized by the principle of reuse whether in the same or in a different battery application, which is may me most effective when battery materials and components are designed to be easily separable for direct reuse. Addressing such design choices is essential for enhancing the sustainability of batteries. Moreover, the reuse and repurposing of entire battery units or their parts requires a comprehensive understanding of their composition and state of health, aspects that are increasingly being addressed through recent regulatory requirements. However, due to the rapid evolution of cell technology and the diversity of material compositions, reusing or repurposing batteries efficiently demands detailed knowledge of their exact characteristics. This approach underlines the necessity of designing batteries with their full lifecycle in mind, from initial production to eventual end-of-life, to ensure they can be reused or repurposed effectively, thereby reducing waste, and maximizing overall sustainability.[13]

3. Recycling and waste handling

Circular design principles extend to the end-of-life stage, shaping the framework for a circular economy in recycling and waste handling. The European Commission's Circular Economy Action Plan sets strategies for efficient recycling processes that minimize waste and facilitate the recovery of valuable materials for recycling, embodying the essence of circular design.[14] Delving deeper, the Journal of Cleaner Production explores technologies for sustainable disposal and resource recovery in battery waste handling, illuminating the crucial role of circular design in addressing environmental concerns at the final stage of the battery value chain.[15] The circular economy integration, guided by circular design, ensures responsible disposal practices, and significantly mitigates the environmental impact of battery waste.

[10] https://single-market-economy.ec.europa.eu/news/green-deal-sustainable-batteries-circular-and-climate-neutral-economy-2020-12-10_en
[11] https://makersite.io/insights/the-emergence-of-eco-design-navigating-the-future-of-sustainable-products/
[12] https://makersite.io/insights/the-emergence-of-eco-design-navigating-the-future-of-sustainable-products/
[13] https://tbb.innoenergy.com/reduce-reuse-recycle-sustainable-design-concepts-for-battery-systems/
[14] European Commission
[15] Journal of Cleaner Production, https://www.sciencedirect.com/journal/journal-of-cleaner-production/publish/guide-for-authors

In conclusion, circular design is not merely a component but a guiding philosophy for sustainable battery production throughout the value chain. From ethical raw material extraction to energy-efficient manufacturing and circular economy integration in recycling, circular design offers a comprehensive strategy for minimizing ecological impacts across the battery value chain. Prioritizing circular design principles aligns the battery value chain with global sustainability goals, marking a transformative journey towards a greener, more responsible future for several industries.

3 Circular design indicators

Defining a comprehensive longlist of indicators for circular design involves a multifaceted approach that draws from regulatory mapping, widely accepted standards, and insights from subject matter experts in Environmental, Social, and Governance (ESG) matters. The following steps delineate the methodology applied:

1. Analysis of regulatory mapping ("Compliance baseline")

The initial step in constructing our longlist involves a meticulous analysis of indicators identified during the regulatory mapping process. This "Compliance baseline" serves as a foundational layer, emphasizing mandatory (future) indicators that emerge from relevant regulations. This thorough examination ensures that our longlist aligns with existing and anticipated regulatory requirements, establishing a robust compliance foundation for circular design principles.

2. Analysis of standards

To enrich our longlist, an expansive review of standards is conducted, encompassing widely used and globally accepted reporting standards, standards associated with global value chains, European-specific financial reporting standards, and overarching global guiding principles and standards. This comprehensive analysis ensures the inclusion of indicators that extend beyond regulatory mandates, incorporating globally recognized benchmarks and best practices in circular design.

3. Gathering ESG indicators via subject matter experts

The expertise of subject matter experts in Environmental, Social, and Governance (ESG) matters is leveraged to gather a nuanced set of indicators. Through collaborative efforts with these experts, we identify and integrate ESG indicators that are pertinent to circular design. This step ensures a holistic perspective, encompassing not only regulatory and standards-based requirements but also insights from practitioners deeply knowledgeable about the environmental, social, and governance dimensions of circular design.

3.1 Indicator framework and selection

In the down selection process of indicators for our framework, the guiding principle of "Identify it, improve it, prevent it" was adopted to establish a robust foundation in alignment with the objectives of the Global Business Alliance (GBA). This framework serves as a strategic lens through which indicators are assessed for their relevance to circular design principles. Building upon the "Identify it, improve it, prevent it" foundation, additional selection criteria were systematically applied to distil a core set, resulting in a concise shortlist of indicators. These criteria are designed to ensure that the selected indicators not only align with the GBA objectives but also capture essential aspects of circular design, fostering a holistic and impactful measurement framework.

Recognizing the dynamic nature of circular design considerations and the evolving landscape of standards, the down selection process undergoes iterative refinement. Regular reviews and updates are integral to the methodology, ensuring that the shortlist remains current and responsive to the latest regulatory developments, standards revisions, and emerging insights from Environmental, Social, and Governance (ESG) subject matter experts.

This iterative refinement process not only ensures that the indicator shortlist remains relevant and effective but also enables agility in adapting to the evolving nuances of circular design principles. By staying updated with the latest developments and insights, we guarantee that our chosen indicators continue to align with both GBA objectives and the dynamic landscape of circular design standards, thus keeping us at the forefront of progress.

3.1.1 Indicator framework

The indicator framework is comprised of four indicators mapped to the three dimensions of identify it, improve it, prevent it.

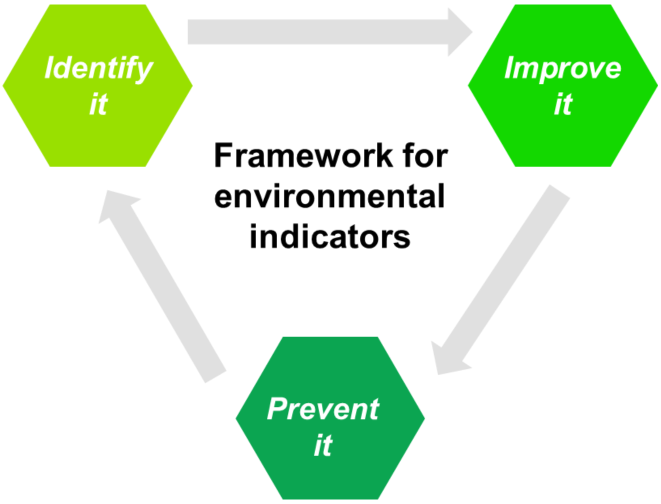

Figure 2: Indicator framework and selected circular design indicators

Identify it: Proactively searching the own operations and the supply chains for circular design on the assumption that it exists.

Improve it: Work towards and report on remedy for those affected.

Prevent it: Take meaningful steps to ensure that the situation does not continue or arise.

Companies participating in the GBA Battery Passport program should have in place those indicators to demonstrate the implementation of the provisions associated with this issue.

3.1.2 Indicator selection rationale

In the process of formulating our eco design rulebook, a meticulous approach has been undertaken to ensure the selection of relevant indicators aligns seamlessly with our objectives. The criteria for choosing indicators encompass a judicious blend of mandatory and optional elements, drawing from various regulations, standards, and expertise.

Mandatory indicators

Mandatory indicators mandated by selected regulations form the foundational components of our circular design rulebook. These indicators were consistently chosen and, wherever feasible or meaningful, aggregated to maintain a balanced representation. The objective here is to establish a baseline that captures the Foundational requirements set forth by regulatory bodies.

Optional indicators from other regulations

Optional indicators, sourced from diverse regulations, were included in our selection process unless they lacked specificity for circular design or primarily addressed aspects more pertinent to future rulebooks or the overarching cross-cutting topics. The aim is to ensure that the chosen indicators contribute meaningfully to circular design principles and enhance the comprehensiveness of our rulebook.

Essential elements of circular design

In the broader context of circular design, indicators from regulations that delineate essential aspects were prioritized. These selections were based on two key considerations:

a) Framework contribution: Indicators that contribute significantly to the overall framework of circular design.

b) Alignment with guiding principles: Indicators that align with one or more guiding principles established within the scope of our work. This dual criterion ensures that the chosen indicators not only fit the framework but also resonate with the core principles guiding our eco design rulebook.

Voluntary indicators from standards and expertise

Voluntary indicators, sourced from standards or leveraging expertise, were incorporated when they added meaningful extensions to the elements of circular design. Like the selection from regulations, the inclusion of these indicators was contingent on:

a) Framework integration: Ensuring that voluntary indicators seamlessly integrate into the broader framework of circular design.

b) Alignment with guiding principles: Verifying that the chosen voluntary indicators align with one or more guiding principles, thereby reinforcing the comprehensive nature of our eco design rulebook.

This meticulous approach ensures that our selection of indicators is not only compliant with regulations but also reflects a nuanced understanding of circular design principles, creating a robust foundation for the development of our eco design rulebook.

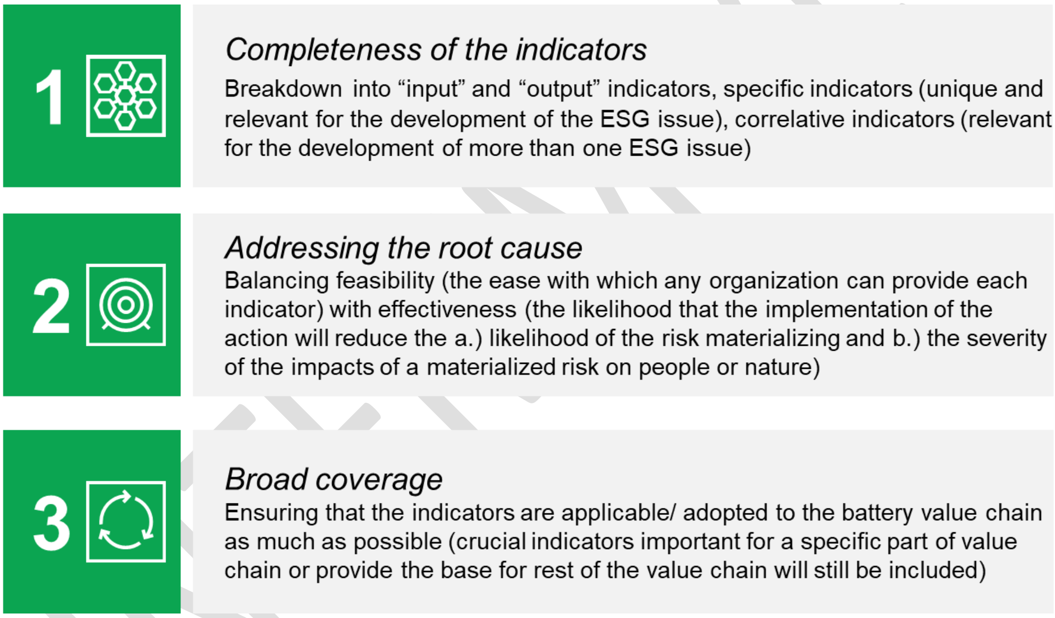

Figure 3: Guiding principles for the indicator selection

3.1.3 Shortlist of circular design indicators

Circular design indicators and their position within the circular design framework	
Assessment of battery and component **durability and reliability**	Improve it, prevent it
Assessment of options for **repairability and reusability**	Improve it, prevent it
Assessment of options for **recyclability** for battery components	Improve it, prevent it
Existence and availability of **circular design information**	Identify it

Following the explained process guided by the principles of the Global Battery Alliance (GBA) objectives and incorporating a strategic framework of "Identify it, improve it, prevent it," our initiative to define circular design indicators has yielded a concise shortlist. This shortlist encapsulates key aspects that are integral to assessing and enhancing circular design practices in alignment with GBA goals. The core set of circular design indicators, meticulously selected through iterative refinement, is as follows:

3.2 Regulations

Various international regulations and standards play a crucial role in promoting sustainable practices across industries. To form the bedrock of our work, we have meticulously considered two pivotal regulations, providing essential guidance on relevant elements and requirements for our circular design indicators. These regulations serve as the cornerstone for our approach, ensuring a robust framework aligned with current sustainability and circular economy standards.

EU Battery Regulation

The EU Battery Regulation, stemming from the 2019 European Green Deal, is a pivotal element in Europe's growth strategy. Aimed at achieving climate neutrality by 2050, it emphasizes the shift to electromobility and recognizes batteries as key to sustainable development. Anticipating a surge in battery demand, the regulation seeks to establish a harmonized framework covering sustainability, performance, safety, and end-of-life considerations. It replaces Directive 2006/66/EC to ensure legal clarity, prevent trade barriers, and apply uniformly across all battery categories. The regulation applies to batteries, whether integrated into products or sold independently within the Union, fostering a clear and unified approach to address the challenges of the evolving battery market.

The pivotal aspects of the EU Battery Regulation for our circular design rulebook lie in its emphasis on durability, recyclability, and ensuring options for repair and maintenance. The regulation stresses the optimization of battery design for long-lasting performance and safety, setting specific sustainability requirements for key battery types. Additionally, it aligns with circular economy goals by promoting increased recycling and recovery of raw materials. Provisions are proposed to ensure the separate collection, treatment, and high-quality recycling of batteries integrated into appliances, underscoring the importance of their removability and replaceability. These core elements serve as a crucial foundation for our circular design rulebook, fostering sustainable and circular practices in battery design while prioritizing durability, recyclability, and options for repair and maintenance.

Proposal for A New Ecodesign for Sustainable Products Regulation (ESPR)

This Regulation is designed to contribute to the Union's climate and energy objectives, aligning with the Paris Agreement's goals and the European Climate Law's commitment to achieving at least a 55 % reduction in net greenhouse gas emissions by 2030 and economy-wide climate neutrality by 2050. Furthermore, it aims to support broader environmental objectives outlined in the 8th Environmental Action Programme, emphasizing the Union's commitment to stay within planetary boundaries and transition to a non-toxic circular economy. The European Green Deal calls for improved monitoring and prevention of pollution in air, water, soil, and consumer products, emphasizing the importance of safe and sustainable materials and products throughout their life cycle. The directive also recognizes the Union's critical role in influencing global standards on product sustainability and design, emphasizing the significance of the internal market's impact. Additionally, Directive 2009/125/EC, along with Regulation (EU) 2017/1369, has already made significant strides in reducing EU primary energy demand for products, with further savings anticipated.

In our circular design rulebook, particular attention is drawn to Article 5, "Ecodesign requirements," of the Ecodesign and Energy Labelling framework (ESPR). This pivotal article empowers the Commission to establish ecodesign requirements tailored to specific product groups, considering all stages of their life cycle. The focus is on enhancing various aspects of products to align with sustainable practices, making Article 5 a cornerstone in shaping our circular design principles. The relevant aspects are defined as:

- Durability
- Reliability
- Reusability
- Upgradability
- Reparability
- Possibility of maintenance and refurbishment
- Possibility of remanufacturing and recycling
- Possibility of recovery of material

In addition to its crucial role in promoting ecodesign requirements through Article 5 of the ESPR, it's important to recognize that the ESPR operates as a horizontal regulation, impacting a wide array of products across industries. As such, it serves as a foundational regulation unless superseded by sector-specific directives. Discussions are currently underway to potentially exempt certain product categories from the ESPR, reflecting ongoing efforts to refine regulatory frameworks and ensure their effectiveness across diverse sectors.

In light of the proposal's inception in March 2022 and the subsequent provisional agreement reached in December 2023, it's pertinent to acknowledge the imminent adoption of the ESPR from the official EU side, signalling its progression toward becoming a pivotal regulatory framework. However, with the final agreement pending and formal adoption of the regulation yet to occur, there exists a window for potential modifications. Notably, discussions are ongoing regarding the delineation of specific product categories subject to ESPR, reflecting the dynamic nature of regulatory refinement aimed at optimizing its applicability across diverse sectors.

Regulations
EU Battery Regulation
Proposal for A New Ecodesign for Sustainable Products Regulation (ESPR)
EURO 7: EU Regulation on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability

Table 1 Regulations with relevance for circular design indicators

3.3 Standards

In addition to the key regulations outlined before, our circular design rulebook is enriched by the incorporation of a set of highly relevant international standards. These standards play a crucial role in shaping and detailing our circular design indicators by providing essential elements and requirements. The utilization of these international standards ensures that our indicators align with global best practices for circular design. By taking into consideration the valuable insights offered by these standards, we enhance the comprehensiveness and robustness of our rulebook, positioning it to meet not only regulatory expectations but also international benchmarks for sustainable and circular design.

Standards
DIN EN 45552: General method for the assessment of the durability of energy-related products
DIN EN 45554: General methods for the assessment of the ability to repair, reuse and upgrade energy-related products
UN Global Technical Regulation (GTR) on in-vehicle battery durability for electrified vehicles
Aluminium Stewardship Initiative (ASI) Performance Standard
Responsible Minerals Initiative Standard (RMI - RMAP ESG Standard for Mineral Supply Chains)
Technical reports and guidance
Battery passport content guidance (based on EU Battery Regulation)
Joint Research Center EU (JRC): Analysis of sustainability criteria for lithium-ion batteries including related standards and regulations

Table 2: International standards with relevance for circular design indicators

3.4 Indicators and requirements

The following indicators represent the requirements that need to be fulfilled for the battery passport. They display a consolidated version of the underlying regulations, standards, and best practices with the goal to make the issue operationalizable for the companies. Whenever applicable, further guidance and background is provided. The GBA recognizes that some of the leading practices outlined in the indicator requirements reflect changes in global practice and norms that have come to the fore only in recent years. Companies participating in the GBA battery passport are required to fulfil the set of circular design indicators. Each indicator is composed of several requirements. These requirements are divided into various requirement levels which directly relate to the performance score of participating companies. These levels are:

I. Foundational requirements - drawing on the regulatory compliance baseline
II. Intermediate requirements - drawing on the regulatory compliance baseline and voluntary sustainability standards
III. Leading practice - drawing on the regulatory compliance baseline and voluntary sustainability standards

Indicators can also be scored as binary:

I. No
II. Yes

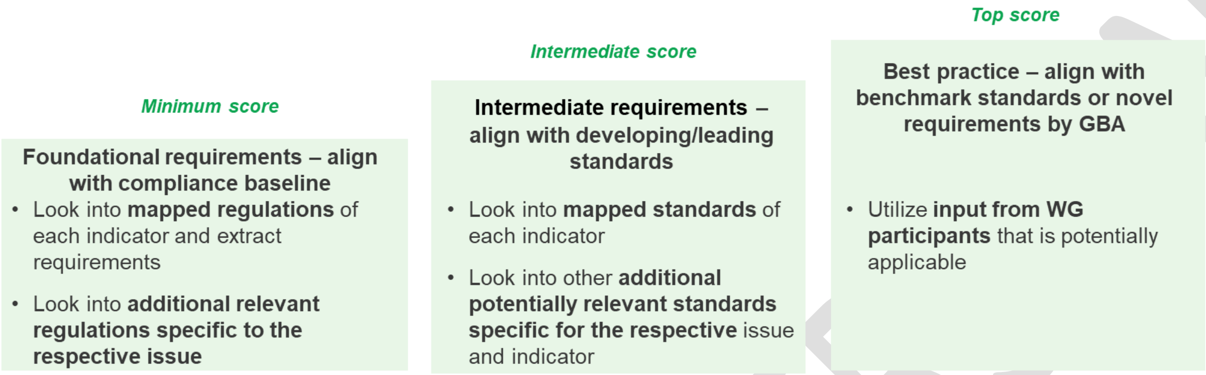

Figure 4: Indicator requirements level

In addition to the initial set of indicators and requirements, it's crucial to emphasize that ongoing updates are essential to align with evolving regulations and interpretations. Regular reviews, guided by the latest guidance from the EU Commission, delegated and implementing acts, and legal guidance and interpretations, ensure the battery passport remains compliant and relevant. This dynamic approach ensures that participating companies stay ahead of regulatory shifts and maintain the highest standards of circular design and sustainability.

To underscore our emphasis on defining disclosure requirements rather than performance metrics, it's imperative to clarify that the primary aim of the battery passport is to establish transparent guidelines for companies to disclose their adherence to circular design principles and sustainability standards. These disclosure requirements serve as a framework for companies to communicate their efforts and progress in meeting the set indicators, fostering accountability and transparency within the industry.

3.4.1 Assessment of battery and component durability and reliability

Introduction

Enhancing battery durability and reliability is crucial for resource efficiency, reducing the demand for raw materials and energy in production and disposal, thereby minimizing environmental impacts. Durability refers to the capability of a product to perform as required until it reaches the end of its useful life under normal conditions of use, maintenance, and repair. Reliability is the probability that a product will perform as expected without failure for a given period, including maintenance under certain conditions. While durability covers the entire expected lifetime of the product, reliability focuses on the probability of efficient performance over that lifetime. Durability is measured in units such as time, operating cycles, or operating distance. This indicator also examines how a battery responds to stresses by identifying potential failure sites, mechanisms and modes and the use of appropriate damage models to assess durability under specific conditions.[16]

[16] DIN EN 45552

Requirements

In the dynamic landscape of modern business, ensuring the durability and reliability of products and services has become paramount. Recognizing the need for a comprehensive framework to assess and communicate these essential qualities, companies are increasingly required to report on a set of meticulously defined requirements. By reporting to these guidelines, organizations can not only meet regulatory expectations but also demonstrate a commitment to delivering products and services that stand the test of time, fostering trust and confidence among stakeholders. It's worth noting that while performance-related requirements and attributes are often mentioned alongside durability-related requirements, they are excluded from this specific context.

Foundational requirements

In accordance with the EU Battery Regulation, Foundational requirements have been established to ensure the durability and reliability of batteries. Economic operators must disclose specific parameters related to electrochemical performance and durability. The two primary provisions outlined in the regulation are as follows:

Foundational requirements	Materially equivalent to
1. A battery passport shall include the following information relating to the battery model, which shall be accessible to the public: 1.1. Expected battery lifetime expressed in cycles, and reference test use 1.2. Temperature ranges the battery can withstand when not in use (reference test) 1.3. C-rate of relevant cycle-life test 1.4. Capacity threshold for exhaustion - minimum percentage of rated capacity, above which the battery is still considered operational as EV (electric vehicle) battery in its current life, provided by economic operator **2. Parameters related to electrochemical performance and durability:** 2.1. Rated capacity (in Ah) and capacity fade (in %). 2.2. Power (in W) and power fade (in %). 2.3. Internal resistance (in Ω) and internal resistance increase (in %). 2.4. Energy round trip efficiency and its fade (in %).	**EU Battery Regulation** • Annex XIII (1j) • Annex XIII (1l) • Annex XIII (1p) • Annex IV Part A **Aluminum Stewardship Initiative (ASI) Performance Standard** (Chapter 4.1) **Responsible Minerals Initiative Standard (RMI - RMAP ESG Standard for Mineral Supply Chains)** (Criterion 30)

Intermediate requirements

As an extension to the foundational requirements, additional specifications underscore a thorough analysis for both durability and reliability. For durability, the temperature sensitiveness of EV (electric vehicles) batteries necessitates a reporting on applicable environmental and operating conditions, stress magnitudes and locations, as well as the mechanisms and modes of stress. Similarly, reliability requirements mandate the reporting of Failure Modes and Effects Analysis (FMEA), Failure Modes, Effects, and Criticality Analysis (FMECA), or equivalent analyses. These evaluations pinpoint failure modes, mechanisms, locations, and implicated parts, collectively ensuring batteries meet high standards of resilience and performance across diverse conditions and use cases.

Intermediate requirements	Materially equivalent to
3. Battery lifetime 3.1. SOCE threshold for exhaustion **4. For the durability analysis shall identify the following requirements:** 4.1. Applicable environmental and operating conditions and related stresses 4.2. Magnitude and locations of stresses 4.3. Failure mechanisms and modes 4.4. The durability using appropriate damage **5. For the reliability analysis, an FMEA, FMECA or equivalent analysis shall be conducted to allow the identification of:** 5.1. The failure modes 5.2. Failure mechanisms 5.3. The locations of the failures and the parts which are involved in the failure for each analysed function	**Battery Passport Content Guidance** Chapter 6.7.3 **JRC:** Analysis of sustainability criteria for lithium-ion batteries including related standards and regulations (Chapter 2.2) **EN 45552:2020** 6.2 & 7.2

Leading practices

In addition to the stipulated Foundational and intermediate requirements, we advocate for the adoption of a set of Leading practices that not only draw from industry expertise but also incorporate insights from established standards and research papers. These Leading practices are intended to offer supplementary guidance, going beyond the baseline requirements, and dynamically responding to the rapidly changing technological landscape in the battery value chain.

Leading practices	Materially equivalent to
6. Battery lifetime (SOCE) 6.1. From start of life to five years or 100,000 km: - Category M1 Vehicles: 80% and - Category N1 Vehicles: 75% 6.2. Up to eight years or 160,000 km: - Category M1 Vehicles: 70% - Category N1 Vehicles 67%	**UNECE GTR (Global Technical Regulation) 22** **EURO 7 (July 2025)** • Annex II (Table 1 and 2)

Recommendations & Guidance

Reporting on reliability and durability has tangible benefits such as improved energy efficiency, heightened consumer confidence, compliance with regulatory standards, and overall progress in the electric vehicle sector. Emphasizing the importance of battery durability is, therefore, a critical component in building a more sustainable and resilient electric transport industry. The realization of these advantages is contingent upon a steadfast commitment to meeting the specified requirements. Additionally, while prioritizing durability remains paramount, it's crucial not to overlook the significance of lightweight design in enhancing the overall efficiency and performance of electric vehicle batteries. Striking the right balance between durability and weight is essential for optimizing energy efficiency and ensuring long-term sustainability in the electric transport industry. Therefore, future advancements should aim to integrate both aspects seamlessly.

3.4.2 Assessment of options for repairability and reusability

Introduction

Emphasizing the crucial role of repair and disassembly in the pursuit of sustainable and responsible battery production and utilization, the focus extends beyond the initial manufacturing phase to encompass the entire lifecycle of electric vehicle batteries. The chapter underscores how these practices profoundly impact the overall lifespan of batteries, shedding light on their significance in ensuring a sustainable and eco-conscious approach. The formulation of guidelines is discussed, playing a pivotal role in assessing the ease with which batteries and their components can be repaired or disassembled within the intricate battery supply chain. Furthermore, the integration of repair and disassembly considerations into circular design strategies is highlighted as not only environmentally beneficial but also as a driver for innovation and efficiency in the battery sector.

While this chapter emphasizes the crucial role of repairability and, it's essential to recognize that this indicator extends its focus beyond these aspects. The overarching framework also encompasses relevant considerations such as dismantling and remanufacturing, utilizing different nomenclature to address diverse facets within the intricate battery supply chain.

Requirements

In the evolving landscape of modern business, the emphasis on the longevity and dependability of products and services is of utmost importance. To acknowledge the necessity for a thorough framework to evaluate and communicate these vital attributes, there is a growing demand for companies to focus on a set of precisely defined requirements, particularly in the context of repair and disassembly. Adhering to these guidelines enables organizations not only to fulfil regulatory expectations but also to showcase a dedication to providing products and services that can be effectively repaired and disassembled, ensuring their sustained functionality over time.

Foundational requirements

In accordance with the EU Battery Regulation, foundational requirements have been established to ensure options for the repairability and reusability of batteries. Organizations must integrate thorough battery passports that encompass crucial information about the battery model, such as part numbers for components, dismantling information, and safety measures. The primary requirements outlined in the regulations are as follows:

Foundational requirements	Materially equivalent to
1. A battery passport shall include the following information relating to the battery model, which shall be accessible only to persons with a legitimate interest and the Commission: 1.1. Part numbers for components […] 1.2. Dismantling information, including at least: - Exploded diagrams of the battery system/pack showing the location of battery cells - Disassembly sequences - Type and number of fastening techniques to be unlocked - Tools required for disassembly	**EU Battery Regulation** • Annex XIII (2b) • Annex XIII (2c) • Annex XIII (2d)

- Warnings if risk of damaging parts exists - Amount of cells used and layout 1.3. Safety measures	

Intermediate requirements

Expanding beyond the standard requirements, it is necessary to provide additional reporting to meet the heightened standards for repairability and reusability requirements. In tandem with the dismantling information, a comprehensive manual for battery pack disassembly is mandated, covering various types of information. Additionally, they must actively avoid technical solutions that could undermine the possibilities of re-use, upgrading, repair, maintenance, refurbishment, remanufacturing, and recycling of both products and components. Moreover, reporting extends to crucial product and support criteria, including working environment details, required skill levels, and spare parts classification. Notably, the usage and removability of adhesives are integral considerations.

Intermediate requirements	Materially equivalent to
2. Manual for disassembly and dismantling of the battery pack, including: 2.1. Type of construction of battery pack, modules, and cells 2.2. Information on replaceability of modules and cells (yes/no) 2.3. Information on fillings, if used: characteristics of foams and/or glues 2.4. Information on casing: type and material (steel/plastic) **3. Standardization of components and toolsets (compatibility)** 3.1. Usage of identical or compatible sizes and types of screws, fasteners, and connectors **4. Construction and assembly design (removability and replaceability)** 4.1. To enable an easy and safe opening of the battery pack case during disassembly, screws and joints should be readily accessible 4.2. Robust module construction and the general use of corrosion-free components for pack or module assembly 4.3. Integrating attachment points for the lift or pick-up of the system	**Battery Passport Content Guidance (based on EU Battery Regulation)** • Chapter 6.6.1
5. Ease of repair and maintenance as expressed through: 5.1. Modularity 5.2. Compatibility with commonly available spare parts 5.3. Use of standard components 5.4. Ease of non-destructive disassembly and re-assembly **6. Ease of upgrading, re-use, remanufacturing, and refurbishment as expressed through:** 6.1. Modularity 6.2. Number of materials and components used 6.3. Use of standard components 6.4. Ease of non-destructive disassembly and re-assembly	**ESPR Annex 1**

7. Avoidance of technical solutions detrimental to re-use, upgrading, repair, maintenance, refurbishment, remanufacturing and recycling of products and components	
8. Product related criteria 8.1. **Classification of working environment** (Use environment / Workshop environment / Production-equivalent environment) 8.2. **Classification of skill level** (Layman / Generalist / Expert / Manufacturer or authorized expert / Not feasible with any existing skill) **9. Support related criteria** 9.1. **Process classification by diagnostic support and interfaces** (Intuitive interface / Coded interface with public reference table / Publicly available hardware/software interface / Proprietary interface / Not possible with any type of interface) 9.2. **Classification of spare parts availability by target group** (Publicly available / Available to independent repair service providers / Available to manufacturer-authorized repair service providers / Available to the manufacturer only / No spare parts available) 9.3. **Classification of spare part interfaces** (Standard part with standard interface / Proprietary part with standard interface / Proprietary part with non-standard interface) 9.4. **Classification of spare parts availability by duration of availability** (Long-term availability / Mid-term availability / Short-term availability / No information on duration of availability) 9.5. **Classification of return options** (Comprehensive return options / Basic return options / No return options)	**EN 45554:2020** • Chapter 6 • Chapter 7
10. Adhesives 10.1. Does adhesive design allow for disassembly? (Y/N)	**Expert input**

Leading practices

In addition to meeting Foundational and intermediate requirements, it's crucial to implement Leading practices that address the dynamic nature of the battery value chain in electric vehicles. We emphasize the importance of reporting the classification of battery platforms, specifically designed for automated disassembly, to facilitate efficient and precise automated disassembly procedures with minimal environmental impact. Additionally, providing detailed information on reversibility triggers for adhesives is essential to allow for the separation of components without damage and for a proper recovery of components and materials as well as the provision of a manual for discharging of the battery pack in order to improve safety. These practices go beyond industry norms, ensuring efficient repair, disassembly, and reuse processes.

Leading practices	Materially equivalent to
11. Automated assembly 11.1. Classification of battery platforms for automated disassembly	**Expert input**

12. Reversible triggers 12.1. Detailed information on reversibility triggers for adhesives **13. Discharging** 13.1. Provision of a manual for discharging of the battery pack	

Recommendations & Guidance

Repair, disassembly, and options for reuse are key components in the life cycle management of electric vehicle batteries and contribute significantly to environmental sustainability. These practices not only prolong the life of the batteries, but also support circular economy principles, which reduces the overall environmental impact resulting from their production. By considering repair, reuse and disassembly at the design stage, companies can ensure that each part of their products can be easily disassembled, encouraging reuse and recycling, and therefore reducing the reliance on new raw materials. Furthermore, while prioritizing repair, disassembly, and reuse are integral to sustainable battery management, it's essential to underscore the importance of lightweight design in optimizing the performance and efficiency of electric vehicle batteries. Balancing these objectives ensures that batteries not only endure but also contribute to reducing carbon footprints throughout their life cycles. Hence, future advancements should aim to integrate lightweight materials without compromising repairability and recyclability.

3.4.3 Assessment of options for recyclability for battery components

Introduction

This chapter explores the vital role of recyclability in establishing a sustainable approach to electric vehicle battery production. It emphasizes the importance of considering recyclability throughout the entire lifecycle, aiming to minimize waste, reduce environmental impact, and promote a closed-loop system. The focus is on formulating guidelines and standardized criteria to seamlessly integrate recyclability assessments into circular design strategies within the battery supply chain. This standardization contributes to a holistic and sustainable product design in the EV battery sector, aligning with environmental goals and fostering innovation. The chapter encourages manufacturers and stakeholders to prioritize recyclability, supporting a resource-efficient and environmentally conscious paradigm for electric vehicles.

Additionally, it is imperative to underscore that the meticulous evaluation of repairability and reusability, along with its detailed requirements outlined in *chapter 3.4.2*, serves as an intrinsic guide for the concurrent assessment of recyclability in the electric vehicle battery sector. The principles, criteria, and methodologies established for gauging the ease of repair and disassembly inherently contribute to the overarching goal of enhancing recyclability. By recognizing the interconnected nature of these indicators, we suggest considering the requirements of repairability and reusability as part of the assessment of options for recyclability for battery components.

Requirements

Recognizing the paramount importance of ensuring sustainable and eco-conscious practices, there is a growing demand for companies to concentrate on a set of precisely defined requirements, especially within the realm of recyclability assessment for battery components. Adhering to these guidelines allows organizations not only to meet regulatory expectations but also to demonstrate a commitment to providing battery products with optimal recyclability, ensuring their sustained functionality over time. As mentioned in *chapter 2.1*, any material-related requirements are covered within the rulebook of material consumption and usage. For example, requirements related to the recycled content of battery components will be covered there.

Foundational requirements

In the evaluation of recyclability for battery components, no specific foundational requirements have been designated. However, it is important to note that all requirements outlined for the repair and reuse indicator are applicable to the assessment of recyclability. Furthermore, within the subsequent table of this chapter, more detailed and specific requirements pertaining to recyclability have been identified for intermediate assessment.

Foundational requirements	Materially equivalent to
Attributes from repair and reuse indicator apply.	**See chapter 3.4.2**

Intermediate requirements

In accordance with the ESPR Annex 1, Foundational requirements have been established to ensure options for the recyclability of battery components. Organizations must prioritize the ease and quality of recycling, as expressed using easily recyclable materials, safe, easy, and non-destructive access to recyclable components and materials (or components and materials containing hazardous substances), material composition, homogeneity, and the possibility for high-purity sorting. To meet the requirement of "Use of easily recyclable materials," organizations should prioritize selecting materials that can be efficiently processed in recycling facilities without compromising their quality or purity. This involves opting for materials that are commonly accepted by recycling systems and have well-established recycling processes. Furthermore, it's essential to note that while we mention the requirement concerning "hazardous substances," the precise definition and regulations regarding these substances will be delineated in a separate rulebook focusing specifically on material consumption and usage. This approach ensures comprehensive coverage of all pertinent aspects while maintaining clarity and specificity within each regulatory framework. Furthermore, efforts should focus on facilitating the identification and isolation of valuable materials, thereby increasing the economic benefit of recycling, and consequently enhancing the recovery rate of these materials. Moreover, it is imperative to prioritize the improvement of recyclers' safety measures to ensure operations are conducted securely and responsibly.

Intermediate requirements	Materially equivalent to
Attributes from repair and reuse indicator apply.	**See chapter 3.4.2**
1. Ease and quality of recycling as expressed through: 1.1. Use of easily recyclable materials 1.2. Safe, easy, and non-destructive access to recyclable components and materials or components and materials containing hazardous substances 1.3. Material composition and homogeneity 1.4. Possibility for high-purity sorting	**ESPR Annex 1**
2. Recycling efficiency, safety, and economic benefits 2.1. Improve the ability for recyclers to identify and isolate hazardous materials, facilitating their proper recovery 2.2. Improve the ability to avoid contaminating materials with other substances, which would otherwise downgrade the quality of recycled materials 2.3. Facilitate the identification and isolation of valuable materials, increasing the economic benefit of recycling and therefore the recovery rate of these materials 2.4. Improving the ability of recyclers to operate safely	**JRC:** Analysis of sustainability criteria for lithium-ion batteries including related standards and regulations (Chapter 3.6)

Leading practices

In addition to fulfilling the fundamental prerequisites, we strongly advocate for the integration of Leading practices aimed at augmenting the recyclability of battery components. Moreover, we suggest that due consideration be given to whether the disassembly instructions encompass the individual cell level of the battery, as this plays a crucial role in facilitating efficient recycling processes.

Leading practices	Materially equivalent to
Attributes from repair and reuse indicator apply.	**See chapter 3.4.2**

Recommendations & Guidance

Assessing the recyclability of battery components is paramount in the comprehensive management of electric vehicle batteries, contributing significantly to environmental sustainability. Emphasizing repair, disassembly, and options for reuse not only extends the lifespan of batteries but also aligns with circular economy principles, thereby mitigating the overall environmental footprint associated with battery production. Incorporating considerations for repair, reuse, and disassembly during the design phase enables companies to ensure that each component of their products can be readily disassembled, facilitating reuse and recycling processes. This approach ultimately diminishes dependence on new raw materials, fostering a more sustainable battery ecosystem. While these requirements are crucial for current battery recycling practices, it's essential to recognize the dynamic nature of technology and recycling methodologies. As advancements in recycling technology continue to emerge, future considerations may necessitate updates to existing standards and requirements. Therefore, ongoing research and development are vital to staying abreast of evolving Leading practices and ensuring that battery recycling efforts remain aligned with the latest technological capabilities and environmental objectives. By remaining adaptable and responsive to emerging innovations, industries can enhance their sustainability efforts and optimize the recyclability of battery components for future generations.

3.4.4 Existence and availability of circular design information

Introduction

In the pursuit of cultivating sustainability and responsibility in battery production and utilization, a crucial aspect lies in ensuring the presence and accessibility of circular design information. This chapter offers a thorough exploration into the significance of having transparent and readily available information regarding circular design practices, emphasizing its pivotal role within the broader context of advancing sustainable battery development. It urges manufacturers and stakeholders to adopt practices prioritizing the existence and availability of circular design information, fostering transparency and accountability. By doing so, the industry can propel sustainable product development, ultimately supporting a more resource-efficient and environmentally conscious paradigm in the dynamic landscape of electric vehicles and their associated technologies. In conclusion, it is crucial to underscore that the requirements of the indicator of "Existence and availability of circular design information" are not isolated but intricately linked to the other three indicators discussed in this comprehensive exploration *(see chapter 3.4.1, 3.4.2 and 3.4.3)*. The guidelines for circular design information provision, encapsulated within this indicator, are interwoven with those pertaining to durability, reliability, repairability, reusability, and recyclability. They collectively form a cohesive strategy, emphasizing that these requirements are interdependent and synergistically contribute to the overarching goal of sustainable product development.

Requirements

In today's sustainable business landscape, transparency and accessibility of circular design information are crucial. Companies recognize the need to share this information and are adopting structured frameworks to meet specific requirements. These frameworks aim to provide a thorough understanding of circular design information, incorporating Foundational Requirements, Intermediate Requirements, and Leading practices. By following these guidelines, organizations not only fulfil regulatory standards but also demonstrate their dedication to transparent and accessible circular design. In an era focused on accountability and transparency, meeting these requirements is vital for businesses committed to environmentally conscious products, shaping a sustainable future.

Foundational requirements

The EU Battery Regulation mandates Foundational requirements for circular design information availability in battery components. Organizations must prioritize easy access to data on durability, reliability, and additional manufacturing information. Clear conditions for accessing sources of replacement spares for repairability and reusability are essential. The primary requirements include ensuring access to safety instructions for the handling of waste batteries.

Foundational requirements	Materially equivalent to
1. Durability and reliability: 1.1. A battery passport shall include the following information relating to the battery model, which shall be accessible to the public: - Period for which the commercial warranty for the calendar life applies 1.2. Parameters for determining the expected lifetime of stationary battery energy storage systems and LMT batteries: - The date of manufacture of the battery and, where appropriate, the date of putting into service	**EU Battery Regulation** • Annex XIII (1m) • Annex VII Part B(1) **Battery Passport Content Guidance (based on EU Battery Regulation)** Chapter 6.7.3
2. Repairability and reusability: 2.1. Information on the label of a battery shall comprise the following information regarding the battery - Usable extinguishing agent 2.2. In order to facilitate communication between economic operators, market surveillance authorities and end-users, economic operators should, as part of their contact details, indicate a postal and, if available, email and website address	**EU Battery Regulation** • Annex VI Part A(9) • Recital 69
3. Recyclability 3.1. Information on prevention and management of waste batteries: - The necessary safety instructions to handle waste batteries, including in relation to the risks associated with, and the handling of, batteries containing lithium	**EU Battery Regulation** • Article 74 (d) **Battery Passport Content Guidance (based on EU Battery Regulation)** • Chapter 6.6.1

Intermediate requirements

Expanding beyond the standard requirements, it is necessary to provide additional reporting to meet the standards for circular design information availability. This entails improving the ability for stakeholders to access crucial data for enhanced durability and reliability. Moreover, intermediate requirements should include comprehensive reporting on repairability and reusability, such as providing part numbers for components and detailed contact information for spare parts sources, including postal address, email address, and web address. Additionally, there are requirements in place to assess the information availability to improve the ease of repair, maintenance, and reuse, ensuring a holistic approach to circular design principles. A classification of information availability by comprehensiveness and target group is vital to ensure accessibility and usability.

Intermediate requirements	Materially equivalent to
4. Further Information on Repairability and reusability: 4.1. Postal address of sources for spare parts 4.2. E-mail address of sources for spare parts 4.3. Web address of sources for spare parts	**Battery Passport Content Guidance (based on EU Battery Regulation)** • Chapter 6.6.1
5. Ease of repair and maintenance as expressed through: 5.1. Conditions for access to product data 5.2. Conditions for access to or use of hardware and software needed	**ESPR Annex 1 (b) (c)**
6. Ease of upgrading, re-use, remanufacturing, and refurbishment as expressed through: 6.1. Conditions for access to product data 6.2. Conditions for access to or use of hardware and software needed 6.3. Conditions of access to test protocols or not commonly available testing equipment 6.4. Conditions for access to or use of technologies protected by intellectual property rights	
7. Classification availability 7.1. Classification of information availability by comprehensiveness (Comprehensive information available / Basic information available / No information available) 7.2. Classification of information availability by target groups (Publicly available / Available to independent repair service providers / Available to manufacturer-authorized repair service providers / Available to the manufacturer only)	**EN 45554:2020 (6 & 7)**
Recyclability	

Leading practices

In addition to fulfilling the fundamental prerequisites, we strongly advocate for the integration of Leading practices. To ensure comprehensive battery management, it is imperative to prioritize the existence and accessibility of software support and updates, particularly for critical systems such as the Battery Management System (BMS). Regular updates not only enhance performance but also address safety concerns and optimize efficiency over the battery's lifespan. Furthermore, alongside technical specifications, the provision of a Material Safety Data Sheet (MSDS) detailing the composition of substances within the battery is paramount. Understanding the chemical makeup facilitates informed handling, disposal, and recycling procedures, promoting both safety and environmental responsibility.

Leading practices	Materially equivalent to
8. Durability and reliability: 8.1. Existence and availability of software support and updates (e.g., for BMS)	**Expert input**
Repairability and reusability: **n/a**	
9. Recyclability 9.1. Provision of a MSDS (Material Safety Data Sheet) of the substances present in the battery	**Expert input**

Recommendations & Guidance

Providing circular design information along the battery value chain is crucial for fostering sustainability and reducing environmental impact. This information facilitates durability and reliability, repair and reuse, and recyclability though extending battery lifespan and minimizing the need for new materials. By promoting transparency and accountability, it supports circular economy principles and encourages innovation in battery design and recycling processes. Overall, integrating circular design information throughout the value chain promotes resource efficiency and minimizes waste, contributing to a more sustainable battery ecosystem.

3.5 Data quality and reporting

Companies may report against the battery passport in one or more of the following ways:

- Where they are assured or audited against a regulation or standard equivalent to the battery passport requirement, provide proof of audit, assurance, or other verification
- Provide original documentation pertaining to company policies, practices, results, in line with guidance derived from materially existing standards

Please refer to the Battery Passport data governance rulebook for additional information on data verification in these two scenarios.

Companies will report on the circular design rulebook via the associated reporting templates. Please see Annex A for further guidance.

4 Final remarks and outlook

The rulebooks developed by the Global Battery Alliance (GBA) serve as a cornerstone for establishing globally harmonized standards aimed at enhancing sustainability across the battery value chain. Through a rigorous collaborative process overseen by GBA's Working Groups, these rulebooks encapsulate high-level principles and operating rules essential for tracking indicators and requirements within the battery passport. The comprehensive development process, inclusive of extensive stakeholder engagement and expert consultation, ensures relevance and robustness in addressing stakeholder expectations.

Central to these rulebooks is the integration of circular design principles, which emphasize minimizing environmental impact throughout the battery lifecycle while upholding product functionality and quality. Circular design indicators focus on durability, repairability, reusability, and recyclability, reflecting a holistic approach towards environmental stewardship and resource efficiency. By incorporating circular design considerations from the initial design stage to end-of-life management, companies can mitigate ecological footprints and promote sustainable practices across the battery value chain. Reporting on reliability and durability emerges as a pivotal aspect, offering tangible benefits such as improved energy efficiency, consumer confidence, and regulatory compliance. Emphasizing battery durability not only bolsters sustainability but also underpins advancements in the electric vehicle sector, fostering resilience and innovation. Moreover, prioritizing repair, disassembly, and options for reuse underscores the importance of circular economy principles in extending battery lifespan and reducing environmental impact. By enabling easy disassembly and facilitating reuse and recycling processes, companies can minimize reliance on new raw materials, fostering a more sustainable ecosystem. Assessing the recyclability of battery components complements efforts towards comprehensive battery management, further reducing environmental footprint and promoting circularity. Integrating circular design information throughout the value chain not only enhances transparency and accountability but also fuels innovation and efficiency, ultimately driving towards a more sustainable battery ecosystem.

In essence, the convergence of globally harmonized rulebooks and circular design principles represents a significant stride towards advancing sustainability within the battery industry. By adhering to these principles and embracing collaborative action, stakeholders can collectively propel towards a future where environmental stewardship and economic prosperity go hand in hand.

Looking forward, the GBA is committed to adapting to evolving global standards in circular design and environmental stewardship, particularly in the context of circular design in the battery supply chain. The GBA will continue to collaborate with international bodies and stakeholders to refine the compliance baseline, integrating new legislative developments and technological advancements. This approach is aimed at not only achieving compliance but also setting a benchmark for sustainable practices in the battery industry.

5 Glossary

Term	Definition
Recyclability	Recyclability of batteries refers to the capability of batteries to be processed through recycling methods to recover valuable materials, reduce environmental impact, and reintroduce these materials into the manufacturing cycle. The goal is to minimize waste, maximize resource efficiency, and reduce the ecological footprint associated with battery production and disposal.[17] According to the EU Battery Regulation, this will in the future include recyclability requirements like for example: - **Material Recovery Targets (Article 58):** The regulation sets specific targets for the recovery of materials from waste batteries. For instance, by 2030, recycling processes must achieve recovery rates of at least 95% for cobalt, copper, lead, and nickel, and 70% for lithium. These targets are designed to ensure that valuable materials are effectively recovered and reused, reducing the environmental impact of battery disposal. - **Recycling Efficiency (Article 57):** The regulation mandates specific recycling efficiency rates for different types of batteries. By 2025, recycling processes for lead-acid batteries must achieve an efficiency rate of 75%, and for lithium-based batteries, 50%.
Vehicle-Category M1	1 (a) Category M consists of motor vehicles designed and constructed primarily for the carriage of passengers and their luggage, divided into: (i) Category M1: motor vehicles with not more than eight seating positions in addition to the driver's seating position and without space for standing passengers, regardless of whether the number of seating positions is restricted to the driver's seating position;[18]
Vehicle-Category N1	1 (b) b) Category N consists of motor vehicles designed and constructed primarily for the carriage of goods, divided into: (i) Category N1: motor vehicles with a maximum mass not exceeding 3,5 tonnes;[19]

[17] Sources: I) REGULATION (EU) 2023/1542 (EU Battery Regulation). Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1542
II) WEEE Europe: The New EU Battery Regulation. Retrieved from: https://www.weee-europe.com/en/new-battery-regulation-2023/
III) EUR-Lex: Regulation (EU) 2023/1542 (EUR-Lex). Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1542
[18] REGULATION (EU) 2018/858, Article 4. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0858
[19] REGULATION (EU) 2018/858, Article 4: Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0858

Annex 1 Reporting template

Please refer to the Annexed Excel workbook for the reporting template and associated guidance for reporting for each indicator.