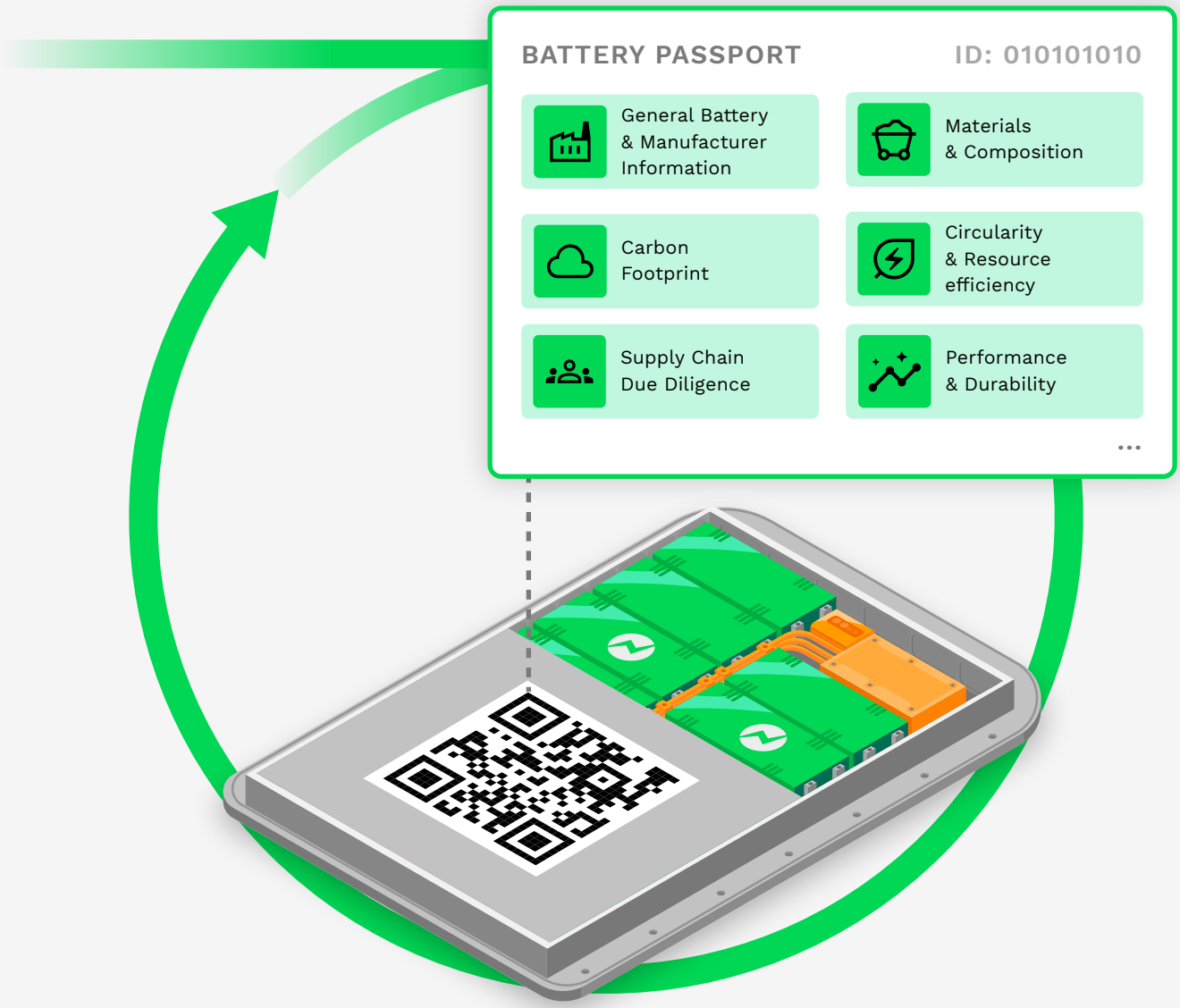
Battery Pass



Battery Passport Content Guidance

Achieving compliance with the EU Battery Regulation and increasing sustainability and circularity.

Version 1.0 / April 2023

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

The Battery Pass consortium

CONSORTIUM LEAD

SYSTEMIQ

CONSORTIUM PARTNERS

acatech · Audi · BASF We create chemistry · BMW GROUP · Circulor · FIWARE FOUNDATION · Fraunhofer IPK · TWAICE · umicore · VDE RENEWABLES *under subcontract

ASSOCIATED PARTNERS

Global Battery Alliance · GS1 in Europe · Mercedes-Benz · RWE · SAP

Co-funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), the Battery Pass consortium project aims to advance the implementation of the battery passport based on requirements of the EU Battery Regulation and beyond. Led by system change company Systemiq GmbH, the consortium comprises eleven partners and a broad network of associated and supporting organisations to draft content and technical standards for a digital battery passport, demonstrate them in a pilot application and assess its potential value.

DISCLAIMER

This document (the “Document”) is for informational purposes only and is being made available to you by the Battery Pass consortium.

This Document is published by the Battery Pass consortium and contains information that has been or may have been provided by a number of sources. The findings, interpretations and conclusions expressed herein are a result of a collaborative process facilitated and endorsed by the Battery Pass consortium. The Battery Pass consortium partners (the partners as set out on the following page of this Document) endorse the overall project approach and findings and the Battery Pass consortium has made efforts to accurately capture stakeholder positions set out by organisations (including supporting partners and further experts), although the results may not necessarily represent the views of all individuals or the organisations they represent. The Battery Pass consortium has not separately verified the information provided from outside sources and cannot take responsibility if any of these statements misrepresent a stakeholder position or if positions evolve over time.

To the extent permitted by law, nothing contained herein shall constitute any representation or warranty and no responsibility or liability is accepted by the Battery Pass consortium as to the accuracy or completeness of any information supplied herein. Recipients of this Document are advised to perform independent verification of information and conduct their own analysis in relation to any of the material set out.

The statements contained herein are made as at the date of the Document. The Battery Pass consortium or any member, employee, counsel, offer, director, representative, agent or affiliate of the Battery Pass consortium does not have any obligation to update or otherwise revise any statements reflecting circumstances arising after the date of this Document.

This Document shall not be treated as tax, regulatory, accounting, legal, investment or any other advice in relation to the recipient of this information and this information should not and cannot be relied upon as such.

If you are in any doubt about the potential purpose to which this communication relates you should consult an authorised person who specialises in advising on business to which it relates.

Copyright © 2023 Systemiq (for and on behalf of the Battery Pass Consortium). This work is licensed under a Creative Commons License Attribution-NonCommercial 4.0 International (CC BY-NC 4.0). Readers may reproduce material for their own publications, as long as it is not sold commercially and is given appropriate attribution.

Table of contents

Preface

Batteries are a pivotal element for sustainable and climate-neutral transport and the energy transition in general. They power electric cars, trucks and other means of transport and they can store the energy intermittently supplied from renewable sources. We cannot decarbonise our societies without batteries. In this context, the German Federal Ministry for Economic Affairs and Climate Action (BMWK) is pursuing two goals:

Firstly, to secure the supply of batteries for Europe in a fast-growing global market. To this end, the entire value chain is taken into account. This entails the localisation of the major part of this value chain (upstream including materials refining in Europe), based on European knowhow including the corresponding machinery. As regards the needed raw materials, we in parallel support the ramp-up of domestic mining in Europe, the establishment of large-scale recycling as well as sourcing the indispensable raw material imports from like-minded countries in a sustainable manner.

Secondly, to ensure that the batteries offered on the EU market comply with the highest – that means world-leading – standards with respect to climate footprint, social and environmental sustainability. This is necessary to comply with our European values. It is further needed to make use of the full decarbonisation potential of battery-powered applications, but there is also an industrial policy angle to it: We strive to establish a European battery industry that is leading globally in terms of environmental and social standards.

To verifiably and credibly ensure that batteries comply with these standards (carbon and environmental footprint, social responsibility, repairability, recyclability, etc.), which now have a regulatory foundation in the EU Battery Regulation, we need a transparency instrument. The battery passport shall deliver just that – a digital record that documents all conditions under which a battery has been produced, logs its relevant usage history and delivers crucial information for repair, reuse and recycling. The battery passport is a striking embodiment of the (digital and green) “twin transition”: it utilises the digital world to facilitate the decarbonisation of the real world. And it rightfully is a key pilot application of digital product passports in general, to be rolled out in other sectors in the future, thus increasing its significance.

The “Battery Pass” project, joining partners from industry and academia along the value chain and funded by BMWK with €8.2 million, develops standards for a battery passport and implements those in a demonstrator. It is the first large-scale project actually tackling a pilot implementation of the Battery Pass comprising all key elements – technical and content standards as well as software implementation and impact evaluation. The project intends to deliver a workable exhibit of how a real-world battery passport will look and work. Its output will focus on the requirements of the EU Battery Regulation but have in mind also the interoperability with other markets.

The document presented here is a major milestone in the 3-year journey of the Battery Pass project. It provides businesses and other actors of the battery value chain with a first comprehensive picture of the content requirements of the upcoming battery passport in Europe and beyond. It is thus an important contribution towards the EU process, detailing the operative elements of the passport mandated in the EU Battery Regulation, as well as towards a smooth and quick implementation of the passport in business reality.

Dr. Tim Schulze, Policy Officer, Unit IV A 6, Federal Ministry for Economic Affairs and Climate Action (BMWK)

Statements

"The work of Battery Pass is a prime example of multi-stakeholder contribution to the European agenda of Digital Product Passports – DPP. Its Content Guidance is the most comprehensive interpretation of the Battery Regulation so far. Not only will it be an asset to all that develop battery passports, but it also gives timely counsel to the regulators how to further shape DPP to advance a more digital, circular European economy."

Janez Potočnik, Co-Chair of the International Resource Panel, Partner Systemiq

---

"acatech is delighted to see the multi-stakeholder process and passionate work of the Battery Pass consortium reap its first rewards with the publication of this Content Guidance. It makes an important contribution to shaping digital product passports (DPP) as part of the emerging European digital ecosystem. With the battery passport at the forefront of DPP implementation, the consortium's comprehensive description of the understanding and content of the battery passport benefits DPP stakeholders of all colors. Enabling trusted data sharing, DPPs will be an important tool for providing transparency and promoting a sustainable and circular economy."

Prof. Dr.-Ing. Thomas Weber, President, acatech – National Academy of Science and Engineering e.V.

"At the Global Battery Alliance (GBA), the world's largest multi-stakeholder partnership to scale sustainable, responsible and circular battery value chains by 2030, we are thrilled to see the progress made by the Battery Pass consortium. The Content Guidance lays a solid foundation for meeting the requirements of the EU Battery Regulation and we have appreciated the productive collaboration, notably building together on the GBA's Greenhouse Gas Rulebook to cover Distribution and End of life and recycling phases to accurately establish the battery carbon footprint and reduce emissions across the value chain. Complementary to the GBA's efforts to establish globally harmonised sustainability expectations for battery value chains, we look forward to continuing to collaborate with the Battery Pass consortium."

Inga Petersen, Executive Director, Global Battery Alliance (GBA)

"Congratulations to the Battery Pass team on the publication of their Content Guidance report for the battery passport. I hereby salute the team's efforts to openness and collaboration. I am certain that by sharing their approaches and methodologies, they will inspire the development of passports in other sectors. I expect this report will be a crucial stepping-stone in the development of future digital product passports for batteries."

Carolynn Bernier PhD, CIRPASS Coordinator, Research Engineer at French Alternative Energies and Atomic Energy Commission (CEA)

“DIN congratulates the Battery Pass consortium on the publication of the Content Guidance report. Definitely one of the central milestones in the European development of the product passport system, also beyond the battery passport itself. Last but not least, due to the transparent development and the holistic view of the process, the activities of the project also provide an excellent basis for contributing content to standardisation and bringing it there together with other national and international activities in a harmonised framework.”

Nico Kimpel, Project Manager, German Institute for Standardization (DIN) & **Benjamin Helfritz**, Head of Quality in Transformation, German Institute for Standardization (DIN)

“Considering the many emerging projects around the battery passport, it is of utmost importance to ensure a general concept is established fitting the needs of all applications and the entire related value chains globally. Furthermore, it is a pre-requisite that well-established tools, methods and processes will find consideration to ensure compatibility with existing data as well as avoiding unnecessary cost. As an example, the International Material Data System (IMDS) has been providing passport-related data for each component of a vehicle from the material manufacturer up to the automotive OEM for more than 25 years. We therefore appreciate the Battery Pass approach of ensuring compliance with the Battery Regulation, their efforts around harmonization with other initiatives such as CIRPASS, Global Battery Alliance and Catena-X, and the suggestions made around building on and leveraging existing systems.”

Antoine Mackie, Environmental Policy Manager, European Automobile Manufacturers’ Association (ACEA)

"The German automotive industry is clearly committed to sustainable mobility and thus to electromobility. However, it is more than just changing the drive: the entire product must meet current and future sustainability requirements – from the selection of raw material sources and the reduction of the CO2 footprint to the creation of repair, reuse and recycling concepts. As a central component for the electric vehicle, special attention is paid to the high-voltage storage unit. Digital tools such as the Battery Passport create the necessary transparency in this regard. The Battery Passport Content Guidance contributes significantly towards establishing digital product passports for sustainable product life cycles – not only for high-voltage storage units."

Hildegard Müller, President, German Association of the Automotive Industry (VDA)

Acknowledgements

All sorted alphabetically by organisations and individuals

Authors of this document coordinated by Systemiq GmbH:

- David Aschermayr, acatech – National Academy of Science and Engineering e.V.
- Dr. Susanne Kadner, previously acatech – National Academy of Science and Engineering e.V.
- Dr. Lisa Risch, acatech – National Academy of Science and Engineering e.V.
- Dr. Johannes Simböck, acatech – National Academy of Science and Engineering e.V.
- Anna Sophia Braunfels, Systemiq GmbH
- Ben Dixon, Systemiq Ltd
- Sophie Herrmann, Systemiq GmbH
- Joana Kleine Jäger, Systemiq GmbH
- Dr. Carl Kühl, Systemiq GmbH
- Stephanie Schenk, Systemiq GmbH
- Achim Teuber, Systemiq GmbH
- Tilmann Vahle, Systemiq GmbH

Consortium partner working group members (excl. the authors):

- Sven Geppert, acatech – National Academy of Science and Engineering e.V.
- Mira Jessenberger, acatech – National Academy of Science and Engineering e.V.
- Josef Schön, Audi AG
- Dr. Torsten Freund, BASF SE / Global Battery Alliance
- Hao Liu, BASF SE
- Dr. Bodo Müller, BASF SE
- Maria-Fernanda Sciulli, BASF SE
- Diana Bartaune, BMW AG
- Claudia Becker, BMW AG
- Dr. Othman Mrani, BMW AG
- Dirk Richter, BMW AG
- Dr. André Schmitz, BMW AG
- Niko D'Agostino, Circulor GmbH
- Ophelia Otto, Circulor GmbH
- Coenraad van Deventer, Circulor GmbH
- Gernot Boege, FIWARE Foundation e.V.
- Jason Fox, FIWARE Foundation e.V.
- Karen Vega, FIWARE Foundation e.V.
- Patrick Gering, Fraunhofer IPK
- Thomas Knothe, Fraunhofer IPK
- Konstantin Neumann, Fraunhofer IPK
- Johannes Drielsma, Global Battery Alliance / Drielsma Resources Europe
- Estelle Levin-Nelly, Global Battery Alliance / Levin Sources
- Matthias Ballweg, Systemiq GmbH
- Christoph Engel, previously Systemiq GmbH
- Anna Schwarzmann, previously Systemiq GmbH
- Jelto Folkerts, TWAICE Technologies GmbH
- Matthias Simolka, TWAICE Technologies GmbH
- Barbara Cooreman, Umicore AG & Co KG

- Clarissa Faulstich, Umicore AG & Co KG
- Wouter Ghyoot, Umicore AG & Co KG
- Christian Hagelüken, Umicore AG & Co KG
- Olivier Hutin, Umicore AG & Co KG
- Sven Jantzen, Umicore AG & Co KG
- Benedicte Robertz, Umicore AG & Co KG
- Gert van Hoof, Umicore AG & Co KG
- Bogislav Wilmers-Rauschert, Umicore AG & Co KG
- Arne Grünewald, VDE Renewables GmbH
- Patrick Heininger, VDE Renewables GmbH

Advisory Council:

- Christian Eckert, ZVEI e.V.
- Dr. Jens Gayko, VDE e.V.
- Thomas Götz, Wuppertal Institut für Klima, Umwelt, Energie gGmbH
- Benjamin Helfritz, DIN e.V.
- Lars Johanssen, BMUV / GIZ GmbH
- Dr. Michael Krausa, KLiB e.V.
- Julia Poliscanova, European Federation for Transport & Environment AISBL
- Ernst Stöckl-Pukall, BMWK
- Ilka van Dalwigk, European Battery Alliance (EBA) / EIT InnoEnergy SE

Associated and supporting partners:

- Dr. Mark Heilig, Alfred Kärcher SE & Co. KG
- Dr. Simon Engelke, Battery Associates Powering Battery Innovation LTD
- Dr. Núria González-García, betteries AMPS GmbH
- Dr. Rainer Hönig, betteries AMPS GmbH
- Mario Beier, DIN e.V.
- Benjamin Helfritz, DIN e.V.
- Nico Kimpel, DIN e.V.
- Dr. Kerstin Sann-Ferro, DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik
- Dr.-Ing. Lukas Förster, DMT GmbH & Co. KG
- Inga Petersen, Global Battery Alliance
- Cem Saydam, GS1 in Europe ASBL
- Sabine Kläser, GS1 Germany GmbH
- Philipp Tho Pesch, Henkel AG & Co. KGaA
- Dipl. Ing. Andreas Guggemos, Hilti Entwicklungsgesellschaft mbH
- Steffen Jahn, Honda R&D Europe (Deutschland) GmbH
- Manfred Kerner, Honda R&D Europe (Deutschland) GmbH
- Sven Doleski, iPoint-systems GmbH
- Nicole Helm, Jungheinrich Norderstedt AG & Co. KG
- Clemens Albrecht, Jungheinrich Norderstedt AG & Co. KG
- Philipp Brunotte, LiBCycle GmbH
- Aman Chitkara, Li-Cycle Corp.
- Tobi Adesanmi, Li-Cycle Corp.
- Michael Bader, Mercedes-Benz AG
- Stina Torjesen, Morrow Batteries ASA
- Ketan Vaidya, Northvolt AB
- Armando Licon, Rock Tech Lithium Inc.
- Dr. Lukas Ibing, RWE Generation SE

- Kati Kongi, RWE Battery Solutions GmbH
- Pauline Ewinger, sonnen GmbH
- Dipl.-Ing. Claudius Jehle, volytica diagnostics GmbH

Further experts:

- Dr.-Ing. Kai Sauerzapfe, Alumina Systems GmbH
- Helge Erkelenz, BASF SE
- Erik Jansen, BASF SE
- Eva Koch, BASF SE
- Ingolf Kuehn, BASF SE
- Stephanie Mueller-Kuche, BASF SE
- Henning Schwabe, BASF SE
- Frank Treffer, BASF SE
- Nikki Kitson, Circulor Ltd
- Lin Guang Liang (Gilbert), Contemporary Amperex Technology Co., Limited
- Carolynn Bernier, Commissariat à l'énergie atomique et aux énergies alternatives (CEA)
- Tom Fairlie, Cobalt Institute
- Susannah McLaren, Cobalt Institute
- Leopold Peiseler, ETH Zurich
- P.Eng M.Eng Eliza Ngai, Natural Resources Canada
- Dr.-Ing. Rüdiger Meyer, Phoenix Contact GmbH & Co. KG
- Nils Steinbrecher, TES Sustainable Technology Solutions GmbH
- Annika Ahlberg Tidblad, Volvo Car Corporation

Design and editorial:

- Design: Giacomo de Panfilis, FIWARE Foundation e.V.
- Proofread: Cassandra Rigg
- Formatting: Leon Renner

List of abbreviations

Abbreviation	Definition
BMS	Battery Management System
BOM	Bill of Materials
CAS Number	Chemical Abstracts Service Number (unique identifier for substances)
CEF	Connecting Europe Facility
CEID	Circular Economy Initiative Germany
CF	Carbon Footprint
CLP Regulation	Classification, labelling and packaging Regulation
CFF	Circular Footprint Formula
CoC	Chain of Custody
C-rate	Defined as ratio of (dis-)charge current (in A) to the battery capacity (Ah). A C-rate of 1 h-1 (or “1C”) is the (dis-)charge of a battery in one hour. Larger and smaller values refer to faster or slower (dis-)charge, respectively.
CSRD	EU Corporate Sustainability Reporting Directive
DG CONNECT	Directorate-General for International Partnerships by the European Commission
DG GROW	Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs by the European Commission
DG TAXUD	Directorate-General for Taxation and Customs Union by the European Commission
DPP	Digital Product Passport
ECHA	European Chemicals Agency
EC Number	European Community number (unique seven-digit identifier for enzymes)
EES	Electronic Exchange System
EOL	End-of-life
ESPR	Ecodesign for Sustainable Products Regulation

EU CSDDD	EU Corporate Sustainability Due Diligence Directive
EU	European Union
EV	Electric Vehicle
GADSL	Global Automotive Declarable Substance List
GBA	Global Battery Alliance
GerSCA	German Supply Chain Due Diligence Act
GHG	Greenhouse gases
GTR	Global Technical Regulation
ICT	Information and Communication Technology
IEC	International Electrochemical Commission
IMDS	International Material Data System
IUPAC	International Union of Pure and Applied Chemistry
LMT	Light Means of Transport
OECD	Organisation for Economic Co-operation and Development
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
SBESS	Stationary battery energy storage system
SCIP	Substances of Concern In articles as such or in complex objects (Products)
SDS	Safety Data Sheet
SoH	State of Health
SoC	State of Charge
SOCE	State of certified energy
SVHC	Substance of very high concern
UBE	Usable battery energy
UNECE	United Nations Economic Commission for Europe
VDA	Verband der Automobilindustrie (German Association of the Automotive Industry)

List of figures

List of tables

Terminology

The Battery Pass Content Guidance uses different terms to differentiate between regulatory requirements, recommendations, and permissible or allowable options:

Term	Expressed intention
Shall (not)	Requirement as per the Battery Regulation or other relevant legislation
Should (not)	Recommendation made by the Battery Pass consortium
May (not)	Option that is permissible
Mandatory	Requirement as per EU Battery Regulation or other relevant legislation (see “shall”)
Voluntary	Recommendation made by the Battery Pass consortium (see “should”)

1 Introduction

This document represents the first version of a comprehensive guidance of the Battery Pass consortium on how to achieve compliance with the battery passport content requirements as mandated by the new EU Battery Regulation. It is intended as a foundation for further refinement, expansion, and standardisation by the Battery Pass consortium within its three-year project horizon and for other organisations to build on the results.

1.1 Context

Batteries are key to a sustainable transition to low-carbon mobility and renewable energy. Circular and sustainable management of the large expected volumes of traction and stationary storage batteries can contribute significantly to achieving the Paris climate goals, decoupling resource use and prosperity, and securing resource sovereignty. Making the transition sustainable demands a systemic approach that enables responsible material sourcing, efficient production, as well as efficient and effective second-life and end-of-life applications and processes.

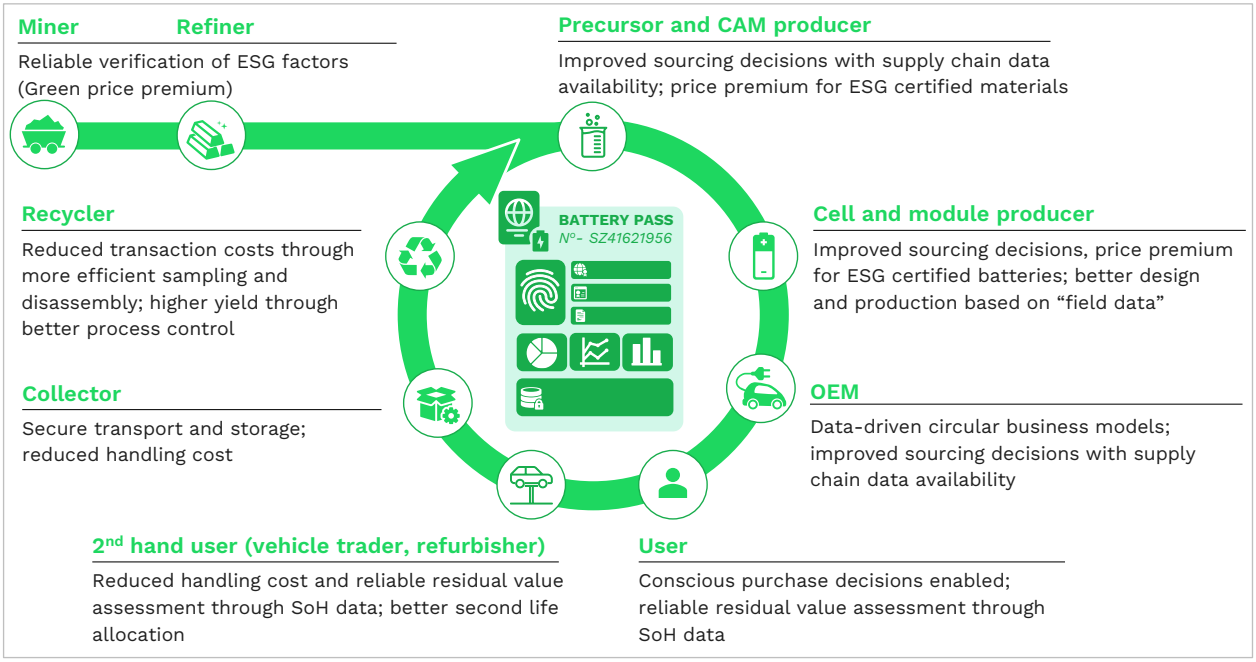
In March 2022, the EU launched the Sustainable Products Initiative (SPI), which included the Proposal for Ecodesign for Sustainable Products Regulation (ESPR). This regulation provides an overarching policy framework for the wide-scale introduction of digital product passports across different product categories as enablers for the transition to a circular economy (CE). Further regulations exist, which include elements of traceability, chain of custody and data sharing requirements, and which all form part of the European Union's Digital Transition and Data Spaces plans designed to harmonise and standardise access to data.

Even before the ESPR was proposed, the European Commission laid the foundation of a systemic approach for a circular and sustainable management of batteries with a new Battery Regulation. This regulation will replace the previous Battery Directive 2066/66/EC and amend regulation 2019/1020. The new EU Battery Regulation is ground-breaking as it is the first product legislation that encompasses the entire life cycle. Its comprehensive requirements include e.g., transparency on carbon footprint including performance classes and maximum threshold values, metal specific recycling rates, recycled content quotas, corporate supply chain due diligence obligations, minimum requirements for durability and performance, as well as the introduction of a digital battery passport – the first of the aforementioned digital product passports (DPP) at European level. After a provisional political agreement between the European Parliament and the Council was reached in December 2022, the Battery Regulation will enter into force in the coming months.

The digital battery passport is detailed in *Article 65* of the EU Battery Regulation and will be mandatory for batteries in light means of transport (LMT), industrial batteries with a capacity above 2 kWh and electric vehicle batteries placed or put into service on the EU market. It will be required from 42 months after entry into force of the regulation (1). With the introduction of a digital battery passport, the European Commission aims to support the sustainable and circular management of batteries by requesting comprehensive data along the entire battery value chain to be documented and exchanged through a digital infrastructure. The information is meant to enable the design of production and value creation processes according to sustainable and circular principles, and support informed consumer decisions. Ultimately, the

life cycle of the entire battery system shall be extended as far as possible (towards a cascaded use) and the recycling of the raw materials, materials and components used should be promoted at the end of the life cycle. The improved data availability is also expected to reduce costs for circular business models along the batteries' life cycle. Furthermore, the battery passport supports the creation of transparent and more digitalised supply and end-of-life chains: the twin transition to a more sustainable and digital economy. Overall, by closing existing information asymmetries along the product life cycle, the battery passport can unlock major value to industry and society alike. With the battery passport, data becomes accessible to actors along the value cycle, based on which processes or costs can be improved and circular business models enabled (see Figure 1).

Figure 1: Overview on selected battery passport value creation examples along the value chain



1.2 The Battery Pass project

The German Federal Ministry for Economic Affairs and Climate Action (BMWK), recognising the strategic importance of this topic, supported the initiation and funding of the Battery Pass consortium, which aims to advance the implementation of the EU battery passport based on the EU Battery Regulation and beyond towards more circularity and sustainability. The consortium project evolved from the Circular Economy Initiative Germany (CEID) dating back to the year 2016, which identified levers for a circular management of traction batteries in its 2020 publication including, among others, the provision of battery data over the entire life cycle of the battery (2). Building on the CEID, the Battery Pass consortium was launched in April 2022. The consortium is led by system change company SYSTEMIQ GmbH and comprises eleven partners – global organisations from relevant industries, research institutions and academies as well as providers of digital services in open standards, battery analysis and tracking: acatech – National Academy of Science and Engineering, AUDI AG, BASF SE, BMW AG, Circulor GmbH, FIWARE Foundation e.V., Fraunhofer IPK, SYSTEMIQ GmbH, TWAICE Technologies GmbH, Umicore AG & Co KG, and VDE Renewables GmbH (under subcontract). Numerous associated partners complement the core partner group, most notably the Global Battery Alliance (GBA), GS1, Kompetenznetzwerk Lithium-Ionen-Batterien e.V. (KLiB), Mercedes Benz AG, RWE

Generation SE and SAP SE. In addition, the Battery Pass advisory council and a growing number of supporting partners ensure availability of further expertise as well as practicality of results. By closely aligning with existing initiatives (e.g., GBA, CIRPASS, Catena-X, BATRAW, BatWoMan) and integrating various perspectives, the impact of the results will be increased through commonly accepted multi-stakeholder views.

Over the course of the project, the consortium will develop a detailed perspective on content requirements for the battery passport, identify and compose necessary and evaluate existing technical standards for the data infrastructure, build a software and physical demonstrator, and qualitatively as well as quantitatively assess the passport's value for business, society, and environment alike (see Figure 2 and Figure 3). With its scope, the Battery Pass consortium is unique in being the first project approaching the topic covering all relevant aspects of a digital battery passport.

While the Battery Pass project mainly targets the European market, efforts are made for a global outreach and initial alignment. With recommendations and results being directed to both battery value chain participants (including international players active on the EU market) and European institutions, the project will provide the basis for the rapid development of a battery passport and support a smooth market implementation. It will ultimately underpin European efforts to become a leader in digitalisation of the battery supply chain, making a unique contribution to climate protection, social responsibility, energy and the circular economy. Since findings will have the potential to pave the way for other products and industries, the European Union will be supported in its ambition to enable digital product passports on a broad level. Furthermore, it will be supported in driving circular life cycle management of batteries, thus helping to achieve the goals of the EU's Fit for 55 strategy and the UN Global Goals.

Figure 2: Overview on Battery Pass consortium work packages and leading organisations

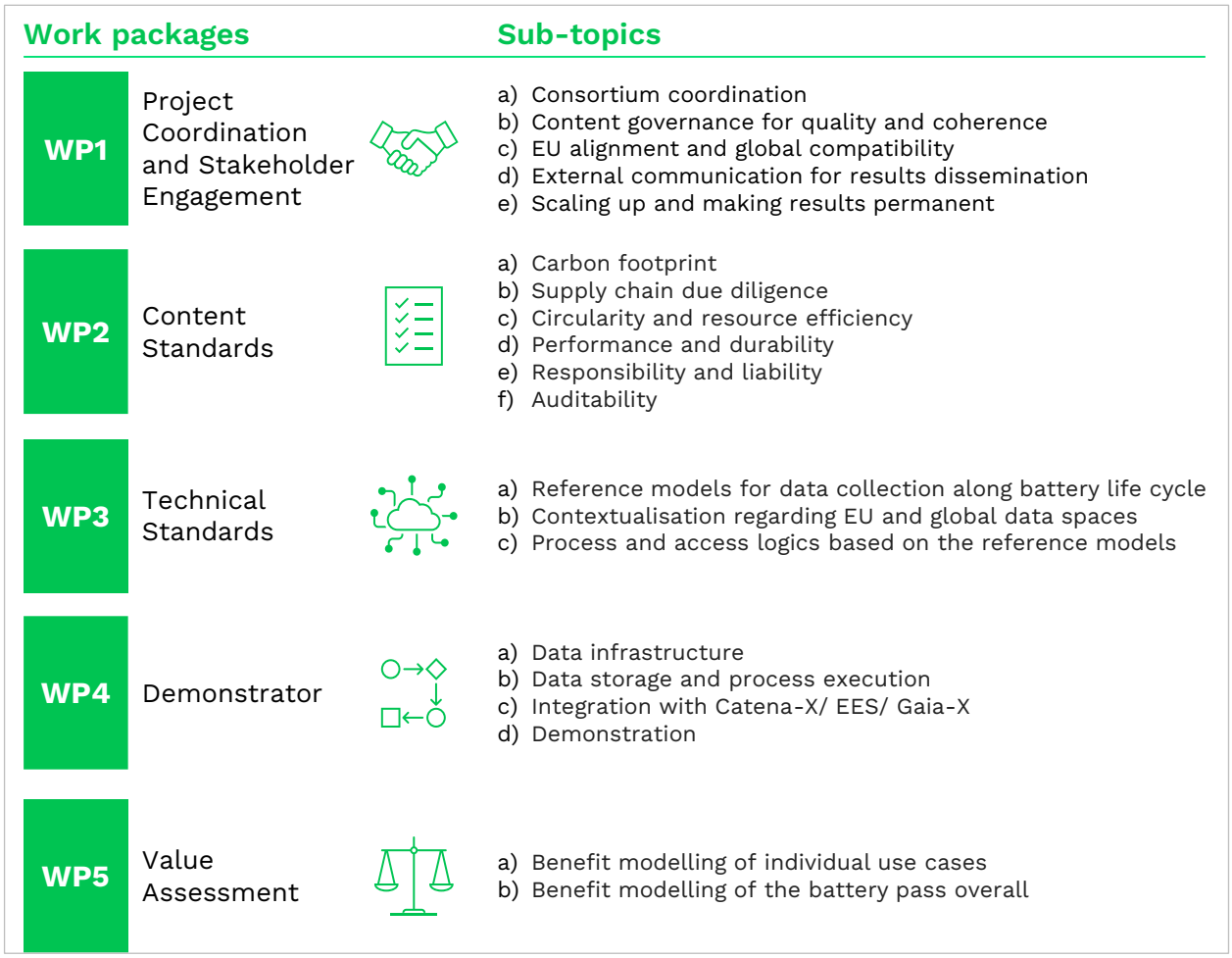
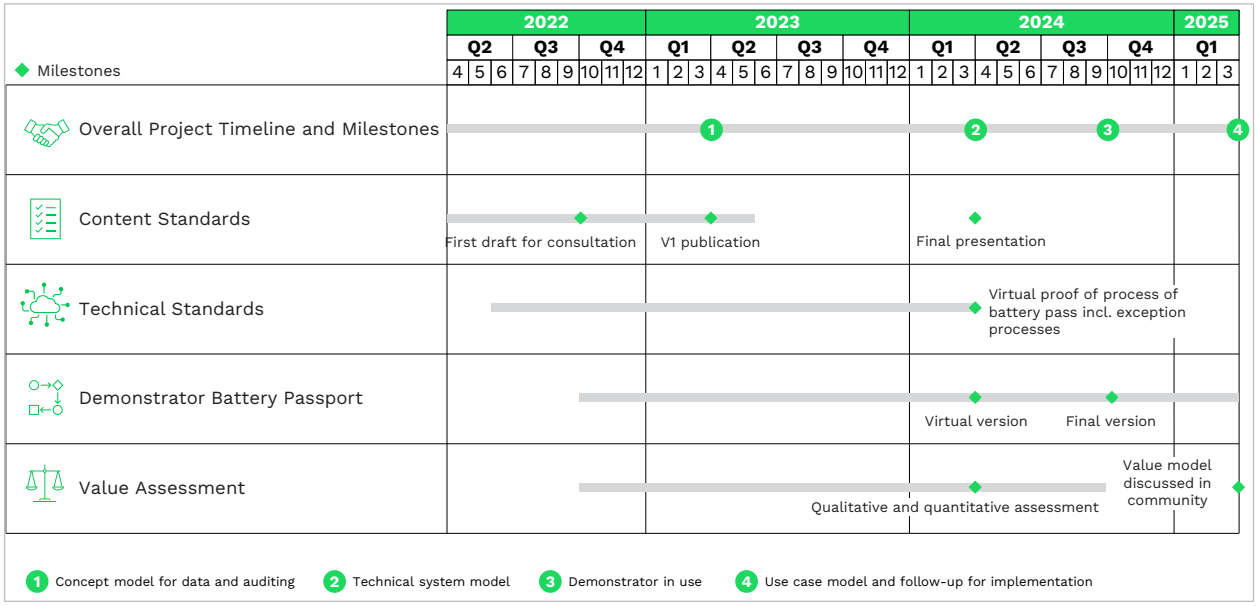


Figure 3: Overview on Battery Pass consortium three year timeline including major milestones



2 Aim, scope and methodology

2.1 Aim of this document

The aim of this document is to provide a timely and comprehensive guidance to organisations responsible for implementing the battery passport (“responsible economic operators”) on how to interpret the content requirements mandated by the EU Battery Regulation and prepare certain data attributes. Furthermore, other battery value chain participants requested to report and/or intended to access battery passport information will benefit from the guidance as a central piece of information.

Beyond the EU Battery Regulation, the guidance builds on further regulatory frameworks (e.g., the Ecodesign for Sustainable Products Regulation) to highlight harmonisation potential and suggests additional value-adding aspects that could be covered to enable increased sustainability and circularity.

The Battery Pass Content Guidance is also directed at other relevant organisations in the broader battery passport ecosystem (e.g., standard development organisations, other consortia/projects, etc.), which can extract insights for their respective purposes and activities to save resources, increase efficiency, and maximise synergy potentials.

By having shared preliminary perspectives with the European Commission during the development phase of the Battery Regulation (trilogue), the guidance also aimed to provide feedback on ambiguities and inconsistencies in the legal text and scope, and to ensure a reasonable balancing of sustainability objectives and industry feasibility. A separate document will be published by the Battery Pass consortium highlighting to the European Commission remaining aspects that need further clarification and elaboration. The project’s multi-stakeholder observations and insights will also provide an important basis for active contribution in the public consultation phase of the upcoming delegated and implementing acts.

Within the very own project scope, the Content Guidance lays the foundation for the development of technical approaches for the battery passport including a formal reference model for data collection as well as an initial framework (standard stack) to cover relevant technical specifications for battery passport operations. In this context, it also plays an important role in the development of the pilot demonstrator. Furthermore, the identification of use cases for individual battery value chain players and the assessment of the overall value of the passport will directly result from identified data points including the respective access rights linked to them.

2.2 Scope and methodology

The scope of this guidance document is based mainly on the provisions for the battery passport by the EU Battery Regulation in terms of battery categories and data attributes covered.

The battery categories are specified in *Article 65(1)* of the Battery Regulation and include:

- Light means of transport (LMT) batteries,
- industrial batteries with a capacity above 2 kWh, and
- electric vehicle batteries.

While the Battery Pass guidance document generally intends to cover all batteries in scope, a focus on a specific battery category or type might apply in certain instances (e.g., electric vehicle batteries with a particular focus on lithium-ion batteries for the Carbon Footprint Rules) due to the overall market significance and available resources following the project timeline.

The requested data attributes for the battery passport are outlined in *Article 65* and *Annex XIII* of the EU Battery Regulation and grouped into content clusters in this guidance starting with overarching elements following the battery life cycle (see chapter 6):

- General battery and manufacturer information
- Compliance, labels, certifications
- Battery carbon footprint
- Supply chain due diligence
- Battery materials and composition
- Circularity and resource efficiency
- Performance and durability

Once more, available resources following the project timeline have impacted the depth of analysis of certain aspects (e.g., the general battery information and labelling requirements), and are therefore only covered to a limited extent.

In addition to the EU Battery Regulation, further regulations were analysed to complement definitions, generate additional background information, and harmonise reporting requirements. The scope was limited to the European Union and key Member States to align with other (upcoming) regulatory requirements in the region. While regulations outside of the EU (such as the United States' Inflation Reduction Act) will also impact battery passport solutions, an in-depth analysis was not conducted since the primary focus of the Battery Pass consortium has been on compliance with EU requirements.

In tandem with mandatory information for the battery passport as stated/referenced in *Article 65* of the EU Battery Regulation, the Battery Pass consortium often makes recommendations where the regulatory text is missing clarity, harmonisation potential with other regulations exists or increased sustainability and circularity could be enabled.

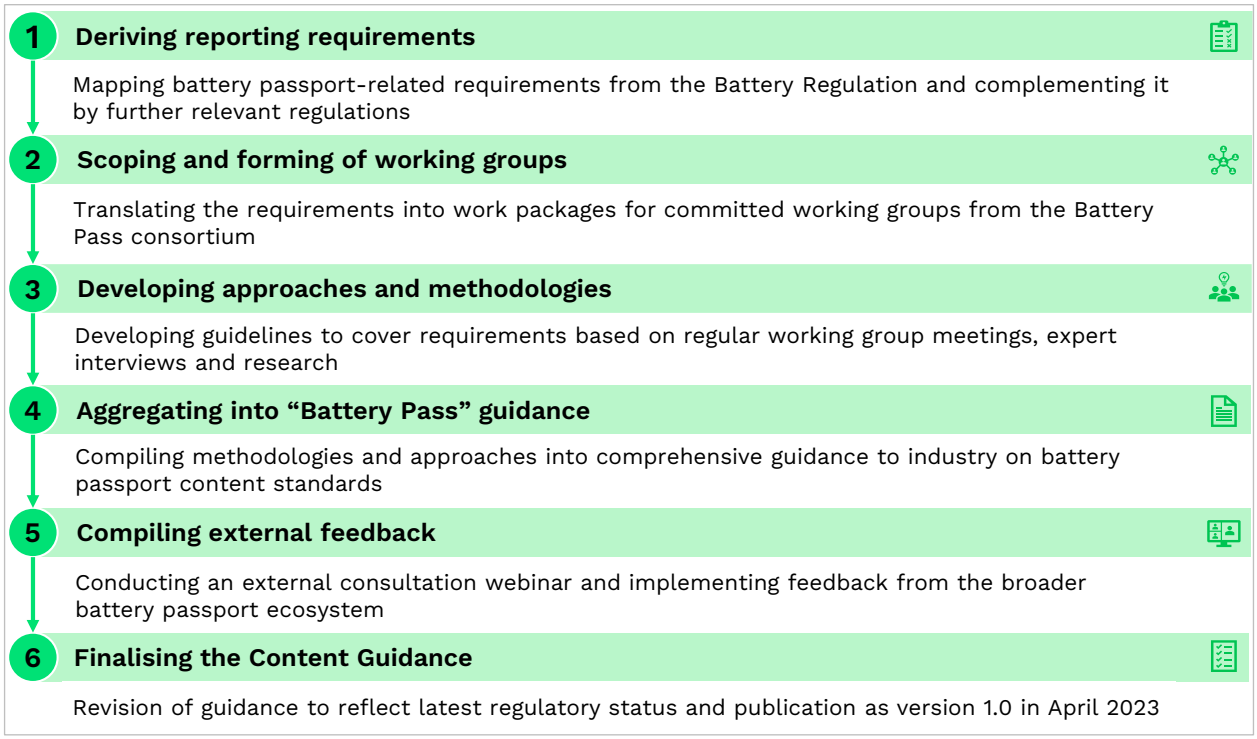
The development of the Battery Pass Content Guidance covered six methodological steps (see Figure 4):

1) **Deriving reporting requirements from the EU Battery Regulation and beyond:** Initially, the different EU Battery Regulation drafts (Commission (3), Parliament (4) and Council (5)) and ultimately the final compromise text were analysed to derive the content reporting requirements for the battery passport, complemented by other relevant regulations.
2) **Scoping of work packages and forming of working groups:** Four major content clusters were defined and consortium working groups formed around them, each being led by either Systemiq or acatech and consisting of further experts from the consortium partners:
    - Carbon footprint (Systemiq)
    - Supply chain due diligence (Systemiq)
    - Circularity (acatech)
    - Performance and durability (acatech)
3) **Developing approaches to define requirements and data attributes:** The working groups developed approaches and methodologies for the data attributes through regular

workshops and interviews (including with Battery Pass supporting partners or the broader ecosystem). Thereby, a consent approach was followed to enable constructive cooperation and support decision-making. Data requirements not directly linked to one of the content clusters were developed in a similar way outside of the dedicated working groups.

4) **Aggregating insights into the Battery Pass Content Guidance:** The working group leads aggregated and translated the initial findings into a version 0.9 of the Battery Pass Content Guidance. For a more compact overview, all data attributes were additionally synthesised in an Excel table (see the "Battery Pass Data Attribute Longlist") which was initially developed in collaboration with the GBA and Catena-X and further specified by the Battery Pass consortium later on.
5) **Compiling external feedback:** In October 2022, an external consultation webinar was conducted. The project's associated and supporting partners, the extended membership network of partner initiatives as well as representatives of European Institutions were invited to join and provide comments on the version 0.9 of the document in the context of a several-week lasting feedback phase. More than 100 organisations joined the consultation webinar submitting more than 250 comments on the Content Guidance, which were discussed and implemented by the working groups' leads afterwards.
6) **Finalising the Content Guidance:** With the publication of the final compromise text of the Battery Regulation being published in January 2023, the guidance was revised once more to reflect the latest regulatory status. Since the content is not expected to change until the regulation will enter into force in the coming months, the Battery Pass Content Guidance is published as a version 1.0 in April 2023.

Figure 4: Overview on methodological steps to derive the Battery Pass Content Guidance



An updated version of the Battery Pass Content Guidance will follow within the next year based on new insights from the technically focused work packages of the consortium as well as further regulatory and market developments.

3 Regulatory references

This chapter provides a high-level overview of the regulations referred to in this guidance document. As mentioned earlier, the selection of relevant regulations was focused on the EU context. They are listed in order of relevance, starting with the most relevant for this guidance document.

EU Battery Regulation (1): In December 2020, the Commission proposed a new Battery Regulation which if passed will replace the current Battery Directive 2006/66/EC. The aim of the legislation is to ensure batteries placed on the European Union market are sustainable and safe throughout their entire life cycle. The regulation spans activities and associated actors across the entire battery life cycle. A provisional political agreement between the European Parliament and the Council was reached in December 2022 with the regulation now likely entering into force by August 2023. *Whenever this document refers to the "regulation", "(EU) Battery Regulation" or certain articles, annexes or recitals without indicating a further source, reference is made to the EU Battery Regulation.*

Ecodesign for Sustainable Products Regulation (ESPR) (6): In March 2022, the EU Commission proposed the Ecodesign for Sustainable Products Regulation as part of the Sustainable Products Initiative (SPI) in the Circular Economy Action Plan (CEAP). The ESPR extends the scope of the Ecodesign Directive from energy-related products to all products, except for food, feed, and medicine. If adopted, the regulation will introduce ecodesign requirements for products placed on the EU market. In addition, the proposal mandates the introduction of digital product passports. The Commission will further specify product-specific requirements in a series of delegated acts. The proposed ESPR still needs to go through the regular legislative procedure and has been submitted to the Council and European Parliament for amendment and adoption.

EU Corporate Sustainability Due Diligence Directive (EU CSDDD) (7): In February 2022, the EU Commission adopted a proposal for a Directive to harmonise corporate due diligence requirements. Companies will be required to identify and, where necessary, prevent, end or mitigate adverse social and environmental impacts of their activities. All EU companies with at least 500 employees and €150 million+ in net turnover worldwide (Group 1) are to be subject to the directive. The new provisions will also apply to companies with more than 250 employees and a net turnover beyond €40 million worldwide that achieve at least 50% of their net turnover in defined high impact sectors (Group 2), including minerals. Small and medium enterprises (SMEs) are not directly in the scope of this proposal. A final decision is not to be expected before 2023 or 2024. The EU CSDDD has been submitted to the Council and European Parliament for amendment and adoption. Due to its status as a Directive, Member States will have two years to transpose it into national law after it is passed.

EU Critical Raw Materials Act (8) (9): The EU Critical Raw Materials Act, proposed by the Commission in March 2023, aims at a secure, diversified, affordable and sustainable supply of critical raw materials. "The Proposal Regulation establishing a framework for ensuring a secure and sustainable supply of critical raw materials" sets a regulatory framework to support the development of domestic capacities and strengthen sustainability and circularity of the critical raw material supply chains in the EU. The related Communication proposes measures to support the diversification of supply chains through new international mutually supportive partnerships. Amongst others, the EU Critical Raw Materials Act proposals identify a list of strategic materials, update the list of critical raw materials, set benchmarks for domestic

capacities along the strategic raw material supply chain by 2030, simplify permitting procedures for critical raw material projects in the EU, require monitoring of critical raw materials supply chains, and aim to diversify the import of critical raw materials.

EU Taxonomy Regulation (10; 11): The EU Taxonomy regulation entered into force in July 2020. It is a classification system, establishing a list of environmentally sustainable economic activities, which aims to help scale up sustainable investment and implement the European Green Deal. The six environmental objectives of the Taxonomy are: (1) climate change mitigation, (2) climate change adaptation, (3) sustainable use and protection of water and marine resources, (4) transition to a circular economy, (5) pollution prevention and control, and (6) protection and restoration of biodiversity and ecosystems. The EU Taxonomy compass breaks down the specific requirements for individual sectors, including the manufacturing of batteries. Under *Article 8* of the EU Taxonomy Regulation, so-called large undertakings in the scope of the current Non-Financial Reporting Directive (NFRD) have to disclose information concerning the degree of alignment of their activities with the Taxonomy. While the Taxonomy has already entered into force, the Commission is still further developing the specific criteria and requirements.

Waste Directive 2008/98/EC (12): In 2008, the Waste Framework Directive entered into force. The directive provides a legal framework for the treatment of waste within the EU. The purpose of this directive is to protect the environment, human health, and resources. It is aimed at moving the EU closer to the goal of a circular economy by increasing the volume of waste that is collected separately and recovered. Among others, it defines legal terms in waste law, introduces the waste hierarchy, defines recycling quotas, and embeds the producer responsibility principle.

German Supply Chain Act (13): The German Supply Chain Act was passed into law in June 2021 and entered into force on 1 January 2023. The law imposes comprehensive due diligence requirements on companies with a principal base in Germany. The German Supply Chain Act provides a comprehensive list of obligations including, among others, the establishment of a risk management system for compliance. It also outlines the necessary preventive and remedial measures, makes complaint procedures mandatory and requires regular documentation and reports. Since 1 January 2023, the Act applies to companies with 3,000 or more employees. From 1 January 2024, it will also affect companies with 1,000 employees and more.

EU Corporate Sustainability Reporting Directive (CSRD) (14): In April 2021, the Commission adopted a proposal for a Corporate Sustainability Reporting Directive (CSRD), which updates the current reporting requirements under the Non-Financial Reporting Directive (NFRD). The directive extends the scope to all large companies and all companies listed on regulated markets (except listed micro-enterprises). In addition, it introduces more detailed reporting requirements, and demands to report according to mandatory EU sustainability reporting standards. To be compliant, companies need to have reported information audited (assurance). The EU Parliament and Council adopted the final text in November 2022 and it is expected to be published in the Official Journal of the European Union in the first half of 2023. Due to its status as a Directive, Member States will have two years to transpose it into national law after it is passed.

REACH Regulation (15): The regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) ((European Commission) No 1907/2006) aims to improve the protection of human health and the environment through identification of the intrinsic properties of chemical substance and to enhance innovation and competitiveness of the EU chemicals industry. The REACH Regulation places responsibility on industry to manage the

risks from chemicals and provide safety information on the substances, e.g., via registration in the central database of the European Chemicals Agency (ECHA). REACH also calls for the substitution of substances of very high concern where possible.

Classification, Labelling and Packaging (CLP) Regulation (16) (17): The CLP Regulation ((EC) No 1272/2008) presents the base for the classification, labelling and packaging of substances and mixtures. In the EU, the CLP Regulation implements the GHS (Globally Harmonized System of Classification and Labelling of Chemicals). The GHS provides globally uniform physical, environmental, and health and safety information on hazardous chemical substances and mixtures and administrated by the United Nations. The goal of the GHS is to facilitate global trade and harmonise communication of chemical hazard information in order to promote regulatory efficiency.

4 Definitions

This chapter serves as a dictionary for the main terms applied in the EU Battery Regulation. It focuses on elaborating battery definitions, on describing and illustrating the battery value chain and different battery actors as well as different operations of battery handling during the battery life cycle. Where not stated otherwise the definition originates from *Article 2* of the EU Battery Regulation. If not addressed in the EU Battery Regulation, sources and definitions – as understood by the Battery Pass consortium – have been added for clarity and marked accordingly. The detailed understanding of the below terms within the battery passport and of more specific terms are covered in chapters 5 and 6.

4.1 Battery definitions

A common understanding of what constitutes a battery and specific terms describing categories, components or characteristics of batteries is crucial in the context of the Battery Regulation and the battery passport.

Battery means **any device delivering** electrical energy generated by direct conversion of chemical energy, having internal or external storage, and consisting of one or more non-rechargeable or rechargeable battery cells, modules or packs of them, including a battery that has been subject to preparing for re-use, preparing for repurpose or repurposing, or remanufacturing (EU Battery Regulation, *Article 2(1)*).

4.1.1 Battery categories

The EU Battery Regulation describes the scope of its requirements regarding different battery categories. The respective definitions are listed below and an overview is provided in Figure 5. The battery passport scope includes LMT batteries, industrial batteries with a capacity >2 kWh and EV batteries (*Article 65(1)*).

> **Battery category**[1] discerns the different use of the battery: “portable battery”, “electric vehicle battery”, “industrial battery”, “stationary battery energy storage system”, “LMT battery” or “SLI battery” (see below).
>
> **Electric vehicle battery** or “EV battery” means any battery specifically designed to provide electric power for the traction to hybrid or electric vehicles of L category as provided for in regulation (EU) No 168/2013, and with a weight above 25 kg, or designed to provide electric power for the traction to hybrid or electric vehicles of M, N or O categories as provided for in regulation (EU) 2018/858 (EU Battery Regulation, *Article 2(12)*).
>
> **Light means of transport (LMT) battery** means any battery that is sealed and weighs below or equal to 25 kg, designed to provide traction to wheeled vehicles that can be powered by the electric motor alone or by a combination of motor and human power including type-approved vehicle of category L in the meaning of Regulation (EU) No 168/2013, and that is not an electric vehicle battery (EU Battery Regulation, *Article 2(9)*).

[1] Not explicitly defined in regulation drafts, derived from context therein.

SLI battery means any battery designed to supply electric power **for starter, lighting, or ignition**, and may also be used for auxiliary or backup purposes in vehicles, other means of transport or machinery (EU Battery Regulation, *Article 2(10)*).

Industrial battery means any battery designed specifically for industrial uses, or any battery intended for industrial uses after being subject to preparing for repurpose or repurposing, and any other battery with a weight above 5 kg excluding portable LMT batteries, electric vehicle batteries and SLI batteries (EU Battery Regulation, *Article 2(11)*).

Stationary battery energy storage system means an industrial battery with internal storage specifically designed to store and deliver electric energy from and into the grid or store and deliver electric energy to end-user, regardless of where and by whom this battery is being used (EU Battery Regulation, *Article 2(13)*).

Other industrial batteries are comprised of all industrial batteries that are not stationary battery energy storage systems.

Portable batteries of general use means rechargeable and non-rechargeable portable batteries specifically produced to be interoperable and with the following common formats: 4,5 Volts (3R12), button cell, D, C, AA, AAA, AAAA, A23, 9 Volts (PP3) (EU Battery Regulation, *Article 2(8)*).

Figure 5: Overview on battery category definitions

Within scope of battery passport

Battery Categories	Battery Definition and Use Cases	Battery Weight
Electric vehicle (EV) battery	• Provide electric power for the traction to hybrid or electric vehicles – of categories L (Regulation (EU) No 168/2013), if larger than 25 kg, or – of categories M, N or O (Regulation (EU) 2018/858)	> 25 kg (category L)
Light means of transport (LMT) battery	• Provide electric power for traction to wheeled vehicles that can be powered by the electric motor alone or by a combination of motor and human power including type-approved vehicles of category L (Regulation (EU) No 168/2013), e.g. e-bikes and e-scooters	≤ 25 kg
Industrial battery[1]	• Designed specifically for industrial uses or • Intended for industrial uses after being subject to preparing for repurpose or repurposing, or • Any battery above 5 kg that is not an LMT, EV or SLI battery • Industrial uses include (*Recital 12*) – industrial activities – communication infrastructure – agricultural activities – energy storage in private or domestic environments – generation and distribution of electric energy – traction in other transport vehicles including rail, waterborne and aviation transport or off-road machinery *Subcategory:* **Stationary battery energy storage system** • Industrial battery with internal storage – specifically designed to store and deliver electric energy from and into the grid or store and deliver electric energy to end-user, regardless of where and by whom this battery is being used	> 5 kg (if no other category applies)
SLI (starter, lighting, or ignition) battery	• Designed to supply electric power for starter, lighting, or ignition • May also be used for auxiliary or backup purposes in vehicles, other means of transport or machinery	-
Portable battery	• Not designed specifically for industrial uses • Neither an electric vehicle battery, nor a light means of transport battery, nor an SLI battery	≤ 5 kg
Portable battery of general use	• Rechargeable and non-rechargeable portable batteries specifically produced to be interoperable • Common formats: 4,5 Volts (3R12), button cell, D, C, AA, AAA, AAAA, A23, 9 Volts (PP3) • Providing traction to wheeled vehicles considered as toys (within Toy Safety Directive 2009/48/EC)	-

[1] Only industrial batteries above 2 kWh within scope of battery passport

4.1.2 Battery terminology

In addition to the battery definition and its categories, different terms are used to define groups of batteries or an individual battery:

Battery model means a version of a battery of which all units share the same technical characteristics relevant for sustainability and safety requirements and labelling, marking and information requirements pursuant to this regulation and the same model identifier (EU Battery Regulation, *Article 2(17)*).

Battery batch[2] refers to (spatially and chronologically) consistently manufactured groups of batteries of a battery model, identifiable by their batch identification code. Individual batteries of a battery batch share identical characteristics in manufacturing process and raw material input, e.g., sourcing and characteristics such as share of renewable energy used.

A **particular or individual battery**[3] is one singular battery (as opposed to groups of batteries per battery model or batch), identifiable by a unique product serial number.

The EU Battery Regulation also describes the following **battery components** including the battery management system (BMS). The Battery Pass consortium thus understands the BMS, if present, as part of the battery that needs to be considered as battery component in information requirements, such as on carbon footprint.

Battery pack means any set of battery cells that are connected together or encapsulated within an outer casing,[4] so as to form a complete unit that the end-user is not intended to split up or open (EU Battery Regulation, *Article 2(1a)*).

Battery module means a set of battery cells that are connected together or encapsulated within an outer casing to protect the cells against external impact, and which is meant to be used either stand-alone or in combination with other modules (EU Battery Regulation, *Article 2(1b)*).

Battery cell means the basic functional unit in a battery constituted by electrodes, electrolyte, container, terminals and, if applicable, separators and containing the active materials the reaction of which generates electrical energy (EU Battery Regulation, *Article 2(2)*).

Active materials means material which reacts chemically to produce electric energy when the battery cell discharges or to store electric energy when the battery is being charged (EU Battery Regulation, *Article 2(3)*).

Battery management system (BMS) means an electronic device that controls or manages the electric and thermal functions of the battery in order to ensure the battery's safety, performance and service life, that manages and stores the data on the parameters for determining the state of health and expected lifetime of batteries laid down in *Annex VII* and that communicates with the vehicle, light means of transport or appliance in which the battery is incorporated, or with a public or private charging infrastructure (EU Battery Regulation, *Article 2(22)*).

[2] Not explicitly defined in EU Battery Regulation. Batches may be distinguished in battery production due to different sourcing. Therefore, from the production point of view it may be necessary to distinguish sustainability information on a battery batch level.
[3] Not explicitly defined in EU Battery Regulation, derived from context therein.
[4] Interpreted as independent of whether cells are structured in modules or not.

The following terms define **further battery characteristics:**

Battery chemistry[5] refers to battery composition in general terms, as indication for battery differences, defined by the Battery Pass consortium as active materials in cathode, anode, and electrolyte (see details in chapter 6.5.1).

Battery status[6] describes the current status of an individual battery in its life cycle, with the options 'original', 're-used', 'repurposed', 'remanufactured' and 'waste' (EU Battery Regulation, *Annex XIII (4b)*).

Non-rechargeable battery means a battery that is not designed to be electrically recharged (EU Battery Regulation, *Article 2(4)*).

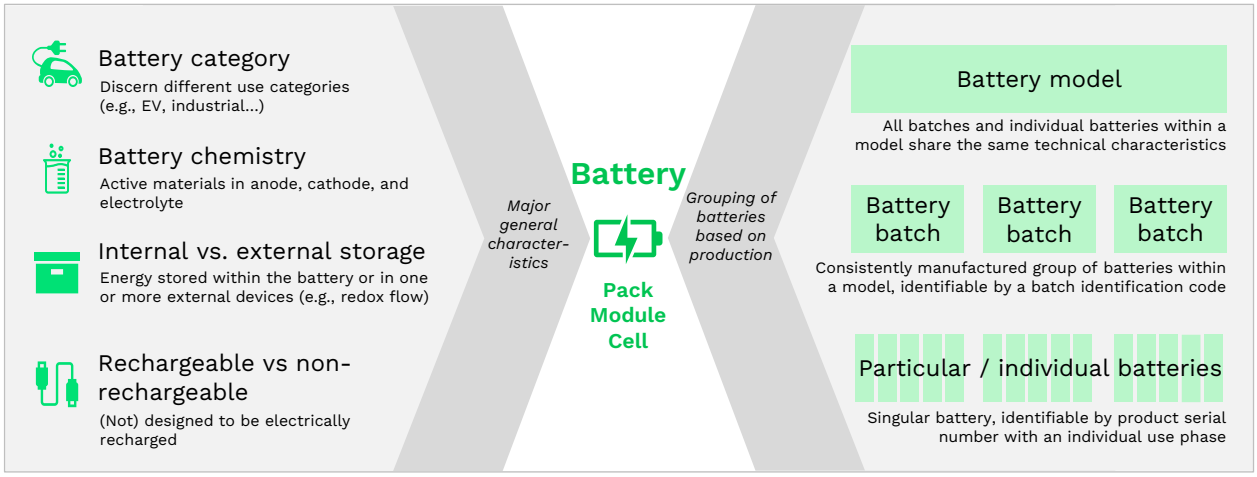
Rechargeable battery means a battery that is designed to be electrically recharged (EU Battery Regulation, *Article 2(5)*).

Battery with external storage means a battery designed to have the energy stored exclusively in one or more attached external devices (EU Battery Regulation, *Article 2(6)*).[7]

Correlations of battery terms

Figure 6 shows the correlation of battery definitions. Battery category and battery chemistry are independent overarching classifications, which are defining properties of the battery. A battery model is designed for use in a specific category, features a certain battery chemistry and is designed for non-rechargeability and/or with external storage. Accordingly, all batches and individual batteries of the same battery model share these and other characteristics. Batches of the same model differ from each other in terms of inputs and period of time of manufacture, thus, also possibly being sourced differently. As a result, batch characteristics may be reflected in varying static data attributes (see chapter 5.1.1): e.g., recycled content, carbon footprint, and due diligence reporting. Individual batteries experience different life cycles (different dynamic data).

Figure 6: Hierarchy of battery definitions



[5] Not explicitly defined in EU Battery Regulation, derived from context therein.
[6] Not explicitly defined in EU Battery Regulation, derived from context therein. See chapter 6.1.7 for a detailed discussion of the battery status.
[7] This definition corresponds in particular with the design of redox-flow batteries.

4.2 Battery actors

This chapter provides an overview of all actors handling batteries as defined by the regulation, which often includes broad definitions such as for the economic operator. Furthermore, these actors are not entirely separate in practice, e.g., one company may assume different roles based on the definitions. They are listed alphabetically:

Authorised representative means any natural or legal person established in the Union who has received a written mandate from a manufacturer to act on its behalf in relation to specified tasks with regard to the manufacturer's obligations under the requirements of chapter IV and VI of this Regulation (EU Battery Regulation, *Article 2,1(53)*).

Distributor means any natural or legal person in the supply chain, other than the manufacturer or the importer, who makes a battery available on the market (EU Battery Regulation, *Article 2,1(55)*).

Economic operator means the manufacturer, the authorised representative, the importer, the distributor or the fulfilment service provider or any other natural or legal person who is subject to obligations in relation to manufacturing batteries, preparing batteries for re-use, preparing batteries for repurpose, repurposing, or remanufacturing, of batteries, making them available or placing them on the market, including online placing on the market, or putting them into service in accordance with this regulation (EU Battery Regulation, *Article 2(19)*).

End-user means any natural or legal person residing or established in the Union, to whom a product has been made available either as a consumer outside of any trade, business, craft or profession or as a professional end-user in the course of its industrial or professional activities (Regulation (EU) 2019/1020, *Article 3*, referenced in the EU Battery Regulation, *Article 2*).

Holder of a battery means the natural or legal person in possession of a used or waste battery (EU Battery Regulation, *Annex XIV (new) (1)*).

Importer means any natural or legal person established within the Union who places a battery on the market from a third country (EU Battery Regulation, *Article 2,1(54)*).

Independent operator means a natural or legal person who is independent from the manufacturer and the producer and is directly or indirectly involved in the repair, maintenance or repurposing of batteries, and include waste management operators, repairers, manufacturers or distributors of repair equipment, tools or spare parts, as well as publishers of technical information, operators offering inspection and testing services, operators offering training for installers, manufacturers and repairers of equipment for alternative-fuel vehicles (EU Battery Regulation, *Article 2(20)*).

Interested person is any natural or legal person with a legitimate interest in accessing and processing battery passport information (EU Battery Regulation, *Article 65(2c)*).

Manufacturer means any natural or legal person who manufactures a battery or has a battery designed or manufactured, and markets that battery under its own name or trademark or puts it into service for its own purposes (EU Battery Regulation, *Article 2(27)*).

National authority means an approval authority or any other authority involved in and responsible for market surveillance in a Member State in respect of batteries (EU Battery Regulation, *Article 2(52)*).

Producer means any manufacturer, importer or distributor or other natural or legal person who, irrespective of the selling technique used, including by means of distance contracts as defined in *Article 2(7)* of Directive 2011/83/EU (EU Battery Regulation, *Article 2(37)*).

Producer responsibility organisation means a legal entity that financially or financially and operationally organises the fulfilment of extended producer responsibility obligations on behalf of several producers (EU Battery Regulation, *Article 2(38)*).

Recycler means any natural or legal person who carries out recycling in a permitted facility (EU Battery Regulation, *Article 2(46)*).

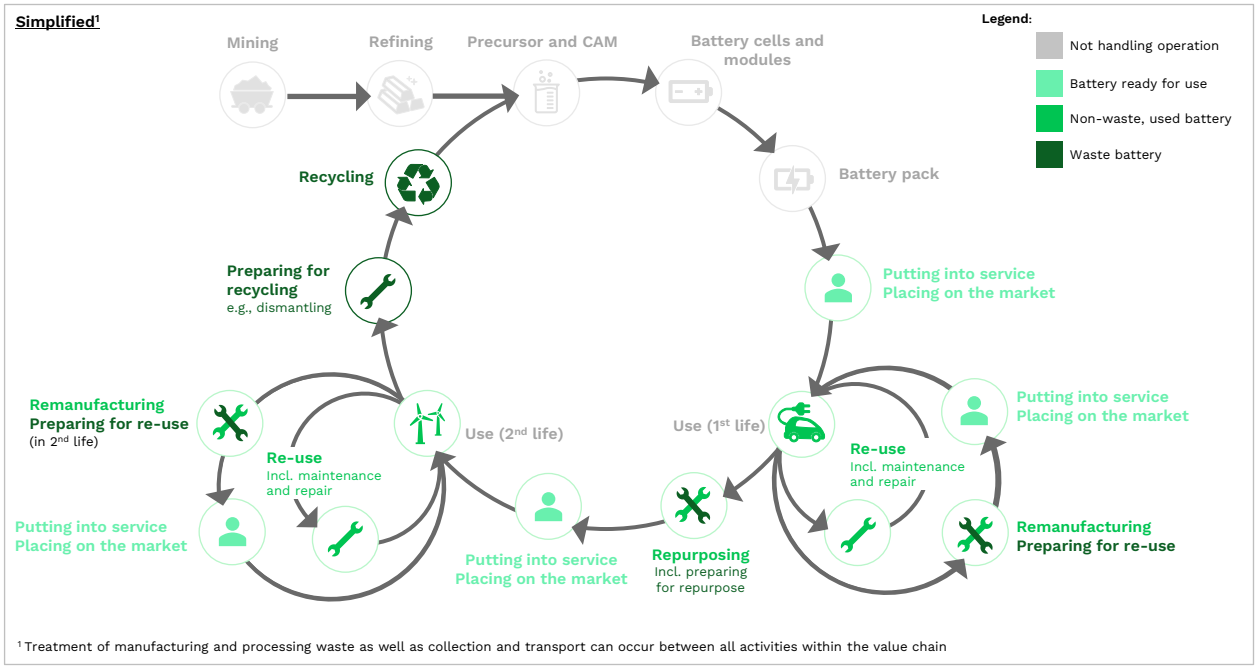
Waste holder means the waste producer or the natural or legal person who is in possession of the waste (Waste Directive, *Article 3(6)* referenced in the EU Battery Regulation, *Article 2*).

Waste management operator means any natural or legal person dealing on a professional basis with the separate collection, sorting, or treatment or recycling of waste batteries (EU Battery Regulation, *Article 2(44)*).

4.3 Battery handling operations

Definitions for different operations of battery handling along the battery value chain are displayed (Figure 7) and listed below. The definitions are sorted according to their position within the life cycles and the condition of the battery.

Figure 7: Overview on battery handling operations along the value chain



For batteries that are ready to be used:

Putting into service means the first use, for its intended purpose, in the Union, of a battery, without having been placed on the market previously (EU Battery Regulation, *Article 2,1(16)*).

Placing on the market means the first making available of a battery on the Union market (EU Battery Regulation, *Article 2,1(14)*).

Making available on the market means any supply of a battery for distribution or use on the Union market in the course of a commercial activity whether in return for payment or free of charge (EU Battery Regulation, *Article 2,1(15)*).

For non-waste, used batteries:

Re-use means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived (Waste Directive, *Article 3(13)* referenced in the EU Battery Regulation, *Article 2*).

Repair means returning a defective product or waste to a condition where it fulfils its intended use (ESPR, *Article 2(20)*).[8]

Maintenance describes an action carried out to keep a product in a condition where it can function as required (ESPR, *Article 2,1(19)*).

Remanufacturing means any technical operation on a used battery that includes the disassembly and evaluation of all its battery modules and cells and the use of a certain amount of battery cells and modules, new, used or recovered from waste, or other battery components, to restore the battery capacity to at least 90% of the original rated battery capacity, and where the state of health of all individual battery cells is homogeneous, not differing more than 3% from one another,[9] and results in the battery being used for the same purpose or application than the one for which the battery was originally designed. (EU Battery Regulation, *Article 2,1(26a)*). A remanufactured product is typically placed on the market with a commercial guarantee (ESPR, *Article 2(16)*).

Repurposing means any operation that results in parts or the complete battery that is not a waste battery, being used for a different purpose or application than the one that the battery was originally designed for (EU Battery Regulation, *Article 2,1(26)*).[10]

[8] Repair can either be seen in the context of a waste battery as preparing for re-use or in the context of a non-waste battery as re-use with different implications for the battery passport. For further explanation on repair see chapter 5.3.

[9] The technical details that “the battery capacity [must be restored] to at least 90% of the original rated battery capacity, and [...] the state of health of all individual battery cells [must be] homogeneous, not differing more than 3% from one another”. The consortium acknowledges the need for specification for the operation of “remanufacturing”. It recommends reconsidering the provisions above and to provide more specific and well-applicable specifications for the remanufacturing process, ideally within or together with the implementing act that determines specification of performance and durability data attributes.

[10] Repurposing, as interpreted by the Battery Pass consortium, usually includes a change of battery category, see chapter 4.1.

For waste batteries:

Treatment means any activity carried out on waste batteries after they have been handed over to a facility for sorting, preparing for re-use, preparing for repurpose, preparation for recycling, or recycling (EU Battery Regulation, *Article 2,1(42)*).

Repair means returning a defective product or waste to a condition where it fulfils its intended use (ESPR, *Article 2(20)*).[11]

Preparing for re-use means checking, cleaning, or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing (Waste Directive 2008/98/EC, *Article 3* referenced in the EU Battery Regulation, *Article 2*).

Preparing for repurpose means any operation, by which parts of or a complete waste battery is prepared so that it can be used for a different purpose or application than the one that it was originally designed for (EU Battery Regulation, *Article 2,1(25a)*).

Preparation for recycling means treatment of waste batteries prior to any recycling process, which shall, inter alia, include storage, handling, dismantling of battery packs or separation of fractions that are not part of the battery itself (EU Battery Regulation, *Article 2,1(42a)*).

Recycling means any recovery operation by which waste materials are reprocessed into products, materials, or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations. (Waste Directive, *Article 3(17)*). Waste materials are either from the manufacturing process (i.e. pre-consumer material) or after consumer use (i.e. post-consumer material) (definition amended by the Guidance Document for the Product Circularity Data Sheet (18)).

Waste management means the collection, transport, recovery (including sorting), and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker (Waste Directive, *Article 3(9)* referenced in the EU Battery Regulation, *Article 2*).

[11] See footnote 8

5 Introduction to the concept of the battery passport

The battery passport is defined as an electronic record of an individual battery (*Article 65*). To provide important information about the sustainability characteristics of batteries and upscale circular economy strategies, the battery passport shall contain information relating to the model and the individual battery in the use phase (*Article 65(2)*). The specific data requirements for the battery passport shall be the focus of this guidance document and are therefore outlined in detail in chapter 6. However, to aid an initial understanding of the concept of the battery passport and provide further context, this chapter addresses the questions below:

- How does the battery passport work from a technical perspective? (chapter 5.1)
- Who is responsible and liable for the battery passport? (chapter 5.2)
- How is the battery passport audited? (chapter 5.3)
- When is a (new) battery passport created, updated, and ceases to exist? (chapter 5.4)

5.1 Technical design and operation of the battery passport

A digital product passport (DPP) is defined by the European Commission as "a structured collection of product related data with predefined scope and agreed data ownership and access rights conveyed through a unique identifier" (19). As outlined in the ESPR (6) (*Recital 33*), an agreement on the technical design and operation of DPPs is essential to enable consistent deployment across sectors and a secure data carriage. "The technical, semantic and organizational aspects of end-to-end communication and data transfer" of the battery passport "shall be fully interoperable with other [digital] product passports" (*Article 65a(a)*). The Commission's Proposal for an Ecodesign for Sustainable Products Regulation (ESPR) of March 2022, mandating the introduction of DPPs, outlines their technical requirements. In addition, the Battery Regulation refers to the eDelivery Network principles,[12] which should be considered for the technical specifications (*Recital 94a*). To advance the technical specifications, the ESPR (6) (*Recital 33*) and the Battery Regulation (*Recital 94a*) both refer to a "harmonised standard referenced in the Official Journal" or as a "fall-back option, common specification adopted by the Commission".[13]

While this chapter does not aim to provide final definitions and solutions for the technical design and operation of the battery passport, it contextualises the technical requirements introduced in the ESPR and EU Battery Regulation by addressing the following questions:

- How is access to the battery passport provided? (chapter 5.1.1)
- What are the technical format requirements for battery passport data? (chapter 5.1.2)

[12] The eDelivery Network principles of the EC Connecting Europe Facility aim to help public administrations to exchange electronic data and documents in an interoperable, secure and reliable way, using a standardised protocol (81). (110)

[13] "A harmonized standard is a European standard developed by a recognized European Standards Organization: CEN, CENELEC, or ETSI. It is created following a request from the European Commission to one of these organizations." (101) If harmonised standards do not exist or are insufficient, Common Specifications are implemented by the EC.

- How is data for the battery passport collected and processed? Which existing systems could be drawn on? (chapter 5.1.3)
- Where will data be stored? (chapter 5.1.4)
- How can different data attributes be grouped on the basis of their behavioural characteristics? (chapter 5.1.5)
- Which actors are granted access to which battery passport information? (chapter 5.1.6)

Further details around technical aspects of the battery passport are currently analysed by the technical working group of the Battery Pass consortium and will be published at a later stage. The below info box provides a first glimpse into the objective, approach, and scope of the technical working group.

Figure 8 summarises the technical design and operation of the battery passport, as introduced in the following chapters.

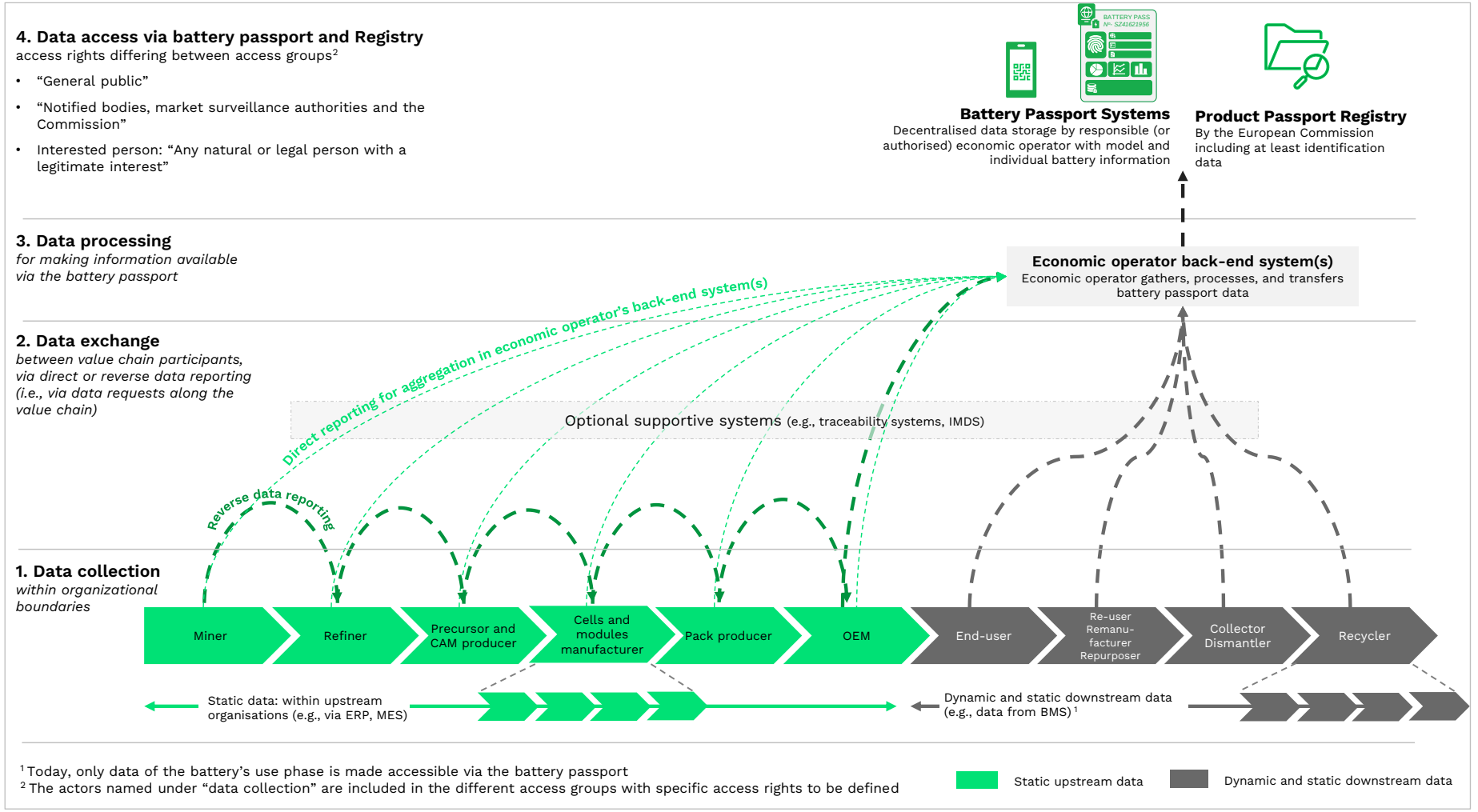
5.1.1 Data carrier

Access to DPPs shall be provided via a **data carrier** (ESPR (6), *Recital 31*), defined as a "linear bar code symbol, a two-dimensional symbol or other automatic identification data capture medium that can be read by a device" (ESPR (6), *Article 2(30)*). For the battery passport, this data carrier shall be a **QR code** (*Article 65(3)*), whereas delegated acts can be adopted by the European Commission to "provide for alternative types of smart labels instead of or in addition to the QR code, in view of technical and scientific progress" (*Article 13(6a)*). The QR code "shall be printed or engraved visibly, clearly legibly and indelibly on the battery"; or, if not possible, affixed to the packaging or accompanying documents (*Article 13(6)*). According to the Battery Regulation (*Recital 28*, *Article 65(3)*) and the ESPR (6) (*Article 9(1)*), the data carrier shall comply with ISO/IEC 15459:2015 (on procedural requirements to maintain identities) and with ISO/IEC 18004:2015 (on requirements for QR codes). Further, the QR code shall be accessible for persons with disabilities in accordance with Directive (EU) 2019/882 (*Recital 28*).

This QR code as a data carrier for the battery passport shall be marked on all batteries "from 42 months after entry into force of the [Battery] Regulation" (*Article 13(5)*). For battery categories requiring a battery passport, the QR code provides access to its information. Also other battery categories shall have a QR code and provide access to defined labelling, marking, and waste battery information (*Article 13(5b)*) as well as information on the change of status of a battery (*Article 13(6b)*). This information represents a sample of the battery passport information. For SLI batteries, the QR code shall also provide access to the amount of cobalt, lead, lithium, and nickel recovered from waste (*Article 13(5)*).

The data carrier shall be connected to a unique identifier (Battery Regulation, *Article 65(3)*; (ESPR, *Article 9(1)*). Standards to follow, both for the data carrier and the unique identifier, will be expanded on by the technical working group of the Battery Pass. The unique identifier is introduced in chapter 6.1.1.

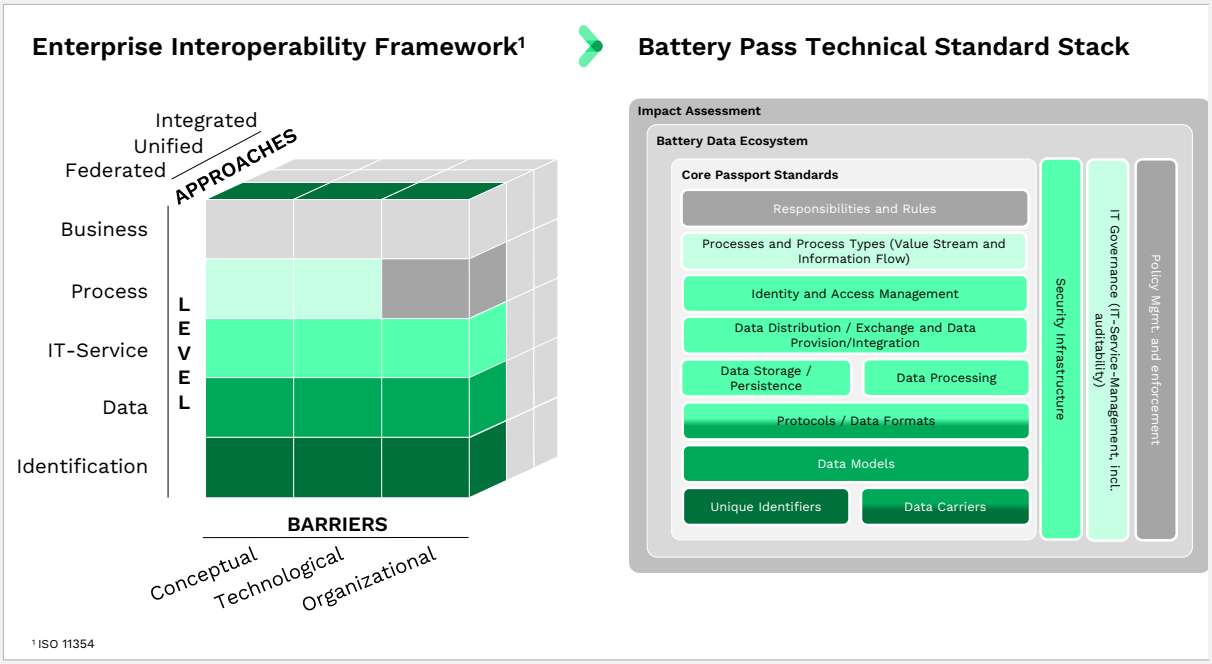
Figure 8: Technical design and operation of the battery passport



The Battery Pass technical working group: objective, approach and scope

The overall objective of the technical working group of the Battery Pass is to provide a recommendation of a suitable set of technical standards, which enables stakeholders in the battery ecosystem to fulfill their responsibilities in a seamless interoperable manner. To achieve this, an initial framework – called the Standard Stack – has been designed to cover relevant technical specifications for battery passport operations (see Figure 9). The Standard Stack follows a modular approach consisting of single standard elements (e.g., "Data Storage/Persistence" to ensure the availability/accessibility of battery data) with modularity supporting an easy adoption for other sectors as required by the regulation. In addition, the approach will limit effort and time in case of a potential extension or required changes (e.g., resulting from technological progress or new requirements from market surveillance).

Figure 9: Overview on the Battery Pass Technical Standard Stack



[1] ISO 11354

For each element of the Standard Stack, potentially suitable existing standards are identified and evaluated against certain criteria from policy requirements and the European Interoperability Framework, as well as functional (e.g., flexible size of data carrier) and non-functional (e.g., total cost of ownership) success factors. Based on the evaluation, recommendations will be publicly communicated at a later stage of the project, which will be based on the following principles:

- Suitability of adoption and application across sectors
- Applied standards shall be open, non-proprietary and independent of any specific technical implementation as far as possible
- Co-existence of standards as much as possible in order to ensure a high adoption rate
- Consideration of the needs of stakeholders in the entire battery eco-system (e.g., economic operators, governmental authorities like market surveillance, battery users, recycling/refurbishing companies, all kinds of suppliers as well as service providers)

Under these principles and considerations, current requirements coming from the ESPR and EU Battery Regulation need to be clarified and discussed. On the one hand, specific standards are already requested (e.g., ISO/IEC 15459-1:2014), though other suitable alternatives exist. On the other hand, other requirements are slightly vague leaving room for interpretation (e.g., "languages, which can be easily understood by end-users"). Further on, the systematics should be discussed (e.g., interoperability requirements only being assigned to select aspects such as "data formats"). In order to have an operational battery passport system up and running, it is necessary to address interoperability as a capability to all required levels as it is defined in ISO 11354.

5.1.2 Data format

The Battery Regulation and the ESPR direct that battery passport information meet certain data format requirements:

- Information "shall be based on **open standards**" (*Article 65(5)*; ESPR, *Article 9(1),* (6)).
- Information shall be "developed with an **inter-operable format**" (*Article 65(5)*).
- Information "shall be **machine readable, structured, and searchable**" (*Article 65(6)*; ESPR (6), *Article 9(1)*).
- Information shall be "**accurate, complete**" (*Article 65(4)*).
- Information shall be "**up to date**"[14] (*Article 65(4)*).
- "**Data authentication, reliability and integrity** shall be ensured" (ESPR (6), *Article 10*).
- The information shall be "in a **language** or languages, which can be easily understood by end-users, as determined by the Member State in which the battery is to be made available on the market [or put into service]" (introduced as obligations of importers and distributors in *Articles 41(2)* and *42(1)* for required documents, instructions, and information accompanying the battery).

5.1.3 Data collection and processing

The battery passport "shall contain information relating to the battery model and information specific to the individual battery including as a result of the use of that battery" (*Article 65(2)*). The responsibility for collecting and processing this battery passport information lies with the economic operator placing the battery on the market (*Article 65(4)*).

Means for economic operators to collect and process the required information (i.e. where can battery passport information be gathered from) are, however, not addressed in the Battery Regulation or ESPR. While the regulation requires an interoperable data exchange network "without vender lock-in" (*Article 65(5)*) for battery passport data provision, the data collection and processing is not further specified.

Examples of existing systems for data collection and processing

Since the regulation touches only very little upon means of how economic operators can collect the required data for the battery passport, some common existing systems are introduced below, all of which have their own advantages and shortcomings. None of these are yet fully tailored towards the technical needs of a data interface with the battery passport.

Examples of information systems collecting data within companies are the **ERP** (Enterprise Resource Planning), a software to manage company information and activities based on shared data, or the **MES** (Manufacturing Execution System), a computer-based software system used in manufacturing industries to manage and track manufacturing processes on the factory floor.

Examples of information systems providing data for multiple participants of the battery value chain are industry-driven information system like the **IMDS** (International Material Data System), which contains information on materials used by the automotive industry (see also chapter 6.5), and the **IDIS** (International Dismantling Information System), which is used by the automotive industry as the central repository of treatment information for end-of-life vehicles. The IMDS

[14] While this term requires further definition, in the Battery Regulation, also in *Recital 30*, "up to date" is cited in the context of data stored in the BMS. Here, it is specified as "at least updated daily and more frequently where this is required by a specific purpose".

and IDIS systems could therefore serve as a base to share and access information on materials, substances, or dismantling information for the battery passport.

Reporting to the Commission

Article 61 describes reporting obligations of actors along the value chain to the competent authority of the Member State, which in turn is required to publicly make available data that describe the battery market and include all battery categories (*Article 62*). The Commission will review data and publish a report on data collection, the sources of data and the methodology including completeness, reliability, timeliness and consistency of that data and recommendation on improvement (*Article 62(4)*).

As depicted in Figure 10, producers, producer-responsibility organizations and waste management operators1 are required to report within six months (*Article 61(7)*) of the end of a reporting year (for which the data are collected) information to the competent authorities of a Member State responsible for monitoring and verifying compliance.

At this point in time, this reporting requirement is not connected with the battery passport and its data. It appears sensible to enable the use of aggregated battery passport data, with due regard for business confidentiality and other competitive concerns, to provide additional insights into development of the battery market and its sustainability aspects. In particular, this could provide for a shorter lead time than the described 18 months for data reporting.

Figure 10: Reporting to the Commission: Regulatory requirements

Who reports to whom?	What needs to be reported?	Reporting timeline
Producers and waste management operators report to the competent authorities (*Article 61(1)-(3)*)	Amount of: • batteries (first time made available on the market), excluding batteries that have left the Member States before being sold to end-users • waste batteries collected and delivered to preparing for re-use or preparing for repurposing • collected waste exported to third countries for treatment, preparation for re-use, preparation for repurposing or recycling • collected waste delivered to facilities for treatment and recycling • waste batteries collected and collection rate reached by the producer or waste operator	**Within 6 months**[1]
Waste management operators (for treatment and recycling) **report to the competent authorities** (*Article 61(5)*)	Amount of: • waste received for treatment and recycling • waste entering preparation for re-use, preparation for repurposing or recycling process Information on recycling efficiencies and levels of recovered materials for waste batteries and on destinations and outcome of the final output fractions	**Within 6 months**[1]
Member States report to the Commission (*Article 62*)	Amount of: • batteries (first time made available on the market) • waste batteries collected and delivered to preparing for re-use or preparing for repurposing • batteries collected and collection rates Values of the achieved recycling efficiencies and recovery efficiencies	**Within 18 months**[1]

Commission
- Data will be collected and reviewed by the Commission
- A report assessing the organisation of the data will be drawn up six months after the first reporting of the data and every four years thereafter

[1] After the end of the reporting year for which the data are collected (each calendar year)

This reporting will be done via an **electronic system**, which the Member States should establish using easily accessible data services. Within 18 months, Member States are required to make this data publicly available (not more than 18 months after the end of the reporting year). The Commission will then collect and review the reported data and **publish a report** assessing the quality of the information within six months of the first reporting period and every four years thereafter. In addition, the reporting depends on tracking the battery status as a mandatory dynamic battery passport attribute.

A **traceability system** would be another example of a common system, which may also cover different value chain participants, i.e. to manage and consolidate data between participants. Such a system records and follows the trail of products or materials, upstream and potentially

also downstream. It could be leveraged for the collection of mandatory (e.g., identification of (critical raw) materials or the recycled content of a battery) as well as voluntary (e.g., third-party supply chain assurances (see chapter 6.4.2.1) or provenance information (see chapter 6.4.2.3) data for the battery passport. Furthermore, companies could utilise a traceability system for data exchange or to run calculations required for battery passport data (e.g., automated carbon footprint data transfer along the value chain). Since the Battery Regulation requires economic operators placing batteries on the market to "establish and operate a system of controls and transparency over the value chain, including a chain of custody or traceability systems, identifying upstream actors in the supply chain" (*Article 45b(d)*), companies will need to operate traceability systems regardless.

Rather than on the battery model level as in the abovementioned examples, dynamic data, particularly performance data such as battery capacity fade, results from the specific usage of a battery and is thus on an individual battery level. Information on this data is typically recorded by the **BMS** (Battery Management System) of the individual battery and transferred to the back-end system of the BMS, which is contingent on available connectivity or storage accompanying the individual battery. After the likely necessary intermediate step of processing the data into the adequate format in a battery passport back-end system of the economic operator, the relevant data for the battery passport would be transferred to the battery passport interface system of the economic operator.

In addition, Member States are required to make key information on (waste) batteries available to the public in an aggregated format. This reporting to the Commission is introduced below.

5.1.4 Data storage

The Battery Regulation states that the battery passport should be based on a **decentralized data system**, set up and maintained by economic operators (ESPR (6), *Recital 32*; Battery Regulation, *Recital 94a*). This way, it should be ensured "that the product passport is flexible, agile and market-driven and evolving in line with business models, markets and innovation" (ESPR (6), *Recital 32*). In this decentralised data system, the responsibility for storing the data lies with the economic operators. Based on the ESPR (6), *Article 10(c)*, economic operators can, however, also **authorise other operators** to act on their behalf and store the data being accessible via the battery passport (for details see chapter 5.2). However, these operators will be prohibited to sell, re-use, or process data beyond the necessary scope (ESPR (6), *Article 10(d)*; (20)). Such authorised service operators are particularly of interest to SMEs. The ESPR (6) (*Recital 45*) points out that SMEs could "face costs and difficulties with some of the [ESPR] requirements" and therefore promise support, in particular for "the technical implementation of the product passport".

Moreover, the ESPR (6) (*Article 10*) specifies that "product passports shall be designed and operated so that a high level of security and privacy is ensured and fraud is avoided". No further details are introduced yet.

Besides economic operators and operators authorised by the same, the European Commission will also aggregate and store selected data of the battery passport in the **product passport registry**. This registry, to be set up and maintained by the Commission, should be accessible to competent national authorities, customs authorities, and the Commission itself (ESPR (6), *Recital 32*, *Article 12*). First, the registry should allow for the verification and authenticity of DPPs. Second, the registry should improve the compliance of products with the ecodesign requirements of the ESPR. And third, the registry should enable customs authorities to efficiently and effectively verify the consistency of customs declarations (ESPR (6), *Recitals 12*

and *32*; *Article 12*). The registry will store at minimum a record of all data carriers and unique identifiers, i.e. the unique battery identifier. If needed for further enforcement, the Commission can specify other information of DPPs to be stored in the registry by means of delegated acts (ESPR (6), *Recital 34*). While the responsibility for secure data processing lies with the Commission as the "controller" (ESPR, *Article 12*), the responsibility for uploading the required information to the registry lies with the economic operator placing the product on the market or putting it into service. An implementing act will further specify the implementation and interconnection of the product passport registry, which should be interconnected with the EU Customs Single Window Certificates Exchange (EU CSW-CERTEX)[15] (ESPR, *Article 12*). This way, an automated exchange of information with the national customs systems and electronic data verification can be enabled (ESPR (6), *Article 13*).

Another data aggregation introduced in the Battery Regulation presents the register of producers. This register, described in the info box below, is only indirectly linked to data accessible via the battery passport and therefore to be seen as a separate tool for authorities.

Register of producers

The register of producers is introduced as a tool for competent authorities to monitor the battery waste treatment obligations of producers. It is to be established and managed by the competent authorities in and announced by each Member State (*Recital 77a*, *109*; *Article 42*).

Before making batteries available on the market, producers need to register batteries and their information. The registration requirements should be simplified across the EU and implementing powers should be conferred on the Commission to ensure uniform conditions (*Recital 74*).

The register should be accessible to "those entities that play a role in the verification of the compliance with the extended producer responsibility obligations and their enforcement" (*Recital 74*). It is added that the registry might be the same as the national register of the Battery Directive of 2006 (2006/66/EC).

5.1.5 Data behavioural characteristics

The technical implementation of the multitude of data attributes in the battery passport calls for grouping different attributes with equal behavioural characteristics. While we assign attributes by content in chapter 6, the technical requirements among other aspects also depend on the regularity of data updates to be provided. While some data attributes may not change at all,[16] the use cases of other data attributes, such as state of health are based on regular updates. The Battery Pass consortium uses "static" and "dynamic" as two different behavioural characteristics of data attributes. The respective definitions and understanding of "static" and "dynamic" are elaborated below.

In addition, each data point of an attribute will be linked to suitable metadata (e.g., a time stamp or the data provider) to enable the tracking and auditing of added information.

[15] The EU CSW-CERTEX is part of EU law since December 2022 and aims at improving the information sharing and digital cooperation between customs administrations and other government authorities.
[16] Disregarding the data behavioural characteristics, there must be a technical option, based on the role-based access model, to correct faulty or erroneously added information in the battery passport. Such changes need to be clearly traceable and be made transparent.

Static data

The Battery Pass applies a definition of static data in accordance with existing language by the European Commission describing it as data **"that do not change often or on a regular basis"** (21). Therein, however, no definition is provided to clarify the terms "not often" or "on a regular basis". In the context of the battery passport, we define static data as data, which is provided upon placing the battery on the market and which may only change through its lifetime, if the battery is subject to a replacement of parts or a change to the operational boundaries set by the battery management system. Static data will encompass among others the carbon footprint, sourcing information and pre-use performance data attributes, which are typically on the battery model level.

Additionally, the consortium acknowledges that certain static data may not change on a given battery passport. One exemplary data attribute falling in this category is the battery identifier. As addressed in chapter 6.1.1, the battery identifier shall assure that the corresponding battery is unambiguously identifiable, which is why its data must not change to ensure accurate identification.

Dynamic data

In contrast to static data, the European Commission defines dynamic data as data **"that change often or on a regular basis"** (21). Dynamic data attributes of the battery passport are expected to change often during the life cycle of a battery as they reflect the change of characteristics upon the individual usage of each battery. Required update intervals or variance thresholds,[17] which are not described in the Battery Regulation (see also chapter 6.7), should be defined individually for dynamic data attributes based on their respective use cases, which should consider connectivity and may include providing time series in the battery passport. While some dynamic data will be monitored by the BMS, other data attributes like information on an accident may have to be added manually. Especially for dynamic and safety relevant data like the state of charge, the information on the up-to-dateness, i.e. time stamp, of the current data point is just as important as the information itself.

5.1.6 Data access

According to both the ESPR (6) (*Article 10(b)*) and the Battery Regulation (*Article 65a(b)*), actors shall have access to the battery passport free of charge. Actors should be granted access to that information in line with their respective access rights (*Article 65a(b)*). While the ESPR (6) (*Article 8*; *Annex VI*) highlights that the European Commission will adopt delegated acts defining actors and their access to DPP information, the Battery Regulation already defines some access groups in *Article 65*. The corresponding data points to be accessible per group are specified in *Annex XIII*. The access groups and type of information per group are as follows:

- **"General public"** with access to a list of battery model information (*Annex XIII*, *point 1*) in order to receive "information about batteries placed on the market and their sustainability requirements" (*Recital 93*).
- **"Notified bodies, market surveillance authorities and the Commission"** with access to (1) results of compliance test reports on the battery model level; (2) battery model information only accessible to interested persons and the Commission (detailed composition, part numbers, dismantling information, safety measures) (*Annex XIII*, *points*

[17] Variance threshold describes the relative change in a data attribute, beyond which an update of the data attribute in the battery passport could be triggered automatically.

2 and *3*) in order to be supported "in carrying out their tasks under [the Battery] Regulation" (*Recital 93*).
- **"Any natural or legal person with a legitimate interest** in accessing and processing that information" with access to (1) individual battery information (performance and durability, state of health, battery status, use information); (2) battery model information only accessible to interested persons and the Commission (see above) (*Annex XIII (2,4)*).

The last group ("persons with a legitimate interest") shall be specified via implementing acts by the European Commission 36 months after entry into force of the Battery Regulation. To determine these persons (as well as their rights to download, share, publish, and re-use battery passport information), two potential use cases should be assessed (*Article 65(2)* and *(7)*):

- To "evaluate the status and residual value of the battery and its capability for further use", as information necessary for making individual batteries available to independent energy aggregators or energy market participants.
- For "preparation for re-use, preparation for repurposing, repurposing, remanufacturing or recycling of the battery, or for choosing between those activities", as information necessary for battery dismantling and to allow repairers, remanufacturers, second-life operators, and recyclers to conduct their activities.

Thereby, it should be ensured that accessing and processing of commercially sensitive information is "limited to the minimum necessary in accordance with applicable Union law" (*Article 65(7)*).

5.2 Responsibility and liability for the battery passport

The EU Battery Regulation defines responsibilities for the battery passport and certain situations where these are to be transferred. In this chapter, the Battery Pass consortium therefore intends to provide an initial understanding on the responsibilities and resulting liabilities laid out by the regulation (chapter 5.2.1) as well as provides recommendations for a harmonised and standardised transfer (chapter 5.2.2). As this guidance is putting primary focus on the battery passport, responsibility and liability concerning the battery itself (e.g., material/personal damages that occur due to a broken battery) are not addressed. Furthermore, it is to be noted that the following text is not a legal assessment.

5.2.1 Overview on responsibilities and resulting liabilities

The analysis of the regulatory requirements laid out in the Battery Regulation identified four **key questions** to be answered:

1) What are the responsibilities/liabilities related to the battery passport?
2) Who is primarily responsible and respectively liable?
3) When are the responsibilities/liabilities transferred to another actor (transfer cases)?
4) What are the consequences in case of non-compliance?

1) What are the responsibilities related to the battery passport?

> **Responsibility vs. liability**
>
> Responsibility is an obligation, i.e. having to do something. Liability means that one is subject to repercussion if duties are not fulfilled, e.g., being liable for damages caused. The notion of responsibility is close to that of "duty", whereas the notion of liability is closer to that of "risk".

The requirements for the battery passport are laid out in *Article 65* and *65a* of the Battery Regulation. A distinction can be made between specific obligations, where the responsible actor is clearly defined and requirements that are defined without naming a responsible actor. Consequently, there is no explicit overall responsibility of one actor for all requirements related to the battery passport.

The economic operator placing the battery on the market or putting it into service (analysed in detail in the second key question) is responsible to:

a. **attribute a unique identifier** that is linked to the QR code that the battery is marked with to make the battery passport accessible (*Articles 65(3)*, *13(5)* and *(6)*).
b. "ensure that the **information** in the battery passport is **accurate, complete and up-to-date**" (*Article 65(4)*).
c. **store the data** included in the battery passport (*Article 65a(c)*).

For the responsibilities b. and c., the economic operator placing the battery on the market is explicitly allowed to authorise another operator "to act on their behalf" (*Articles 65(4)* and *Article 65a(c)*).

The remaining requirements laid out in *Article 65* and *65a* including the regulation of access as well as the technical design and operation of the battery passport (please refer to chapter 5.1 for a detailed analysis of these requirements), do not designate a specific actor responsible for their fulfilment. It is not explicitly defined whether the economic operator placing the battery on the market is also responsible for these. However, *Recital 94* indicates that "the responsibility of compliance with the provisions for the battery passport should lie with the economic operator placing the battery on the market", implying that this responsibility refers to all requirements.

Two of those requirements are particularly important for the question of responsibility and liability:

- "The product passport shall remain available" in the case that the economic operator responsible for "ensuring the information in the passport is accurate, complete and up to date" (see above under b.) "ceases to exist or ceases its activity in the Union" (*Article 65a(e)*). However, it is unclear who is responsible and how this can and needs to be ensured e.g., for the case of an insolvency. An indication for this can be found in the requirement of interoperability "with other digital product passports required by Union legislation concerning ecodesign" (*Article 65a(a)*). The proposal for the Ecodesign for Sustainable Products Regulation mentions specifically a product passport registry which should be set up and maintained by the Commission (6). The Battery Pass technical standards working group will examine this subject in more detail, both at the organisational level (procedures according to IT service management standards) and in terms of technologies (e.g., back-ups).

- "A battery passport shall cease to exist after the battery has been recycled" (*Article 65(6b)*), which indicates that someone needs to be responsible to end the existence of the battery passport. Yet, it does not become clear who the responsible actor is, whether this only refers to the concept of the battery passport and if the information in the passport could remain to be stored elsewhere (see also chapter 5.2.2). Furthermore, the Battery Regulation does not specify at which exact point in the recycling process, which potentially involves multiple entities, the battery is considered recycled.

2) Who is primarily responsible and respectively liable?

The starting point for responsibility is the concept of **economic operator**. Economic operator is defined by (*Article 2,1(19)*):

1) Any entity (the manufacturer, the authorised representative, the importer, the distributor or the fulfilment service provider or any other natural or legal person)
2) Who is subject to
    a. Obligations in relation to manufacturing batteries,
    b. Preparing batteries for re-use,
    c. Preparing batteries for repurpose,
    d. Repurposing, or remanufacturing, of batteries,
    e. Making them available, or
    f. Placing them on the market, including online placing on the market, or
    g. Putting them into service in accordance with the EU Battery Regulation.

In the specific case of the battery passport, this initial range of possible economic operators is limited to some extent by the activities of "placing a battery on the market" or "putting it into service" (*Article 65(1)*). Pursuant to the *specific responsibilities* (see first key question a-c), it is the **economic operator placing the battery on the market** who bears the responsibilities towards the battery passport. However, in the case that the battery has not been placed on the market yet, **putting it into service** represents the activity that determines the responsible actor (*Recitals 46* and *46a*).

Thereby the regulation's definition of a battery (see chapter 4.1) needs to be considered. Moreover, the battery passport is only required for specific defined battery categories: LMT batteries, industrial batteries above 2 kWh and EV batteries placed on the market or put into service. Therefore, the specifications for these battery categories are crucial (see chapter 4.1.1).

Putting a battery into service

This activity is defined as "the first use, for its intended purpose, in the Union, of a battery, without having been placed on the market previously" (*Article 2,1(16)*). Hence, this activity does not take place when the battery is placed on the market before its first use. This could refer to putting a battery into service for own purposes, which the regulation includes in the manufacturer definition:

A **manufacturer** is "any natural or legal person who manufactures a battery or has a battery designed or manufactured and markets that battery under its own name or trademark or **puts it into service for its own purposes.**" (*Article 2,1(27)*).

Furthermore, the regulation recites that its provisions also hold for importers putting batteries into service (*Recitals 52*, *53* and *55*), which suggests that this activity is also in their scope. Yet, this is not clearly reflected in the importer's definition:

An **importer** “means any natural or legal person established within the Union who places a battery on the market from a third country” (*Article 2,1(54)*).

Generally, each importer and distributor who places a battery on the market or puts it into service under its own name or trademark or significantly modifies a battery (e.g., changing the purpose) needs to be regarded as the manufacturer and therefore taking on the manufacturer’s obligations (*Recital 55*). Only when considered as manufacturer, the distributor is also a possible responsible economic operator:

A **distributor** is “any natural or legal person in the supply chain, other than the manufacturer or the importer, who makes a battery available on the market” (*Article 2,1(55)*).

At present, it is unclear if prototypes for safeguarding and test batteries in research are subject to this activity and therefore would require a battery passport. Fulfilling all requirements of the regulation might not be feasible on a development stage, where technical data is not available entirely, and could be a barrier towards effective research.

Placing a battery on the market

This activity is defined by the EU Battery Regulation with “first making available of a battery on the Union market”, while “making available on the market means any supply of a battery for distribution or use on the Union market in the course of a commercial activity whether in return for payments or free of charge” (*Article 2,1(14)* and *(15)*). Among potential economic operators, the **manufacturer** and **importer** are the only actors who can place products on the market (*Recital 10*). If the battery is placed on the EU market from within the Union, the manufacturer is the economic operator (22). If the battery is placed on the EU market from outside the Union, the importer is the economic operator.

As listed in the above economic operator definition, online placing on the market falls in the general scope of placing on the market (*Article 2,1(19)*). This activity is not defined in the EU Battery Regulation, though the Commission published a notice in 2017 outlining the concept in greater detail (23). If the product is being marketed by an actor established in the EU, only the selling technique differs, and the products are considered to have already been placed on the market. In this case, the responsible economic operator is either the manufacturer or the importer.

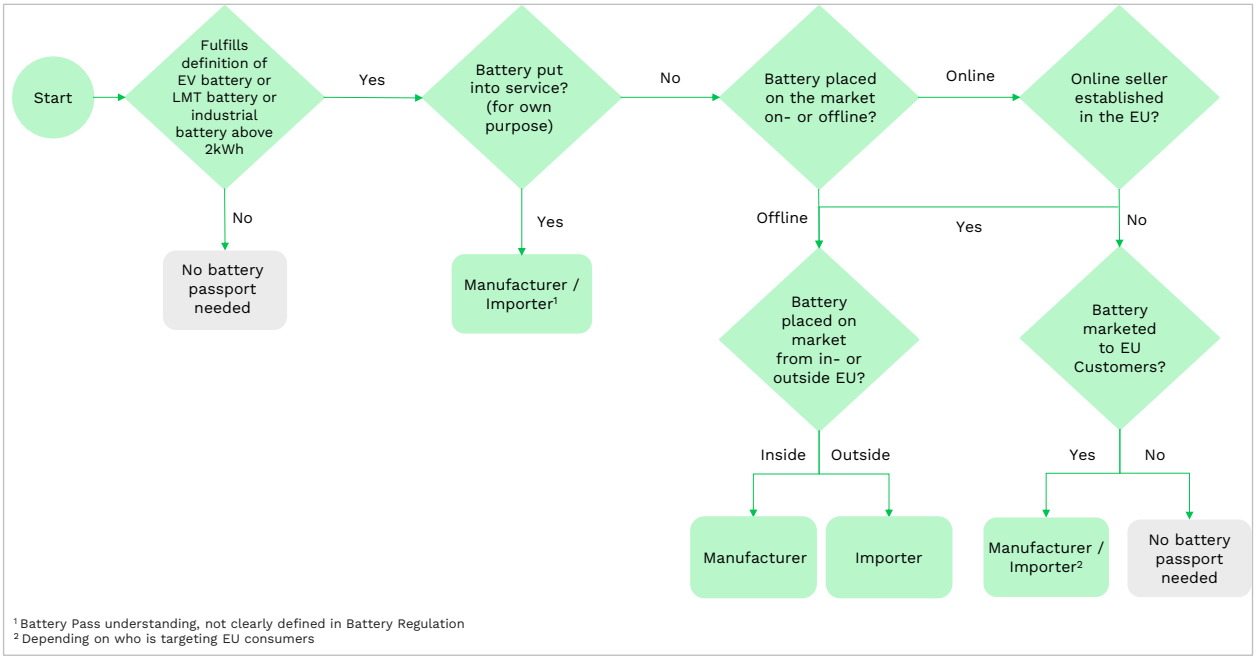
If the seller is based outside the EU, it needs to be clarified whether the online seller targets EU end-users (23). Generally done on a case-by-case basis, this is most likely the case if the seller delivers to EU addresses, accepts EU currencies as payments, and uses any EU language on the website (23). If this holds true, EU product legislation applies (in this case the EU Battery Regulation) and the EU Commission notice on e-commerce suggests that the online seller places the product on the market (23). The online seller in this case would refer to the manufacturer, or importer depending on who is targeting EU consumers.

Allocation of the responsible economic operator on the battery value chain

As explained above, the manufacturer and importer are the possible types of economic operators to be responsible for the battery passport obligations. Which of those is responsible depends on the industry and business model.

Figure 11 illustrates a decision tree for identifying if a battery passport is required as well as the type of economic operator responsible for it. Examples of individual steps are provided below.

Figure 11: Decision tree delineating the types of economic operators responsible for the battery passport



- **Battery fulfils definition of EV battery, LMT battery or industrial battery above 2 kWh.**
    - An EU-based automotive manufacturer (OEM) purchases battery cells and assembles these (incl. integrating the BMS) into an 'EV battery' that is designed to traction EVs > The OEM is the "manufacturer" of the EV battery and therefore the economic operator responsible for the obligations related to the battery passport
- **Battery put into service:** this only applies to batteries that haven't been placed on the Union market before being firstly used for their intended purpose.
    - An EU-based utility company is directly importing a stationary storage battery from outside the EU and puts it into service for own purposes > This is not clearly defined in the Battery Regulation. According to the Battery Pass consortium understanding, the utility company is the "importer" putting the battery into service for own purposes and is therefore the responsible economic operator
- **Battery placed on the market offline:** this covers batteries being sold in e.g., car dealerships or physical stores (e.g., for LMT batteries or stationary storage systems)
    - **...from inside the EU:** an EU-based automotive OEM imports battery cells from outside the EU and assembles these into an EV battery, installs it in an EV and sells it to a customer > the automotive OEM is the "manufacturer" placing the battery on the market and therefore the responsible economic operator
    - **...from outside the EU:** an industrial battery above 2 kWh is imported from outside the EU to be sold as a stationary storage system in a physical store in the EU > the "importer" is placing the battery on the market and is therefore the responsible economic operator
- **Battery placed on the market online:** this covers batteries being sold on online platforms or direct to consumer business models, such as stationary storage batteries.
    - **...with the seller based inside the EU:** an industrial battery above 2 kWh is imported by an online reseller established in the Union > the online reseller is the "importer" placing the battery on the Union market and is therefore the responsible economic operator

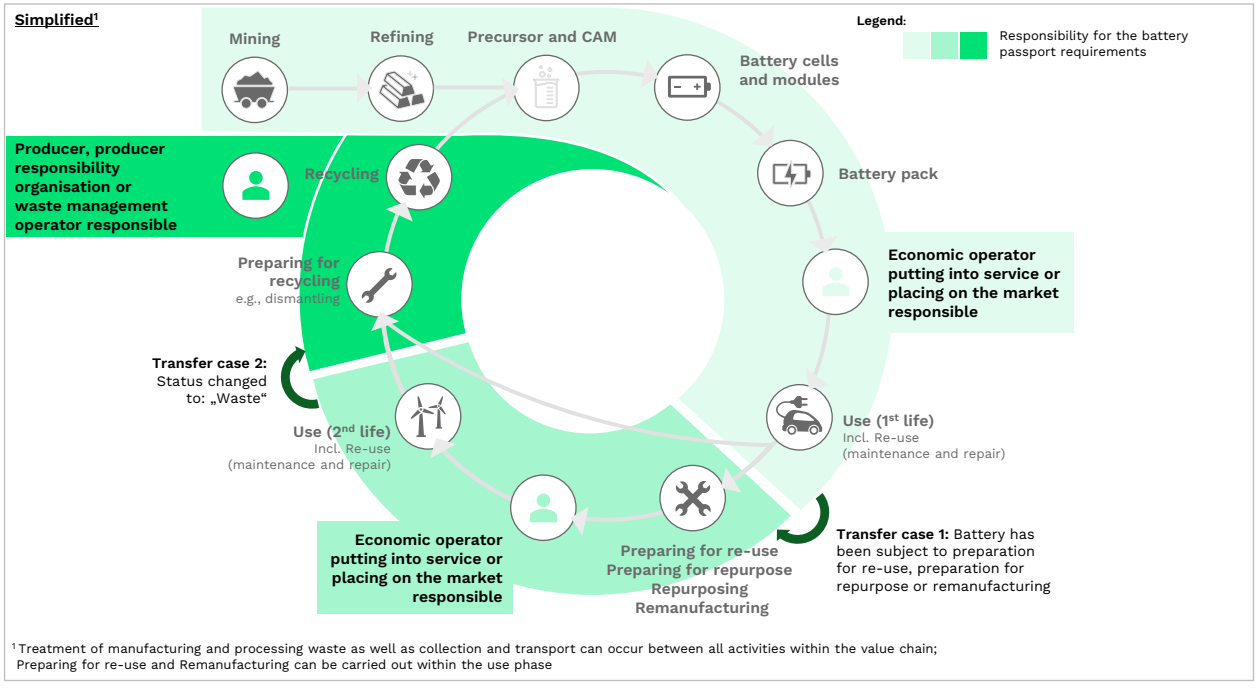
- **...with the seller based outside the EU:** an LMT battery, manufactured by a non-EU manufacturer is sold directly to an EU consumer in a direct-to-consumer business model by accepting EU currency and delivering to the EU address > the "manufacturer" is directly marketing to EU consumers and is therefore the responsible economic operator

Although the economic operator analysed in this chapter is responsible for the specific obligations regarding the battery passport, other operators must fulfill their obligations laid out by the Battery Regulation independently of the battery passport. For example, "supplier of battery cells and battery modules shall provide the information and documentation necessary to comply with the requirements of this regulation when supplying battery cells or modules to the manufacturer. The information shall be provided free of charge" (*Article 38a*), which supports the responsible economic operator in fulfilling its duties.

3) When is the responsibility/liability transferred to another actor (transfer cases)?

In two cases, the regulation specifically requires the responsibility b. (ensuring the information in the battery passport is accurate, complete and up-to-date) to be transferred from one economic operator to another (*Article 65(6a)*). For responsibility c. (storing the data included in the passport) a reference is made to the transfer requirements. Figure 12 visualises these transfer cases along the battery value chain:

Figure 12: Responsibilities in relation to the battery passport as defined by the Battery Regulation visualised along a simplified value chain



This shows that the responsibility of the economic operator for the battery passport extends over a period of time when the battery is in use, in which the responsible economic operator is not likely to own or have direct control over the battery.

Transfer case 1: Battery has been subject to preparation for re-use, preparation for repurpose, repurposing or remanufacturing

Since a battery which has been subject to preparation for re-use, preparation for repurpose, repurposing or remanufacturing, is considered as a new product, a new battery passport is required, which is supposed to be "linked to the battery passport or passports of the original battery or batteries" (*Article 65(6a)*). In this case, the responsibility for the data record in the Battery Passport is transferred to the new "economic operator that has placed that battery on the market or has put it into service" (*Article 65(6a)*).

For example, a European energy company repurposes EV batteries to industrial batteries above 2 kWh and puts them into service for their own stationary storage purposes > the energy company becomes the economic operator responsible.

It is not clear, though, if the "new" economic operator only holds the responsibility to store the data of the new battery passport or also of the previous one that it is linked to. The same question remains for responsibility b. (accurate, complete and up-to-date information).

Transfer case 2: Status changed to "Waste"

When the status of the battery changes to a waste battery – occurs when the holder discards or intends/is required to discard the battery (*Article 2(39)* of the EU Battery Regulation and *Article 3(1)* of Directive 2008/98/EC) – the responsibility is transferred to either the **producer**, a **producer responsibility organisation** (who takes over the responsibility if it is appointed by the producer in accordance with *Article 47a(2)*) or **waste management operator** (*Article 65(6a)*). In this case, a new battery passport is not required.

- The term **producer** specifies who is accountable for fulfilling extended producer obligations in a Member State and may apply to any manufacturer, importer or distributor who makes a battery available in a specific Member State (*Article 2,1(37)*). Batteries may not be made available in a Member State unless there is a registered producer or appointed producer responsibility organisation (*Article 46(2)*). This contrasts with the manufacturer and/or importer, who are placing a battery on the Union market.
- A **producer responsibility organisation** is defined as "a legal entity that financially or financially and operationally organises the fulfilment of extended producer responsibility obligations on behalf of several producers" (*Article 2,1(38)*). Producers may entrust or be required by the respective Member State to entrust a producer responsibility organisation to carry out extended producer responsibility obligations on their behalf (*Article 47a(1)*).
- A **waste management operator** according to the Battery Regulation "means any natural or legal person dealing on a professional basis with the separate collection or treatment of waste batteries" (*Article 2,1(44)*).

It is not clearly defined in the regulation under which condition either the producer (the producer responsibility organisation as substitute) or the waste management operator are responsible. *Article 61* suggests that the information responsibility depends on which of the above-mentioned actors (producer, producer responsibility organisations or waste management operator) collects and/or treats/recycles the waste battery.

    - For example, a private EV owner has to scrap his car including the EV battery. For this he returns the EV to the automotive OEM that is the responsible economic operator and also accountable for extended producer obligations, who changes the status of the battery to "waste" and sends it to his recycling network > The Battery Regulation is

unclear if the responsibility in this case stays with the automotive OEM representing the producer (the producer responsibility organisation, if appointed by the automotive OEM) or is transferred to the waste management operator performing the recycling. Battery Pass suggests that the responsible economic operator changing the status to “waste” needs to indicate who is responsible from this point on (see chapter 5.2.2).

Although in transfer case 2, no new passport is issued, it is not explicitly defined if after the transfer, responsibility b. of ensuring accuracy, completeness and up-to-dateness also applies to data included by and transferred from the previous economic operator(s).

4) What are the consequences in case of non-compliance?

Formal non-compliance is regulated in the Battery Regulation in *Article 69*. However, no reference is made to the responsibilities and requirements of *Article 65*. Yet, consequences are defined for specific requirements that are also necessary information in the battery passport, such as e.g., the supply chain diligence obligations (see chapter 6.4).

Furthermore, the Battery Regulation indicates that market surveillance authorities “should, in line with Regulation (EU) 2019/1020 carry out checks of the information contained in battery passports” (*Recital 93*). This regulation referred to relates to market surveillance and compliance of products and comprehensively lays out the procedures and capacities of the EU Member State’s market surveillance authorities to ensure that only compliant products that fulfil EU requirements are made available on the European market. It defines that Member States need to “confer on their market surveillance authorities the powers of market surveillance, investigation and enforcement necessary for the application of this Regulation and for the application of Union harmonisation legislation” ((EU) 2019/1020 *Article 14,1* (24)). These powers comprise at least to e.g.:

- Require economic operators to provide relevant documents and information
- Require economic operators to take appropriate action to bring an instance of non-compliance to an end
- Prohibit or restrict the making available of a product on the market or to order that the product is withdrawn or recalled
- Power to impose penalties
- Etc. (please refer to (EU) 2019/1020 *Article 14,4* (24))

The Battery Regulation is not yet listed in the Union harmonisation legislation in regulation (EU) 2019/1020. However, as it specifically amends this regulation, both the specific requirements of the Battery Regulation and the general provision of the regulation 2019/1020 will apply. As the Battery Regulation does not specifically define consequences for non-compliance with the battery passport requirements, the public-legal consequences depend on the respective Member States and their market surveillance authorities as regulated in EU 2019/1020 and no Europe-wide consequence is defined.

The above statements relate to the breach of obligations or duties under public law. Yet, this does not necessarily lead to civil liability. Placing the battery on the market can result in various claims arising from the relationship of the responsible economic operator and the end-user. These can be of contractual nature or from Product Liability Law. A liability of the economic operator placing the battery on the market would require a claim against this economic operator based on civil law. However, the Battery Regulation may have an influence on this as well. The Battery Regulation mentions civil liability only in relation to the supply chain due diligence requirements (*Recital 70*) stating that EU legislative instruments may address civil liability of

companies or damages caused and refer to national rules, in case these are not addressed. E.g., the German Supply Chain Act explicitly states that the breach of obligations does not establish any civil liability, whereby this exclusion shall not affect any civil liability established independently from it (German Supply Chain Act, Division 2, Section 3 (25)). This co-existence of public law and civil law could be conceivable for the battery passport as well, but would have to be legally examined.

5.2.2 Recommendations for the fulfilment of responsibilities incl. their transfer

The recommendations provided in this chapter are proposed by the Battery Pass consortium to fulfil the responsibilities laid out by the Battery Regulation. Therefore, they address aspects that remain unclear in the regulation, as indicated in chapter 5.2.1 and consider additional aspects necessary for the practical application. They are structured in three thematic blocks:

1) Recommendations that apply during the responsibility period,
2) Recommendations to harmonise the transfer of responsibility,
3) Considerations regarding the case of non-compliance.

1) Recommendations that apply during the responsibility period

Although not specifically named, it should be assumed that the economic operator placing the battery on the market is responsible for all provisions with regard to the battery passport as indicated in *Recital 94*. Therefore, the responsibility includes the implicit requirements specifically those regarding the technical design and operation of the battery passport laid out in *Article 65a* (see chapter 5.1 for a detailed analysis of these requirements).

Unauthorised third parties or independent operators are not allowed to change existing data in the passport, but need to include it additionally if an update is required. In such cases, the economic operator placing the battery on the market should not be responsible for the information included by an unauthorised independent operator (e.g., when the battery undergoes operations in the use phase that the responsible economic operator has no control over). The responsibility for the additionally included data should rather be transferred to the independent operator performing these operations (e.g., independent repair workshop). Thereby, due to the free market choice of consumers, trusted third parties such as TÜV in Germany could be authorised by the responsible economic operator to check the information included.

Whenever the economic operator placing the battery on the market decides to authorise another operator to act on their behalf, the responsibility of compliance with the provisions for the battery passport stays with the economic operator that places the battery on the market (s*Recital 94*). Hence, the economic operator placing the battery on the market would be well advised to ensure that the operator acting on their behalf regarding the battery passport fulfils all requirements laid out in the regulation. Claims may still exist in the internal relationship of the parties, but these are not Battery Regulation obligations. Technical solutions, such as signing the data included by the authorised operators could facilitate the enforcement of these claims.

In cases of information in the battery passport not being accurate, complete and up-to-date, a correction process is technically needed. However, a correction process should not enable the deletion of data. Certain correctness of the data could be algorithmically ensured, e.g., by automatically testing if the unit is correct.

After the battery has been recycled, the economic operator responsible for the "waste battery" (see transfer case 2) should be responsible to ensure the battery passport ceases to exist. Where the battery passport is linked to the original passport(s), the previous economic operator(s) need(s) to be informed and the existence needs to be ceased, too. Yet, the information and data could remain stored elsewhere to allow respective economic operators to gather and re-use information they provided.

If the battery is exported and leaves the European Union, the operator exporting the battery should have the responsibility to decommission the battery passport. If it is reimported, the importer becomes the economic operator placing the battery on the market and therefore holds its responsibilities.

2) Recommendations to harmonise the transfer of responsibility

Transfer procedure:

1) The parties involved should be informed that a transfer of responsibility for the battery passport is taking place:[18]
    - Transfer case 1: The newly responsible economic operator should inform the previous economic operator, e.g., when the new economic operator accesses data and creates the new battery passport including the link to the previous battery passport.
    - Transfer case 2: The responsible economic operator should transfer the responsibility to the applicable actor (producer/producer responsibility organisation/waste management operator) when changing the status to "waste battery", i.e. the responsible entity must be appointed ahead of the transfer.
2) It should be recognisable in the battery passport who is the responsible economic operator:
    - The name of the transferor and transferee and the date of transfer should be clearly defined and filed in the battery passport, e.g., in a repository, which is only accessible to authorised operators and not to the public.
3) Transfer conditions should be regulated between the parties:
    - Previously responsible economic operators are still responsible for the accuracy, completeness, and correctness of the information they provided and should keep storing the information of the previous battery passport(s) as of date of transfer.
    - Newly responsible economic operators have the responsibility for the correctness etc. of the entire information in the new battery passport, i.e. also the information that has been transferred from the previous battery passport(s). Therefore, they should sense-check the data provided by former operators (e.g., technically or algorithmically check if data are complete and in correct units), but it is not realistic that detailed tests are carried out.

The transfer procedure should not differ if a previous transfer of responsibilities has taken place. It could be further harmonised by a technical process that ensures that the responsibility is clear at any time and the exact moment of transfer is managed and documented.

[18] The economic operator responsible for the battery passport is likely not to own the battery at the time of a transfer, but the user of the battery, e.g. private EV owner. Therefore there is most likely no contract between the previously responsible and the newly responsible economic operator with the exception of transfer case 3, when the battery is returned via a take-back system. Hence the previously responsible economic operator might not know that a transfer has taken place.

3) Considerations regarding the case of non-compliance

In order to define cases of non-compliance and to avoid any legal uncertainty on rights, duties and obligations, the auditability (please refer to chapter 5.4) and clear definition of requirements is crucial. Detection and consequences depend on the Member State and the respective market surveillance authorities. Yet, harmonisation is needed on a European level (e.g., potential fines) to avoid different legal consequences. A violation of requirements for the battery passport should lead to an appropriate sanction in any Member State.

It can be assumed that the battery passport will be subject to legal review. Within this process the burden of proof should be defined in a reasonable and practicable manner. Furthermore, the legal nature of the battery passport should be clarified on, e.g., whether and to what extent the battery passport could be seen as a compound deed with certain evidentiary effect for the recipient. The legal review should also examine whether the Battery Regulation could present the legal basis for liability claims under private law.

5.3 Implications of handling operations on the battery passport

As elaborated in chapter 5.2, the economic operator – by putting a battery into service or placing it on the market – has the responsibility to fulfill the requirements laid out in *Article 65*, which include the creation of a battery passport as well as ensuring the data is “up to date” (*Article 65(4)*).

After the original battery passport has been created, the battery will undergo certain operations along its life cycle (e.g., maintenance, remanufacturing or repair) that require modifications of data attributes (mostly dynamic, but also static data; see also definition on battery handling operations in chapter 4.3). Depending on the type of handling operation, this may either involve an update to the existing battery passport or the creation of a new one. However, for repair operations, the consequences for the battery passport are not entirely clear. Two cases have to be differentiated: “re-use” (repair of non-waste batteries) demands no new battery passport to be issued, while repair in terms of “preparing for re-use” (for waste batteries) requires a new battery passport. To understand this distinction, the term “waste” has to be looked at more closely (see info box below).

In the following, we discern and provide further details on those handling operations that only require an update to the existing passport (chapter 5.3.1) in contrast to those operations upon which a new battery passport needs to be created (chapter 5.3.2). After the battery has been recycled, the passport is required to “cease to exist” (*Article 65(6b)*). This is elaborated further in chapter 5.3.3.

Waste vs. non-waste batteries in the Battery Regulation

The distinction of non-waste and waste batteries is of great importance in practice. The EU Battery Regulation (*Article 65(6a)*) features provisions of different cases of battery handling (e.g., remanufacturing) on the effects of change of data in the battery passport. These provisions and definitions include the waste status of a battery to discern between the major downstream handling operations. This bears tremendous ramifications as transport conditions and the corresponding cost increase significantly for waste batteries, which in turn affects the economic case of potentially returning waste batteries to a second life.

The Battery Regulation refers to the *Waste Directive, Article 3(1)* defining waste as "any substance or object which the holder discards or intends to or is required to discard". This broad definition is amended only by a description on the distinction of waste and used batteries in *Annex XIV (new)* that is intended to provide guidance for the shipping of batteries. In the understanding of the Battery Regulation, waste batteries may enter the recycling process or be returned to a safe use by "preparing for re-use" or "preparing for repurpose" (see definitions in chapter 4.3). *Recital 88* lays out the need to develop uniform conditions to further define the requirements a battery needs to fulfil to cease to be waste, which should be covered through implementing powers of the European Commission.

The example of transport

The EU Battery Regulation provides little guidance to distinguish between used batteries and waste batteries. According to *Annex XIV* battery holders with the intent of shipping the battery must provide evidence that the battery is a used battery. Generally, used batteries can be sent back to the producer/third party acting on this behalf as "defective for repair", if it is intended for re-use (*Annex XIV (2)*). In the absence of proof, the battery is considered as waste and as transported illegally (*Annex XIV (5)*).

The provided guidance covers only the intent for re-use and not the case of non-defective batteries that have no further use and are therefore intended for recycling. The broad definition of waste above could mean that all batteries intended for recycling may be designated waste, thus unnecessarily causing costly logistics. A desirable remedy would be to apply the distinction of non-waste/waste status based on the individual conditions of the battery also for the case of transport to recycling.

5.3.1 Updates to the existing battery passport

Re-use represents the only battery handling operation that may require updates in the battery passport but does not warrant a new battery passport (*Article 65(6a)*).

As indicated in chapter 4.3, the term re-use includes any operation by which products or components that are not waste are used again for the same purpose. Maintenance and repair of non-waste batteries comprise the most relevant operations covered by this term:

- **Maintenance** is not expected to lead to significant changes to the battery and the battery data respectively. Therefore, no data update is necessary except for potentially tracking information on the occurred maintenance.
- **Repair of non-waste batteries** (Re-use) could include significant changes to the battery (e.g., through exchange of a module). In this case, also static data (e.g., sourcing information) in the existing battery passport would need to be updated.

However, if the repair is done on a waste battery, it is defined as preparing for re-use and a new battery passport is required (see chapter 5.3.2).

This interpretation based on the provisions of the EU Battery Regulation leaves open how data changes resulting from repair of non-waste batteries (re-use) should be handled. The Battery Pass consortium recommends keeping data history available in the battery passport in such cases, while ensuring that the up-to-date data is clearly discernible. Further amendments or elaboration by the European Commission on this issue would be helpful for implementation of the battery passport.

5.3.2 Creation of a new battery passport

When a battery was subject to **remanufacturing, repurpose** or one of the treatment operations **preparing for re-use** and **preparing for repurpose**, the EU Battery Regulation (*Article 65(6a)*) states that a battery has to be placed on the market again and a new battery passport shall be issued.[19] While remanufacturing and repurposing is carried out on non-waste batteries, preparing for re-use and preparing for re-purpose are defined to be carried out on waste batteries. In these cases, the economic operator that puts the battery into service or places it on the market again, is responsible for the creation of a new battery passport and its data and all other obligations described in the Battery Regulation (see transfer case 1 in chapter 5.2.1).

The need for a new battery passport is interpreted on the fact that changes to the components or to the battery management system will cause static data, such as sourcing information or rated capacity, to be altered. However, the regulation is inconsistent with respect to the repair of non-waste batteries that, as described in chapter 5.3.1, does not require a new battery passport although static data might need to be updated.

The new battery passport will include unchanged data attributes that are transferred from the record of the original battery passport to the new battery passport. In addition, static data, like sourcing information, will need to be updated in case e.g., a battery module is exchanged. The EU Battery Regulation mandates that the original inactive battery passport(s) (including the original battery passport records[20]) shall be linked to the new battery passport (*Article 65(6a)*). This way, the valuable history of the battery will be recorded for other economic operators as well as the end-user, while being able to clearly distinguish current from outdated information.

The requirement for a new battery passport excludes an update to carbon footprint and recycled content (*Article 7(3a)* and *Article 8(3a)*). This is regarding batteries that have been subject to preparing for re-use, preparing for repurpose, repurposing or remanufacturing, if the battery had already been placed on the market or put into service before undergoing such operations.

5.3.3 Recycling and the end of the battery passport

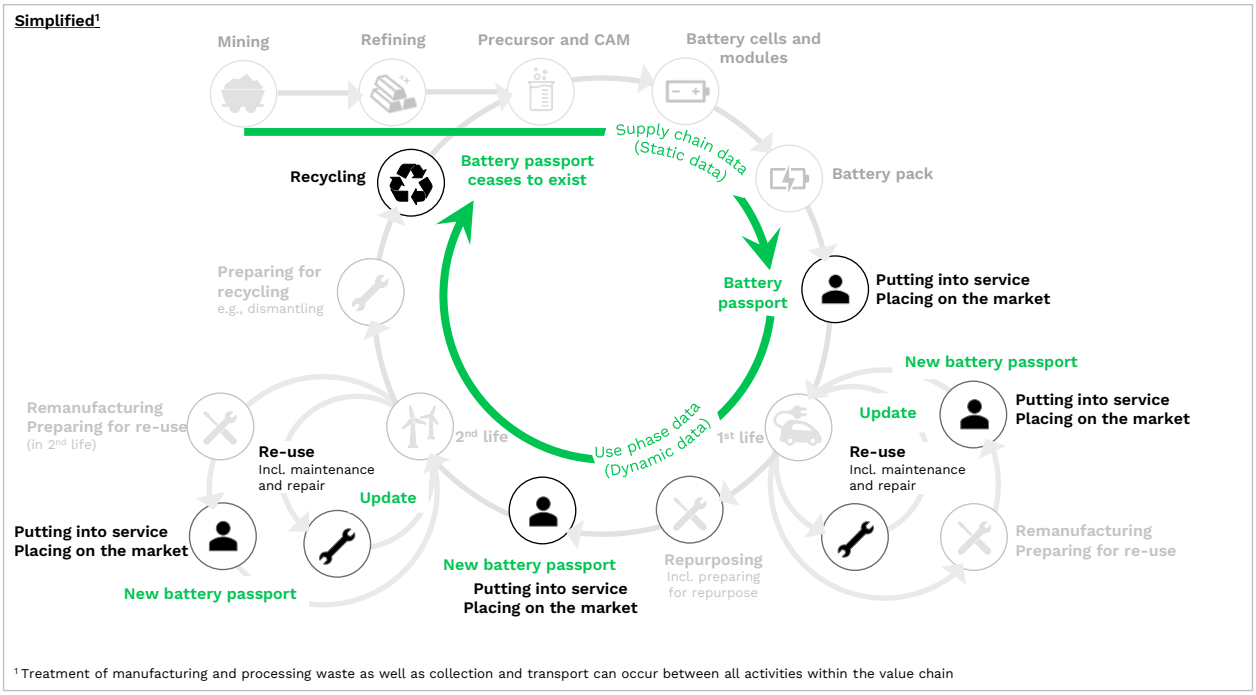
The EU Battery Regulation mandates that “a battery passport shall cease to exist after the battery has been recycled” (*Article 65(6b)*) but does not elaborate on this topic further. It remains unclear at which point in the multi-step recycling process a battery counts as recycled, how the “ceasing to exist” of the battery passport will proceed in practice, and who must be involved (see chapter 5.2.1). It also remains elusive whether “cease to exist” includes the instant deletion of all data. The Battery Pass consortium proposes that the passport and its data should not cease to exist immediately after the battery is recycled. The relevant tracking information

[19] A new battery passport is understood by the Battery Pass consortium as independent entity with a new unique identifier. Furthermore, see chapter 4.3 for definitions of the battery handling operations.
[20] There may be multiple original battery passport records linked to the new battery passport, if a module, which has been used before in a battery, is used together with modules that were part of another battery. The attribution of the original records to the corresponding modules must be provided in a clear fashion.

of the end-of-life fate will be attributed to the battery passport and thus allow for tracking the steps of adequate battery recycling. This could be used by economic operators as verifiable information to prove the origin of recycled content for the next life cycle of the recycled material – and its next battery passport. In concrete terms, information from battery producers on post-consumer recycled content shares could be made traceable and verified.[21] Ensuring adequate recycling processes and realising a high quality of recycling could be a key use case to enable authorities to trace back information on the recycling of a battery after they entered the process of recycling.[22] Further guidance by the Commission on these issues will be needed.

Figure 13 summarises the above explained implications of handling operations on the data and status of the battery passport and indicates, when a (new) passport needs to be issued or when it ceases to exist.

Figure 13: Battery life cycle and implications of battery handling operations on the data as well as start and end of the battery passport



[21] This topic is further detailed in chapter 6.6.2.1

[22] If the battery passport ceased to exist upon dismantling of the battery, further tracking of the whereabouts of the battery material would not be possible, leaving the door open for material leakage towards inadequate recycling. The tracking of recycling steps could contribute to responsible recycling back to battery grade materials, although any implementation requires that material flows after extraction from batteries can be attributed back to single battery entities. The implementation has not been evaluated in detail by the Battery Pass consortium.

5.4 Auditability of the battery passport

Audit is defined by ISO 9000:2015 as a “systematic, independent and documented process [...] for obtaining objective evidence [...] and evaluating it objectively to determine the extent to which the audit criteria [...] are fulfilled” (ISO 9000:2015 p.59). Furthermore, the standard adds that determination of conformity is to be “carried out by personnel not being responsible for the object audited” (ISO 9000:2015 p.59) and it can be conducted as internal or external audit.

The general auditing requirements follow from the Battery Regulation. The regulation defines **conformity assessment** (see also chapter 6.2.4) as “the process demonstrating whether the sustainability, safety, labelling, information or due diligence requirements of this Regulation have been fulfilled” (*Article 2(33)*) and **conformity assessment body** as “a body that performs conformity assessment activities including calibration, testing, certification and inspection” (*Article 2(34)*). Lastly, a **notified body** is defined as a conformity assessment body fulfilling the requirements of Chapter V (notification of conformity assessment bodies) of the Battery Regulation (*Article 2(35)*).

Auditing as such is therefore an essential part to ensure trust in the data contained within the battery passport. This is challenging though since the data in the battery passport originates and relates to the entire life cycle from design to production and usage.

As a consequence, it is not possible to test and verify data in a specified procedure in a laboratory as some of the dynamic data points cannot be retested afterwards. The aim is therefore to create a secure monitoring and verification system to ensure the data is correct, which is also a requirement of Battery Regulation *Article 65(4)*, externally towards market regulation authorities and general public or other stakeholders, as well as internally for involved parties of the battery value chain. The system needs to be easy to adapt as regulatory and market demands are constantly changing and at the same time should entail as little additional cost as possible. Overall, this chapter only provides a first glimpse into the topic, which will be further specified in the course of the technical work of the Battery Pass project.

5.4.1 Initial audit concept

The initial audit concept as shown in Figure 15 covers what, how and by whom aspects of the battery passport ecosystem are to be monitored and verified. The term ecosystem is used to highlight that the audit concept is understood as a broader task as it not only includes company-level audits but also facilitates audits on market level. Requirements for the audit system result from four different sources:

1) **The Battery Regulation:** defines specific requirements for monitoring and verification.
2) **The ESPR:** adds aspects e.g., with regards to digital product passports.
3) **The Battery Pass Standard Stack** (see chapter 5.1): covers the technical aspects to facilitate the operations and the management of the entire battery passport ecosystem across organisations along the value chain as well as the governmental authorities. It includes standard elements to ensure availability and accessibility of battery data, such as aspects of data storage. It adds a technological view to the content described in chapter 6. As those aspects need to be monitored and verified to ensure compliance as well, they are included as an information source.

4) **The Battery Pass Reference Model** (see info box below): helps to establish the requirements for auditing the compliance of processes and data points by linking the battery life cycle to the data flow. This defines where data points are generated and who is responsible, which in turn also helps to define where and what must be monitored and verified.

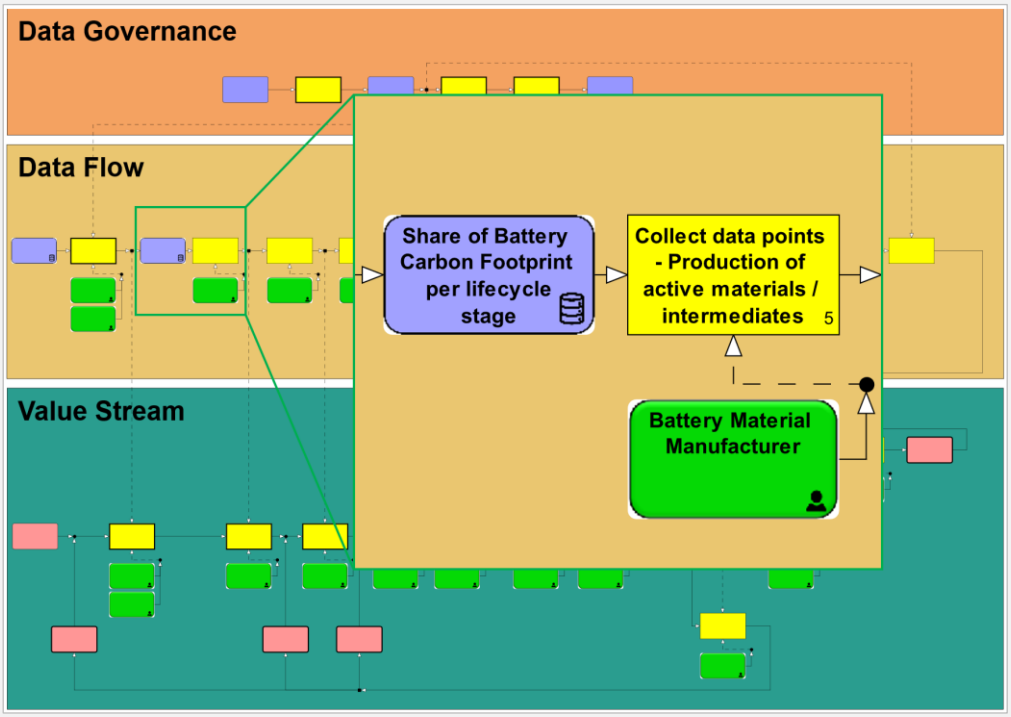
The focus at this stage of the project has been on an initial analysis of the requirements of the Battery Regulation with the other sources to be further explored or developed as the work of the technical working group of the Battery Pass continues.

The Battery Pass Reference Model

The Reference Model by the Battery Pass technical working group covers all relevant battery business and data objects of three major processes:

1) **Value stream:** all upstream (from mining to "placing the battery on the market") and downstream (from usage until end-of-life) processes of the battery value chain.
2) **Data flow:** the data flow along the individual value chain steps and respective data processing in between to create and feed the battery passport with static and dynamic data.
3) **Data governance:** data governance processes, which are linked to the data flow in order to ensure the participation of eligible partners, perform data analysis (e.g., to check abnormalities in processes and data) or even impact analysis of the entire system.

Figure 14: The Battery Pass Reference Model levels (including zoom-in example)



The process steps are shown in yellow and can be refined into sub-models which are interconnected. The purple, red and green boxes are representing business and data objects which are related to the process steps:

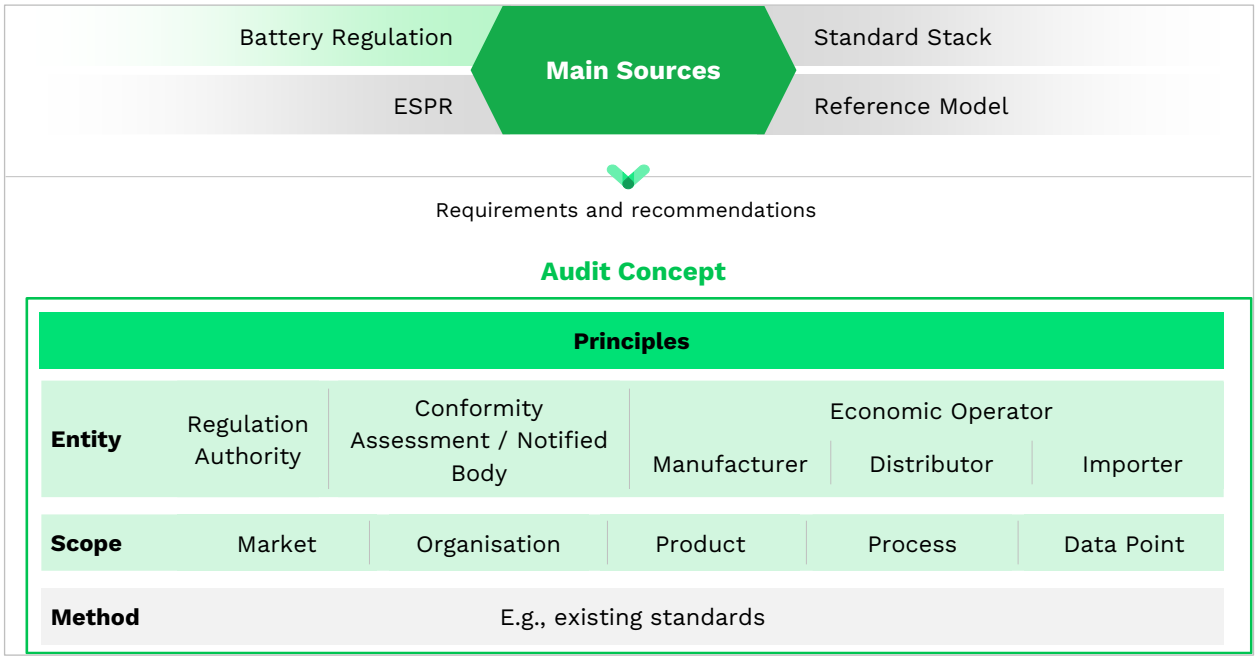
- Purple colour: Data points (e.g., carbon footprint)
- Red colour: Material and battery elements (e.g., raw material)
- Green colour: Roles (e.g., battery material manufacturer)

General principles for conducting audits such as integrity, independence etc. (e.g., as defined by ISO 19011:2018 for management systems or Generally Accepted Auditing Standards (GAAS) for financial audits) will form the foundation of the concept.

The different entities have different tasks with regards to monitoring and verification. Actors within the initial auditing concept are regulation authorities like the European Commission or Member States, conformity assessment/notified bodies and the economic operator. The economic operator itself can be further differentiated in the types described in chapter 4.2.

The entities have to monitor and verify different aspects on different levels. These levels range from the overall market to an organisation and specific product, to different processes and single data points stored in the battery passport. All levels require different methods to assess compliance. While for some aspects, e.g., the due diligence, the regulation already includes specific requirements on how to conduct the audit, a methodology for other aspects, e.g., those derived from the Standard Stack, will need to be specified as the technical working group further progresses. Although the market level is included in the illustration and general scope, a related methodology will not be in focus of the Battery Pass audit specification, as the focus is on the economic operator and there are established mechanisms.

Figure 15: Initial Audit Concept (grey boxes will be in focus in the coming months)



Based on the previously introduced auditing concept, Table 1 provides an overview of exemplary contents the entities have to monitor and verify. As explained earlier, the focus has been on analysing the Battery Regulation with further requirements from the other sources (ESPR, Standard Stack and Reference Model) to be added during the coming months. The requirements are exemplary and structured along the battery passport content clusters as laid out in chapter 6.

Table 1: Exemplary audit requirements by entity and scope

Entity / Scope	Regulation authorities	Conformity assessment/ Notified body	Economic operator
Market	• Verify recognised due diligence schemes (*Article 45f 3*) • Designate one (or more) competent authorities to monitor and verify that obligations with regard to waste management are fulfilled (*Article 45g*) • Specify modalities for verifying compliance with requirements of waste collection (*Article 47b(3)*) • Monitor collection rates and verify measures for achieving collection targets, verify this information and compliance with calculation methodology (*Article 55(2)*) • Establish detailed technical and verification requirements that batteries have to fulfill to be considered waste (*Article 59(7)*) • Commission might designate a public testing facility of a Member State as a Union testing facility for the purpose of compliance and market surveillance (*Recital 95b*).	To be assessed at a later stage	To be assessed at a later stage
Organisation	To be assessed at a later stage	Conduct periodical audits in accordance with *Article 45a(1a)* and third-party verification in accordance with *Article 45d* (*Article 25 (6)*)	• Have its due diligence verified by a notified body (*Article 45(1a)*) • Establish a system to document third-party verification reports concerning upstream suppliers (*Article 45b, d, v*) • As part of their risk management over the supply chain: might also carry out third-party verifications (*Article 45c*).

Entity / Scope	Regulation authorities	Conformity assessment/ Notified body	Economic operator
Process	To be assessed at a later stage	To be assessed at a later stage	To be assessed at a later stage
Product	To be assessed at a later stage	Conduct tasks of conformity assessment as described in *Annex VIII* (*Article 25(6)*)	• Verification of carbon footprint (*Article 7*) and recycled content requirements (*Article 8*) and recycling efficiencies and recovery of material (*Article 57(4)*) • Conformity assessment as described in chapter 6.2.4 (*Article 17*) • Special requirements for importers and distributors, e.g., verify that conformity assessment has been carried out (*Article 41* and *42*)
Data point	To be assessed at a later stage	To be assessed at a later stage	To be assessed at a later stage

5.4.2 Outlook for further work on auditability

The requirements described in the previous chapter can be fulfilled by different methods. These will be elaborated by the technical working group of the Battery Pass in the coming months. As the Battery Regulation often only describes requirements on what is to be done with regard to monitoring and verification, other sources need to be leveraged. These solutions are both researched along the battery value chain, and derived from assessing compatibility of auditing solutions in other sectors. A first glimpse into possible solutions is presented in the following.

On an organisation level, existing standards could be used to prove compliance and at the same time reduce additional efforts required for auditing. For example, the Standard Stack contains the module of IT Governance, which “provides the responsibilities, principles and processes for managing the technical infrastructure for the battery passport”. Derived from this it becomes apparent that it is necessary to ensure that participating companies fulfil requirements for safe data processing, which is relevant for procedures, infrastructure and organisational capabilities. Also, the aspect of having procedures and infrastructure for data persistence, e.g., in case of disaster or company insolvency, can be derived from the Standard Stack.

Example: Using existing standards for audit of aspects of the Standard Stack

There are several standards available, like ITIL (IT infrastructure Library), ISO 27001 for information security or TISAX which is already applied in the automotive industry and includes specifications for the accreditation as well. For instance, ITIL is requesting dedicated procedures and solutions for disaster recovery and business continuity management. By using existing instruments conformity can be ensured. The consequence is, that companies, which are already certified according to such comprehensive standard do not need to undertake additional efforts for being accepted in the battery passport ecosystem.

On a process and product level, fulfilment of requirements could be verified by a certification-based approach, where certificates verify required data (e.g., GHG emissions) of battery components and respective material along the supply chain. Where automatic data flows are in place, specification of data points and processes for performing anomality analysis could also be used for monitoring and verification.

Certification-based vs. automatic data flow-based auditing

Certification-based auditing: Specifications for certificates from accredited certification authorities have to be elaborated to ensure product parts or materials are compliant with requirements, e.g. from the EU Battery Regulation and ESPR. Required specifications for certificates have to contain process context information, e.g., related sub-processes, inputs and outputs, location, and subcontracted companies. Requirements for process conformity have to be derived by rules for documenting process outputs and the influencing parameters.

Automatic data flow-based auditing: Processes and data objects in the model representing the required data have to be stored in the used IT systems and has to be made accessible to supply chain partners and authorities for performing conformity checks (e.g., sample checks for conformity of data accuracy and anomalies).

In the coming months, the Battery Pass consortium will elaborate a system specification for auditing and propose a governance structure. In order to do so, requirements in accordance with the sources identified in chapter 5.4.1 will be elaborated as well as, in parallel, the initial concept be extended, validated, revised and refined together with auditing stakeholders. Afterwards, the requirements will be integrated into the revised concept and practices from existing standards be assigned and evaluated based on their ability to fulfil auditing requirements. The relevant success factors for the auditing have been defined as: effectiveness, cost for stakeholder and industrial adoption rate.

6 Battery passport content requirements

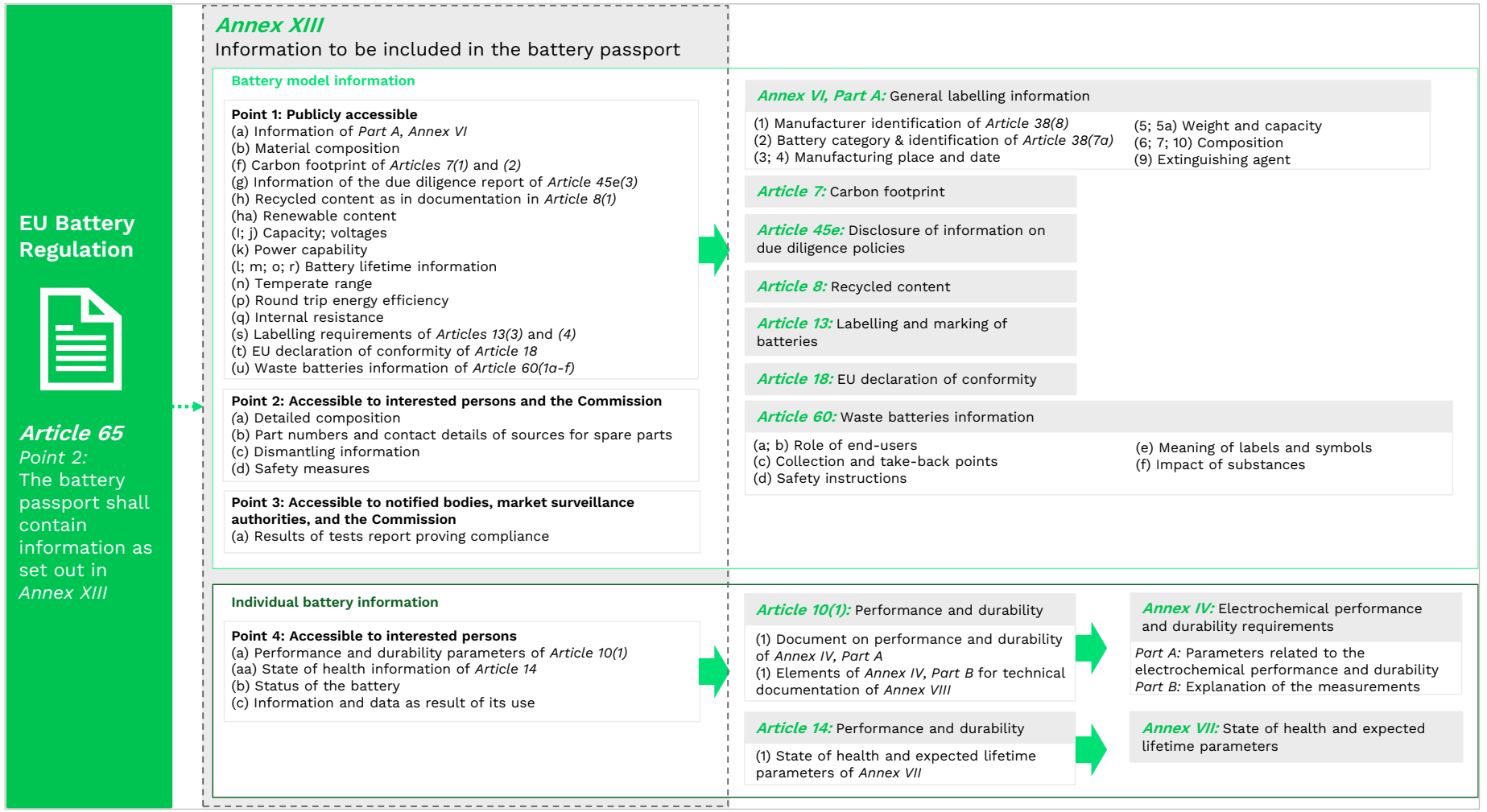
The EU Battery Regulation includes a comprehensive set of information in *Article 65* and *Annex XIII* about which data attributes need to be made available in the battery passport. Figure 16 provides an overview on the many articles and annexes of the Battery Regulation further detailing these requirements. As already mentioned in chapter 2.2, the Battery Pass consortium has grouped these into content clusters starting with overarching elements following the battery life cycle, as outlined below:

- General battery and manufacturer information (chapter 6.1)
- Compliance, labels, certifications (chapter 6.2)
- Battery carbon footprint (chapter 6.3)
- Supply chain due diligence (chapter 6.4)
- Battery materials and composition (chapter 6.5)
- Circularity and resource efficiency (chapter 6.6)
- Performance and durability (chapter 6.7)

The required respective data attributes of these clusters as well as voluntary amendments by the Battery Pass consortium are depicted in Figure 17. The overview summarises individual characteristics of the data attributes, such as the applicable battery categories, data access, and data behaviour characteristics. For a more compact overview, all data attributes were additionally synthesised in an Excel table (see the "Battery Pass Data Attribute Longlist").

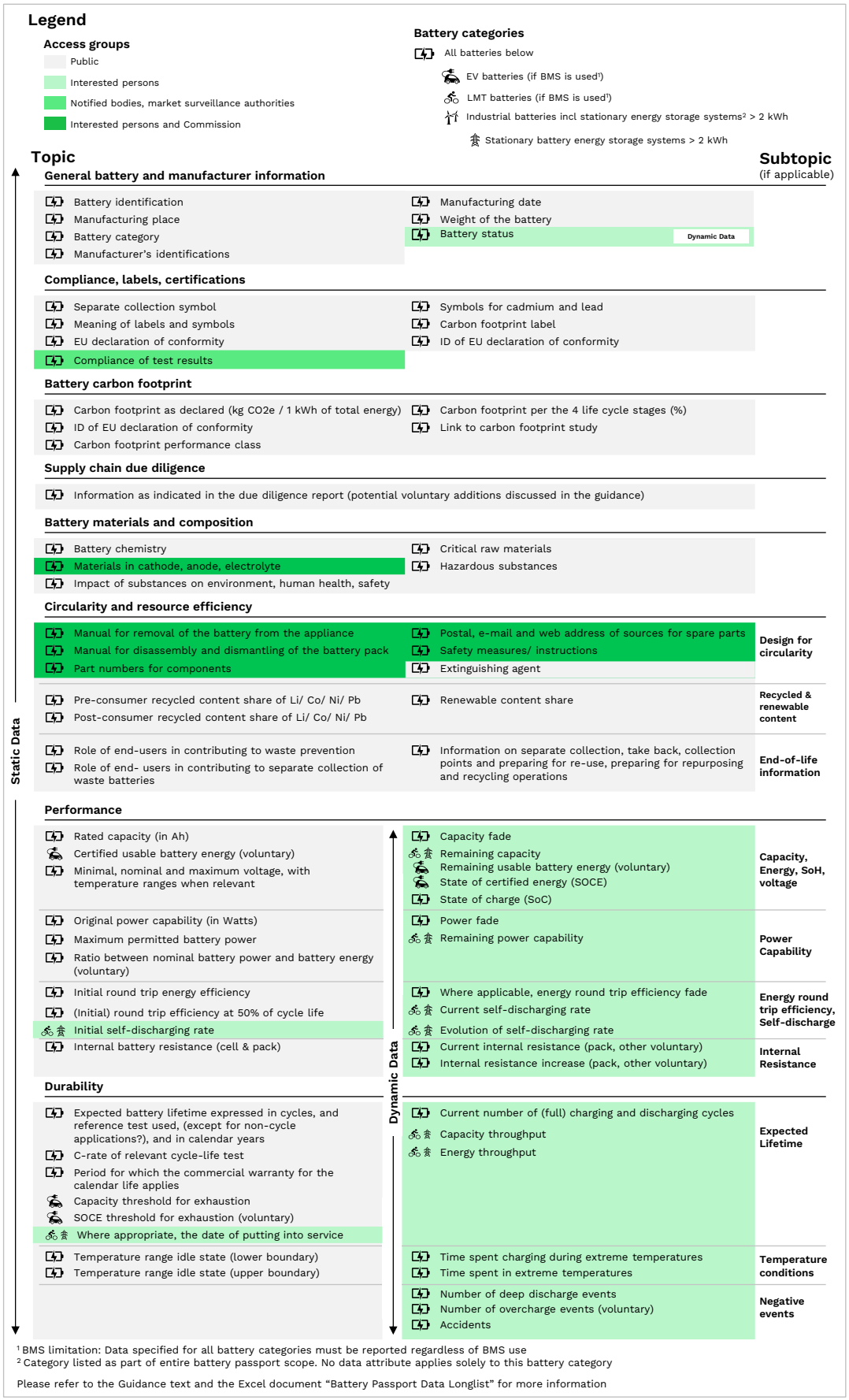
As applicable, the respective (sub-) chapters typically include an info box at the beginning with a brief overview on the mandatory data attributes for the battery passport as well as a summary of the suggestions and outlook provided by the Battery Pass consortium. Subsequently, a table lists the single data attributes once more in detail including further guidance on how to calculate, report, and compile the information. The following content of the (sub-) chapters provides a comprehensive overview including extensive background information going well beyond the direct requirements for the battery passport also covering related aspects in the broader context of the EU Battery Regulation and beyond. Thereby, green text boxes indicate a content excursion or an elaborated focus topic.

Figure 16: Battery passport information flow in the Battery Regulation.[23]



[23] Enumerations, including missing numbers, reflect the current enumeration in the Battery Regulation. See Figure 33 in chapter 6.7.1 for a dedicated performance and durability information flow.

Figure 17: Battery passport information by battery categories and access groups



[1] BMS limitation: Data specified for all battery categories must be reported regardless of BMS use
[2] Category listed as part of entire battery passport scope. No data attribute applies solely to this battery category

Please refer to the Guidance text and the Excel document "Battery Passport Data Longlist" for more information

6.1 General battery and manufacturer information

Battery passport guidance in brief on general battery and manufacturer information

Mandatory data: Battery identification; manufacturer's identification; manufacturing place; manufacturing date; battery category; battery weight; battery status (*Annex VI, Part A* and *Annex XIII*)

Our suggestions and outlook: General information about the battery and manufacturer should be made accessible in an aligned and clear manner via the battery passport. For an unambiguous identification, we recommend unique identifiers as introduced in the Battery Regulation and/or ESPR. For other data points, commonly used reporting approaches such as manufacturing codes for the date or kilograms for the weight are suggested. For battery specific terms such as battery category or battery status, the Battery Regulation offers initial definitions.

As per *Annex XIII(1a)* of the Battery Regulation, information about the battery model specified in *Annex VI, Part A* has to be accessible to the public via the battery passport. This chapter introduces general information about the battery and manufacturer with *points 1-5* of *Annex VI, Part A* being outlined below.

For batteries to be marked with a label containing the general information about batteries of *Part A of Annex VI*, a timeline of 36 months after entry into force of the regulation or after 18 months after entry into force of the implementing act on harmonized labelling (whichever is later) is introduced.

Table 2: General battery and manufacturer information to be made available via the battery passport

Data attribute	Battery Regulation reference	Data Access	Definition/ Understanding	Suggested reporting
Battery identification	*Article 65(3)*; *Annex VI, Part A*, to *Article 38(7)*	Public	Unambiguous identification of an individual battery and its corresponding battery passport	Unique battery identifier (as unique string of characters), to be compliant with ISO/EC 15459:2015 or equivalent
Manufacturer's identification	*Annex VI, Part A(1)*; *Article 38(8)*	Public	Unambiguous identification of the manufacturer of the battery	State the name, trade name or mark, postal address, web address, e-mail address. Suggested reporting via a unique operator identifier (see requirements of unique battery identifier).
Manufacturing place	*Annex VI, Part A(4)*	Public	Geographical location of the battery manufacturing facility	State country, city, street, building (if needed). Suggested reporting via a unique facility identifier (see requirements of unique battery identifier).
Manufacturing date	*Annex VI, Part A(4a)*	Public	Month and year of battery manufacturing	State date in form of manufacturing codes, specifying year and month.

Data attribute	Battery Regulation reference	Data Access	Definition/ Understanding	Suggested reporting
Battery category	*Annex VI, Part A(2)*	Public	Intended use of the battery	Specify use: 'stationary battery energy storage system', (other) 'industrial battery', 'LMT battery', or 'electric vehicle battery'.
Weight of the battery	*Annex VI, Part A(5)*	Public	Mass (here called weight) of the battery	Specify the weight of the entire battery in kilograms. Voluntary: if the battery is defined on pack or module level: also specify the weight of the modules and/or cells.
Battery Status	*Annex XIII, 4(b)*	Interes-ted persons	Characteristic of the battery in its life cycle	Describe battery status as one of 'Original', 'Repurposed', 'Re-used', 'Remanufactured' or 'Waste' (mandatory).

6.1.1 Battery identification

Batteries need to be identifiable in a way that battery-specific and model-specific information can be attributed accordingly. Therefore, each individual battery, and with it also the corresponding battery passport, shall be unambiguously identifiable. While the Battery Pass working group on technical standards together with the GBA ID working group are advancing the topic of battery identification, basic principles of battery identification are introduced below. These are based on requirements and definitions of the Battery Regulation.

The Battery Regulation states that the battery passport shall be "accessible through [a] QR code" (see chapter 5.1.1). This QR code shall be linked to a "unique identifier that the economic operator placing the battery on the market shall attribute to it" (*Article 65(3)*).

Further, *Annex VI, Part A* on general information about batteries on labels requires "the identification in accordance with *38(7a)*". This requirement is linked to the battery passport via *Annex XIII(1a)*. *Article 38(7)* outlines that batteries shall "bear a model identification and batch or serial number, or product number or another element allowing their identification".

Definition of battery identification

A **"unique identifier"** is defined in the Battery Regulation (*Article 2(55a)*) as "a unique string of characters for the identification of batteries that also enables a web link to the battery passport". The unique identifier shall comply with the standard ISO/IEC 15459:2015 or equivalent (*Article 65(3)*). That standard specifies the procedural requirements to maintain identities. The regulation adds that the Commission can adopt delegated acts to replace this standard or add other European or international standards the unique identifier shall comply with.

To understand on which level a battery needs to be identifiable, the terms battery model and battery batch, both used in *Article 38(7)*, are defined in chapter 4.1.2. In comparison to a model or batch identification, a "serial number" is uniquely assigned to each individual battery.

Suggested reporting granularity of battery identification

As required per regulation, each battery passport shall be linked to a unique identifier. The unique identifier should allow for the unambiguous identification of each individual battery and hence each individual battery passport. Therefore, the identification of the battery should be serialised, i.e. identifying each battery via a serial number. In addition, since some data attributes may be assigned on a model level, also the battery model should be identifiable. If identification on product at batch level is additionally needed, that will need to be explored.

Following the Battery Regulation, the unique battery identifier shall:

- Comply with the standard ISO/IEC 15459:2015 or equivalent (*Article 65(3)*) for the procedural requirements,
- Enable a web link to the battery passport (*Article 2(55a)*),
- Follow open standards ("respecting open standards for third-party use", *Article 62(1c)*).

The technical working group of the Battery Pass will identify and evaluate potentially suited standards for the unique identifier.

Battery passport data available on battery module or cell level?

The EU Battery Regulation specifies the battery passport on a battery level, without specifying data availability for battery components like modules. As per the battery definition, a battery pack, module or cell may constitute a battery (see chapter 4.1). With respect to the battery passport-relevant categories (industrial > 2 kWh, LMT, EV), in particular EV and industrial batteries often consist of one or multiple packs, where each pack has a battery passport. Depending on the design of the battery, a pack comprises a multitude of cells that may be housed in separate modules (see also definitions in chapter 4.1).

When a battery needs to be repaired, remanufactured or is prepared for re-use or for repurpose, by exchange of a defect module for example, the waste module will be recycled. If only the battery pack bears the identifying QR code, the battery handler cannot access any data for the particular module, e.g., information about its composition. Different options to address this issue, considering particularly the implementation in practice, will be assessed further by the Battery Pass consortium.

One step further would be to set the overall granularity of data reporting in the battery passport to the module or cell level. Currently, the Battery Regulation mandates reporting on the highest level, which often is the battery pack (industrial, EV batteries) or a stand-alone module (e.g. LMT batteries). A more granular reporting could be beneficial to convey varying information within a battery pack, different ageing of modules for example, to a repurposer or remanufacturer. Based on the state of health reporting on module level, the repurposer could more easily decide upon repurposing the battery. At the same time, the more granular data level causes more effort to economic operators and may in some cases be physically impeded, e.g., measuring the resistance of a cell in a serially connected cell group. A more granular reporting should be reviewed for future iterations of the Battery Regulation.

6.1.2 Manufacturer's identification

"The manufacturer's identification in accordance with *Article 38(8)*" (*Annex VI, Part A(1)*) is mandatory to be accessible by the public via the battery passport (reference from *Annex XIII (1a)*). *Article 38(8)* lists the manufacturer information to be provided on the battery, as listed below.

Also, the ESPR (*Recital 30,* (6)) states that "where appropriate, the passport should allow for the tracing of the actors and manufacturing facilities related to that product".

Definition of manufacturer's identification

The term "manufacturer" is defined as "any natural or legal person who manufactures a battery or has a battery designed or manufactured, and markets that battery under its own name or trademark or puts it into service for its own purposes" (*Article 2(27)*). The "manufacturer's identification" should provide sufficient information about the manufacturer to uniquely identify that player.

The ESPR (*Article 2(32),* (6)) introduces the "unique operator identifier", a "unique string of characters for the identification of actors involved in the value chain of products". Per Battery Regulation, for the battery passport, this identifier should refer to the manufacturer of the battery. The unique operator identifier follows the same principles as the unique battery identifier outlined in chapter 6.1.1 and hence shall also comply with the ISO/IEC standard 15459:2015 (*ESPR*, *Article 11(1)),* (6)). Delegated acts of the Commission might replace this standard "in light of technical and scientific progress" (*ESPR*, *Article 11(4)),* (6)).

Suggested reporting granularity of manufacturer's identification

We suggest identifying the manufacturer in line with the information requirements introduced in *Article 38(8)*, being:

- The name
- Registered trade name or registered trademark
- The postal address, indicating a single contact point
- A web address, where one exists
- An e-mail address, where one exists.

This information should be, at least, made accessible in text form via the battery passport. We suggest, however, adding a unique operator identifier for the manufacturer, as introduced in the ESPR (6). Such an identifier could entail the above-listed information. Today, examples of common operator identifiers include the DUNS®-Number (a number assigned to a single business entity, issued by Dun and Bradstreet), GLN (Global Location Number, issued by GS1), the EORI number (Economic Operators Registration and Identification number, issued by the EC), BIC (Business Identifier Codes, issued by SWIFT), LEI (Legal Entity Identifier based on ISO 17442), or national VAT numbers. The principles for this identifier should be the same as those introduced for the unique battery identifier in chapter 6.1.1 and will be further elaborated by the Battery Pass technical working group.

The ESPR (*Article 11(2),* (6)) adds that where a unique operator identifier is not yet available, "the economic operator creating the product passport shall request a unique operator identifier on behalf of the relevant actor".

6.1.3 Manufacturing place

The "manufacturing place (geographical location of a battery manufacturing facility)" (*Annex VI, Part A(4)*) is mandatory to be accessible by the public via the battery passport (reference from *Annex XIII (1a)*).

Also, the ESPR (*Recital 30,* (6)) states that "where appropriate, the passport should allow for the tracing of the actors and manufacturing facilities related to that product".

Definition of manufacturing place

The manufacturing place refers to the "geographical location of the battery manufacturing facility" (*Annex VI, Part A(3)*).

The ESPR (*Article 2(33),* (6)) introduces the "unique facility identifier", a "unique string of characters for the identification of locations or buildings involved in the value chain of a product or used by actors involved in the value chain of a product". Per Battery Regulation, for the battery passport, this identifier should refer to the manufacturing facility of the battery. The unique facility identifier follows the same principles as the unique battery identifier outlined in chapter 6.1.1 and hence shall also comply with the ISO/IEC standard 15459:2015 (*ESPR*, *Article 11(1),* (6)). Delegated acts of the Commission might replace this standard "in light of technical and scientific progress" (*ESPR*, *Article 11(4),* (6)).

Suggested reporting granularity of manufacturing place

We suggest identifying the manufacturing facility by specifying its geographical location. The address should be, at least, made accessible in text form via the battery passport. We suggest, however, making the manufacturing place available via a unique facility identifier, as introduced in the ESPR (6). Common examples for location identification today include ISO-31661-1 country codes or GLN for addresses (Global Location Number, issued by GS1). The principles for this identifier should be the same as those introduced for the unique battery identifier in chapter 6.1.1 and will be further elaborated by the Battery Pass technical working group.

The ESPR (*Article 11(3),* (6)) adds that where a unique facility identifier is not yet available, "the economic operator creating the product passport shall request a unique facility identifier on behalf of the actor responsible for the relevant location or building".

To allow for a harmonised reporting, the granularity of the geographical location should be specified (country, city, street, or even building if several facilities operate under one address).

6.1.4 Manufacturing date

The "manufacturing date (month and year)" (*Annex VI, Part A(4a)*) is mandatory to be accessible by the public via the battery passport (reference from *Annex XIII (1a)*).

Definition of manufacturing date

As defined in the Battery Regulation, the manufacturing date refers to the month and year a battery was manufactured.

Suggested reporting granularity of manufacturing date

We suggest stating the manufacturing date in form of manufacturing date codes (year/month).

Already today, date codes are printed on batteries. These date codes vary, with digits and/or letters indicating the date. For instance, an "A" or "2021" can indicate the year 2021; a "317" can indicate the 317th day of a year; or a "14" can indicate the 14th calendar week of a year.

The date code made accessible via the battery passport should be agreed upon to ensure an unambiguous readout of the date. If no unique date code is determined, the respective date code standard should be stated.

6.1.5 Battery category

The battery category is mandatory to be publicly accessible via the battery passport (reference from *Annex XIII (1a)* to *Annex VI, Part A(2)*).

Definition of battery category

In line with its use in the Battery Regulation, we define a “battery category” as the intended use of the battery, with the following categories relevant for the battery passport: “LMT battery”, “electric vehicle battery” or “industrial battery”. The latter includes the subcategory “stationary battery energy storage system” complemented by “other industrial batteries” (*Article 2*; see chapter 4.1.1).

Suggested reporting granularity of battery category

We suggest specifying the battery category based on the intended use of the battery within the options provided by the EU Battery Regulation. For the category nomenclature, it should be considered whether the classification should also distinguish between batteries with exclusively external storage (redox-flow batteries) and others as well as between rechargeable and non-rechargeable batteries, if requirements for these characteristics differ. For this data point it should be kept in mind that the battery category might change in case of a second use of a battery (e.g., EV battery as stationary battery energy storage).

6.1.6 Battery weight

The “weight” of the battery is mandatory to be accessible by the public via the battery passport (reference from *Annex XIII (1a)* to *Annex VI, Part A(5)*).

Definition of battery weight

We define the weight of the battery as referring to the mass (hence, in comparison to weight, not being subject to gravity) of the entire battery (see battery definition in chapter 4.1). Since the term weight is more commonly used than mass and is also stated in the Battery Regulation, we also refer to battery weight here.

Suggested reporting granularity of the battery weight

We suggest reporting on the weight of a battery by stating the weight of the entire battery (which might be the pack, module, or cell) in kilograms. Hence, the weight should refer to the weight of the battery as defined by the battery passport.

In addition to the weight of the pack, for batteries defined on pack or module level, we suggest the voluntary specification of the weight of the battery modules and/or cells since this level of granularity will allow optimisation of the dismantling, disassembly, and recycling processes. Knowing the weight of the modules and cells will also be important for recyclers to calculate recycling efficiencies, even if sampling will still be required.

On a cell level, “interested persons and the Commission” (*Annex XIII (2)*) will also have access to the weight of materials in the cathode, anode, and electrolyte (see chapter 6.5.3). The weight per component (including the modules and cells) is already available in e.g., the IMDS used by the automotive industry (for details see chapter 6.5).

To allow for a harmonised and precise reporting of the weight via the battery passport, the weighing approach (e.g., weighed or calculated based on production information), the tolerated accuracy, and the resolution (number of decimal places) should be further specified.

6.1.7 Battery status

The “battery status” is mandatory content of the battery passport (EU Battery Regulation, *Annex XIII (4b)*). It is dynamic and describes the current status of an individual battery in its life cycle (see battery status options in Table 3) that confer important information to economic operators and end-users.

Table 3: Battery status options according to EU Battery Regulation, *Annex XIII (4b)*

Battery Status	Understanding
Original	A battery in its original state as placed on the market or put into service
Repurposed	A battery that has been subject to repurposing or preparing for repurpose
Re-used	A battery that has been subject to re-use or preparing for re-use
Remanufactured	A battery that has been subject to remanufacturing
Waste	A battery that is considered waste according to the definition of “waste”

Handling of the battery status

A battery is in the state “original” when it has been placed on the market or put into service. During its life cycle, the battery is subject to changes in its status. The economic operator is responsible for keeping the battery status up to date during the battery use phase. However, the EU Battery Regulation does not provide specifics regarding the handling of the battery status. Updates to the battery status will likely occur e.g., at the end-of-life or after repair, repurpose of a battery, by the respective operator or by a third party on its behalf (see use cases mentioned in chapter 5.2). The change of the battery status is accompanied with a time stamp and information about the battery handler. Once the battery has reached its end-of-life it will be designated as waste (see chapter 5.3.1). The battery status will be accessible to/by interested persons.

6.2 Compliance, labels, certifications

Battery passport guidance in brief on compliance, labels and certifications

Mandatory data: Separate collection symbol; symbols for cadmium and lead; carbon footprint label (see chapter 6.3.1); meaning of labels and symbols; EU declaration of conformity and its ID; compliance of test results.

Our suggestions and outlook: Economic operators placing batteries on the market are required to prove compliance with EU requirements and make key compliance documents accessible via the battery passport. In addition, the meaning of all symbols labels printed on the physical battery label or accompanying documents as well as up to three defined labels themselves (separate collection, lead, cadmium) have to be made accessible via the battery passport.

As per *Annex XIII (1s)* of the Battery Regulation, the labelling requirements of *Articles 13(3)* and *13(4)*, as introduced below, have to be accessible to the public via the battery passport. In addition, a "conspicuous, clearly legible and indelible label indicating the carbon footprint of the battery" as well as the carbon footprint performance class is required to be attached to the battery. This information shall be accessible via the battery passport (*Article 7(2)*) (see chapter 6.3.1). For the specific case of batteries having been subject to preparing for re-use or repurpose, repurposing, or remanufacturing, these "shall be marked with new labels or markings" (*Article 13(6b)*). This, however, does not hold true for the carbon footprint label as the carbon footprint instruments do not apply to batteries that have already been placed on the market before being subject to preparing for re-use or repurpose, repurposing, or remanufacturing. In addition, producers or producer responsibility organisations shall make available to end-users and distributors the meaning of labels and symbols, also via the battery passport (*Article 60*) (see chapter 6.2.3).

Besides labelling and marking batteries accordingly, economic operators placing batteries on the market are required to prove compliance with European directives or regulations via the EU declaration of conformity. This document as well as results of test reports proving compliance with Battery Regulation requirements are mandatory to be accessible via the battery passport, as outlined in chapter 6.2.4.

Table 4 provides an overview of all battery passport data on compliance, labels, and certifications. Regulatory requirements stem from *Annex XIII point 1* for labels and the EU declaration of conformity; and from *point 3(a)* for the compliance of test results.

Table 4: Overview of battery passport data attributes for compliance, labels and certifications

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting
Separate collection symbol	*Article 13(3)*	Public	A label indicating a product must be sent to a separate collection facility for recovery and recycling	Display separate collection symbol and translate the symbol into text to ensure machine readability of the battery passport.
Symbols for cadmium and lead	*Article 13(4)*	Public	Chemical symbol "Cd" for cadmium contained in the battery above 0.002%; "Pb" for lead above 0.004%.	Display cadmium and/or lead symbols if contained above the defined thresholds; and translate the symbol into text to ensure machine readability of the battery passport.
Meaning of labels and symbols	*Article 60(1e)*	Public	Meaning of all labels and symbols, if available, based on existing regulation.	State an explanation of the meaning of all labels and symbols displayed on the battery as well via the battery passport.
Carbon footprint label (see chapter 6.3.1)	*Article 7(2)*	Public	A label indicating the carbon footprint and carbon footprint performance class	Display carbon footprint label and translate label into text/ numbers to ensure machine readability of battery passport.

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting
EU declaration of conformity	*Article 18*	Public	Declaration to be signed by responsible economic operators to declare compliance with the EU requirements	Upload of the document that declares compliance with the EU requirements and assumes responsibility
ID of EU declaration of conformity	*Article 7(1f)*, via *Annex XIII (1f)*	Public	Identification number of the EU declaration of conformity of the battery	Display ID of the EU declaration of conformity
Compliance of test results	*Annex XIII (3a)*	Notified bodies, market surveillance authorities, the EC	Test results of the market conformity assessment procedure	To be discussed when further guidance is provided by EC

6.2.1 Separate collection symbol

The “separate collection” symbol is mandatory to be accessible by the public via the battery passport (reference from *Annex XIII (1s)* to *Article 13(3)*). Batteries shall be marked with the separate collection symbol from 24 months after entry into force of the regulation.

Definition of the separate collection symbol

The “separate collection” symbol or “WEEE label” (see Figure 18) indicates that a “product should not be discarded as unsorted waste but must be sent to separate collection facilities for recovery and recycling”. The symbol must appear on any electrical and electronic equipment placed on the EU market. This label is introduced in the EU directive on waste electrical and electronic equipment (WEEE).

Figure 18: Separate collection symbol

Suggested reporting of the separate collection symbol

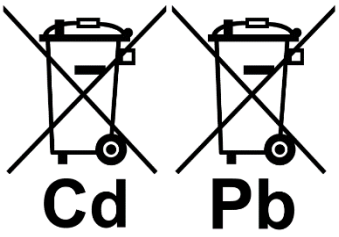
We suggest specifying in the battery passport for any battery that a separate collection is required. The separate collection symbol is also to be printed as a symbol on the physical label of the battery (with the symbol displayed in *Annex VI, Part B* and the required size of the symbol specified in *Article 13(3)*).

We suggest displaying the symbol via the battery passport since the public is familiar with it and will therefore easily recognise it. In addition, we suggest translating the symbol into text to be made accessible for the battery passport to ensure machine readability.

6.2.2 Cadmium and lead symbols

The symbol for cadmium is mandatory to be accessible by the public via the battery passport if a battery contains more than 0.002% cadmium; the symbol for lead if a battery passport contains more than 0.004% lead (reference from *Annex XIII (1s)* to *Article 13(4)*).

Figure 19: Cadmium and lead symbols underneath the separate collection



Definition of the symbols for cadmium and lead

The symbol for cadmium represents the chemical symbol “Cd”. The symbol for lead represents the chemical symbol “Pb”. The symbols indicate that the battery contains heavy metal above the defined threshold (see Figure 19).

Suggested reporting of the symbols for cadmium and lead

The symbols are also to be printed on the physical label of the battery (with the required size of the symbol specified in *Article 13(4)*).

We suggest displaying the symbols via the battery passport if a battery contains more than 0.002% cadmium and/or more than 0.004% lead. Hence, the “Cd” or “Pb” symbols should be displayed beneath the separate collection symbol. In addition, we suggest translating the symbols into text made accessible via the battery passport to ensure machine readability.

6.2.3 Meaning of labels and symbols

Producers or, where appropriate, producer responsibility organisations shall make the “meaning of the labels and symbols marked on batteries [...] or printed on their packaging or in the document accompanying batteries” available to end-users and distributors (*Article 60(1e)*). This explanation is required for each battery model made available on the market, “as a minimum at the point of sale”. Producers shall communicate this information “in a visible manner and through online marketplaces” (*Article 60*).

The meaning of labels and symbols is also mandatory to be accessible by the public via the battery passport (reference from *Annex XIII (1u)* to *Article 60(1e)*).

Definition of symbols and labels

The meaning of the labels and symbols refers to the separate collection symbol and symbols for cadmium and lead introduced above. In addition, however, the meaning of other labels to be displayed on batteries, but not required to be accessible via the battery passport, is also covered by this requirement.

The meaning of labels and symbols can in most cases be derived from other regulations. The separate collection symbol, for example, is introduced in the WEEE directive; and the capacity label in Directive 2006/66/EC.

Suggested reporting on the meaning of symbols and labels

We suggest adding an explanation of the meaning of all symbols and labels. This would include the separate collection; cadmium and lead; and carbon footprint and carbon footprint performance class labels, which are accessible via the battery passport. In addition, the

meaning of symbols and labels marked or printed on batteries or their accompanying documents but not included in the battery passport should be added.

We recommend linking the symbols to be accessible via the battery passport to the explanation of meaning. This way, if the symbol is added, the corresponding explanatory text could be automatically added to the battery passport. For labels and symbols not accessible via the battery passport but still printed on the battery or its documents, it will first need to be specified if the symbol or label is applicable. Only then, the text on the meaning can be added to the battery passport.

In line with *Article 60*, this information shall be communicated in (a) language(s) easily understood by end-users as determined by the Member State. We recommend that the explanatory texts are agreed on across the industry, potentially even prescribed by regulation, to ease the implementation for companies and ensure comprehensibility for the public.

6.2.4 Conformity assessment procedure

Batteries need to fulfil compliance requirements in accordance with the conformity assessment procedure introduced in *Article 17* and per reference in *Annex VIII*. The conformity assessment procedure is carried out by a designated conformity assessment body before the battery can be sold and it shall demonstrate that legal requirements are met. As part of this conformity assessment, the responsible economic operator shall draw up a technical documentation for relevant data attributes which is the basis of the conformity assessment procedure attributes, in accordance with obligations of manufacturers (*Article 38*) and importers (*Article 41*).

As described in *Annex VIII*, the technical documentation provides information on the design, manufacturing and operation of the battery and shall contain all the details necessary to demonstrate the battery conforms to the applicable requirements. The documentation shall enable the assessment of the battery's conformity with the relevant requirements. More details on the requirements for the technical documentation can be found in *Annex VIII, Parts A-C*. For instance, in *Module A* (as per *Annex VIII, Part A*), the manufacturer ensures and declares conformity with *Articles 6-10* and *12-14*. In *Module D1* (as per *Annex VIII Part B*), the quality assurance assessment for the carbon footprint declaration (*Article 7*) and share of recycled content (*Article 8*) is carried out (on a voluntary basis also for *Articles 6, 9, 10, 12, 13* and *14*). *Module D1* requires, among others, to provide studies on the carbon footprint and share of recycled content. *VIII Part C* (*Module G*) mandates the conformity based on unit verification.

Authorised notified conformity assessment bodies ("notified bodies", see *Chapter V*) shall carry out the conformity assessment procedure. Hence, these assess the technical documentation and quality system as well as carry out examinations, calculations, measurements and tests. When compliance of the battery and the relevant regulatory requirements has been demonstrated in the conformity assessment procedure, responsible economic operators shall draw up an EU declaration of conformity in accordance with *Article 18* and affix the CE marking in accordance with *Articles 19* and *20*.

The following data attributes require conformity assessment procedures (as described in *Article 17* and *Annex VIII*) and an underlying technical documentation:

- **Article 6:** Restriction of substances
- **Article 7:** Carbon footprint
- **Article 8:** Recycled content

- **Article 9:** Performance and durability requirements for portable batteries of general use[24]
- **Article 10:** Performance and durability requirements for LMT, industrial and EV batteries
- **Article 12:** Safety of stationary battery energy storage system
- **Article 13:** Labelling and marking of batteries
- **Article 14:** Information on the state of health and expected lifetime of batteries using a battery management system
- **Articles 45a-45e:** Due diligence policies. Additional obligations arise from due diligence policies which are discussed in more depth in chapter 6.4.

Where non-compliance is assessed, the responsible economic operator shall eliminate the non-compliance. If this is not the case, the respective Member State "shall take all appropriate measures to restrict or prohibit the battery being made available on the market or ensure that it is recalled or withdrawn from the market" (*Article 69*).

The following two elements for the conformity assessment procedure are described in more detail as these relate to battery passport-relevant data attributes.

6.2.4.1 EU declaration of conformity

The EU declaration of conformity is a special form of declaration in the legal area of the EU to prove compliance with the requirements of European Directives or European Regulations. As such, it is a mandatory document that needs to be signed by economic operators placing batteries on the market, declaring compliance with the EU requirements, i.e. the Battery Regulation and other complementary regulations. With signature, full responsibility is taken for the battery's compliance (26).

Article 18 of the Battery Regulation specifies the requirements for the EU declaration of conformity. The document shall state the fulfilment of the requirements specified in *Articles 6-10* and *12-14* as described in the previous chapter. In turn, the content requirement declarations need to refer to the EU declaration of conformity. For instance, the carbon footprint declaration shall refer to the identification number of the EU declaration of conformity of the battery (*Article 7(1f)*).

With respect to battery passport-relevant information, *Annex XIII, Part A(1)* of the EU Battery Regulation lists the data attributes to be accessible via the battery passport for the public. As per sub-point (*t*), "EU declaration of conformity" is listed. Additionally, referring to the carbon footprint requirements in *Article 7*, the identification number of the EU declaration of conformity of the battery shall be accessible via the battery passport. Also, *Article 13(5)* requires access to the declaration of conformity via a QR code.

The EU declaration of conformity shall use the model structure provided in *Annex IX* and contain the elements specified in *Annex VIII*. In case the battery needs to draw up an EU declaration of conformity in accordance with other regulations or directives, one single declaration shall be drawn up reflecting all requirements including other EU acts. This includes, for instance, the requirements from the ESPR (*Article 37*): "The EU declaration of conformity shall state that the fulfilment of ecodesign requirements specified in the applicable delegated acts adopted [...] has been demonstrated."

[24] Note that *Article 9* however is not relevant for the battery passport, as the battery passport is only required for LMT, industrial (> 2 kWh) and EV batteries.

In case of preparation for re-use, repurpose or remanufacturing, an additional declaration shall be drawn up. As per *Article 41* (obligations of importers), importers shall only place batteries on the market, if the conformity assessment and declaration of conformity have been carried out and provided by the manufacturer.

6.2.4.2 Reporting of compliance of test results for the battery passport

The "results of test reports proving compliance with the requirements set out in this Regulation or any implementing or delegated act adopted on its basis" shall be accessible via the battery passport to notified bodies, market surveillance authorities and the Commission (*Annex XIII (3α)*). These test reports are part of the market conformity assessment procedure and need to be included in the technical documentation (*Annex VIII, Part A(2e)* and *Part B(2j)*).

The results of test reports proving compliance refer to all requirements as per the technical documentation (*Annex VIII*). Hence, data attributes resulting from *Articles 7-10*, *Articles 12-14* and due diligence policies shall bear the test results in the technical documentation and make these available via the battery passport to the market surveillance authority and notified bodies.

As the format or specific contents of the test reports are not further specified, we suggest that, until further guidance is provided by the European Commission, a placeholder for the reference to these test reports is included, potentially via the technical documentation.

6.3 Battery carbon footprint

Battery passport guidance in brief on battery carbon footprint

Mandatory data: declared carbon footprint; share of battery carbon footprint per life cycle stage; carbon footprint performance class; web link to public carbon footprint study; administrative information about the manufacturer; information about the geographic location of the battery manufacturing facility; information about the battery model for which the declaration applies (*Annex XIII (1)* and *Article 7(1-2)*)

Our suggestions and outlook: The carbon footprint (CF) will be a key policy instrument under the Battery Regulation introduced in three consecutive steps with the carbon footprint declaration for EVs and industrial batteries (except those with exclusively external storage) being required before the battery passport is implemented.

- The Regulation sets essential elements for the CF with a more detailed methodology for the CF calculation to be specified in category-specific secondary legislation (delegated acts) – together, these specify the regulatory (minimum) requirements.
- As such, current developments indicate that primary (company- or supply chain-specific) data are only required for the "Main product production / Manufacturing" life cycle stage which sets the focus of company-specific CF data on this narrow scope while in other life cycle stages, secondary (i.e. average) data may be used.
- The consortium recommends calculating the battery carbon footprint based on the GBA GHG Rulebook and Battery Pass Rules to provide the data basis for measuring and optimising real-world CFs along the value chain – both documents build on existing standards in compliance with the regulatory requirements and together cover the battery life cycle cradle-to-grave based on guidance and prescriptions for the collection and usage of company-specific data end-to-end.

Table 5: Overview of carbon footprint-relevant data attributes for the battery passport

Data category	Data attribute	Battery Regulation reference	Data access	Definition/ Understanding
General information	**Manufacturer information**	*Article 7(1a)* Via *Annex XIII (1f)*	Public	Administrative information about the manufacturer – **please refer to chapter 6.1.2 for manufacturer identification information**
	Battery model information	*Article 7(1b)* Via *Annex XIII (1f)*	Public	Information about the battery model for which the declaration applies – **please refer to chapter 6.1.1 for battery identification information**
	Geographic location of the battery manufacturing facility	*Article 7(1c)* Via *Annex XIII (1f)*	Public	Information about the geographic location of the battery manufacturing facility – **please refer to chapter 6.1.3 for manufacturing place information**
Battery carbon footprint	**Carbon footprint (as declared)**	*Article 7(1d)* Additional info in *Annex II* Via *Annex XIII (1f)*	Public	The carbon footprint of the battery, calculated as kg of carbon dioxide equivalent per one kWh of the total energy provided by the battery over its expected service life
	Carbon footprint per Raw material acquisition and pre-processing stage	*Article 7(1e)* Additional info in *Annex II (4)* Via *Annex XIII (1f)*	Public	The carbon footprint of the battery differentiated per life cycle stage as described in *point 4 of Annex II* (Raw material acquisition and pre-processing stage)
	Carbon footprint per Main product production / Manufacturing stage	*Article 7(1e)* Additional info in *Annex II (4)* Via *Annex XIII (1f)*	Public	The carbon footprint of the battery differentiated per life cycle stage as described in *point 4 of Annex II* (Main product production/Manufacturing stage)
	Carbon footprint per Distribution stage	*Article 7(1e)* Additional info in *Annex II (4)* Via *Annex XIII (1f)*	Public	The carbon footprint of the battery differentiated per life cycle stage as described in *point 4* of *Annex II* (Distribution stage)
	Carbon footprint per EOL and Recycling stage	*Article 7(1e)* Additional info in *Annex II (4)* Via *Annex XIII (1f)*	Public	The carbon footprint of the battery differentiated per life cycle stage as described in *point 4 of Annex II* (EOL and Recycling stage)
Technical documentation	**ID of EU declaration of conformity**	*Article 7(1f)* Via *Annex XIII (1f)*	Public	Identification number of the EU declaration of conformity of the battery (please refer to chapter 6.2.4 for further information)
	Link to carbon footprint study	*Article 7(1g)* Via *Annex XIII (1f)*	Public	A web link to get access to a public version of the study supporting the carbon footprint values declared in the functional unit and differentiated per

Data category	Data attribute	Battery Regulation reference	Data access	Definition/ Understanding
				life cycle stage (referred to in *Article 7(d)* and *(e)*). Note that the form of the CF declaration is to be defined via an implementing act (see Figure 20)
Carbon footprint performance class	**Carbon footprint performance class**	*Article 7(2)* Via *Annex XIII (1f)*	Public	The carbon footprint performance class that the relevant battery model per manufacturing plant corresponds to (effective from 2026 onwards)

The battery carbon footprint – a key policy measure under the Battery Regulation – will be implemented in three consecutive steps and included in the battery passport for compliance and communication purposes. The battery passport shall report the carbon footprint as declared in kg of carbon dioxide equivalent per one kWh of the total energy provided by the battery over its expected service life and differentiated per life cycle stage (as shares of the overall carbon footprint). Additional information to be reported comprise manufacturer information, general battery information, the identification number of the EU declaration of conformity, a web link to the study containing the carbon footprint calculation, and – once required due to the implementation date – the carbon footprint performance classes.

To provide guidance on fulfilling the carbon footprint requirements, the following chapter first presents regulatory requirements for the CF measures (6.3.1) and subsequently for the calculation of the CF (6.3.2). Then, the Battery Pass consortium recommended approach to calculate the battery carbon footprint based on the GBA GHG Rulebook and the Battery Pass life cycle stages extensions is described (6.3.3). Lastly, an outlook is provided for the envisioned data collection approach and other environmental impact factors (6.3.4).

6.3.1 Regulatory measures and requirements

Annex XIII, Part A of the Battery Regulation requires the digital battery passport to make publicly available the "(f) Carbon footprint information in the units indicated in the relevant implementing measure(s)". The implementing measures are regulated in *Article 7* with reference to *Annex II*, stipulating the essential elements for the carbon footprint (CF) calculation and declaration.

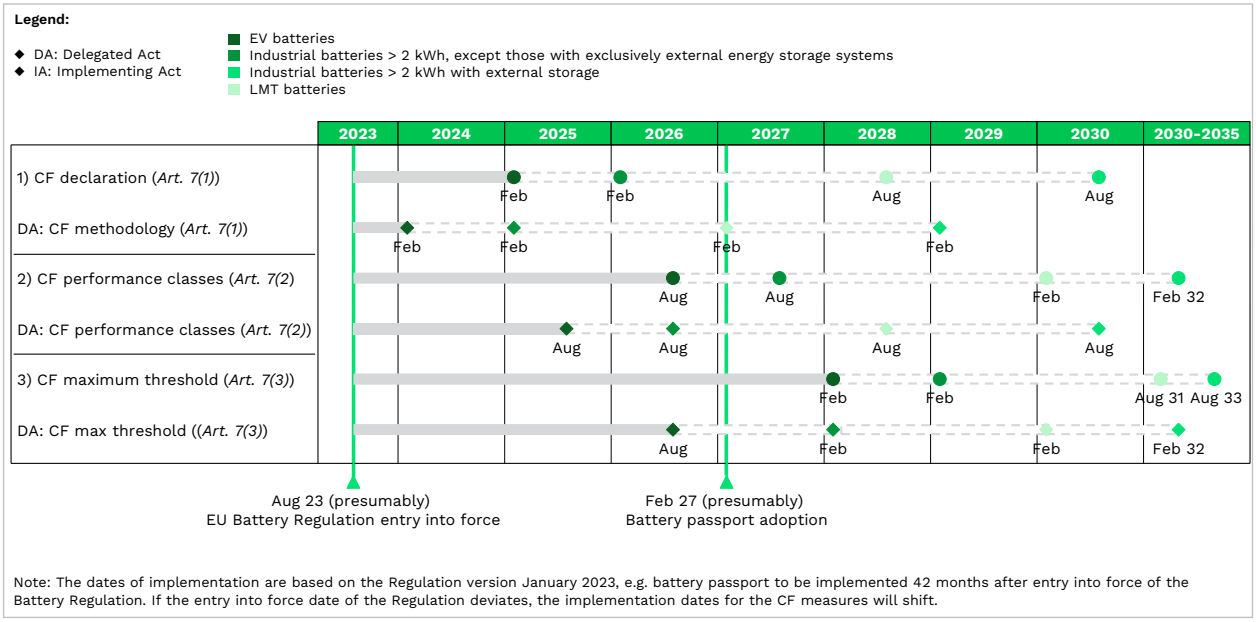
The carbon footprint requirements are implemented in three consecutive steps, partly even before or after the battery passport is required depending on the battery category:

1) Carbon footprint declaration;
2) Carbon footprint performance classes;
3) Carbon footprint maximum thresholds.

Each of these policy measures is complemented by underlying delegated acts which are to be published prior to the implementation of the respective measure. Figure 20 highlights the timeline of implementation of the CF measures and the according delegated acts for all relevant battery categories (1). Accordingly, the battery passport of the respective battery category shall include the carbon footprint data attribute once it is required as per the Battery Regulation timeline. The scope of Battery Pass carbon footprint work reflects the staged approach of the

Battery Regulation in terms of implementing the requirements for EV batteries first and subsequently for other battery categories.

Figure 20: Timeline for carbon footprint requirements and policy entry



Note: The dates of implementation are based on the Regulation version January 2023, e.g. battery passport to be implemented 42 months after entry into force of the Battery Regulation. If the entry into force date of the Regulation deviates, the implementation dates for the CF measures will shift.

1) The carbon footprint declaration

Article 7 requires manufacturers placing LMT batteries, rechargeable industrial batteries with a capacity above 2 kWh and electric vehicle batteries on the EU market to perform a carbon footprint declaration for each battery model per manufacturing plant. This CF declaration will be applicable from 18 months after entry into force of the regulation for EV batteries, 30 months after entry into force for rechargeable industrial batteries except those with exclusively external storage, 60 months after entry into force for LMT batteries, and 84 months after entry into force for rechargeable industrial batteries with external storage (see Figure 20). The CF declaration must be accompanied by a carbon footprint technical documentation and be in accordance with the to be published delegated and implementing acts. The declared CF is subject to the conformity assessment of batteries with requirements set in *Article 17* and the responsible economic operator must provide the EU declaration of conformity in line with *Article 18*. The declaration shall contain, at least:

a. Administrative information about the manufacturer,
b. Information about the battery model for which the declaration applies,
c. Information about the geographic location of the battery manufacturing facility,
d. The carbon footprint of the battery, calculated as kg of carbon dioxide equivalent per one kWh of the total energy provided by the battery over its expected service life,
e. The carbon footprint of the battery differentiated per life cycle stages as described in *point 4 of Annex II*,
f. Identification number of the EU declaration of conformity of the battery,
g. A web link to get access to a public version of the study supporting the carbon footprint declaration result's values referred to in *points (d)* and *(e)*.

The delegated act regulating the methodology for the carbon footprint will be published 6 months after entry into force of the regulation for EV batteries, 18 months for industrial batteries except those with exclusively external storage, 42 months for LMT batteries, and 66

months for industrial batteries with external storage. Additionally, an implementing act with the same time frame will establish the format of the declaration (see Figure 20). The declaration must accompany the battery until it becomes accessible via a QR code as stipulated in *Article 13(5)*.

2) The carbon footprint performance classes

Article 7(2) specifies the CF performance classes. Starting from 36 months (EV batteries), 60 months (industrial batteries without external storage), 78 months (LMT batteries) and 102 months (industrial batteries with external storage) after entry into force of the regulation (industrial batteries), batteries in these categories "shall bear a conspicuous, clearly legible and indelible label indicating the carbon footprint of the battery [...] and the carbon footprint performance class that the relevant battery model per manufacturing plant corresponds to". A delegated act will establish the CF performance classes and an implementing act will establish the formats for the labelling per category.

A technical documentation referring to *Annex VIII* (conformity assessment procedures) shall demonstrate that the carbon footprint declared and the related classification into a carbon footprint performance class have been calculated in accordance with the methodology set out in the CF delegated acts. The calculations made shall be included and the evidence and information determining the input data for those calculations are required (*Annex VIII (2h)*).

The performance classes will – in accordance with *Annex II (8)* – include "a meaningful number of classes of performance [...] with category A being the best class with the lowest carbon footprint life cycle impact". These classes are intended to allow for differentiation between the batteries placed on the market. The classes will be identified based on the distribution of the values of the batteries' carbon footprint declarations of the previous three years. The Commission will review the number of performance classes and the thresholds between them every three years to reflect technical progress and market realities.

3) The carbon footprint maximum thresholds

Manufacturers placing batteries on the market need to demonstrate in the technical documentation of the CF declaration from 2028 onwards that a certain maximum threshold for the life cycle CF is not surpassed. This maximum threshold will be effective 54 months (EV batteries), 66 months (industrial batteries without exclusively external storage), 96 months (LMT batteries) and 120 months (industrial batteries with external storage) after entry into force of the regulation. The threshold applies to relevant battery models per manufacturing plant and a delegated act will establish this threshold per category (see Figure 20). The exact implications of cases where the life cycle carbon footprint is not below this maximum threshold are not stipulated to date. In the context of the market conformity assessment *Article 69* holds that where non-compliance (with the maximum threshold) is assessed, the responsible economic operator shall eliminate the non-compliance. If this is not the case, the respective Member State "shall take all appropriate measures to restrict or prohibit the battery being made available on the market or ensure that it is recalled or withdrawn from the market".

As per *Annex II (9)*, the maximum threshold will take into account the relative distribution of the carbon footprint values of in-scope batteries placed on the market as well as the carbon footprint reduction progress and the contribution to the EU's 2050 objective for sustainable mobility and climate neutrality. A dedicated impact assessment to determine those values will accompany the considerations of the relative distribution of the CF.

The regulation specifies that these three requirements “shall not apply to a battery that has been subject to preparing for re-use, preparing for repurpose or repurposing, or remanufacturing, if the battery had already been placed on the market or put into service before undergoing such operations” (*Article 7(3a)*). It remains to be clarified whether placement on the market or putting into service only applies to the EU market or if imported second-life batteries, i.e. if the initial placement on the market was outside the EU, are subject to a CF declaration. As placing on the market and putting into service is defined within the regulation to refer to the European Union (*Article 2(1)*, *(14)* and *(16)*), CF requirements might apply to imported second-life batteries from non-EU markets.

6.3.2 Calculation requirements as basis for the carbon footprint declaration

The carbon footprint shall be calculated in accordance with the essential elements set out in *Annex II* of the regulation and reported in the functional unit and per life cycle stage as basis for the CF declaration. The calculation shall be in compliance with the latest version of the Commission’s Product Environmental Footprint (PEF) (27) method and relevant Product Environmental Footprint Category Rules (PEFCRs) (28) (29) and reflect the international agreements and technical/scientific progress in the area of life cycle assessment. The 2018 version of the “*PEFCR – Product Environmental Footprint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Applications*” is currently updated by PEFCR TS to reflect market and technological realities for the fulfilment of CF regulatory requirements. The update is to be expected in Q2 or Q3 2023.

The calculation of the carbon footprint shall be based on the bill of materials, the energy, and auxiliary materials used in a specific plant to produce a specific battery model. In particular, the electronic components (e.g., battery management units, safety units) and the cathode materials have to be accurately identified, as they may become the main contributor for the battery carbon footprint. Further essential elements and conditions, such as the functional unit and reference flow and the use of company-specific and secondary datasets, are mandated in *Annex II*.

As per *Annex II (4)*, the CF shall be calculated and declared in four life cycle stages, specifying the system boundary (*Article 7(1)*):

- Stage 1: Raw material acquisition and pre-processing
- Stage 2: Main product production
- Stage 3: Distribution (transport to the point of sales)
- Stage 4: End-of-life and recycling (collection, dismantling and recycling)

The use phase shall be excluded as not being under direct influence of the manufacturer unless it is demonstrated that design choices by the manufacturer can make a non-negligible contribution to this impact. The regulation does not further specify which party needs to demonstrate non-negligibility of design choices and impacts. As it stands, the use phase shall in general be excluded which is reflected in the Joint Research Centre’s draft carbon footprint rules which will inform the development of the delegated act (30).

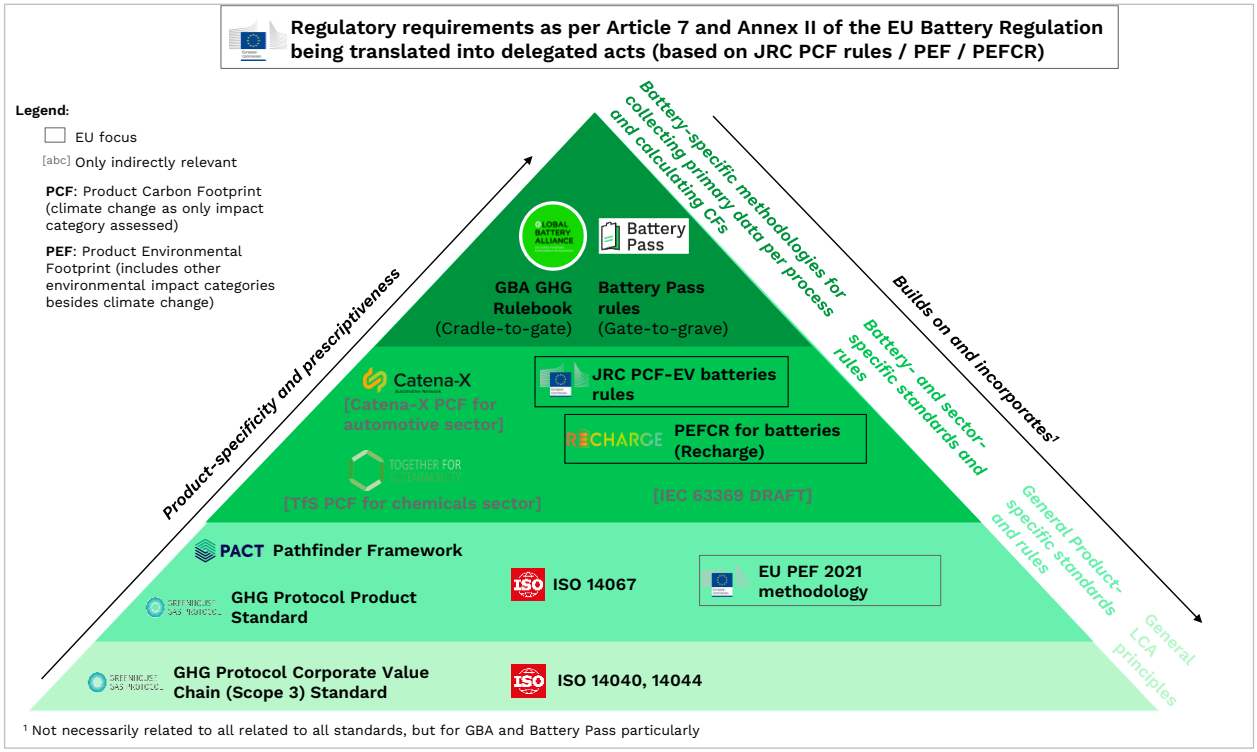
Moreover, steps that would lead to a further use cycle such as repurposing or remanufacturing are not included. This is related to the above-mentioned *Article 7(3a)* which implies that the CF requirements do not apply to second-life batteries that have been placed on the market previously, but potentially for imported second-life from outside of the EU.

6.3.3 Guidance and recommendation to fulfil carbon footprints requirements

In the context of the EU Battery Regulation, the carbon footprint calculation shall be in compliance with PEF, PEFCR and the category-specific delegated acts that will be developed in accordance with the timeline in Figure 20. The Joint Research Centre (JRC) recently published their "Harmonised rules for the calculation of the Carbon Footprint of Electric Vehicle Batteries (CFB-EV)" which will inform the development of the delegated act specifying the methodology for the CF calculation per law. The recent JRC study increased the level detail in regard to the application of the PEF methodology. This is also expected for the update of the PEFCR (presumably to be published in Q2 or Q3 2023).

However, these standards and methodologies do not provide sufficient detail and guidance to cover company-specific data collection along the entire battery value chain and life cycle. Reporting product carbon footprints follows the purpose to differentiate individual operations and incentivise operational excellence measures to reduce the respective CF. Given that carbon footprint maximum thresholds will be implemented in the EU starting from 2028 onwards, there is a strong push for company-specific data that enable the optimisation of declared CFs. CFs declared based on secondary (i.e. average) data will not sufficiently contribute to steering operational measures that reduce the life cycle CF of batteries.

Figure 21: Relevant standards and methodologies for the battery carbon footprint calculation

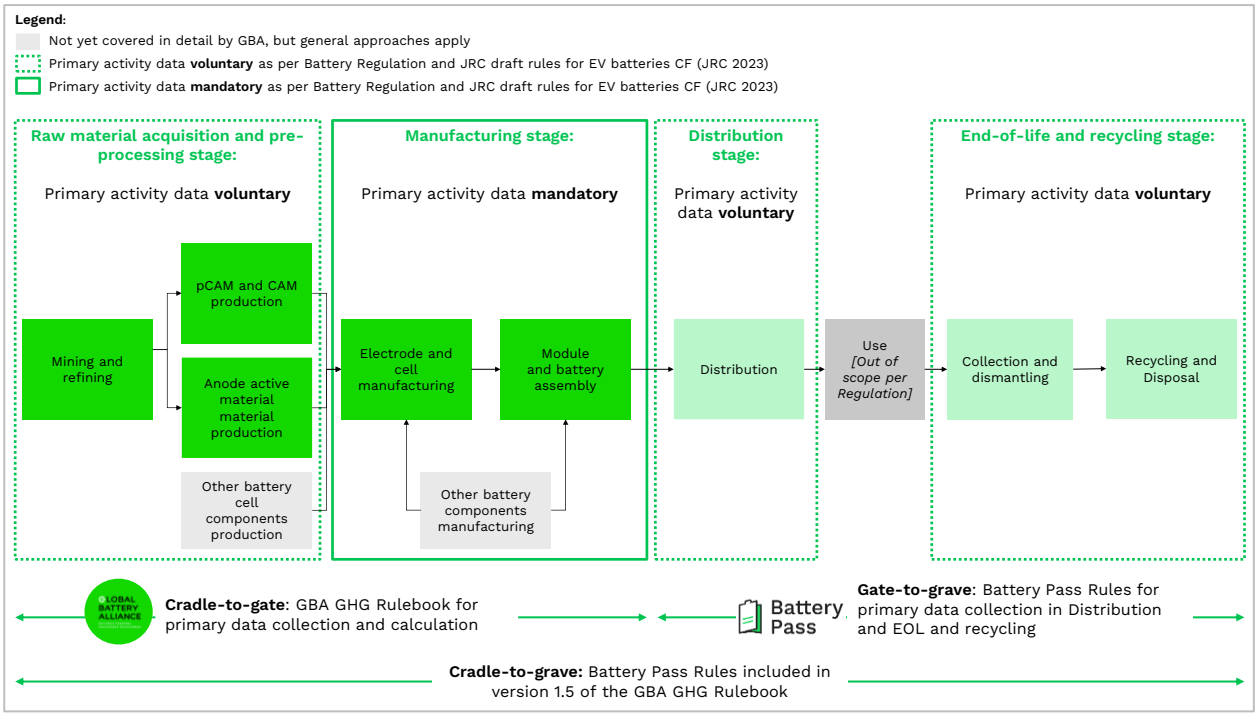


The GBA and Battery Pass consortium joined forces to develop a "cradle-to-grave" rulebook that enables company-specific data collection and CF aggregation to fulfill the EU regulatory requirements, in compliance with existing standards (see Figure 21). The Battery Pass Rules and the GBA GHG Rulebook apply existing CF accounting standards and translate these into practicable methodologies that enable company-specific data collection and aggregation with the goal to achieve Battery Regulation compliance. Even though existing standards provide

valuable frameworks, the detailed production process-specific application and data collection would leave too much room for interpretation.

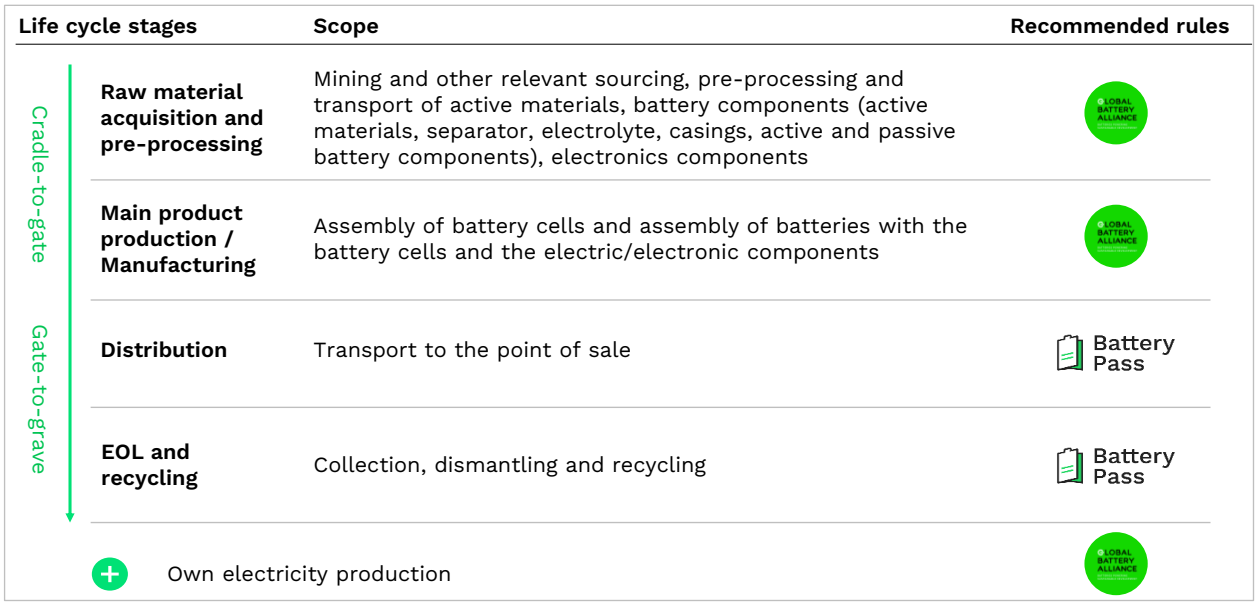
Therefore, the Battery Pass Rules and the GBA GHG Rulebook provide detailed guidance on applying existing standards to the battery value chain for companies to be able to provide transparent, consistent and comparable battery carbon footprint calculations based on company-specific data where possible (see Figure 22). While the Battery Regulation requires company-specific data ("primary data") only on the level of the "main product production/Manufacturing" life cycle stage, companies may use company-specific data for the remaining life cycle stages. As only company-specific data yield real world improvement potentials compared to secondary data usage (average data per region or literature data), the Battery Pass consortium recommends battery manufacturers having to declare the CF to use company-specific activity and emissions data wherever possible and based on the GBA GHG Rulebook and Battery Pass Rules. This can only materialise, if regulatory requirements specify default values and secondary data in a way that primary data usage is incentivized, which is currently limited in the EU context. If secondary data is sampled too positively, there is a risk that company-specific data will not be applied, restricting the potential of data for operational improvements of carbon emissions.

Figure 22: Company-specific data requirements as per the Battery Regulation and the JRC draft rules



To this end, the Battery Pass consortium recommends using the GBA GHG Rulebook and Battery Pass Rules to calculate the Carbon Footprint for the CF declaration (see Figure 23). A brief note on scope: the general Battery Pass Rules for calculating downstream emissions are, as the GBA GHG Rulebook (31) for upstream emissions, applicable to all battery types, while the cluster-specific Battery Pass Rules initially focus on electric vehicle batteries with a particular focus on lithium-ion batteries. They present a basis on which further battery chemistries, production processes (e.g., recycling processes), and functional units can be included, and additional rules developed. The approach reflects the sequenced timeline of implementation of CF requirements for different battery categories.

Figure 23: Battery carbon footprint guidelines per life cycle and required processes



The GBA GHG Rulebook version 1.5 update will integrate the Battery Pass Rules. Then, the GBA GHG Rulebook will cover the cradle-to-grave emissions. As the GBA GHG Rulebook version 1.5 is published in parallel to this document, the steps cradle-to-gate and gate-to-grave are described separately in the following.

1) Cradle-to-gate: emissions in the 'Raw material acquisition and pre-processing' as well as 'Main product production/Manufacturing' life cycle stages

The Battery Pass consortium recommends following the GBA GHG Rulebook (31) as a basis for calculating the battery carbon footprint for the cradle-to-gate (upstream) life cycle stages. The GBA GHG Rulebook is a methodological application of carbon accounting rules and standards providing detailed guidance to battery value chain participants to calculate and report the battery carbon footprint based on primary data. Version 1.4 focuses on the cradle-to-gate emissions of lithium-ion batteries for electric vehicles. It can be applied to all kinds of lithium-ion chemistries as well as raw materials, active or passive materials, and components across the electric vehicle battery value chain.[25] It provides missing details from existing global standards and aims at compliance with PEF, PEFCRs and the EU regulatory requirements. To ensure compliance with the EU Battery Regulation, the Battery Pass consortium carbon footprint working group exercised a standards screening, mapping the GBA GHG Rulebook line-by-line to the PEF (27), PEFCR guidance (28) and Recharge PEFCR for batteries (27) (28) (29). As a result, only minor deviations from these standards with no significant impact on the overall reporting were identified, except for electricity and EOL modelling. The Battery Pass consortium and the GBA GHG working group will continue to work on an alignment and harmonised approach in regard to these outstanding topics. For instance, it remains to be seen which approach to electricity modelling will be implemented in the delegated act. The GBA proposed a dual reporting approach, which has benefits compared to the proposal made by the JRC,

[25] Note that new chemistries entering the market in the future, such as Lithium Iron Manganese Phosphate (LFMP) or solid-state batteries, are potentially included in an updated version of the rulebook, "ideally accompanied by an analysis to identify possible additions or changes (hot spots in the supply chain, secondary data demand, chemistry specific rules, etc.)" (31).

particularly in light of global value chains where residual grid mix data are not always publicly available.

The GBA GHG Rulebook comprises general rules and cluster-specific rules. The general rules provide guidance on the required framework of the calculation such as the functional unit and reference flow, system boundaries and cut-off criteria, allocation rules, requirements for primary and secondary data as well as impact assessment categories and calculation. The cluster-specific rules define the general rules on a process-specific level. Thereby, the focus is set on identifying company-specific activities and specifying a primary data collection for those. Detailed data collection frameworks are provided. These ensure that general carbon accounting principles are applied in a sector-aligned and harmonised manner. For further details on the rules as well as the data collection and calculation approaches for upstream emissions, the Battery Pass consortium refers to the GBA GHG Rulebook and its expected future updates: *GBA GHG Rulebook version 1.4 (2023)*

2) Gate-to-grave: emissions in the 'Distribution' as well as 'End-of-life and recycling' life cycle stages

The Battery Pass consortium carbon footprint working group proposed complementary rules for the lifecycle stages 'Distribution' as well as 'EOL and recycling' to the GBA GHG Rulebook. Therefore, to calculate the gate-to-grave life cycle stages, the Battery Pass consortium recommends following the complementary rules, which are integrated in the updated GBA GHG Rulebook version 1.5, for the two life cycle stages:

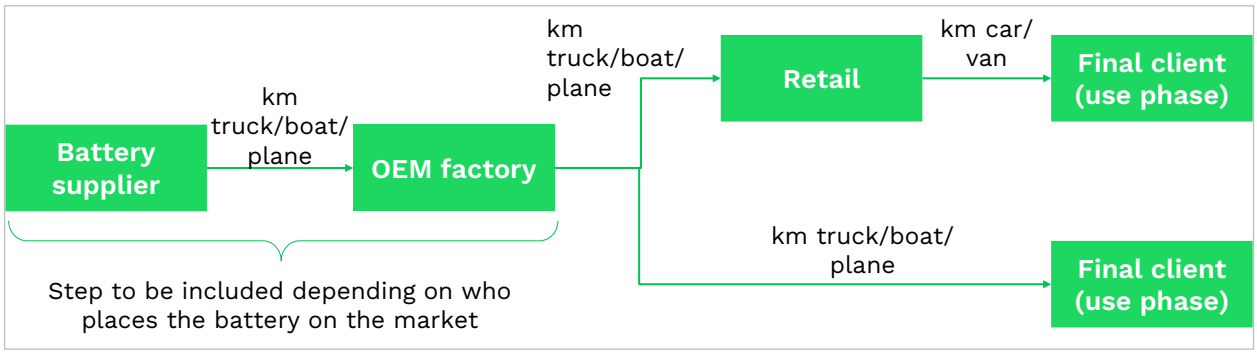
- **Distribution:** Please refer to the document "*Battery Carbon Footprint: Rules for calculating the Carbon Footprint of the 'Distribution' and 'End-of-life and recycling' life cycle stages"*.
- **End-of-life and recycling:** Please refer to the document "*Battery Carbon Footprint: Rules for calculating the Carbon Footprint of the 'Distribution' and 'End-of-life and recycling' life cycle stages"*.

This set of rules presents approaches to account emissions of the respective life cycle stage, including the essential elements, data collection and allocation requirements. The general approach taken by Battery Pass consortium to writing the rules are as follows:

1) Assessment of requirements as per Battery Regulation (chapter 2)
2) Assessment of requirements as per existing standards, with PEF / PEFCR being prioritized (*Annex A.1*)
3) Evaluation of the chosen approaches, for recycling allocation in terms of a qualitative and quantitative assessment (chapter 3)
4) Developing rules as proposal for inclusion in the next version of the GBA GHG Rulebook (chapter 4 and chapter 5):
    a. **General rules:** System boundary, functional unit, allocation, specification of data requirements and description of processes to include in calculations
    b. **Cluster-specific rules:** application of processes and calculation logics per process including the data collection
5) Translating the methodological choice of the cut-off approach for the EOL and recycling allocation into a guidance and set of rules complying with the EU requirements of the Circular Footprint Formula (chapter 6)

The 'Distribution' cluster covers the transport from the economic operator placing the battery on the market to the final user. Depending on where the responsible economic operator is situated in the battery value chain (see chapter 5.2), the number of supply chain steps to be included might vary (see Figure 24). The rules for the Distribution life cycle stage sets general rules for the outlined scenarios and specifies primary data collection guidance as well as, in case specific data are not available, default scenarios and values in compliance with PEF and PEFCR. The method to obtain company-specific data (e.g., transport type, transport distance, utilisation ratio) builds on the GBA GHG Rulebook chapter 4.2.4 defining approaches for calculating transport emissions. The secondary data requirements and default scenarios build on the PEF recommendation and PEFCR pilot by Recharge. While packaging emissions are systematically excluded from the carbon footprint calculation due to negligible life cycle impacts (29), environmental optimisation strategies to reduce the impacts from battery transport packaging should be followed, e.g., opting for reusable packaging systems which reduces negative effects such as resource use and waste generation.

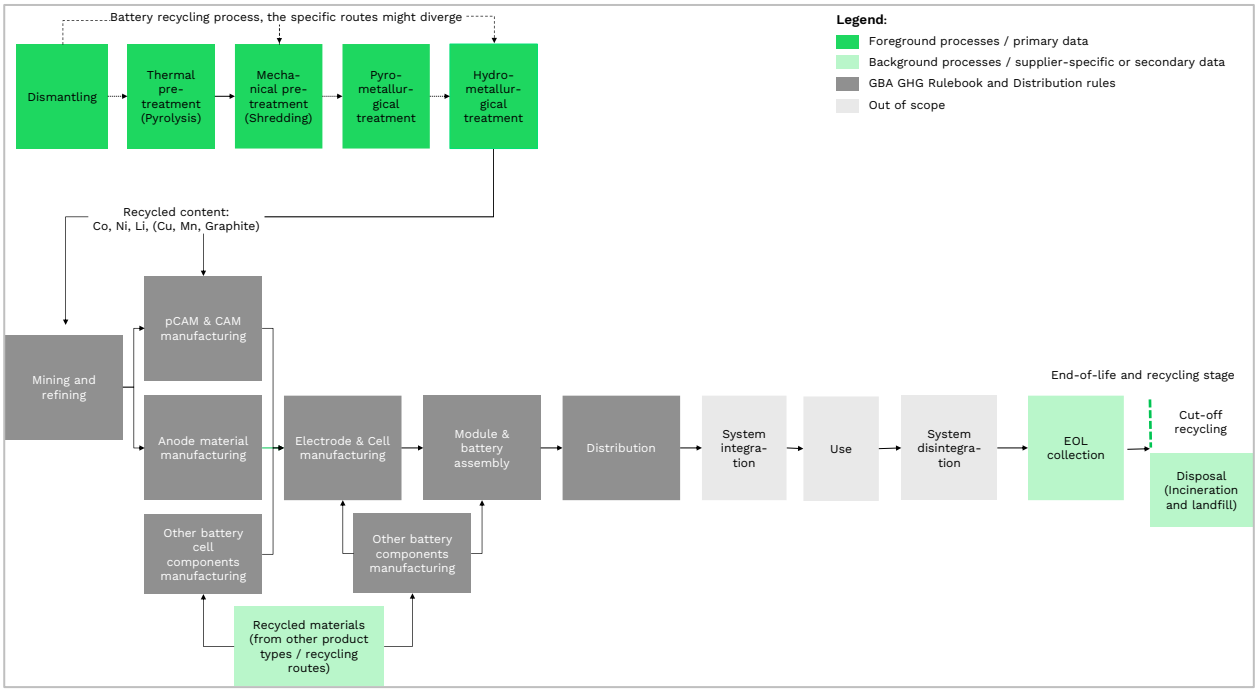
Figure 24: Transport scenarios for the Distribution life cycle stage



The 'End-of-life and recycling' cluster covers the system boundary requirements in the essential conditions of the Battery Regulation (*Annex II*) and builds on relevant product carbon footprint standards as well as extends the scope of the GBA GHG Rulebook chapters "End-of-life allocation" (3.4.2.) and "Recycled content of materials" (3.5.). Therefore, guidance and specifications on data collection are provided for the end of life collection of the spent battery as well as the recycling processes and disposal (see Figure 25).

Overall, three major allocation methods exist: the cut-off approach, substitution approach and Circular Footprint Formula (CFF), which significantly differ in terms of resulting emissions associated with the 'End-of-life and recycling' processes. Therefore, the Battery Pass consortium analysed and compared the three allocation methods for the case of batteries, both qualitatively as well as quantitatively: please refer to the document *"An analysis complementing the Battery Pass Rules for calculating the Carbon Footprint of the 'End-of-life and recycling' life cycle stage"*.

Figure 25: End-of-life and recycling allocation in the cut-off approach



As a result, in the opinion of the Battery Pass consortium, the cut-off approach is the most transparent and accurate approach to allocate end-of-life emissions in terms of attributing emissions as occurred at the time of placement on the market, outweighing the shortcomings of the approach and the benefits of the other two methods. Both the substitution approach as well as the Circular Footprint Formula fundamentally require assumptions on future processes and technologies that could overestimate credits and therefore underestimate actual carbon footprints, yielding unreliable CF estimations. The choice of the cut-off approach is in line with the current approach proposed by the GBA and other industry-led sector initiatives, for instance the Together for Sustainability Initiative or the Pathfinder Framework (32) (33). While the cut-off approach retains the fundamental principle of accounting based on measured and differentiating data, the two other methods allow assumptions blurring accuracy and do not contribute to steering operational measures to reduce the battery carbon footprint.

Under the cut-off allocation approach, the Battery Pass consortium defines general rules for the functional unit and reference flow, system boundaries, data requirements and multi-output allocation mechanisms. As the cut-off approach allocates recycling emissions to the product system via the recycled content, the Battery Pass Rules include detailed data collection guidance to obtain company-specific data for the foreground materials being cathode and anode materials. Hence, the specification of recycling processes focuses on battery recycling treatment. A generalised data collection for other materials is provided, with the general rules applying.

In the likely case that the Circular Footprint Formula will be required by the delegated act defining the methodology for calculating the CF – as it is the method for EOL allocation and waste modelling stipulated by the PEF and PEFCR – the defined rules by the Battery Pass consortium present a significant value add through providing guidance for calculating specific parameters of the Circular Footprint Formula mostly based on primary data. These can be extended with secondary data and default values and datasets provided by the PEFCR *Annex C* (34) and the EF compliant datasets (35) to match the requirements of the CFF and the EU

regulation. Detailed guidance and corresponding rules are presented in the "*Battery Carbon Footprint: Rules for calculating the Carbon Footprint of the 'Distribution' and 'End-of-life and recycling' life cycle stages" as well as the GBA GHG Rulebook version 1.5*. Due to the complexity and non-availability of data for material-specific parameters required for materials contained in the battery or occurring as waste along production processes, the CFF addition should be considered the best possible approach under remaining uncertainty and ongoing alignment between EU institutions. The work on the CFF will be continued after the publication of the Battery Pass Guidance Document.

6.3.4 Outlook on data collection and other environmental impact categories

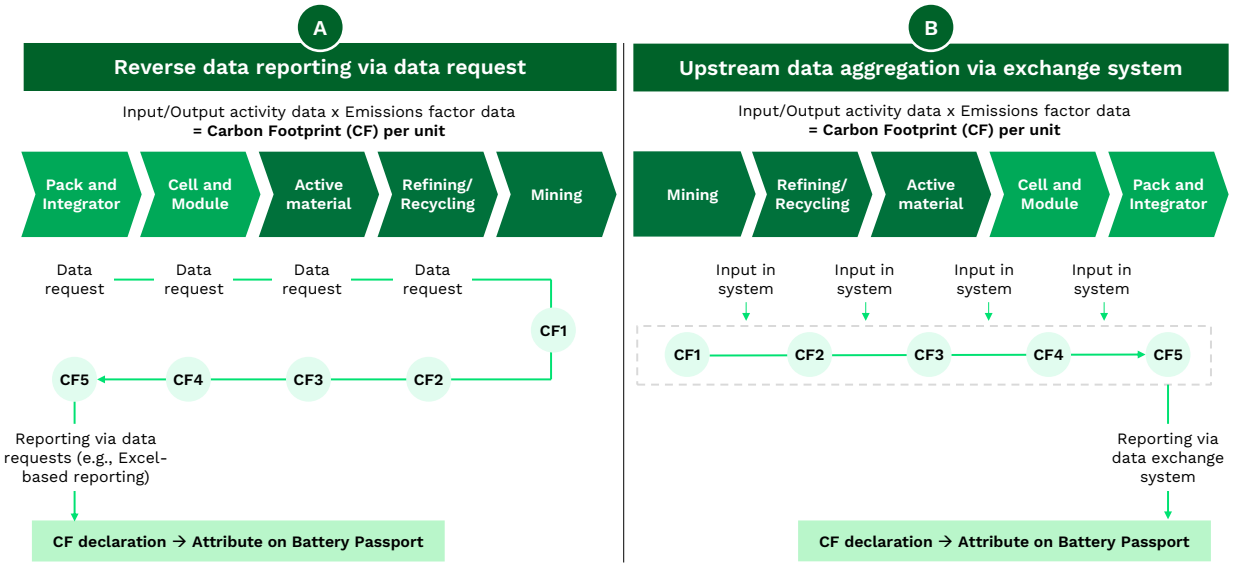
On data collection and exchange

Company-specific data along the value chain will become increasingly important. The EU Battery Regulation will emphasise the need for primary/company-specific data for materials and components. For the battery CF declaration, company-specific activity data is at least required for cathode, anode, electrolyte, and cell casing in the Manufacturing life cycle stage. However, with regard to the CF performance classes (expected for August 2026 for EVs) and subsequently the carbon footprint maximum threshold (expected for February 2028), battery manufacturers having to declare the CF will need to move towards collecting (aggregated) primary CF data that are more immediately linked to actual activities along the supply chain, thus allowing companies to take effective measures to decarbonise and optimise the CF.

The European Commission, JRC, PEF and PEFCR approach is to take on a single-actor view where the CF declarant performs the life cycle assessment looking backwards into the supply chain (see *A) reverse data reporting* in Figure 26). Once primary data-based CFs become more important for differentiation of and optimisation in entire value chains, upstream data aggregation and exchange with each actor adding Scope 1 and Scope 2 emissions to received materials and components will increase reliability, accuracy and insights into decarbonisation efforts (see *B) Upstream data aggregation*). While sensitive activity data will likely not be shared due to confidentiality, exchanging overall product carbon footprints per organisation for the respective materials or components – verified by independent third parties – does not face confidentiality concerns. This upstream data aggregation approach is envisioned by the Global Battery Alliance (GBA) and other initiatives such as Catena-X and PACT. The Battery Pass consortium supports this vision with its technical working group currently developing a Standard Stack (see chapter 5.1) that is required for such data exchange.

This CF collection and aggregation approach entails differences in the way current carbon accounting and disclosure practices are applied via the life cycle assessment approach, e.g., the choice of EOL allocation. Further alignment between leading initiatives is needed to design carbon accounting systems where real-world data enables decarbonisation strategies. As the goal of the Battery Regulation is to lower carbon emissions on a global level, a primary data-based CF collection and aggregation system should be reflected in future approaches to CF methodologies.

Figure 26: CF reporting systems: reverse data reporting versus upstream data collection and aggregation



On other environmental impact categories

The Battery Regulation CF measures focus on one impact category of environmental footprinting: the Global Warming Potential (GWP), also referred to as Climate Change. At the same time, the PEF methodology, the PEFCR for batteries and the ESPR refer to the environmental footprint which combines activity data and emissions factors with up to 16 impact categories. This would yield a more comprehensive picture of product-related environmental burdens. While carbon emissions are rightly in the centre of attention, other environmental aspects such as resource depletion, land use, and human toxicity should not be neglected in light of humanity already overshooting several planetary boundaries (36). Environmental footprinting would provide companies with insights on product-related environmental hotspots.

In essence, the activity data collected can be coupled with other impact categories beyond carbon emissions. Once the CF data collection, calculation and reporting is implemented and operated, companies should use this as a basis to add additional impact categories. Thus, the environmental footprint requirements as per PEF/PEFCR and ESPR could be achieved. Additional insights on the environmental burdens would enable managing environmental risks. This holds true for additional insights on environmental data attributes as per ESPR (see info box below).

Additional environmental parameters for the battery passport (voluntary basis)

The Proposal for Ecodesign for Sustainable Products Regulation (ESPR) mandates DPPs and introduces certain requirements, that are mostly on a technical and general product information level. Delegated acts will further specify the information to be included in DPPs (ESPR, *Annex III*). Besides these requirements, the ESPR also introduces a set of product performance parameters, which could be added to the battery passport since potentially being of interest to companies in order to increase transparency.

Though most product parameters of *Annex I* of the ESPR are already covered in the scope of the battery passport, gaps were identified for a few parameters addressing key impact categories across the battery life cycle (e.g., water use, land use, air pollution, acidification, etc.) (6) (27):

- "**Consumption of energy, water, and other resources** in one or more life cycle stages of the product" is only partially covered for energy. In particular, water consumption could be of interest for batteries.
- "**Environmental footprint** of the product" is only partially covered via the carbon footprint (to be in line with Product Environmental Footprint (PEF) Rules). Evaluating additional environmental categories could be of interest for batteries. Also, the Proposal for the EU Critical Raw Materials Act Regulation (8) introduces mandatory environmental footprint declarations for critical raw materials, with delegated acts to be developed, determining the reporting-relevant environmental categories as well as the calculation and verification method.
- "**Emissions to air, water, or soil released** in one or more life cycle stages of the product" is not included. Particularly emissions to water and soil in upstream production could be of interest for batteries.
- "**Amounts of waste** generated" is not included but could be of interest for batteries.

Rather than recommending one or several of the above sustainability parameters, the Battery Pass consortium recommends companies to first follow a careful parameter selection process. While the ultimate goal is to include all relevant and salient parameters in the battery passport to cover all environmental impact categories of batteries, pragmatically, an initial set of parameters should be chosen. Here, the following questions can be of help:

1) **Is the risk salient across the battery's life cycle?**
   It can be, e.g., drawn upon existing life cycle analyses of batteries as well as industry/NGO reports. To specify the impact categories of the environmental footprint, e.g., *Annex V* of the Proposal for a Critical Raw Materials Regulation requires a "hotspot analysis performed in line with scientifically sound methodologies developed at international level", considering the "relative importance".

2) **Is there an established calculation method for the parameter?**
   Only with established calculation methods can parameters be quantified and results compared. The EU Product Environmental Footprint Category Rules (for batteries) can be, e.g., consulted for environmental footprints.

3) **What is the perceived stakeholder importance of the parameter?**
   The GBA's ranking of battery ESG issues based on stakeholder perceptions could for example be consulted. As a second criterion for the hotspot analysis to choose impact categories, the Proposal for a Critical Raw Materials Regulation refers to the needs of downstream companies wishing to communicate on the environmental footprint of the critical raw materials used.

6.4 Supply chain due diligence

Battery passport guidance in brief on supply chain due diligence

Mandatory data: Information on responsible sourcing as indicated in the report on due diligence policies (due diligence report) (reference from *Annex XIII 1(g)* to *Article 45e(3)*).

Our suggestions and outlook: The due diligence report is the only mandatory supply chain due diligence requirement for the battery passport. Therefore, the Battery Pass consortium further explored the content, potential harmonisation with other legislation and additional voluntary supply chain due diligence information for the battery passport.

- Due diligence report: we recommend creating and uploading the report based on the five-step OECD framework, aligned with the scope and elements required per Battery Regulation. We recommend harmonising the report with other regulatory requirements (e.g., EU CSDDD). Further, we recommend exploring if key information of the report could be reported as individual data points via the battery passport.
- To further advance supply chain sustainability, we recommend companies to explore which and how additional information could be made available voluntarily via the battery passport. Third-party supply chain assurances, enhancing risk identification and putting regulatory compliance into practice, allow companies to make sustainability-related claims, potentially also via the battery passport. ESGE+ indices (under development by the GBA) enable to score the sustainability performance of companies and batteries. They could further advance sustainability-related claims.

In the EU Battery Regulation, "battery due diligence" refers to obligations aiming at "identifying, preventing and addressing actual and potential social and environmental risks linked to the sourcing, processing and trading of the raw materials and secondary raw materials required for battery manufacturing" (*Article 2(36)*). From 24 months after entry into force of the regulation, economic operators placing batteries on the market need to comply with two major of such obligations (*Article 45a(1)*). These obligations are following a risk-based approach to identify, prevent, mitigate, and if needed address adverse impacts. They are to be scaled to all activities and supply chain relationships (*Recital 65*). These two obligations are:

1) A management system (*Article 45b*)
2) A risk management plan (*Article 45c*)

The obligations can be "implemented in collaboration with other actors, including through due diligence schemes, recognised under the [....] Regulation" (*Article 45a(1c)*). The recognition process will be introduced in implementing and delegated acts (*Article 45f(1,3)*).

Economic operators need to disclose/keep three types of information/documentation (*Article 45a(1b); 45e*) on these obligations:

1) To Member States' market surveillance or national authorities: documentation demonstrating compliance with the due diligence obligations including:
    a. A third-party verification report of the supply chain due diligence policies (*Article 45a(1a); 45d*)
    b. An approval decision (*Article 45d*)
    c. The audit reports of the notified body (*Article 45a(1a)*)
    d. Available evidence of compliance with a due diligence scheme recognised by the Commission.

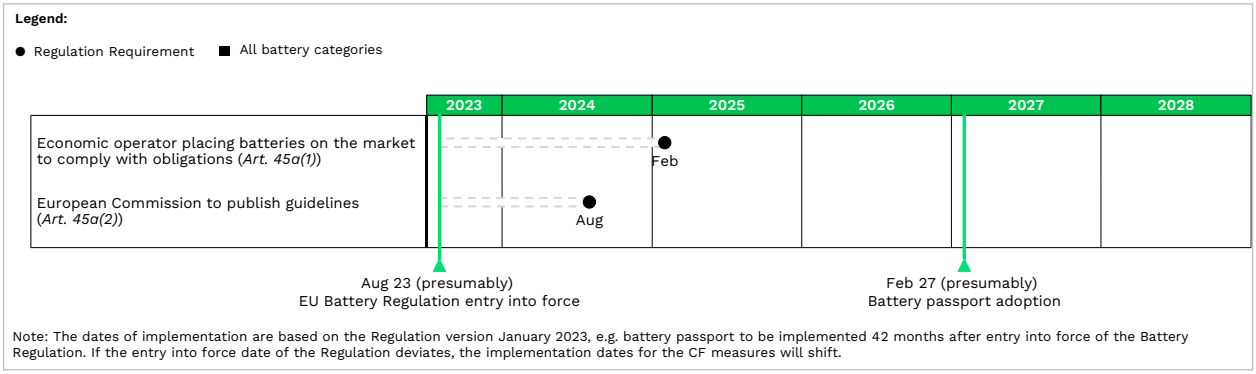
2) To immediate downstream purchasers: relevant information on due diligence policies.
3) To the public (including on the internet): a report on the two above mentioned obligations, a summary third-party verification report, and an elaboration on access to information, public participation in decision-making and access to justice.

Of those disclosures, only the information indicated under 3., the due diligence report, is mandatory to be included in the battery passport (*Annex XIII (1)*).

Upcoming additional information on these due diligence obligations will be twofold:

- 18 months after entry into force of the regulation, the Commission shall publish guidelines regards the application of the due diligence requirements (*Article 45a(2)*).
- Member States may set up websites, platforms or portals to provide information and support to economic operators on their obligations; the Commission may complement and support these (*Article 45a(3)*).

Figure 27: Supply chain due diligence timeline per Battery Regulation



The regulation introduces two cases, for which the due diligence obligations are not effective:

- If batteries, which have been subject to re-use, preparing for repurpose, repurposing, or remanufacturing, were already placed on the market or put into service before undergoing such operations (*Article 45a(1)*).
- For economic operators (or their parent group) with a net turnover of less than €40 million in the second last financial year (*Article 45a(1)*).

In case of non-compliance with the due-diligence obligations, Member States shall require the economic operator to end the non-compliance. Otherwise, the Member States shall take measures to restrict or prohibit the economic operator from making the batteries available on the market; or even recalling or withdrawing the batteries from the market (*Article 69a*).

In terms of accountability resulting from these obligations, the Battery Regulation did not incorporate any passage on compensation for end-users or affected people as the EU CSDDD for instance does (see below). Economic operators of batteries may however fall under additional regulations (“in so far as there are no specific provisions with the same objective”, *Recital 70*), also in terms of civil liability for damages arising when not fulfilling due diligence requirements. Where EU instruments do not cover the liability (completely), national rules may apply.

Supply chain due diligence information for the battery passport

For examining supply chain due diligence information for the battery passport, first, the Battery Regulation was analysed. In addition, other regulations were taken into account to arrive at comprehensive and ideally harmonised suggestions. Important regulations from a supply chain due diligence perspective, which were considered, are introduced in the info box below. While the due diligence report is to be made available via the battery passport to ensure compliance with the Battery Regulation, the Battery Pass consortium also explores potential additional attributes to be added voluntarily (in the future).

Table 6: Suggested supply chain due diligence information to be made available via the battery passport

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting
Information of the due diligence report	*Annex XIII (1g)*; *Article 45e(3)*	Public	Report on the supply chain due diligence policy, risk management plan, and summary of third-party verification ("due diligence report")	Make information of the report available via the battery passport
Potential voluntary supply chain due diligence additions				
Third-party assurances (e.g., certifications) of recognised schemes	Not mandatory for the battery passport, but *Article 45f* on recognition of due diligence schemes	Public	Assurances, such as certifications, of recognised supply chain schemes	Based on the provided guidance, explore which And how to best make third-party assurances available via the battery passport
Supply chain indices	Not mandatory and not referenced by the Battery Regulation	Public	ESGE+ indices under development by the GBA, scoring and benchmarking sustainability performance	Once developed, explore how to best make the indices available via the battery passport

Chapter 6.4.1 introduces the mandatory and 6.4.2 the potential voluntary supply chain due diligence information for the battery passport. For the due diligence report, the following questions are addressed:

- Which elements and scope should the due diligence report entail?
- Which requirements do other regulations of relevance for European companies set for the report and how can these be harmonised?
- Are any efforts needed to make the due diligence report machine readable?

Regarding additional voluntary attributes for the battery passport, the below is explored:

- How can third-party supply chain assurances add value? (chapter 6.4.2.1)

- How can supply chain responsibility be measured and compared? (chapter 6.4.2.2)
- Which role might the provenance of materials as well as traceability and chain of custody systems play in the future? (chapter 6.4.2.3)
- Which other sustainability reporting documents could be voluntarily added to the battery passport? (info box in chapter 6.4.2.3)

6.4.1 The due diligence report

From the due diligence obligations outlined above, only the "information on responsible sourcing as indicated in the report on its due diligence policies referred to in *Article 45e(3)*" (*Annex XIII (1g)*) is mandatory for the battery passport, to be publicly accessible. The annual report on the due diligence policies referred to, shall be made available to the public, also on the internet, be "easily comprehensible for end-users", and clearly identify the batteries concerned. Since not further specified in the regulation, we recommend only linking to the annual due diligence report valid for the specific battery at the time of placing it on the market.

The information in the battery passport shall be "machine-readable, structured, and searchable" (*Article 65(5)*). Today, due diligence reports are typically made available as PDFs. For the battery passport, a link to the PDF uploaded to the company website should be made available. This way, the information is digitally available and (to a certain degree) machine readable, though the exact definition of machine readability should be clarified. While extracting all information from the due diligence report to the battery passport would add little value, certain key information of it could be reported as individual data points, if providing a clear value-add for certain stakeholders (e.g., end consumer or authorities). We recommend further exploring if and which information could add value.

The report and hence also the information in the battery passport shall clearly identify the batteries concerned and provide data and information on four aspects:

1) **Supply chain due diligence policy:** steps taken by the economic operator to comply with the requirements of *Article 45b.*
2) **Risk management plan:** steps taken by the economic operator to comply with the requirements of *Article 45c*, including findings of significant adverse impacts
3) **Summary report of the third-party verification** carried out (*Article 45d*).
4) An elaboration on **access to information, public participation** in decision-making and access to justice.

To understand the responsible supply chain information to be entailed in the due diligence report (to be also made available via the battery passport), the due diligence report requirements were analysed. First, the elements to report on (chapter 6.4.1.1) and second, the scope of supply chain activities covered in the report (chapter 6.4.1.2) were examined. In both cases, the EU Battery Regulation and the German Supply Chain Act (GerSCA), as well as the EU Corporate Sustainability Due Diligence Directive (EU CSDDD) (as relevant in the German and EU context), were consulted to derive recommendations on how to harmonise reporting duties.

Due diligence and traceability obligations beyond the EU Battery Regulation

German Supply Chain Act (GerSCA) (13): The GerSCA imposes comprehensive due diligence requirements. It provides a comprehensive list of obligations including the establishment of a risk management system, necessary preventive and remedial measures, mandatory complaint procedures, and regular documentation and reports. Since 1 January 2023, the Act applies to companies with 3,000 or more employees. From 1 January 2024, it will also affect companies with 1,000 employees and more. The prerequisite is that the company's administrative centre, head office, headquarters, place of effective management, economic domicile or statutory registered office is located in Germany. The Supply Chain Act also applies to branch offices of foreign companies that have reached or surpassed the abovementioned employee numbers. The GerSCA does not introduce any compensation to end-users, but solely fines in case of violations.

EU Supply Chain Due Diligence Directive (EC SCDDD) (7): At EU level, the Commission worked towards harmonising corporate due diligence to prevent non-uniform competition conditions arising from differing national supply chain laws. In February 2022, the Commission adopted a proposal for a Directive on corporate sustainability due diligence. Companies will be required to identify and, where necessary, prevent, end or mitigate adverse impacts of their activities. All EU companies that have at least 500 employees and €150 million+ in net turnover worldwide (Group 1) are to be subject to the directive. The new provisions are also to apply to other companies with more than 250 employees and a net turnover of €40 million worldwide and more that achieve at least 50% of their net turnover in defined high impact sectors (Group 2), including minerals. The provisions do not apply to this second group of companies until two years after they enter into force for Group 1. SMEs are not directly in the scope of this proposal. Under the EU CSDDD, persons suffering damage can claim compensation, with liability lying with the Member States. The Commission's proposal marks the first step in the EU legislative process and will be followed by feedback from Parliament and Council. A final decision is not to be expected before 2023 or 2024. After it is passed, Member States will have two years to transpose it into national law.

Chinese Traceability Regulation: In 2018, the Chinese Ministry of Information and Industry Technology (MIIT) issued the "Interim regulations on the Traceability of new Energy Vehicle Power Batteries". This regulation stipulates the establishment of an integrated, blockchain based, management platform. In the future, the traceability regulation could also become mandatory for Chinese companies operating in other countries (121).

Forced Labour Regulations: Since forced labour is being associated to materials processed in the region of Xinjiang in China, in the US, the Uyghur Forced Labour Prevention Act prevents goods produced in Xinjiang from entering the US market. The Commission is currently working on a new trade instrument, which will ban the import of goods manufactured using forced labour from any region, likely entering into force in 2026. This instrument shall complement the EU CSDDD (44) and initially, high-risk sectors and geographies are likely to be targeted to enforce the regulation (80).

US Inflation Reduction Act: Approved in August 2022, this Act shall boost the local economy and, amongst others, determines that consumers in the US will receive a credit per new EV, being penalised however if 40% (rising to 80%) of critical raw materials are not extracted, processed, or recycled in the US/North America; or if 50% (rising to 100%) of battery components are sourced outside of North America (44) (128) (128).

EU Critical Raw Materials Act (8): Introduced in chapter 3, "The Proposal Regulation establishing a frame-work for ensuring a secure and sustainable supply of critical raw materials" of March 2023, sets, amongst others, targets for the 2030 EU share of strategic raw material extraction, processing, and recycling.

Conflict Minerals Regulation: For tin, tantalum, tungsten, and gold, the Conflict Minerals Regulation was passed in 2017 to ensure that these materials are imported from responsible sources only, e.g., by meeting international standards set by the OECD (five-step framework). The due diligence obligations of the Battery Regulation apply "without prejudice to those laid down" in the Conflict Minerals Regulation.

6.4.1.1 Elements of the due diligence report

Table 7 introduces the requirements of the four elements to be covered in the due diligence report per EU Battery Regulation. Since, just like the Battery Regulation, also the EU CSDDD and GerSCA take a risk-based approach to due diligence deriving reporting requirements from the OECD Guidance for Responsible Business Conduct and the UN Guiding Principles (7; 13), a direct comparison between the regulations is possible. In addition, all are based on the five-step framework of the OECD Due Diligence Guidance for Minerals.

Moreover, the GerSCA requires companies to “prepare an annual report on the fulfilment of its due diligence obligations in the previous financial year and make it publicly available free of charge on the enterprise’s website” (*GerSCA, Article 10*). Similarly, under the EU CSDDD, companies not being subject to reporting under Directive 2013/34/EU (annual statements, consolidated financial statements and related reports of certain types of undertakings), are required to publish an annual statement on the matters covered by the Directive on their website. Information on the description of due diligence, potential and actual adverse impacts, and actions taken on those shall be included. Delegated acts shall be adopted by the Commission concerning the content and criteria for such reporting. Since the required elements for the reports under the GerSCA and EU CSDDD are similar to those for the due diligence report under the Battery Regulation, the Battery Pass consortium suggests harmonising reporting efforts in one due diligence report. This way, doubling requirements can be avoided.

Table 7: Regulatory comparison of elements of the due diligence report

Elements of the due diligence report	Requirements per…			Implication for the due diligence obligations/report
	EU Battery Regulation	**Germany Supply Chain Act**	**EU CSDDD**	
Economic operator's management systems (*Article 45b***)**				
Adopt and clearly communicate a company due diligence policy for batteries	*Article 45b:* The policy for batteries shall concern the raw materials outlined in *Annex X (1)* and the associated social and environmental risk categories of *Annex X (2)*.	*Article 6-2:* Companies must issue a description of priority ESG risks, stakeholder expectations (e.g., supplier code of conduct). Information needs to be entailed in the annual report.	*Article 5:* Must adopt and publish due diligence policy, which includes: approach, stakeholder code of conduct. The ESG rights are listed in annex. In the annual statement, the due diligence needs to be described.	Similar requirements, but slightly differing risk categories. Ensure that the policy is described in the due diligence report and that the policy spans all relevant risk categories from the three regulations.
Incorporate standards in due diligence policy	The policy should incorporate internationally recognised standards listed in *Annex X (3a)*. For the standards in scope, see chapter 6.4.1.2	The introduction of the act states that it implements the UN Guiding Principles on Business and Human Rights.	This directive refers explicitly to the UNGP Reporting Framework as a standard and reference for companies (*Recital 26*).	Since all three regulations refer to the UN Guiding Principles on Business and Human Rights, economic operators should align their due diligence policy to this guideline.
Structure internal management systems to support due diligence policy	Report on the implementation of an internal management system by assigning responsibility to the top management level to oversee the policy and maintain records for a minimum of ten years.	(Senior) management is responsible for the establishment and implementation of due diligence measures in all relevant business processes (*Article 4 & 24*). Management has to appoint a human rights officer to monitor risk management whom management will support or who will work autonomously (*Article 4-3*). Information needs to be entailed in the annual report.	Directors of companies are responsible for putting in place and overseeing due diligence (*Article 26-1*).	The EU CSDDD's specification that the directors are responsible for due diligence aligns best with the "top management" of the Battery Regulation. In addition, the EU GerSCA requires a human rights officer.

Elements of the due diligence report	Requirements per...			Implication for the due diligence obligations/report
	EU Battery Regulation	**Germany Supply Chain Act**	**EU CSDDD**	
Establish and operate system of controls and transparency	Report on the establishment and operation of a system of controls and transparency over the value chain, including a chain of custody or traceability system, identifying upstream actors. The documentation required in that system is specified (e.g., on the raw materials, their suppliers, origin, third-party verification reports of upstream suppliers). If verification reports are not available, for raw materials from conflict-affected and high-risk areas, additional information (e.g., mine of origin, transaction points) are required.	Not mentioned	Not mentioned	Follow the guidance from the EU Battery Regulation to set up a system of controls and transparency and OECD Due Diligence Guidance for information for raw materials originating from conflict-affected and high-risk areas required. In the battery passport, only reporting that the system is set up is required (no inclusion of the information required in the system).
Strengthen engagement with suppliers	Incorporate the due diligence policy into contracts and agreements with suppliers, including their risk management measures.	Requires economic operators to seek contractual assurances from suppliers that they will comply with the due diligence policy (*Article 6-4(2)*).	Companies should seek contractual assurances from direct business partners (e.g., compliance with code of conduct), including also cascading these through the value chain) (*Article 7-2b*).	If economic operators want to harmonise with the EU CSDDD, they need to make sure that there are steps taken to cascade contractual assurances along the value chain.
Establish a grievance mechanism	Establish or provide for (through collaborative agreements) a grievance mechanism, including an early-warning risk-awareness system and a remediation mechanism. Or facilitate recourse to an external expert or body,	Economic operators must provide possibility to stakeholders to submit complaints (*Article 8*). Information needs to be entailed in the annual report.	Economic operators must provide possibility to stakeholders to submit complaints, spanning the entire value chain (*Article 9*). Companies will have to provide remedies to	To be compliant with all requirements, a complaint procedure, warning system, and remediation mechanisms along the entire value chain are needed. Collaboration and external expert options

Elements of the due diligence report	Requirements per...			Implication for the due diligence obligations/report
	EU Battery Regulation	**Germany Supply Chain Act**	**EU CSDDD**	
	such as an ombudsman. Mechanism to be based on the UNGP.		affected stakeholders, if deemed so by supervisory authorities (*Article 18-4*).	introduced by the Battery Regulation. Reporting of that required in due diligence report.
Risk Management Plan *(Article 45c)*				
Identify and assess risks in the supply chain	*Article 45c:* For all risk categories listed in *Annex X (2)*, economic operators need to report on their risk identification and assessment activities. Information to be consulted for this are the elements of the management plan (see above, *Article 45b*) and on any other relevant information being publicly available or provided by stakeholders.	Human rights and environmental risks defined in *Article 2*. Risk analysis obligations apply only to the company's own business operations and direct suppliers, but not to indirect suppliers – only when there is "substantiated knowledge" of an infringement (*Article 5*, *Article 9-3*). Information needs to be entailed in the annual report.	Listing violations as cited in international conventions to define adverse environmental and human rights impacts. Companies should rely on quantitative and qualitative secondary sources and carry out consultations with potentially affected stakeholders to gather information on risks (*Article 6-4*).	All three list risks/violations, which should be mapped against each other to end at a harmonised reporting list. Source of information, at least: traceability system, grievance mechanism, supplier engagement, external/ secondary information. See chapter 6.4.2.1 for a suggested additional datapoint (third-party assurances), also helping in risk identification. Responsibility lies with the economic operator, supported by third-party verification (see chapter 5.2).
Identify and adopt risk management measures	Economic operators need to (i) report findings of the risk assessment to the top management level; (ii) adopt risk management measures consistent with the standards listed in *Annex X (3a)* (see chapter 6.4.1.1); exert	Operators must take remedial action if adverse impacts are discovered (*Article 7*; *Article 9-3*). Information needs to be entailed in the annual report.	Outlines different actions that companies are required to take in order to bring actual adverse impacts to an end (*Article 8-3*). Companies need to monitor the effectiveness	Measures outlined very similar to those in the EU Battery Regulation.

Elements of the due diligence report	Requirements per...			Implication for the due diligence obligations/report
	EU Battery Regulation	**Germany Supply Chain Act**	**EU CSDDD**	
	pressure on suppliers and their subsidiaries and subcontractors.		of the risk identification, prevention, mitigation, and bringing to an end (*Article 10*).	
Implement risk management plan and conduct additional assessments	(iii) Economic operators need to design and implement a risk management plan, monitor and track the performance, and suspend engagement with a supplier if mitigation failed. (iv) Economic operators need to conduct additional assessments after change of circumstances.	Effectiveness of remedial action and preventive measures needs to be assessed on an annual basis (*Article 6-5*; *7-4*). Information needs to be entailed in annual report, as well as conclusions being drawn from the assessment for future measures. (*Article 10*).	Requires companies to follow-up on risk management activities and to suspend or terminate relationship if impacts cannot be prevented (*Article 8-3*).	Measures outlined very similar to those in the EU Battery Regulation.
Stakeholder consultation	Consultation with suppliers and stakeholders concerned required if continuing or temporarily suspending trade before establishing a risk mitigation strategy.	Not explicitly mentioned.	A corrective action plan shall be developed in consultation with stakeholders (*Article 8*).	Measures outlined in Battery Regulation and EU CSDDD very similar.
Reporting on adverse impacts	In the Due Diligence Report, economic operators need to report on findings of significant adverse impacts and how they have been addressed. The findings are to be reported to top management level.	In the annual report, statement and identification of risks or violation (human rights and environmental) are required.	In the annual statement, companies need to report on potential and actual adverse impacts and actions taken on those.	Similar requirements on reporting in adverse impacts in the report.
Third-party verification of battery due diligence policies *(Article 45d)*				
Third-party verification	Third-party verification of battery due diligence policies via a notified body. In its scope, the audit should include all	No audit or third-party verification reports mentioned.	Contractual assurances need to be accompanied by measures to verify compliance (e.g., third-party verification	EU CSDDD largely similar, only adds that economic operators need to bear the costs, if reports obtained by

Elements of the due diligence report	Requirements per...			Implication for the due diligence obligations/report
	EU Battery Regulation	**Germany Supply Chain Act**	**EU CSDDD**	
	activities, processes and systems used by economic operators to implement their due diligence requirements. Where relevant, checks on undertakings and information shall be gathered from stakeholders; areas for potential improvement identified. As outcome, the notified body shall issue a verification report and approval decision in case of compliance.		reports/industry initiatives) (*Article 7-4*; *8-5*). If these are obtained from SMEs, the company shall bear the cost of the independent third-party verification.	SME. For the due diligence report mandatory per Battery Regulation (and also for the battery passport), a summary report of the third-party verifications, including the name of the notified body ("with due regard for business confidentiality and other competitive concerns") is required.
Additional requirements				
Access to additional information	The due diligence report shall also, where relevant, elaborate on: access to information, public participation in decision-making, and access to justice in environmental matters when sourcing, processing, and trading raw materials	Only access to information on complaints procedure required.	No mention of such information.	Reporting only required by Battery Regulation.
Emissions reduction plan	In *Annex X*, the UN Paris Agreement is cited as international instrument, which should cover the risks.	No mention.	The EU CSDDD adds a requirement for group 1 companies to have an emissions reduction plan in line with the Paris Agreement (*Article 11*).	Economic operators are advised to wait for the Commission's implementing acts to see if this plan needs to be included in a company's due diligence report.

6.4.1.2 Scope of the due diligence report

In addition to understanding and comparing the requirements of the four elements to be covered in the due diligence report (see chapter 6.4.1.1), the scope of the due diligence requirements of the Battery Regulation and how it compares to the GerSCA and the EU CSDDD is analysed in this chapter. To allow for a better understanding and to harmonise due diligence reporting requirements for companies (including the information to be accessible via the battery passport) the Battery Pass consortium analysed the below:

1) **Activities** covered by the due diligence obligations
2) **Materials** in scope of the due diligence obligations
3) **Guidelines** to align activities and reporting

Activities covered by the due diligence obligations

The Battery Regulation sets the scope of the battery due diligence obligations to the "sourcing, processing and trading of the raw materials and secondary raw materials required for battery manufacturing" (*Article 2(36)*). Even if the regulation uses "battery due diligence" as a generic term, the above wording indicates a supply chain approach (while for the risk management plan even a direct reference to the "supply chain" is being made). The supply chain concept excludes the use and disposal of the product (37; 7). Secondary raw materials are, however, in scope (*Recital 63*; *Article 2(36)*). Conforming to the logic of the cut-off approach for the carbon footprint (see chapter 6.3), this results in recycling processes being covered as allocated via the recycled content, i.e. the secondary raw materials included in the battery. The term "value chain" is only used by the regulation in the context of the "system of controls and transparency". However, since the information requirements for that system only refer to the supply of materials, the implications of this term remain open.

In comparison, the EU CSDDD refers to the entire value chain of companies, including the own operations, its subsidiaries, and in the value chain. Where the Battery Regulation only considers "suppliers in the chain and their subsidiaries[26] or subcontractors, that perform such activities" (*Article 2(36)*), the EU CSDDD includes the entire life cycle of production, use, and disposal of the product or provision of services (EU CSDDD, *Recital 17* (7)). The Commission will issue additional guidance as a practical tool for companies on their disposal behaviour (EU CSDDDso, *Recital 26* (7)). With that, additional due diligence requirements could emerge from the EU CSDDD to be ideally integrated into the due diligence report.

Like the Battery Regulation, the GerSCA only includes the supply chain, with all steps necessary to produce the products and provide the service, until the end customer. Actions of the company, direct and indirect suppliers are included (GerSCA, *Article 2* (13)).

The Battery Pass consortium underlines the importance of monitoring the entire value chain to ensure that also, e.g., recycling processes follow human rights and environmental standards. It is highlighted that on the one side these processes are covered by including secondary raw materials in scope of due diligence obligations, and on the other side other tools than the battery passport might be better suited to ensure product stewardship, such as via the Extended Producer Responsibility (EPR) obligations introduced in *Article 47*.

[26] In the Battery Regulation a "subsidiary" is defined as "a legal person through which the activity of a 'controlled undertaking' as defined in *Article 2(1), point (f)*, of Directive 2004/109/EC of the European Parliament and of the Council is exercised" (*Article 2(36aa)*).

Materials in scope of the due diligence obligations

The Battery Regulation limits the scope of the due diligence obligations, including the due diligence report, to those materials listed in *Annex X (1)*, being: cobalt, natural graphite, lithium, nickel, and chemical compounds based on these raw materials being necessary for manufacturing battery active materials. Both the EU CSDDD and the GerSCA do not specify material restrictions or exclusions. According to these regulations, due diligence ought to be a risk-based process. As a result, it should span all materials with significant human rights and associated risks associated with them.

In line with the above, even though the Battery Regulation limits due diligence to the above listed materials, the Battery Pass consortium recommends a material agnostic approach. This way, companies can be compliant with the obligations of the EU CSDDD and the GerSCA. At the same time, battery raw material compositions, technology, and innovation change quickly and human rights and environmental risks extend beyond the listed materials. The Battery Pass consortium advises each company to carefully assess the risks of all battery materials.[27]

Guidelines to align activities and reporting

The Battery Regulation specifies that the due diligence policy should incorporate internationally recognised standards listed in *Annex X (3a)*, being:

- The International Bill of Human Rights, including the international covenant on Civil and Political Rights and the International Covenant on Economic, Social and Cultural Rights
- UN Guiding Principles for Businesses and Human Rights (UNGP)
- OECD Guidelines for Multinational Enterprises
- ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy
- OECD Due Diligence Guidance for Responsible Business Conduct
- OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas

This list of guidelines takes the most widely recognised international standards on corporate responsibility to respect human rights and the environment into account. Since also the EU CSDDD and the GerSCA are derived from the UNGP, reporting efforts for the Battery Regulation can easily be harmonised. Similarly, in *Annex III (4)*, also the Proposal for a European Critical Raw Materials Act (8) refers to all of the above guidelines except the International Bill of Human Rights, as a base to assess if a project fulfils the criteria for recognition of strategic projects (*Article 5*). In addition, also the OECD Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector and the OECD Principles of Corporate Governance are listed in the Act's Proposal.

For the implementation of the guidelines in policies, companies should identify overlaps between the guidelines. Certain very comprehensive guidelines like the UNGP can serve as a helpful foundation, though others cover additional aspects such as the OECD Responsible Minerals Supply Chain Guidance requiring companies to implement a chain of custody or transparency system.

[27] Some battery materials commonly known to be prone to environmental or social risks are iron, copper, bauxite, manganese, mica, and the so called 3TGs (tin, tantalum, tungsten, gold) (no claim on completeness, holistic battery material assessments should be consulted). In addition to the ones listed in the Battery Regulation, they should be screened particularly carefully.

6.4.2 Potential voluntary supply chain due diligence additions

The due diligence obligations of the Battery Regulation introduced in chapter 6.4 can contribute to sustainable supply chain practices. For the battery passport, however, the only mandatory supply chain due diligence information to be made available is the due diligence report. Consequently, responsible supply chain topics are only covered sparsely. In addition, the due diligence report primarily focuses on policies and management systems, rather than stipulating or communicating on concrete risks, practices, and measures on the ground.

With increasing due diligence obligations of the Battery Regulation and other regulations, companies operating in complex and dynamic battery value chains are confronted with various challenges, aiming to meet those obligations. While increased due diligence efforts are needed regardless of the battery passport requirements, the battery passport can serve as a communication medium for key due diligence information. Therefore, beyond the mandatory due diligence report, we recommend exploring additional supply chain due diligence information, which could be voluntarily made available via the battery passport. This way, transparency, attention, and with that pressure for responsible supply chain practices could be raised.

While further elaboration on the integration of such information in the battery passport would be needed, first potential data points are discussed in this chapter. When considering meaningful additional battery passport information beyond the Battery Regulation requirements, the following should be kept in mind:

a. The availability of data,
b. The feasibility of making the information available via the battery passport,
c. The value for different stakeholders, and
d. The regulatory obligations (also beyond the Battery Regulation) companies need to follow.

On this basis, three additional potential future supply chain due diligence data points for the battery passport were identified and are discussed in the following:

- Third-party supply chain assurances: allow companies to demonstrate that supply chain practices adhere to defined standards (chapter 6.4.2.1)
- Supply chain indices: as developed by the Global Battery Alliance (chapter 6.4.2.2)
- Provenance information: as an exemplary traceability data point (chapter 6.4.2.3).

6.4.2.1 Third-party supply chain assurances

Third-party supply chain assurances (for a definition see the info box below) enable companies to engage with others on responsible practices along the supply chain (38). The Battery Regulation refers to due diligence schemes recognising those, which will adhere to its due diligence obligations. By following such schemes, companies can put regulatory compliance into practice. In addition, assurances based on third-party, site-specific verification and assessments allow the identification of risks and adverse impacts. Still, third-party assurances should be seen as one measure towards responsible supply chains, which only work well in affiliation with other tools and measures. Beyond regulatory obligations and risk minimisation, third-party assurances (e.g., certifications) allow companies to make sustainability-related claims. This way, businesses can create value since e.g., OEMs and the public are interested in reliable showcases of responsible supply chain practices. For the battery passport, third-party

assurances could add value by differentiating batteries and therefore e.g., impacting purchase decisions or justifying higher prices.

Third-party supply chain schemes: definition and examples

Definition: Third-party supply chain assurances demonstrate (e.g., via certifications) that supply chain practices adhere to defined standards. Typically, the assurances are a result of verification (e.g., third-party audit), covering a broad range of social, environmental, and economic standards. Today, most of these are set up by the industry, e.g., as a collaboration of mining companies (38). The landscape of such schemes has been growing and developing fast in recent years. While memberships in supply chain scheme initiatives are growing, the number of e.g., certified mine sites is still limited globally (38).

Examples: Supply chain schemes can either be mineral-agnostic, as the two examples introduced below, or mineral specific, such as the Copper Mark, the Aluminium Stewardship Initiative (ASI), the Responsible Steel Standard, or the Responsible Business Alliance's Standards, e.g., on mica, cobalt, or gold.

IRMA (Initiative for Responsible Mining Assurance): The multi-stakeholder governed standard system focuses on social and environmentally responsible mining through standards, independent third-party verification and certification. Globally, all mineral commodities except for energy fuels are covered. IRMA certifies mine sites (operational stage through closure), excluding artisanal and small-scale mining (ASM). Other standards are under development (mineral exploration, development, mineral processing, purchase of mined materials, chain of custody tracking) (38).

CERA 4in1: With CERA 4in1 (partly funded by EIT Raw Materials), TUEV NORD GROUP is developing a certification scheme, aiming to holistically evaluate social, environmental, and economic responsibility across the complete mineral raw material value chain. Globally, all mineral commodities except for energy fuels are covered. CERA 4in1 divides the value chain into 4 certification schemes: 1) The Readiness Standard (exploration and evaluation in the pre-investment phase), 2) The Performance Standard (mining, processing, and refining of large-scale mines), 3) The Chain of Custody Standard (the run-of-mine and trading of commodities), and 4) The Final Product Standard (end-product and its component) (124).

When considering making third-party supply chain schemes available via the battery passport, companies should address two major questions:

1) **Which scheme to follow and communicate via the battery passport?**
    a. **Recognition under the EU Battery Regulation:** We recommend following and making available via the battery passport third-party assurances recognised under the Battery Regulation. For such recognition, schemes need to demonstrate full compliance with the due diligence obligations. The approach for the equivalence of due diligence schemes still has to be developed by the Commission (*Recital 100*). We recommend following schemes also recognised under other relevant regulations, such as in future the Proposal for a European Critical Raw Materials Act (8). Here, some generic criteria schemes shall meet to be recognized are introduced in *Annex IV*. As currently seen for the Conflict Minerals Regulation, the recognition process might take time.[28] Therefore, companies are facing uncertainties today in terms of schemes to follow when striving towards compliance with the Battery Regulation. However, schemes are

[28] For the Conflict Minerals Regulation, for example, which is applicable since January 2021, tenders asking for technical work to advance the recognition of schemes, were only launched in September 2022.

today already largely following common references[29] (see chapter 6.4.1.2 for guidelines required per Battery Regulation schemes should consider).

b. **Coverage of supply chain schemes:** Currently, the space of supply chain schemes is fragmented and comprehensive assurances covering several battery minerals or even all value chain steps of one mineral are falling short (39). Scheme owners are just beginning to close the gap by introducing assurances covering, e.g., mine exploration, mineral processing, or the chain of custody. With no silver bullet today, companies should assess their available assurances of specific sites and/or minerals in light of a meaningful communication via the battery passport. For end-consumer buying a battery (appliance)[30], rather than making all site- and mineral-specific assurances available via the battery passport, we suggest exploring a bundling of site-specific assurances (e.g., indicating the percentage of all battery minerals originating from certified mine sites); a bundling across a mineral's supply chain (e.g., once possible, indicating a specific mineral is assured from the mine to the final battery); and assurances on a company level (e.g., assurances of the entire chain of custody or environmental management system such as by ISO 14000). As an ultimate vision for assurances, the Battery Pass consortium envisages a holistic assessment of the sustainability performance of a battery or an organisation (imagine a sustainability score, label, or guarantee). For instance, supply chain assurances could be compared against each other by creating a standard equivalence index. This approach is currently followed by the Global Battery Alliance (GBA), as introduced in chapter 6.4.2.2.

c. **Credibility and quality of supply chain schemes:** Assurances on the battery passport should be credible and of high-quality. The GBA is currently developing assessment criteria in the context of their standard equivalence work (see chapter 6.4.2.2). In addition, we suggest drawing on existing assessments and quality criteria. For instance, the comparative overview of sustainability standards by BGR (38) may help choose high-quality schemes. Similarly, ISEAL[31], defined "Codes of Good Practices", allowing supply chain schemes to participate and be approved ISEAL code compliant. As a general guidance, the Battery Pass consortium recommends taking the draft principles, derived from literature review and expert interviews (40) (41) (42) (38) and summarised in the info box below, into account.

2) **How to communicate assurances via the battery passport?**
It will need to be discussed how to make the official third-party assurance document and the corresponding third-party audit report available via the battery passport. Solutions should ensure validity and veracity of the documents. Digital solutions should be explored, such as verifiable credentials (tamper-evident credentials that can be verified cryptographically by a competent authority). In addition, we suggest exploring which assurance-related information could be made available as additional data points via the battery passport. This way, key information about the assurances of each battery could be easily communicated. In light of differing coverages of schemes, as outlined above, the coverage needs to be clearly and transparently communicated. Building upon

[29] Common references include as ISO 14001, ISO 45001/OHSAS 19001, or UNGP (38).
[30] Even though downstream purchasers of battery materials are also interested in assurances of battery materials, the battery passport is only issued later in the supply chain and will therefore not serve as a communication tool for them.
[31] The International Social and Environmental Accreditation and Labelling Alliance is a global membership organisation for credible sustainability standards. The ISEAL code is renowned as the quality benchmark for the governance of standard systems.

the LME (London Metal Exchange) passport's[32] voluntary reporting on sustainability disclosure (43), the Battery Pass suggests exploring an integration of the information listed in the info box. By corresponding to and thus being compatible with the existing passport of the LME, consolidation of systems will be ensured (43).

Third-party assurance draft principles and possible information for the battery passport

Draft principles supply chain schemes (40) (41) (42) (38)

a. **Stakeholder representation:**
   - Decision-making boards of scheme-owners to have a fair representation of civil society
   - Audits to also interview stakeholders outside of companies and consider all holders of rights
   - Representation of the global south, ideally localising the initiatives in national or local multi-stakeholder bodies
b. **Verification:**
   - A credible third-party verification and assessment process, including regular and broad third-party audits of the mine site
   - A certification in case of successful verification
   - Site-specific verification (rather than site-specific samples or enterprise-specific verification only)
   - Communicate transparent, detailed audit results
   - An independent oversight mechanism
   - An issues resolution system as whistle-blowing mechanism
c. **Themes covered:**
   - Standards should cover a broad range of sustainability themes to consider all impact categories of relevance for battery materials
   - Consideration of forward-looking issues not related to the performance of a facility, e.g., promotion of renewables, a Circular Economy, innovation, and a quality workplace
   - Publishing results about single standard requirements
d. **Following common references:**
   - To allow for equivalency between standards and for mutual recognition, following common references such as ISO 14001, ISO 45001/OHSAS 19001; UNGP

Possible third-party assurance information for the battery passport

- Specify the **name** of the supply chain scheme as well as the issuer
- Specify the awarded **assurance** and if applicable level or method (e.g., certification)
- Specify the **coverage/ completeness** (if applicable):
  - Material(s)
  - Entities/value chain steps
  - Risk categories (based on those required per EU Battery Regulation)
  - (Management) system(s)
- Specify the **time period**/expiration of validity of the assurance
- Make the official third-party assurance **document** and the corresponding third-party **audit report** available (as outlined above)

[32] The London Metal Exchange (LME) developed a digital and centralised register for provenance information, containing Certification of Analysis (COA) records. From 2024 on, the LME passport will be required for producers of LME brands and LME approved warehouses. The COA records include data points such as the origin, purity, size, shape, weight, or breakdown of chemical composition (43).

6.4.2.2 Supply chain indices

Compliance with the EU Battery Regulation and related legislation is primarily oriented at ensuring responsible business conduct in line with international conventions and frameworks, whose mechanisms for implementation by businesses are typically organised around the imperatives to manage risks and avoid, minimise, mitigate, and remedy adverse impacts. Hence, the due diligence report being mandatory for the battery passport, also follows such a risk-based approach.

We believe that being compliant with regulations such as the EU Battery Regulation, and with that focusing on addressing risks and adverse impacts, presents the necessary first step on the journey towards responsible supply chains. However, we acknowledge that as a necessary subsequent step, the focus needs to shift towards also accelerating positive impacts through the supply chain practices of companies. This is particularly possible for battery supply chains, considering the current global mobilisation of capital into their development.

To that end, the Global Battery Alliance's Battery Passport project is developing a set of ESGE+ indices that will allow companies and batteries to be scored and benchmarked for their sustainability performance, capturing the actions necessary to comply with national and regional regulations and with voluntary standards, as well as the "leading practice" actions most likely to generate high impact developmental outcomes for specific issues, such as eliminating child labour or life cycle analysis. The GBA's initial indices are in greenhouse gases, human rights, and child labour. The latter two capture the relative quality of a company's efforts to manage and eliminate human rights or child labour risks by taking actions that will reduce risk salience. For example, in the Child Labour Index companies are scored for having a minimum age commitment (legal compliance) as well as having a commitment to take actions to address the root causes of child labour or taking action on paying a living wage/income and supporting flexible working for people with parental responsibilities (beyond compliance leading practices).

In that sense, we see the work of the GBA as a continuation of the recommendation by the Battery Pass consortium. Our suggested integration of supply chain assurances such as certifications as a voluntary element into the battery passport can build the base for the standard equivalence (assessing the comprehensiveness of standards) conducted by the GBA. Once a multi-stakeholder-accepted, comprehensive, integrated, and audited reporting framework is established in industry, this can advance transparency and comprehensibility, in particular for the public while reducing the effort of multiple auditing of companies.

6.4.2.3 Provenance information

The provenance of a material refers to the source location/origin of the material. Provenance may refer to the exact location/mine of origin or the region or country of origin only. Since attention for so-called conflict-affected and high-risk-areas (CAHRAs), often associated with unsustainable sourcing practices, has grown significantly, companies are increasingly working on provenance transparency. If downstream purchasers of battery minerals can trace the provenance back, practices can be monitored, risks identified, and corrective measures implemented in a targeted manner.

Also from a regulatory perspective, materials from CAHRAs are addressed, e.g., by the Conflict Minerals Regulation's supply chain due diligence obligations and related guidelines.[33] Further, the European Commission is working on a trade instrument likely entering into force in 2026, which will ban the import of goods manufactured from any region using forced labour. This instrument shall complement the EU CSDDD (44), with high-risk sectors and geographies likely first being in scope. In the US, the Uyghur Forced Labor Prevention Act prevents goods produced in Xinjiang, China from entering the US market since forced labour is being associated to battery materials processed in the region. And even beyond risk identification, provenance comes to the fore of regulations. The US Inflation Reduction Act aims to boost the local economy by granting consumers in the US a credit per new EV unless critical raw materials or battery components stem from outside of North America.[34]

In light of the above regulatory developments and that future regulations may require the disclosure of the material's provenance in the EU, making provenance information available via the battery passport could support market surveillance authorities in carrying out conformity assessments. For a potential US battery passport in the US, this use case would already hold true today. Here, also the public would be interested in the provenance as credits are offered. Similarly, with the recently published Proposal for a European Critical Raw Materials Act (8), in future, it might also be of interest to communicate a EU or non-EU provenance (or even processing beyond extraction) via the battery passport.[35] Furthermore, beyond conformity with (potential) regulations, public attention on specific geographies is increasing. To address the concerns of end consumers buying (appliances with) batteries, we suggest further exploring the battery passport as medium to communicate provenance information.

When considering making the provenance available via the battery passport, companies should, however, address two major questions:

1) **Where could reliable provenance information stem from?**
   Provenance information of raw materials can stem from different sources like supply chain questionnaires, audits, as well as traceability or chain of custody (CoC) systems. To reliably ascertain and disclose the provenance of battery materials, companies first need to build up the required internal processes and systems. These will likely present a mix of different sources and include, e.g., also third-party assurances and related audits as outlined in chapter 6.4.2.1.

[33] Tin, tantalum, tungsten, and gold originating from CAHRAs are addressed in the Conflict Minerals Regulation of 2017. This regulation is based on the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. The definition of CAHRAs can be found in the EU CAHRA list. In 2018, the Commission also published a non-binding guideline for the identification of CAHRAs and other supply chain risks under the Conflict Minerals Regulation.
[34] Under the US Inflation Reduction Act approved in August 2022, consumers are granted a credit per new EV unless critical raw materials or battery components stem from outside of North America with penalties applying if 40% (rising to 80%) of critical raw materials are not extracted, processed, or recycled in the US/North America; or if 50% (rising to 100%) of battery components are sourced outside of North America (44) (128) (128).
[35] To strengthen the different stages of the strategic raw materials value chain, the Proposal for a European Critical Raw Materials Act introduces the following benchmarks for the EU's annual consumption by 2030: 10% extraction, 40% processing, 15% recycling, and not more than 65% at any processing stage from a single third country (*Article 1(2)*).

a. **Traceability and chain of custody systems:** Traceability and CoC systems are increasingly implemented by companies (see definitions of both systems and the functioning of traceability systems in the info box below). To ensure well-functioning traceability or CoC systems, companies need to, amongst others, also ensure well-defined processes for a structured realisation, available and high quality data, and (especially for traceability systems) the technical capacity in the supply chain. Also in the Battery Regulation, the establishment and operation of a traceability or CoC system is required as one due diligence obligation,[36] as introduced in the info box below. Hence, based on a company's preference, either a CoC or traceability system needs to be implemented. Both systems can increase supply chain transparency, enable companies to mitigate risks from geographic concentration, achieve supply chain assurances, and make proven sustainable claims. For the battery passport, going beyond provenance information, traceability and CoC systems could be used to collect data for battery passport information or their calculation (see also chapter 5.1.3). Besides provenance, other voluntary supply chain due diligence information from a CoC or traceability system for the battery passport, such as market transactions or locations of the raw materials along the value chain, could in future also be assessed.

2) **How should provenance information be communicated via the battery passport?**
The information to be potentially made available on provenance information via the battery passport should be carefully assessed. Since companies at times still lack exhaustive provenance information of all their battery materials, creative while transparent solutions should be sought to start with the information available today without making false claims.

a. **Geographical granularity:** Rather than unveiling all mines of origin of all battery materials via the battery passport, companies should assess the geographical granularity (i.e. potential clustering by regions or countries) of interest. Authorities would require information to carry out conformity assessments. Hence, at the example of the US Uyghur Forced Labor Prevention Act, knowing if materials stem from the region of Xinjiang. The end consumer, however, could be interested in understanding if materials stem from CAHRAs. As another example, the US Reduction Inflation Act would arouse public interest in specifying a North American or US provenance. Importantly, clustering the provenance by regions or countries would also anticipate antitrust law concerns resulting from publicly communicating specific mines of origin.

b. **Information accompanying the provenance:** To avoid misleading information, the blanket expulsion of businesses from certain geographies, and provide information of interest for end consumers, the provenance information could be accompanied by additional information. For materials from CAHRAs, for instance, third-party supply chain assurances (e.g., a certification of the mines concerned) could be linked. This way, practices in high-risk areas would receive additional attention rather than business relationships simply terminated.

[36] For provenance information, the Battery Regulation does not explicitly require making them accessible via the battery passport. Still, *Recital 93* lists the "origin of the materials used" in the context of information to be provided via the battery passport. We, therefore, recommend to the European Commission excluding or clarifying this reference to avoid confusion.

Traceability and chain of custody systems: definitions, functioning, and obligations per Battery Regulation

- **Chain of custody (CoC)** is a process by which inputs and outputs of individual steps in the supply chain and associated information are transferred, monitored and controlled as they move through each step in the relevant supply chain.
- **A chain of custody system** sets measures designed to implement a chain of custody including documenting of these measures. The purpose of a CoC system is to provide credibility that the given material or product has a set of specified characteristics (e.g., content of recycled material, location of origin, performed processes for the carbon footprint determination). Different chain of custody models can be used to implement a CoC system (e.g., mass balance).
- **Traceability** is the ability to trace the history, application, location or source(s) of a material or product across the whole relevant supply/value chain.
- **A traceability system** provides means to implement a CoC system. It provides visibility into the supply chain and enables companies to identify value creation opportunities and potential problems to take corrective action.

Traceability system: The basic building blocks:

- **Unique identification:** Each commodity is assigned to a unique machine-readable identifier, such as a barcode, QR code, or RFID tag. This identifier is used to track the commodity throughout the supply chain. Analytical fingerprinting allows material to be traced back to its origin by analysing its chemical properties. For provenance analysis, this is seen as the “least corruptible method” (39).
- **Data collection:** At each stage of the supply chain, data is captured about the relevant material or product characteristics, including location, condition, etc., and any relevant events or milestones as well as third-party verification documentation. This data is usually captured using handheld scanners, mobile devices, or other tracking technologies. Some systems use distributed ledger technology (e.g., Blockchain) to create immutable and verifiable records to prove that claimed distinguishable features of a material or product along the supply chain are correct.
- **Data transmission:** Data is transmitted to a database or platform that aggregates and analyses the data to provide supply chain insights.
- **Data analytics:** The system uses data analytics tools to analyse the data based on definable business logic and provide insights into potential risks and opportunities. Data analytics can involve artificial intelligence and machine learning to identify anomalies.
- **Alerts and reports:** The system can generate alerts and reports to inform stakeholders of problems or anomalies in the supply chain.
- **Visualisation:** The system presents the analysed data in a user-friendly format, for example in the form of dashboards, maps or diagrams.

Documentation via the traceability or CoC system required per Battery Regulation

Article 45(d) of the Battery Regulation specifies the information to be documented via the mandatory company’s traceability or chain of custody system, being:

- “(i) description of the raw material, including its trade name and type;
- (ii) name and address of the supplier that supplied the raw material [...];
- (iii) country of origin of the raw material and the market transactions from the raw material’s extraction to the immediate supplier to the economic operator that places the battery on the market;
- (iv) quantities of the raw material [...];
- (v) third-party verification reports [...] concerning the upstream suppliers [...]
- (vi) if the reports referred to in point (v) are not available: where the raw material originates from a conflict-affected and high-risk areas, additional information in accordance with the specific recommendations for upstream economic operators, as set out in the OECD Due Diligence Guidance, where relevant, such as the mine of origin, locations where raw materials are consolidated, traded and processed, and taxes, fees and royalties paid."

Other sustainability information for the battery passport

In addition to the above discussed potential voluntary supply chain due diligence information, other, easily available sustainability information might be made available via the battery passport, of which two are introduced in the info box below. While these documents are not mandatory for the battery passport, most companies will have them ready anyway. Hence, the value of the battery passport could be easily improved and access to those documents eased.

Additional sustainability reporting as voluntary for the battery passport

Taxonomy disclosure statement

The EU Taxonomy Regulation (104), designed to support the transformation of the EU economy to meet the Green Deal objectives (11; 10), classifies the sustainability of different economic activities. For this, it is examined if an activity makes a substantial contribution to at least one of the EU's climate and environmental objectives;[1] and if the activity does not harm any of the other objectives while respecting basic human rights and labour standards.

Per *Article 8* of the EU Taxonomy Regulation, large undertakings need to disclose information to the public on how and to what extent their activities are associated with environmentally sustainable economic activities.[1] This disclosure needs to report on the proportion of (1) the turnover, and (2) the capital and operating expenditure associated with/derived from Taxonomy activities (11; 10). The Battery Pass consortium suggests companies voluntarily make the Taxonomy disclosure statement available via the battery passport. This way, regulatory requirements can be streamlined and differentiation by reporting on specific quantifiable KPIs achieved.

Sustainability Report

In January 2023, the Corporate Sustainability Reporting Directive (CSRD) entered into force, amending the previous Non-Financial Reporting Directive (NFRD). The first companies have to apply to the new rules in the financial year 2024, for reports published in 2025 (105). The EU CSRD applies to a larger scope of entities than the previous Non-Financial Reporting Directive[1] and to "large undertaking"[1] that is either an EU company or an EU subsidiary of a non-EU company. The CSRD requires EU companies to draft a sustainability report.

We suggest making a sustainability report publicly available via the battery passport. The sustainability report is not only mandatory for the majority of economic operators but also presents a key document for communicating non-financial performance to investors, customers, and other stakeholders. Adding the sustainability report to the battery passport provides additional information that can help customers make purchasing decisions.

6.5 Battery materials and composition

Battery passport guidance in brief on battery materials and composition

Mandatory data: Battery chemistry; critical raw materials; materials used in the cathode, anode, and electrolyte; hazardous substances; impact of substances on the environment and on human health or safety.

Our suggestions and outlook: Information about the composition of batteries are of interest for both the public to support purchase decisions, as well as recyclers and logistic companies alike to ensure appropriate and safe handling and processing of (waste) batteries. Composition information accessible to the public should allow assessing battery differences, the presence of critical raw materials, and potential hazards and negative impacts of battery materials. However, the detailed composition often raising confidentiality concerns, will, however, have restricted access, with the exact access group still to be defined in implementing acts.

Table 8: Battery materials and composition information to be made available in the battery passport

Data attribute	Battery Regulation reference	Data Access	Definition/ understanding	Suggested reporting
Battery chemistry	*Annex XIII (1b)*; *Annex VI, Part A(6)*	Public	Battery composition in general terms (for the cathode, anode, and electrolyte).	Reporting cathode and anode as well the electrolyte material on a high level, e.g., “Li-NMC/ Carbon/LiPF6”.
Critical raw materials	*Annex XIII (1b)*; *Annex VI, Part A(10)*	Public	Raw materials classified by the Commission as “critical” in COM(2020)474final “Critical Raw Materials Resilience”.	Specifying all critical raw materials above 0.1% weight by weight via stating the official name.
Materials used in the cathode, anode, electrolyte	*Annex XIII (2a)*	Interested persons and the Commission	Materials (as composition of substances) in the cathode, anode, and electrolyte.	Specifying materials in cathode, anode, and electrolyte via stating official name, related identifier, and weight in grams.
Hazardous substances	*Annex XIII (1b)*; *Annex VI, Part A(7)*	Public	Substance that poses a threat to human health and the environment, classified according to hazard classes and categories of the CLP Regulation.	Specifying hazardous substances (other than mercury, cadmium, lead) above 0.1% weight by weight via stating the name (agreed nomenclature), hazard classes/categories, related identifier, location of the substance, and concentration range in %.
Impact of substances on the environment and on human health or safety	*Annex XIII (1u)*; *Article 60(1f)*	Public	Impacts of substances according to the impact categories of the CLP Regulation and due to inappropriate discarding of waste batteries.	Specifying the impact of substances by citing commonly used statements for all hazard classes applicable, e.g., based on REACH or GHS.

All data points falling under the “battery materials and composition” category are summarised in Table 8. Most of these datapoints are accessible to the public (as introduced in *Annex XIII, Part A(1)*), only the “detailed composition, including materials used in the cathode, anode and electrolyte” (introduced in *Annex XIII, Part A(2)*, defined as in chapter 6.6.3) is restricted to “interested persons and the Commission” (see chapter 5.1.6 for details on this access group).

For batteries to be marked with a label containing the general information about batteries of *Part A of Annex VI*, including the chemistry, hazardous substances, and critical raw materials, a timeline of 36 months after entry into force of the regulation or after 18 months after entry into force of the implementing act on harmonized labelling (whichever is later) is introduced.

An overview with options and recommendations on how granular to report on composition datapoints in the battery passport, in light of their use case and potential confidentiality concerns, are outlined below and summarised in Table 10 at the end of chapter 6.5.5.

Companies are already collecting, transmitting, and reporting data on product compositions in various ways. Such systems are relevant for the reporting envisioned by the battery passport, as they could be used as a basis for required data. The text box below includes details on two important systems for materials and/or substances.

Existing reporting systems relevant for battery composition data

IMDS (International Material Data System): The IMDS is “the automotive industry’s material data system” and “has become a global standard used by almost all of the global OEMs” (84). The IMDS is used by automotive manufacturers to meet obligations by standards, laws, and regulations, both nationally and internationally. The system is used for internal compliance checks, not by authorities.

In the IMDS, “all materials used for automobile manufacturing are collected, maintained, analysed and archived” (84). Suppliers share this information via material data sheets. The IMDS breaks down automotive structures into components, semi-components, materials, and substances. Materials and substances are classified with their CAS number (a numeric identifier), quantity (grams for materials and portion in % for substances), the VDA classification for materials, its presence on the GASDL list, and if being a substance of very high concern.

In the IMDS, all (semi-)components and materials are listed, but for substances only those covered in the GADSL (Global Automotive Declarable Substance List). The GADSL entails all substances requiring specific declaration following regulations of different geographies. The reporting threshold lies at 0.1% with companies being able to hide up to 10% of their substances as confidential – if they are not classified as hazardous and contained below a specified threshold.

SCIP (Substances of Concern in articles as such or in complex objects (Products)): SCIP is a database created and maintained by the European Chemical Agency (ECHA) for the EU, building on the REACH regulation’s candidate list of substances of very high concern (SVHCs). SCIP stores safe-use information for (SVHCs) present in products placed on the EU market, aiming at information accessibility and transparency for waste operators and consumers.

Companies are required to submit information for SVHCs above 0.1% weight by weight to the SCIP database. For each product, all SVHCs with their substance name must be listed, the article be identifiable e.g., via an item or serial number (not necessarily being disclosed publicly), the reason for inclusion (related hazard class(es)), concentration, location, and information for the safe use of the article stated. This information is submitted in form of dossiers in the IUCLID format (a defined and structured data format for exchange of chemical information, via IUCLID 6 zip files).

6.5.1 Battery chemistry

The information on the battery chemistry is mandatory to be accessible by the public via the battery passport (*Annex XIII (1b)*; and via labelling information of *Annex VI, Part A(6)*).

Definition of the battery chemistry

The term battery chemistry is mentioned but not defined in the EU Battery Regulation. We suggest defining battery chemistry as the cathode and anode active as well as electrolyte material.

The cathode, anode, and electrolyte classify the composition of a battery in general terms and serve as indication for battery differences, e.g., in safety, lifespan, performance, recycling, or re-use. This can be of interest for the public to support purchase decisions as well as for logistic companies to be able to classify a battery prior to its transport, affecting, e.g., required transport materials.

While today, Li-ion batteries are mostly classified by the cathode active material, the anode active material is equally important for other battery chemistries and new technologies. With next-generation solid state batteries the electrolyte also increasingly differentiates batteries.

Suggested reporting granularity of battery chemistry in the battery passport

We suggest reporting the cathode, anode, and electrolyte active material on a high level, e.g., “Li-NMC/Carbon/LiPF6” or “Lithium-Nickel-Manganese-Cobalt/Carbon/Lithium hexafluoro-phosphate” or its respective acronym. “SSB” can be added in the case of solid-state batteries. While the stoichiometry (e.g., Li-NMC 811 describing a ratio of nickel, manganese and cobalt of 8:1:1), as well as the type of carbon used (e.g., natural or artificial graphite), would be of little interest to the public, second-life operators will have access to this more detailed level via the datapoint “materials used in…” (chapter 6.5.3).

To allow for an unambiguous and coherent specification of the battery chemistry, an agreed battery classification (either nomenclature or coding) will be needed despite certain active materials already being typically named via the same acronyms (e.g., LCO, NMC, NaS, Ni-Cd). For some battery chemistries, a simplified reporting might be possible. For a Li-ion battery, for instance, specifying the anode and electrolyte might not be needed. For a solid-state battery, however, the electrolyte presents an important component to report on. The nomenclature of the IEC (International Electrochemical Commission) could be a starting point, e.g., IEC 61960 introducing letter codes for Li-ion batteries. An example of such IEC naming is ICP/35/48 (“I” indicating lithium-ion, “C” cobalt, “P” prism shape, “35” the width, and “48” the height). While this code by the IEC could also be made available via the battery passport, the battery chemistry to be reported as per Battery Regulation will need to be communicated in a simplified version, being comprehensible to the public. Further work on such classification and nomenclature is needed.

In the case of hybrid batteries, which contain cells with different chemistries, the battery passport would either need to state all chemistries used or indicate the information on a module or cell level.

Link to other data points, existing systems, and databases

The battery chemistry datapoint could be automatically generated if linked to the data entry under “materials used in cathode, anode, electrolyte” (see chapter 6.5.3).

6.5.2 Critical raw materials

The information on critical raw materials contained in the battery is mandatory to be accessible by the public via the battery passport (*Annex XIII (1b)*; and via labelling information of *Annex VI, Part A(10)*).

Definition of critical raw materials

The EU Battery Regulation references the document "Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability" (45) by the European Commission, which defines the term critical raw material as follows: "Those raw materials that are most important economically and have a high supply risk", i.e. they are both economically important and vulnerable to supply disruption. Here, the fourth list of critical raw materials for the EU with 30 raw materials, classified as critical by the EU in 2020,[37] can be found. This list is subject to change, and the Commission committed to updating it at least every three years to reflect production, market and technological developments. The latest list will be made available via the Raw Materials Information System (RMIS) of the EU Science Hub (46). The Proposal for a European Critical Raw Materials Act (8) (*Annex II*) of March 2023 introduced a new list of 34 materials to be considered critical. This list can also already be found on the RMIS. Compared to the list of 2020, borate, indium, and natural rubber are not included anymore, while 7 materials (as marked in the table) were added.

Table 9: List of raw materials classified as critical by the EU (2023)

Antimony	Gallium	Phosphate rock
Arsenic (2023)	Germanium	Phosphorus
Bauxite	Hafnium	Platinum group metals (PGM)
Baryte	Helium (2023)	Scandium
Beryllium	Heavy rare earth elements (HREE)	Silicon metal
Bismuth	Light rare earth elements (LREE)	Strontium EN 4 EN
Boron (2023)	Lithium	Tantalum
Cobalt	Magnesium	Titanium metal
Coking coal	Manganese (2023)	Tungsten
Copper (2023)	Natural graphite	Vanadium
Feldspar (2023)	Nickel – battery grade (2023)	
Fluorspar	Niobium	

Since the list is updated regularly, also the definition of critical raw materials in the battery passport needs to be flexible.

Suggested reporting granularity of critical raw materials in the battery passport

We suggest specifying all critical raw materials of the battery above a concentration of 0.1 % weight by weight within each (sub-)component of the battery (*Annex VI, Part A(7)*).[38] The critical raw materials should be reported in an aggregated way for the entire battery.

Link to other data points, existing systems, and databases

[37] The Battery Pass did not examine this list of critical raw materials on completeness or correctness, it is taken from the Commission's list.
[38] According to SCIP, "by weight" refers to the weight of the (sub-)components (articles) within a battery (complex object). See the explanation in chapter 6.5.

The “critical raw materials” datapoint could be partly automatically generated if linked to the data entry of “materials used in cathode, anode, electrolyte” (see chapter 6.5.3) and subject to these being marked as such. All remaining critical raw materials outside of the cell would still need to be reported upon additionally. The reporting on critical raw materials in the battery passport would aggregate them for all components.

The automotive industry can build on the data stored in the IMDS (for information on the IMDS, see the green box in chapter 6.5), building upon the Global Automotive Declarable Substance List (GADSL), also entailing the critical raw materials group (47). The GADSL (48) is a list of several thousand substances expected to be present in a material or part of vehicles and requiring specific declaration following regulations of different geographies. For other industries it will need to be explored if similar systems can be built upon.

In addition to critical raw materials, the Proposal for a European Critical Raw Materials Act (8) introduces 16 strategic raw materials[39]. The Battery Regulation does not require reporting on strategic raw materials. This, however, could be subject to change with the newly introduced list of strategic raw materials.

6.5.3 Materials used in cathode, anode, and electrolyte

The “detailed composition, including materials used in the cathode, anode, and electrolyte” is mandatory to be accessible via the battery passport, only, however, to “interested persons and the Commission” (*Annex XIII (2a)*). See chapter 5.1.6 for details on this access group, which will be further defined in implementing acts. We recommend that sorters and dismantlers would also obtain access to this information, which they require to assess a battery’s state and value and consequently decide on their subsequent handling route and approach (e.g., repurposing vs recycling). See the green box below for confidentiality considerations when sharing the detailed battery composition via the battery passport.

Definition of materials

The term “material” is not defined in the EU Battery Regulation. In line with the IMDS reporting structure, we suggest defining a material as a composition of substances, i.e. one material may consist of one or several substances. A material is defined as such if being homogeneous.

Suggested reporting granularity of materials used in the cathode, anode, and electrolyte in the battery passport

Reporting should be done on the cathode, anode, and electrolyte level respectively:

1) Specifying all materials in the respective component (anode, cathode, electrolyte). We suggest a reporting threshold of 0.1 % weight by weight (within each (sub-) component within or being the anode, cathode or electrolyte[40]) to be aligned with the thresholds for reporting on critical raw materials in the battery passport, substances of very high concern (SVHC) under REACH, and substances of the GADSL list in the IMDS. However,

[39] The following raw materials are listed as strategic: (a) Bismuth (b) Boron - metallurgy grade (c) Cobalt (d) Copper (e) Gallium (f) Germanium (g) Lithium - battery grade (h) Magnesium metal (i) Manganese - battery grade (j) Natural Graphite - battery grade (k) Nickel - battery grade (l) Platinum Group Metals (m) Rare Earth Elements for magnets (Nd, Pr, Tb, Dy, Gd, Sm, and Ce) (n) Silicon metal (o) Titanium metal (p) Tungsten.

[40] According to SCIP, “by weight” refers to the weight of the (sub-)components (articles) within a battery (complex object). See the explanation in chapter 6.5.

we recommend a specification by the Commission of the reporting threshold for materials.

2) Naming the materials according to public standards, such as EN 10027 for steels, EN 573 for aluminium alloys, or ISO 1629 for elastomers (which is as also described as an IMDS rule). This naming should also differentiate between natural and artificial graphite of the anode, which have the same CAS numbers.
3) Adding the related identifier(s) of the materials. We recommend using the CAS number[41] since being most common (e.g., also used in the IMDS and GADSL). Whether CAS numbers can be clearly mapped to EC numbers[42] still needs to be determined.
4) Specifying the weight of the listed materials in grams.

The use case and confidentiality concerns of sharing materials on cell level

Reporting detailed cell-level information is controversial mainly due to confidentiality concerns. **In the specific case of material weight, this information is of relevance for remanufacturers, second-life operators, and recyclers for several reasons**:

- It serves as input for the accurate and fraud-free calculation of the levels of recycled content in active materials, being mandatory for cobalt, lead, lithium, and nickel (*Article 8* and *Annex XII, Part C*).
- The mass of the input of materials and substances into the recycling process is required for the calculation of recycling efficiencies (*Annex XII, Part B*). It would significantly ease this process since manual weighing of cathode, anode, and electrolyte materials is difficult/not feasible and leaves more room for inaccurate/ illicit reporting.
- It allows operators to calculate the value of a battery at its end-of-life (relevant when the battery or parts or materials of it are being sold).
- It eases the recycling process since direct information availability about materials can result in improved efficiencies of recycling in terms of time and cost.

To realise a circular economy, the data shared via the battery passport should be limited to data actually required, such as materials used and their weight. To ensure the confidentiality of this data, technical solutions to protect and manage data within the battery passport need to be developed (e.g., by the technical standards work package of the Battery Pass). In addition, legal solutions such as renewed confidentiality agreements with suppliers or legal information barriers within companies operating at different steps of the battery value chain will need to be explored. For instance, even beyond a mandatory sharing of the detailed composition information with “interested persons” as to be defined by implementing acts, business partners are free to agree on a bilateral confidentiality agreement. This way, they could provide restricted access to facilitate the technical implementation of data transfer for the battery passport. Another example is the confidentiality rule of the IMDS allowing the concealment of up to 10% of non-hazardous substances, which could also be applied to the battery passport. Further, it is important to ensure data sovereignty of companies, so they remain the owner of information, even if shared via the battery passport.

For the battery passport, however, it should be kept in mind that (besides the disclosure of hazardous substances), only information on a material level is shared. Further information such as processing techniques, trace elements, and structural conditions down to nano-level, often being decisive to derive confidential insights on the battery performance, are not accessible via the battery passport. Hence tactic risks are much smaller.

[41] The CAS (Chemical Abstracts Service) number is a numeric identifier for chemicals that can contain up to 10 digits, e.g., 7440-70-2 for calcium.
[42] The EC number is the official number of the substance within the EU. It is a seven-digit system, e.g., 231-179-5 for calcium.

Link to other data points, existing systems, and databases

To retrieve the materials used in cathode, anode, and electrolyte, companies can build on already existing documentation, in particular the bill of materials (BOM). BOMs are a comprehensive inventory of materials, components, and parts, including the quantities of each. For batteries, the cell and non-cell materials, the related component, as well as its weight or concentration in percentage are stated in a BOM. Even though BOMs are a likely source of help for the battery passport reporting, they might not always be granular enough to provide all material data on a cell level.

Once more, the automotive industry can build on the data stored in the IMDS (for information on the IMDS, see green box in chapter 6.5). Since the format and granularity of the IMDS data are aligned with the Battery Pass suggestion, data transfer is facilitated. We would encourage the automotive industry to further explore the use of the IMDS for the battery passport. While the IMDS is a data exchange system used by the automotive industry, other industries make use of similar systems. For example, in the construction sector, the digital Building Information Modelling (BIM) system could be used or evolved to a similar effect.

Lastly, for linkages to other data points, the materials used in cathode, anode, and electrolyte could directly be linked to automatically generate the input for the “battery chemistry” and “critical raw materials” (which, at least for cell level, could be automatically labelled as such).

6.5.4 Hazardous substances

The information on “hazardous substances contained in the battery other than mercury, cadmium or lead” is mandatory to be accessible by the public via the battery passport (*Annex XIII (1b)*; and via labelling information in *Annex VI, Part A(7)*).

Definition of hazardous substances

A **substance** is defined by ECHA as “a chemical element and its compounds in the natural state or the result of a manufacturing process”. Mixtures of substances are not considered a substance under the EU chemicals legislation, i.e. for mixtures, the individual substances are to be considered (49).

A **hazardous substance** is “any substance that poses a threat to human health and the environment” (50). Examples of hazards are unstable explosive substances or flammable gases. For a substance to be classified as hazardous, certain criteria relating to physical, health, or environmental hazards need to be fulfilled.[43] These criteria are laid down in *Annex I* (criteria of parts 2 to 5 applicable for the Battery Regulation) of the CLP Regulation (for details see green box below). Besides introducing hazard classification criteria, the CLP Regulation also provides a list of substances already being classified regarding their hazards. The Battery Regulation should complement the REACH and CLP regulations and “allow the adoption of risk management measures related to substances including the waste phase” (*Recital 14a*).

[43] By way of example, criteria for flammable gases are being flammable when in a mixture of 13% or less by volume in air or when having a specified flammable range.

In *Recital 41*, the **EU Battery Regulation narrows the reporting on hazardous substances** to those falling under defined hazard classes and categories of the CLP Regulation,[44] being:

- Physical hazards: “hazard classes 2.1 to 2.4, 2.6 and 2.7, 2.8 types A and B, 2.9, 2.10, 2.12, 2.13 categories 1 and 2, 2.14 categories 1 and 2, 2.15 types A to F”
- Health hazards: “hazard classes 3.1 to 3.6, 3.7 adverse effects on sexual function and fertility or on development, 3.8 effects other than narcotic effects, 3.9 and 3.10”[45]
- Environmental hazards: “hazard class 4.1”
- Additional hazards: “hazard class 5.1”

Since those hazards excluded appear to be those not applicable to batteries, reporting is required for most or even all hazards classified by CLP. Based on the above list of hazard classes and categories, companies can and apply the CLP classification list of substances to those used in batteries. If, however, substances are used, which are not yet classified, a self-classification must be conducted. Here, a substance is applied to all hazard classes where classification criteria are fulfilled, according to its definition in CLP.

Beyond defining and reporting on hazardous substances via the battery passport, the Battery Regulation also restricts the usage of mercury, cadmium, and lead (*Annex I*) and introduces a mapping exercise, which ECHA will conduct till 2027 to identify substances of concern in batteries and define follow-up measures for those (*Article 6 (5a)*).

[44] Hazard class tables are available on the ECHA website, listing all hazard classes and the corresponding chapter in the document “Part 1 of the Guidance on the application of CLP criteria”.
[45] By way of example, hazard class 3.1 is “acute toxicity” and 3.2 “skin corrosion/ irritation”.

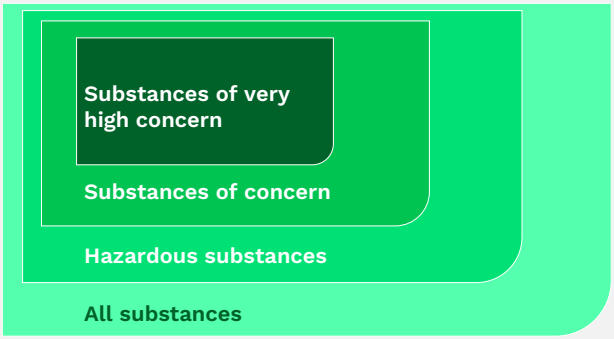
Hazard classification of substances

The CLP Regulation ((EC) No 1272/2008) presents the base for the classification, labelling and packaging of substances and mixtures. The CLP Regulation is based on the GHS (Globally Harmonized System of Classification and Labelling of Chemicals), defining hazard classes and its classifications. For these hazard classes, *Annex I* of the CLP Regulation outlines definitions, classification criteria, hazard communication, and additional classification considerations. Further, in *Annex VI, part 3*, tables with harmonised classification and labelling of substances can be found. For those substances, the index number, international chemical identification (name), EC No, CAS No, and classification (hazard class and category codes(s), and hazard statement code(s)) are provided. Here, approximately 4,500 substances are allocated to hazard classes. The pool of **hazardous substances** comprises both substances already classified in the CLP Regulation as well as substances to be self-classified, fulfilling the criteria for classification.

The **Battery Regulation** requires reporting only on hazardous substances falling under a defined list of hazard classes and categories. To determine which hazardous substances fall under this selection, companies can make use of the harmonised classification tables for substances from the CLP Regulation. If a substance is not listed, a self-classification has to be conducted, based on the classification criteria introduced in the CLP Regulation.

As the visual shows, within the pool of hazardous substances, other substance groups exist. These are also based on defined hazard classes and categories. In the Proposal for Ecodesign for Sustainable Products Regulation **(ESPR)** the term **substances of concern** is introduced (6). Substances of concern sit within the classification of hazardous substances, specifying only certain hazard classes and categories.

Figure 28: Hazard classification of substances (adopted from BASF)



Further, within the classification of substances of concern sits the group of **substances of very high concern (SVHC)**. This term is introduced in the **REACH** Regulation (EC 1907/2006). If SVHCs are included in REACH *Annex XIV*, all uses are prohibited unless they are exempted or authorised by the European Chemicals Agency (ECHA). In addition, under the Waste Framework Directive 22008/98/EC, article producers are obliged to notify articles containing SVHCs to the SCIP database (for details see info box in chapter 6.5). All the lists are available at ECHA's website.

In light of different substance groups, to reduce administrative burden for companies, we suggest keeping the number of groups to a minimum, while still meeting all required purposes. Similarly, we suggest aligning the definitions (in terms of hazard classes and categories defined) between product-specific regulations, e.g., also for digital product passports.

Suggested reporting granularity of hazardous substances

If a battery contains[46] substances (other than mercury, cadmium, and lead) classified as fulfilling one or several of the hazard classes or categories listed in the EU Battery Regulation, we suggest reporting on these hazardous substances via the battery passport as outlined below. All substances and their hazards contained in the battery, also if potentially converted via chemical reactions, need to be listed to ensure appropriate safety measures under any condition. Hazardous substances should be reported for the entire battery (defined as complex object[47]). We suggest a reporting threshold of 0.1 % weight by weight within each (sub-) component (defined as article[48]) of the battery to be aligned with the thresholds for reporting on substances of very high concern (SVHC) under REACH, substances of the GADSL list in the IMDS, and on critical raw materials in the battery passport. The hazardous substances information per article within the battery need to be reported by the producer or importer of these articles in the first place. The economic operator issuing the battery passport will need to consolidate this information for the entire battery.

1) Specifying all hazardous substances via an agreed substances nomenclature, e.g., the IUPAC name[49] or the chemical name. This battery passport information is most interesting for recyclers from a health and safety standpoint as well as to improve processing (e.g., information on hazardous substances in solvents to better process waste streams and treat wastewater appropriately).
2) Specifying the hazard classes and/or categories of the substance, as defined by the CLP Regulation.
3) Adding the related identifier(s) of the substances. We recommend using the CAS number[50] since being most common (e.g., also used in the IMDS and GADSL). Whether CAS numbers can be clearly mapped to EC numbers[51] still needs to be explored. Further, the index number[52] of the CLP Regulation should be added.
4) Specifying the location of the substance within the battery on a (sub-)component-level to allow for the safe handling of the battery in the dismantling and recycling process. For this, a unique identifier or nomenclature should be used and the components and subcomponents within the battery broken down in a structured way. Also, as part of SCIP reporting, the location of a substance has to be identified within the battery by stating the specific article and linking it to the parent complex object. Equally, the IMDS specifies the component for each substance. The location of the hazardous substances is also required under *Article 60* of the Battery Regulation, outlining information requirements for waste batteries.

[46] Hazardous substances, which are used in the manufacturing process but cannot be found in the final product, do not have to be reported on.
[47] According to ECHA, a complex object is “any object made up of more than one article” (112). A complex object entails articles and/or other complex objects, which again entail article(s). The SCIP reporting requirements concern each article, rather than the entire complex object only. Therefore, also the reporting threshold of 0.1% weight by weight applies per article within the battery.
[48] An article is defined as “object which during production is given a special shape, surface or design which determines its function to a greater degree that does its chemical composition” (112).
[49] IUPAC developed a recognised chemical nomenclature and terminology.
[50] The CAS (Chemical Abstracts Service) number is a numeric identifier for chemicals that can contain up to 10 digits, e.g., 7440-70-2 for calcium. While most mixtures have no assigned CAS number, their hazardous components have.
[51] The EC number is the official number of the substance within the EU. It is a seven-digit system, e.g., 231-179-5 for calcium.
[52] The index number lists according to the atomic number of the element most characteristic of the properties of the substance. The index number is in the form of digit sequence, e.g., 020-001-00-X for calcium.

5) Specifying the concentration range of the substance in % (as also provided in Safety Data Sheets, the IMDS, the SCIP database, as required for substances of concern under the ESPR, and as being of interest for recyclers). The concentration range should be specified per (sub-)component (article) of the battery. SCIP provides guidance on pre-defined concentration ranges in weight by weight, which are based on the most relevant concentration limits of the Waste Framework Directive (51).

Besides the mandatory reporting on hazardous substances in the battery passport, companies could specify optionally if a hazardous substance is also classified as a substance of very high concern (SVHC) (details see green box). We recommend investigating if marking substances as SVHCs in the battery passport could add value either to recyclers, the public, or authorities (e.g., to facilitate the REACH authorisation process). Further, we recommend also taking chemical reporting requirements outside the EU into account. While the battery passport will become mandatory within the EU, companies might also be subject to other (regional) legislation. Companies should aim at an internally aligned (at least for geographies of relevance, e.g., for the company's import and export of batteries for second-life applications) reporting on hazardous substances in the battery passport.

In addition, companies transporting batteries need to be compliant with transportation guidelines such as the IATA DGR (Dangerous Goods Regulation), the ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road), or the IMDG (International Maritime Dangerous Goods) Codes. The Battery Pass consortium recommends exploring if and how a battery passport can, besides the above-outlined reporting on hazardous substances, also cover the hazard classification required by such guidelines.

Link to other data points, existing systems, and databases

As described above as well as in the green box, the hazard classification criteria and the tables of harmonised substance classification of the CLP Regulation can be used as a starting point to identify and report hazardous substances in the battery passport. To facilitate the reporting for companies, we want to highlight the benefit of integrating a list of substances fulfilling the criteria for hazard classes or categories set out in the Battery Regulation into other systems, e.g.,

The "universe of registered substances" by ECHA - a mapping tool of all registered substances with each substance assigned to a pool, indicating the regulatory actions needed.

The GADSL list (applicable to the automotive industry). This way, the substances would also be reported in the IMDS. To ensure up-to-datedness, this list has to be continually augmented by new substances introduced in battery manufacturing.

For gathering information on a substance level, we recommend utilising existing reporting formats, entailing many of the required battery passport data on hazardous substances:

- Safety Data Sheets (SDSs)[53] are provided to downstream users, REACH dossiers to ECHA (for every chemical substance manufactured, imported or used in the EU above 1 MT per year). For batteries, not considered manufactured items, SDSs are not required, but some battery manufacturers provide them. More importantly, upstream suppliers in

[53] Following the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) of the UN, previously called Material Data Sheets (MDSs) are now called Safety Data Sheets (SDSs). SDSs have to follow a standard 16-section format with signal words, universally standardised hazard and precautionary statements, and hazard pictograms.

battery (material) manufacturing will need to complete SDSs. Passed through the supply chain, these can serve as input for the battery passport.
- Information in the SCIP database (see green box in chapter 6.5) can be utilised to provide the hazardous substances information for the battery passport. Here, companies are required to submit detailed information for SVHCs.
- The automotive industry can build on the data stored in the IMDS (for information on the IMDS, see green box in chapter 6.5). In the IMDS, substances listed in the GADSL are reported, including their location, and quantity. Up to 10% of substances can be marked as confidential in the IMDS. This exemption however excludes substances classified as hazardous. Therefore, if companies decide to voluntarily also report non-hazardous substances via the battery passport, for harmonisation, the IMDS confidentiality rule of 10% should be followed.

To uniquely identify the components in the battery, which is needed to specify the location of a substance, battery component identifiers or a nomenclature would be needed. Today, component names used in the industry often differ. Still, components typically carry article numbers, which eases their identification. Moreover, the granularity of specifying the components has to be determined.

Besides reporting on hazardous substances via the battery passport, the Battery Regulation introduces mandatory testing on hazardous substances, recording of the results, and attaching the results on the battery (*Annex XIV (3)*). The hazardous substance data of the battery passport could serve as a base for this testing.

6.5.5 Impact of substances on environment, human health, safety, persons

The information on “the impact of substances, in particular, hazardous substances, contained in batteries on the environment and on human health or safety of persons, including impact due to inappropriate discarding of waste batteries such as littering or discarding as unsorted municipal waste” is mandatory to be accessible by the public via the battery passport (reference from *Article XIII (1u)* to *Article 60(1f)*) (see also Table 10).

Definition of the impact of substances

The (potential) impact(s) of substances, in particular hazardous ones, are not defined directly in the Battery Regulation, but the impact categories (environment, human health, safety, persons) to consider are listed. These correspond with the hazard classes introduced in parts 2 to 5 of the CLP Regulation, as cited in the Battery Regulation. Further, the impact due to the inappropriate discarding of waste batteries is highlighted.

We suggest basing impact statements in the battery passport on already commonly used statements. For instance, “hazard statements” are introduced in REACH and in the GHS (Globally Harmonized System of Classification and Labelling of Chemicals) and are already used in, e.g., Safety Data Sheets. Similarly, “precautionary statements” are introduced in GHS and standardised hazard symbols are introduced in CLP (CLP icons/pictograms).

It will need to be further defined which information is required in the battery passport as part of the “impact of substances on…” datapoint and in how far these are covered by existing hazard statements.

Suggested reporting granularity of impact of substances on

We suggest specifying the impact of hazardous substances by citing commonly used statements for all hazards of the battery, based on the identified hazardous substances and their hazard classes. Which information adds value depends on the respective user of the battery passport. For example, a recycler would be most interested in information ensuring the safe handling and processing of batteries. Furthermore, the impact of substances depends on many parameters, e.g., duration and way of exposure, which might need to be defined as well. In addition to stating the impact of substances, to ensure the safe handling of batteries, other information such as on the status (see chapter 6.1.7), the state of health (see chapter 6.7.2.1), or safety measures (see chapter 6.6.1.3) are important.

Link to other data points, existing systems, and databases

As mentioned above, the specification of the impacts of substances should follow the same formats as already used in other reports such as Safety Data Sheets, or as described in the SCIP database.

We recommend exploring how, based on the hazardous substances and their respective hazard classes and categories as reported via the battery passport (see chapter 6.5.4), the related hazard statements could be (automatically) derived from existing sources, e.g., reporting systems.

Table 10: Battery Pass reporting granularity assessment and recommendation on battery composition

Data attribute	Mandatory and access to?	Battery components in scope	Reporting granularity	Confidentiality concerns?	Use case	Battery Pass recommendation
Battery chemistry *Reporting option 1*	Mandatory in the battery passport Accessible to the public	Cathode and anode active material, electrolyte	Specify active material of the cathode, anode and electrolyte	No	For the public, e.g., to support purchase decision Logistic companies, e.g., to classify the battery	*Recommended:* specify anode, cathode active material and electrolyte
Reporting option 2			+ specify stoichiometric relation	Tbd	Second-life operators etc., though these will have access to this more detailed level via "materials used in…"	*Not recommended*
Critical Raw Materials *Reporting option 1*	Mandatory in the battery passport Accessible to the public	All components	Listing all CRMs contained in the battery (official name)	No	For the public due to focus on critical raw materials	*Recommended:* list all critical raw materials
Reporting option 2			+ specify the location within the battery	Tbd, likely not	Not of interest for the public, recyclers receive information via "materials used in"	*Not recommended:* no clear use case of location specification identified
Reporting option 3			+ specify the weight (grams)	Tbd	Not of interest for the public, recyclers receive information via "materials used in"	*Not recommended:* no clear use case identified
Materials used in … *Reporting option 1*	Mandatory in the battery passport Accessible to interested persons and the Commission	Cathode/ anode/ electrolyte (respectively)	List all materials used (official name)	No, since only shared with interested persons (to be defined, see chapter 5.1.6) and the Commission	Serves as input for the calculation of levels of recycled content, recycling efficiencies, and the EOL value of batteries; eases the recycling process	*Recommended:* specify materials
Reporting option 2			+ related identifier			*Recommended:* identify materials
Reporting option 3			+ weight of the materials			*Recommended:* specify weight of the materials

Data attribute	Mandatory and access to?	Battery components in scope	Reporting granularity	Confidentiality concerns?	Use case	Battery Pass recommendation
Reporting option 4	Not mandatory for all battery components	All components	Reporting options as above	Tbd	Not needed, materials outside the cell can be analysed and weighed more easily	*Not recommended:* no clear use case identified for specifying materials outside the cell
Hazardous substances *Reporting option 1*	Mandatory in the battery passport Accessible to the public	All components	List all hazardous substances used (official name)	No, if only for hazardous substances and already shared in other formats today	For recyclers from a health and safety standpoint and to improve processing	*Recommended:* list hazardous substances
Reporting option 2			+ hazard classes/ categories			*Recommended:* specify type of hazards
Reporting option 3			+ related identifier			*Recommended:* identify substances
Reporting option 4			+ location within the battery			*Recommended:* specify location of hazardous substances
Reporting option 5			+ concentration range (in %)			*Recommended:* specify concentration range
Reporting option 6			+ specify if substance is also a SVHC (substance of very high concern)		Use case for recycler, public, or authorities to be investigated, e.g., for ECHA authorisation or REACH obligations	*Not recommended:* Use case to be further investigated
Impact of substances on environment, human health, safety, person	Mandatory in the battery passport Accessible to the public	All components	Cite commonly used hazard/ impact statements	No, already stated in other formats	Recyclers to ensure safe handling and processing of batteries	*Recommended:* reference common hazard/ impact statements

6.6 Circularity and resource efficiency

In the European Green Deal (52), the Commission committed itself to developing a legislative proposal to promote a safe, sustainable and **circular battery value chain**. The circularity potential of batteries is defined significantly at the beginning of the lifecycle, in the design process. However, many batteries are still not designed to be easily repaired, re-used or recycled – if one part fails, the whole battery is usually discarded (53). The Battery Regulation addresses this issue by placing requirements on the batteries' removability and replaceability. Yet, these requirements provide only insufficient guidance to implement a circular product design. While the Battery Regulation does not introduce further concrete design principles, it demands related information on:

a. **Disassembly and dismantling** and
b. **Spare parts** to enable the replacement and repair of batteries and components, as well as
c. **Safety instructions** to ensure safety when handling batteries.

Ultimately, the objective is to enhance resource efficiency and reduce the EU's dependence on third countries for raw materials. Therefore, the Battery Regulation aims to **increase the collection and recycling rates of <u>all</u> batteries and the recovery of raw materials** (*Recital 8*). It does so by:

d. Promoting the use of recyclates (*Recital 20*) by setting **recycled content** targets for cobalt, lead, lithium and nickel (*Article 8*);
e. Requesting instructions for the **separate disposal of waste batteries** and information on take-back and collection points;
f. Introducing **collection targets for waste** portable batteries and waste LMT batteries;[54]
g. Defining **minimum recycling efficiencies** for different battery chemistries and **recovery rates** for cobalt, lead, lithium and nickel.

For the battery passport, only information on (a) – (e) is required to be reported. This chapter touches upon the diverse battery circularity aspects introduced above by addressing the following questions:

- Which design-related data attributes aiming to facilitate the battery's removability and replaceability are required for the battery passport? In which form should the information be made available? How could the measurement of circularity be further improved? (see chapter 6.6.1)
- How should recycled and renewable content shares be calculated and provided for the battery passport? (see chapter 6.6.2)
- Which information on collection and disposal of batteries will be required for the battery passport? Which other end-of-life requirements exist? (see chapter 6.6.3)

[54] Although the regulation sets specific collection targets only for portable and LMT batteries, the separate collection of waste batteries is relevant for **all** battery categories. This is emphasised in several recitals (*Recitals 8, 72, 78, 83*) of the regulation.

6.6.1 Design for circularity

Battery passport guidance in brief on design for circularity

Mandatory data:
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; warnings if risk of damaging parts exists; amount of cells used and layout); part numbers for components and contact details of sources for replacement spares; safety measures (*Annex XIII (2b-d)*); usable extinguishing agent (*Annex VI, Part A(9)*).

Our suggestions and outlook:

- Integrate the mandatory dismantling information in two separate manuals (one manual for the removal of the battery from appliance and one manual for the disassembly of the battery pack) with the respective URL being provided in the battery passport. In addition, for the manual for battery pack disassembly, include information on the battery's type of construction, on format and dimensions of battery cells, modules and pack, on the orientation of the battery cells, on the replaceability of modules and cells, on fillings (if used), casing (type and material) and the characteristics of joints, screws, fasteners used.
- Provide the "part numbers for components" and "contact details of sources for spare parts" per URL linking to PDF.
- Provide the safety measures via an instruction manual as URL linking to PDF. Information on the usable extinguishing agent on the battery label should refer to classes of extinguishers (A, B, C, D, K).
- For future iterations of the battery passport, a Circularity Score based on circularity indicators that make the battery's removability, replaceability and recyclability measurable and comparable could be introduced.

Table 11: Design for circularity – data attributes

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting	Format/ Unit
Manual for removal of the battery from the appliance	*Annex XIII (2c)*	Interested persons and Commission	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 • Warnings if risk of damaging parts exists • Amount of cells used and layout	Manual for removal of the battery from the appliance, including: • Disassembly sequences • Characteristics of the joints, screws, and fasteners: type, number, materials and number of fastening techniques to be unlocked • Tools required for disassembly • Risk warnings and safety measures **The Battery Pass consortium suggests providing the dismantling information required by the EU Battery Regulation as part of manuals.** The contents “exploded diagrams of the battery system/pack showing the location of battery cells” and “amount of cells used and layout” as mentioned in the Battery Regulation are not necessary in this manual since only relevant for the disassembly of the battery pack. We propose to adopt the following aspect in this manual: • Risk warnings and safety measures (replacing “Warnings if risk of damaging parts exists”)	URL
Manual for disassembly and dismantling of the battery pack				Manual for disassembly of the battery pack, including: • Exploded diagrams of the battery system/pack showing the location of the battery cells and modules, including format and dimensions of battery cells, modules and pack, and orientation of the battery cells • Type of construction of battery pack, modules, and cells • Information on replaceability of modules and cells (yes/no) • Disassembly sequences	URL

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting	Format/ Unit

				• Characteristics of joints, screws, and fasteners: type, number, materials, and number of fastening techniques to be unlocked
				• Information on fillings, if used: characteristics of foams and/or glues
				• Information on casing: type and material (steel/plastic)
				• Tools required for disassembly
				• Risk warnings and safety measures
				• The Battery Pass consortium proposes to add or adopt the following aspects in this manual:
				• Concretization of “exploded diagrams of the battery system/pack showing the location of the battery cells”:
				  ○ showing location of modules
				  ○ including format and dimensions of battery cells, modules, and pack in the diagram
				  ○ integrating orientation of battery cells
				• Adding type of construction of battery pack, modules, and cells
				• Adding information on replaceability of modules and cells (yes/no)
				• Integrating characteristics of joints, screws, and fasteners
				• Integrating information on fillings and casing
				• Risk warnings and safety measures (replacing “Warnings if risk of damaging parts exists”)
				• “Amount of modules used and layout” is deleted, since contained in “exploded diagrams”	

Part numbers for components	*Annex XIII (2b)*; *Recital 51*	Interested persons and Commission	“Part numbers for components”	The information on spare parts could be provided within the two manuals.	URL linking to pdf: Longlist with part numbers

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting	Format/ Unit
Postal address of sources for spare parts			"Contact details of sources for replacement spares" Postal address, including name and brand names, postal code and place, street and number, country, telephone, if any	The postal address has to be stated.	Text
E-mail address of sources for spare parts			"Contact details of sources for replacement spares" Email address	The e-mail address has to be stated.	Text
Web address of sources for spare parts			"Contact details of sources for replacement spares" Website	The web address has to be stated.	URL
Safety measures/ instructions	*Annex XIII (2d)*; *Article 60 (d)*	Interested persons and Commission	"Safety measures" "Necessary safety instructions to handle waste batteries, including in relation to the risks associated with, and the handling of, batteries containing lithium"	Safety measures and instructions should also take past negative and extreme events as well as the separate data attributes "battery status" and "battery composition/chemistry" into account.	URL linking to pdf
Extinguishing agent	*Annex VI, Part A (9)*	Public	"Extinguishing agent" to be used in case of emergency	We recommend that the information on the usable extinguishing agent refers to classes of extinguishers (A, B, C, D, K).	Text on label

A circular product design allows for easy access, removal, and replacement of the battery – a prerequisite for the implementation of different circular strategies. Despite the importance of product design for circular battery value chains, the topic is scarcely addressed in the EU Battery Regulation. While the Battery Regulation does not provide any suggestions for the design of batteries, it does, however, require the reporting on parameters that yield information linked to the product design. In this context, information on the disassembly and dismantling of batteries as well as on spare parts and safety must be provided by the battery passport, as introduced in this chapter.

Alongside the EU Battery Regulation, the ESPR proposal (6) provides important definitions and specific ecodesign aspects for circularity. In particular, the circular product design parameters as introduced in the ESPR (see info box below) are taken into account and their understanding for the use case of batteries is evaluated. Based on this analysis, the Battery Pass consortium makes first circular design recommendations and additional battery passport suggestions. These recommendations aim at providing relevant information on the design and thus enable an extended first-life of the battery, as well as second- and end-of-life strategies.

For batteries with often complex structures, a circular product design is of particular importance. The battery pack consists of a multitude of cells, which are often grouped and encased into several battery modules, and other electrical, mechanical, and thermal components including the housing. The cell is the smallest building block of the functional battery, consisting – at least – of an anode and cathode, the separator between the electrodes and the ion-conducting electrolyte. The latter enables the charge transport between the electrodes. (54)There are different formats of battery cells: for instance, cylindrical cells, prismatic cells, and pouch cells that lead to various assembly designs of the cells within a module or pack. As alternatives to the conventional cell-module-pack approach, cell-to-pack, or cell-to-vehicle designs[55] (55) may be implemented. The design concept “cell-to-pack” uses a different assembly method, foam for example, instead of separately encased battery modules.

[55] The module of EV batteries in the conventional battery cell-module-pack design has been growing in size during the last years. Some of the early EV battery packs contained 30+ modules. This number has been reduced by some manufacturers to 12 or even only 4 larger modules. In next generation battery designs cell-to-pack and cell-to vehicles (removal of the battery case) are investigated (55).

Circular product design parameters (*Annex I, points b-d* of the ESPR (117))

Ease of repair[a] **and maintenance:** characteristics, availability and delivery time of spare parts, modularity, compatibility with commonly available spare parts, availability of repair and maintenance instructions, number of materials and components used, use of standard components, use of component and material coding standards for the identification of components and materials, number and complexity of processes and tools needed, ease of non-destructive disassembly and re-assembly, conditions for access to product data, conditions for access to or use of hardware and software needed.

Ease of upgrading,[b] **re-use, [repurpose],**[c] **remanufacturing and refurbishment:** number of materials and components used, use of standard components, use of component and material coding standards for the identification of components and materials, number and complexity of processes and tools needed, ease of non-destructive disassembly and re-assembly, conditions for access to product data, conditions for access to or use of hardware and software needed, conditions of access to test protocols or not commonly available testing equipment, availability of guarantees specific to remanufactured or refurbished products, conditions for access to or use of technologies protected by intellectual property rights, modularity.

Ease and quality of recycling: use of easily recyclable materials, safe, easy and non-destructive access to recyclable components and materials or components and materials containing hazardous substances, material composition and homogeneity, possibility for high-purity sorting, number of materials and components used, use of standard components, use of component and material coding standards for the identification of components and materials, number and complexity of processes and tools needed, ease of non-destructive disassembly and re-assembly, conditions for access to product data, conditions for access to or use of hardware and software needed.

[a] The different strategies are defined in chapter 4.3.
[b] "'Upgrading' means enhancing the functionality, performance, capacity, or aesthetics of a product" (ESPR proposal, *Article 2(17)*). In the context of second-life application for batteries, "upgrading" is not considered by the EU Battery Regulation and will not be addressed in this document.
[c] 'Ease of repurpose' is not mentioned in *Annex I* of the ESPR proposal. However, in the context of battery product design it should be considered.

6.6.1.1 Dismantling and disassembly information

Dismantling information is mandatory for the battery passport. The information is accessible only by interested persons and the Commission since being classified as sensitive commercial information (*Annex XIII (2c)*; *Recital 93a*). Exact access groups are still to be defined and should keep the protection of sensitive battery design information into account[56] (see also chapter 5.1.6). According to the Battery Regulation, the dismantling information shall include, 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
- Warnings if risk of damaging parts exists
- Amount of cells used and layout

The **Battery Pass consortium supports the integration of dismantling information in the battery passport**. However, the term "dismantling" is associated with end-of-life operation, e.g., the recycling of the battery, and may cause damage to the battery. By contrast, the term

[56] The depth and type of dismantling information has yet to be defined and should be considered in the context of access rights. Where appropriate, more detailed information could be made available and restricted to specific stakeholder groups to fulfil specific information needs and thereby ensure the safety of workers during dismantling or recycling processes.

“disassembly” means the non-destructive handling of the battery – to prepare the battery for maintenance, re-use, repair, refurbishment, and remanufacturing operations.

In order to distinguish battery removal from the appliance, e.g., an EV, and the disassembly of the battery pack, the **Battery Pass consortium recommends that the dismantling[57] information required by the EU Battery Regulation should be integrated into two separate manuals whose URL is provided in the battery passport**:

- **Manual for removing the battery from the appliance**
- **Manual for disassembly of the battery pack**

Since the amount of cells used and the battery layout are only relevant for battery disassembly, this information is only needed for the latter manual. The Battery Pass consortium suggests the provision of supplementary information on format and dimensions of cells, modules and the battery pack, as well as on the orientation of the battery cells. We propose integrating these aspects as “exploded diagrams of the battery system/pack showing the location of the battery cells and modules and including format and dimensions of battery cells, modules and pack and orientation of the battery cells”. Furthermore, we advise **integrating the following voluntary information** (not required by the Battery Regulation) into the manual for the disassembly of the battery pack:

- Type of construction of battery pack, modules, and cells
- Information on replaceability of modules and cells (yes/no)
- Information on fillings, if used: characteristics of foams and/or glues
- Information on casing: Type and material (e.g., steel/plastic)

Moreover, the Battery Pass consortium proposes that both manuals contain **information on the type of screws, joints, and fasteners used**.

To facilitate the handling of these manuals, a clear and **standardised structure** and, in the future, **machine readability** should be achieved. For some elements, such as the diagrams, ways to ensure machine readability will need to be found, e.g., by translating these to text.

In addition, **safety measures and potential risks** should be addressed with respect to dismantling information and be included. The Battery Pass consortium proposes replacing the required dismantling information “warnings if risk of damaging parts exists” – which is limited only to the case that the battery or components are destroyed or damaged, not taking into account operations such as the repair or maintenance of the battery – with the more general “risk warning and safety measures”. Moreover, information on negative and extreme events (see chapter 6.7.3.3) should be considered and known before the disassembly of the battery for safe handling.

The recommendations of the Battery Pass consortium for the parameters in the battery passport related to dismantling and disassembly information are summarised in Table 11.

Beyond battery passport requirements, the Battery Regulation imposes broader requirements on the removability and replaceability of batteries (*Article 11*). These requirements are summarised in the info box below.

[57] As the regulation lists the information as “dismantling information”, this term is used when referring to the information from the EU Battery Regulation. However – as described in the text – the word “disassembly” should be added here from the Battery Pass consortium’s point of view.

Removability and replaceability requirements from the Battery Regulation

1) Requirements for portable and LMT batteries

From 42 months after entry into force of the Battery Regulation (see timeline below), portable and LMT batteries shall be readily removable and replaceable – at any time throughout the lifetime of the product (*Article 11*). Thereby, a portable and LMT battery "[...] is readily replaceable where, after its removal from an appliance or a light mean of transport, it can be substituted by a similar battery, without affecting the functioning or the performance or safety of that appliance or light mean of transport" (*Article 11(5)*). Moreover, incorporated portable and LMT batteries shall be available as spare parts of the equipment they power for a minimum of 5 years after the last unit of the model has been placed on the market, "with a reasonable and non-discriminatory price for independent professionals and end-users" (*Article 11(5)*). *Article 11(6)* states that the exchange of a portable, LMT, or key battery components shall not be affected by software.

a. **Portable batteries:** A portable battery shall be considered readily removable by the end-user, "where it can be removed from a product with the use of commercially available tools,[a] without requiring the use of specialised tools unless provided free of charge with the product, proprietary tools, thermal energy, or solvents to disassemble" (*Article 11(1)*). For portable batteries, this requirement only applies to batteries as a whole and not individual cells or other parts included in the batteries (*Article 11(1)*). If the safety of the user and the appliance should require so, portable batteries incorporated in appliances specifically designed to operate primarily in a wet environment and batteries for certain medical devices may be removable and replaceable only by independent professionals (*Article 11(2)*; *Recital 26a*). In addition, products incorporating portable batteries are to be accompanied by instructions and safety information on the use, removal and replacement of the batteries, to be made available on a publicly accessible website.[b]

[a] "Commercially available tools are tools available on the market to all end-users without the need for them to provide evidence of any proprietary rights and that can be used with no restriction, except for health and safety reasons." (*Recital 26* of the EU Battery Regulation)

[b] The (legal) person who places the product with incorporated batteries on the market is responsible for the provision of the instructions and safety information (concerning products with portable batteries) and for the availability of spare parts (concerning products with portable or LMT batteries).

b. **LMT batteries:** A LMT battery shall be readily removable by the independent professional. The battery pack, but also individual battery cells shall be readily removable and replaceable.

2) Requirements for SLI and EV batteries

SLI batteries and electric vehicle batteries shall be removable and replaceable by independent professionals (*Recital 26*). The Battery Regulation refers to Directive 2000/53/EC on end-of-life vehicles and suggests considering in its provision that batteries can be removed, replaced and disassembled, including with respect to joining, fastening and sealing elements. Furthermore, a reference is made to regulation (EU) 2018/858[c] for the design, manufacturing, and repair of SLI and electric vehicle batteries. This regulation requires manufacturers to provide the relevant vehicle on-board diagnostic information, repair, and maintenance information on a non-discriminatory basis to any interested manufacturer, installer or repairer.

[c] Regulation (EU) 2018/858 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.

3) Standards for interoperability and design

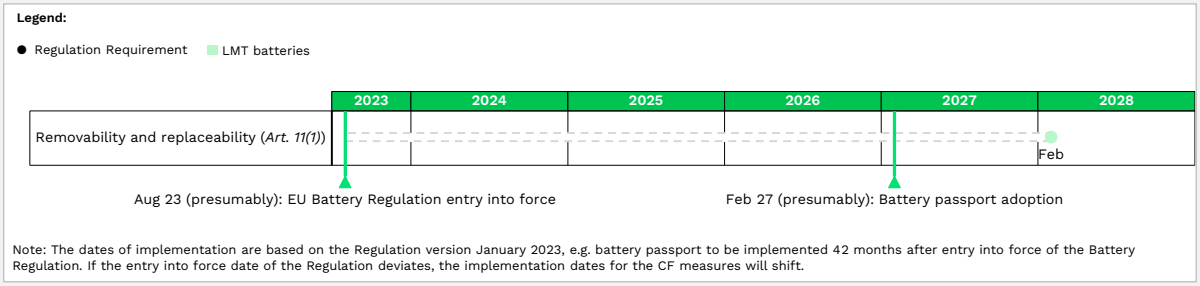
The EU Battery Regulation (*Recital 26b*) calls on the Commission to review how interoperability can be enabled through harmonised standards for common chargers for certain battery categories (common chargers for LMT and rechargeable batteries in electrical and electronic equipment, in particular). This way, waste and costs for consumers could be reduced. In addition, and in order to facilitate the maintenance, repair and repurpose of batteries and battery packs, *Recital 26c* requests the Commission to encourage the development of standards for design and assembly techniques.

4) Safety measures

To ensure consumer safety when using and handling repaired batteries, the requirements of Directive 2001/95/EC on general product safety apply (*Recital 26aa*). In addition, for the safety of repaired and exchanged EV and SLI batteries, the requirements of regulations (EU) 2019/2144 and (EU) 2018/858 apply to type-approved vehicles in classes M, N and O.[d] Non-destructive tests are intended to make the safety of these batteries assessable (*Recitals 13* and *26aa*).

[d] Vehicles of category M are defined as vehicles carrying passengers, category N vehicles are vehicles carrying goods (92). Vehicles of category O refer to trailers (including semi-trailers).

Figure 29: Timeline for removability and replaceability requirements as per EU Battery Regulation



Note: The dates of implementation are based on the Regulation version January 2023, e.g. battery passport to be implemented 42 months after entry into force of the Battery Regulation. If the entry into force date of the Regulation deviates, the implementation dates for the CF measures will shift.

6.6.1.2 Spare parts

Information on spare parts of a battery is essential – not only to prolong a battery's lifetime, but also to extend the service time of appliances, light means of transport or electric vehicles that they power. The availability and compatibility of spare parts for the battery and its system facilitate the maintenance, re-use, repair, refurbishment, and remanufacturing process.

The Battery Regulation (*Annex XIII (2b)*) further demands that "part numbers for components and contact details of sources of replacement spares"[58] shall be accessible via the battery passport to interested persons and the Commission. According to *Recital 51*, economic operators – and in this context the sources for spare parts – "should, as part of their contact details, indicate a postal, email and website address."

The data attributes related to "spare parts" and our recommendations are depicted in Table 11.

6.6.1.3 Safety measures

The EU Battery Regulation states that "reliable batteries are fundamental for the operation and safety of many products, appliances, and services. Therefore, batteries should be designed and manufactured to ensure their safe operation and use [...]" (*Recital 27*). When handling waste batteries and batteries entering a second life cycle, safety is key, as also stated by the Battery Regulation: "A market for the second-life of used industrial batteries and electric vehicle batteries is emerging and [...] specific rules should thus be defined to allow responsible repurposing of used batteries while taking into account the precautionary principle and ensuring the safety of use for end-users [...]" (*Recital 88*). While safety measures are mandatory for the battery passport (*Annex XIII (2d)*), these measures are not further described.

A safety measure for the battery passport –the adequate extinguishing agent – is introduced in *Annex VI, Part A (9)*. Information on the extinguishing agent must be provided on the battery label.

[58] The term "replacement spares" used in the EU Battery Regulation is little used therefore we have replaced it with "spare parts" in this document.

Article 60 requires producers to make information on the prevention and management of waste batteries, including safety instructions to handle waste batteries and information on the impact of (hazardous) substances contained in batteries on the environment, human health or the safety of persons (see also chapter 6.5.5) available to end-users and distributors (*Articles 60 (1d)* and *(1f)*).

When considering safety data attributes for the battery passport, the status of the battery (see chapter 6.1.7), hazardous substances and their location (see chapter 6.5.4), as well as the possible occurrence of past negative and/or extreme events (see chapter 6.7.3.3) should be taken into account. An overview of the safety data attributes required by the EU Battery Regulation and the recommendations of the Battery Pass consortium are summarised in Table 11. The info box below introduces additional safety requirements from the Battery Regulation which are not mandatory content of the battery passport.

Safety considerations of the Battery Regulation beyond the battery passport

Annex XII, Part A(4) of the EU Battery Regulation addresses the battery handling, sorting and storage, but refers only to waste lithium-based batteries. These measures include protection of the battery from exposure to:

1) Excessive heat, (such as high temperatures, fire, or direct sunlight),
2) Water (stored in dry place, protected from precipitation and flooding),
3) Any crushing or physical damage.

Waste lithium-based batteries "shall be stored in their normally installed orientation (never inverted), in well-ventilated areas and covered with a high voltage rubber isolation. Storage facilities of waste lithium-based batteries shall be marked with a warning sign." (*Annex XII, Part A(4)*). Beyond these provisions, batteries should be stored according to their specification as determined in testing. Requirements for the safety of batteries, which are described in the IEC 62133 standard series, should be considered. For the transportation of lithium cells and batteries, tests according to UN 38.3[1] shall be fulfilled. The tests simulate different transport conditions and evaluate the response of the battery samples to electrical (external short circuit, overcharge, forced discharge), mechanical (vibration, shock, impact/crush), and environmental (low-pressure and thermal) conditions.

The safety of repaired electric vehicle batteries and SLI batteries is addressed in *Recital 26aa* of the Battery Regulation. For these batteries, the safety requirements of regulation (EU) 2019/2144 apply. Non-destructive tests shall ensure the safety of the repaired batteries. With respect to repaired LMT batteries, the Commission will develop rules on the safety of micro-mobility devices. For other repaired batteries intended for or likely to be used by consumers, the requirements of Directive 2001/95/EC on general product safety apply. Safety is also of great importance for stationary battery storage systems, as these batteries are currently not covered by other Union legislation. The Battery Regulation therefore calls for safety testing parameters for these batteries taking into account and supplementing them with applicable standards (*Recital 27*).

The Battery Pass consortium supports the requirements to test batteries not only when they have been declared waste, but also when batteries have been repaired or have undergone other significant modifications.

The handling of defective or damaged batteries is only shortly addressed in the Battery Regulation (see also info box on waste vs. non-waste batteries in chapter 5.3.1). However, such batteries can have serious safety consequences. In particular, the risk of a short circuit, which can lead to a rapid increase in the internal battery temperature (thermal runaway), should be taken into account. A short circuit can be caused by electrolyte impurities, external damages (e.g., a punctured battery casing), or when battery terminals come into contact with other batteries, metals, or conductive surfaces. Consequently, lithium-ion batteries can vent, explode, or catch fire.

[1] "The UN Manual of Tests and Criteria contains criteria, test methods and procedures to be used for the classification of dangerous goods that may be transported, according to the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations. [...] The tests and procedures specified in the Manual are intended to supplement national and international regulations and standards regarding the transportation of potentially dangerous goods. [...] Part 3, Section 38.3, of the UN Manual addresses those requirements that apply to lithium cells and batteries." (134)

6.6.1.4 Circularity Score

In addition to the battery design information required by the Battery Regulation, further design parameters should – from the Battery Pass consortium's view – be assessed for inclusion in the battery passport. To better understand the need for and importance of these parameters, relevant design criteria for circularity are laid out and explained below. These are based on suggestions from the ESPR (6) and considerations from the Battery Pass consortium. Outlined below, as an outcome of the parameter assessment, we suggest the introduction of a Circularity Score, accessible via the battery passport in its future iterations.

Combining different approaches can help overcome the below-introduced challenges and improve dismantling and recycling capability. Three battery design levers promoting removability, replaceability, and recyclability were identified:

1) Standardisation of components and toolsets (compatibility)

Challenge: Due to a large variety of battery pack designs and connection technologies, the dismantling and disassembly[59] of battery packs is complex, time-consuming, and cost-intensive. Depending on the manufacturer and application, different special tools are required. The abundance of battery designs, and the use of poorly soluble compounds and of heterogeneous components that are difficult to separate, result in lithium-ion battery packs usually being disassembled manually (54). However, individual semi-automated processes exist and general approaches to standardised disassembly are subject of current research projects.[60]

Solution approach: **Standardised components and toolsets** together with a structured and **modular** arrangement of the internal battery system allow for an easy and safe replacement of parts. In particular, (ideally) **identical or compatible** sizes and types of screws, fasteners, and connectors should be used. Via standardised labelling, unambiguous identification of parts and materials can be guaranteed. These design criteria can ensure removability, replaceability, and disassembly of the case, of individual battery cells, or other key components, without damaging the battery. The standardisation of the battery design and the system's components presents an important basis for the automation of process steps e.g., during recycling, which is essential for upscaling.

2) Construction and assembly design (removability and replaceability)

Challenge: The battery modules are connected to the battery pack housing via screw connections, plugging, or gluing (56). Adhesives, foams, or waxes, which are sometimes used by manufacturers for additional fixation, are difficult to remove. The individual cells in the module housing can usually not be removed without damaging them due to design aspects, e.g., because welded connections cannot be easily re-fitted or because they are glued together for heat distribution and electrical insulation (54).

Solution approach: To enable an easy and safe opening of the battery pack case during disassembly, screws and joints should be readily **accessible**. Furthermore, the **arrangement** of cells and/or modules in the battery should be known. Through modifications in the electrode

[59] In literature, **"battery dismantling"** usually refers to removing the battery pack's housing (69), (119) to gain access to modules and cells to remove or replace them – the term "dismantling" is thereby mostly associated with end-of-life operations (recycling) and **does not exclude damage to the battery. "Battery disassembly"** refers to processes – the separation of the battery into its individual parts and components for example – in preparation for e.g., the remanufacturing, refurbishing, or repurposing of the battery (72), **without damaging it.**

[60] Automated disassembly of batteries is the subject of research work and is currently developed in the project DemoSens, for example (95).

and connector geometry, the cells could be mechanically disassembled and separated into anodes, cathodes, and polymer separators (57). In practice, changes in geometry prove difficult to implement, especially from an economic point of view since process steps are adapted to the existing geometries. For this reason, the overall structure and design of the module and pack should be reconsidered. A robust module construction and the general use of corrosion-free components for pack or module assembly, prevent the necessity of frequent interventions and repairs. At the same time, access to damaged parts of the system can be facilitated. Furthermore, the disassembly of the battery system can be eased by integrating attachment points for the lift or pick-up of the system.

3) Choice of materials (removability and recyclability)

Challenge: Due to the complex chemical composition and diversity of components used for lithium batteries, several process steps are required to achieve a high recovery rate in the battery recycling process.

Solution approach: The **choice of materials** – also beyond the active components – should be considered in light of design criteria for removability, replaceability, and recyclability. The most relevant example is the use of non-removable adhesive seals and glue, preventing the removal and recycling of individual parts. The use of rubber seals and screws instead of adhesive seals for the casing facilitates the removal and replacement of battery cells or other components of the system. Avoiding or limiting the use of composite materials improves the recycling of materials since the heterogeneous nature of composite materials, as well as the cross-linked nature of the thermoset matrix, complicate the recycling process (58).

Circularity Score

While it is important to understand the relevance of the battery product and process design for circularity, as described above, detailed design recommendations should – from the Battery Pass consortium's perspective – not be subject to provisions in the EU Battery Regulation. **The Battery Pass consortium instead suggests defining circularity indicators that make the removability, replaceability, and recyclability measurable and comparable as part of the battery passport.**

The compilation of measurable indicators that allow a comparative evaluation of battery products by yielding an overall score could enable greater transparency and a conscious purchasing decision – in particular for the end-user. The introduction of such a score could incentivise the production of circularly designed batteries. Relevant parameters could be derived from the requirements of the battery passport and be discussed and developed with different stakeholders outside the project. In this context, existing work (59) (60) can be taken up and reviewed for its transferability to the use case of batteries. However, the development and adequate definition of metrics combined in a comprehensive score requires an in-depth process, being beyond the scope of the Battery Pass project. Nonetheless, **the Battery Pass consortium considers the introduction of a Circularity Score as a vital part of the battery passport in its future iterations**.

6.6.2 Recycled and renewable content

Battery passport guidance in brief on recycled and renewable content

Mandatory data:

- Recycled content (share of cobalt, lithium, and nickel recovered from battery manufacturing waste or post-consumer waste present in active materials, and the share of lead recovered from waste present in the battery) for each battery model per year and per manufacturing plant (*Annex XIII (1); Article 8*)
- Renewable content share (*Annex XIII (1)*)

Our suggestions and outlook:

- Calculate and declare the recycled content shares from pre-consumer waste and post-consumer waste of cobalt, lithium and nickel and lead, separately. This results in eight data attributes to be reported for the battery passport.
- Recycled content shares of further elements can be reported on a voluntary basis.
- The methodology for recycled content calculation will be set out in a delegated act.
- Depending on future material availabilities, market developments and technological progress, further materials might be included in the scope for recycled content.
- Renewable content requires additional specifications regarding the reporting and materials considered (whether only active materials are considered).

Table 12: Recycled and renewable content – data attributes

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting	Format/ Unit
Pre-consumer recycled nickel share	*Annex XIII (1)*; *Article 8(1)*	Public	"Share of, respectively, cobalt, lithium or nickel recovered from battery manufacturing waste or post-consumer waste present in active materials, and share of lead recovered from waste present in the battery, for each battery model per year and per manufacturing plant."	Recycled content shares are calculated by the mass of recycled content (secondary material) of the chemical element divided by the total mass of the chemical element. **We suggest the recycled content shares from pre-consumer waste and post-consumer waste be calculated and reported separately.**	% Comment: Accuracy (integral/ decimal numbers) is not defined yet
Pre-consumer recycled cobalt share					
Pre-consumer recycled lithium share					
Pre-consumer recycled lead share					
Post-consumer recycled nickel share					
Post-consumer recycled cobalt share					
Post-consumer recycled lithium share					
Post-consumer recycled lead share					

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting	Format/ Unit
Renewable content share	*Annex XIII(1ha)*	Public	"Share of renewable content"	If the proportion of renewable content is greater than zero, **specify which material** is involved.	% Comment: Accuracy (integral/ decimal numbers) is not defined yet

The increased use of recovered materials is essential for a Circular Economy as emphasised in the first and second Circular Economy Action Plans of the European Commission (52) (61). Currently, the use of recycled material in battery production varies significantly between the battery chemistries. While the collection and recycling of lead-acid and NiMH batteries are common in the European Union, this does not hold true for Li-ion batteries. A reason is the limited availability of waste Li-Ion batteries (62) as well as complex recycling processes.

The EU Battery Regulation introduces different requirements to promote the re-use of materials from waste batteries, particularly the reporting and increase of the proportion of recycled content. In addition, renewable content shall be reported via the battery passport.

6.6.2.1 Recycled content information

Reporting of recycled content for the battery passport

According to *Annex XIII (1)* **of the EU Battery Regulation, information on the recycled content shall be included in the battery passport.** The information – which is to be reported per year and manufacturing plant, referring to the battery model – shall be accessible to the public. As set out in *Article 8(1)*, by 36 months after entry into force of the regulation, the format of the documentation alongside the "methodology for the calculation and verification of the share of cobalt, lithium, or nickel recovered from waste present in active materials and share of lead recovered from battery manufacturing waste or post-consumer waste present in battery" shall be established through a **delegated act**.

For recycled content, the EU Battery Regulation focuses on cobalt, lithium, lead, and nickel as relevant elements. However, according to *Article 8(4a)* of the regulation, **other materials** could also be included in the scope of the Regulation in the case of changing market requirements, technical, or scientific progress. Therefore, should recycled content for other elements be voluntarily reported or even becomes mandatory, the calculation methodology for the defined element should be transferable to others.

As reasoned by the industry and also supported by the Battery Pass consortium, the final compromise text of the Battery Regulation includes **pre-consumer waste**, rather than only considering **post-consumer waste**. Since waste batteries are not expected to account for a significant proportion of recycled material until the 2030s, industry stakeholders question their ability to meet recyclate targets: "[...] batteries placed on the market today will reach their end of life only after 10–15 years. The raw materials recovered from those batteries will clearly be insufficient to manufacture the much higher number of batteries needed in 2030 and 2035." (62). In contrast, the concern of wrongfully declared waste during the battery production was

raised by the legislator. To address this concern, the Battery Regulation includes a clear definition of pre-consumer waste (or “battery manufacturing waste”).

Since introducing a separate declaration later on might be difficult and would involve considerable additional resources, we advocate in favour of a separate calculation of pre- and post-consumer shares from the beginning. Depending on future market developments and technical advances, the issue might be raised again. In addition, such a separate and transparent declaration of pre-consumer recyclate can address the concern of the legislator about the misuse and detect violations of the rules more easily. First and foremost, though, a separate reporting allows observing the development of the different recyclate shares over time. Should post-consumer shares, against current expectations and forecasts, not increase over time, problems in the end-of-life will become evident. Also, data transparency and the ability to compare with forecasts will reduce opportunities for misuse and facilitate a realistic validation of the declared recycled content.

Separating the quantities of recycled metals by origin (pre-/post-consumer battery waste) should require little additional effort for organisations since they should be aware of the origin of their batteries for recycling. If companies should not know the origin of the battery waste, separate reporting will raise the threshold for professional and compliant battery handling. This could help in creating a circular economy and level playing field.

As argued above, the **Battery Pass consortium proposes to make eight recycled content share data attributes available via the battery passport** (see Table 12). These contain the **shares of recycled content for nickel, cobalt, lithium, and lead from pre- and post-consumer waste**.

Furthermore, the recycled content share of other chemical elements, not yet being subject to mandatory reporting, could be included in the analysis on a voluntary basis and also be made accessible via the battery passport. Similarly, also the total share of recycled content contained in the battery cell, module, or pack could be reported voluntarily.

Definition of recycled content

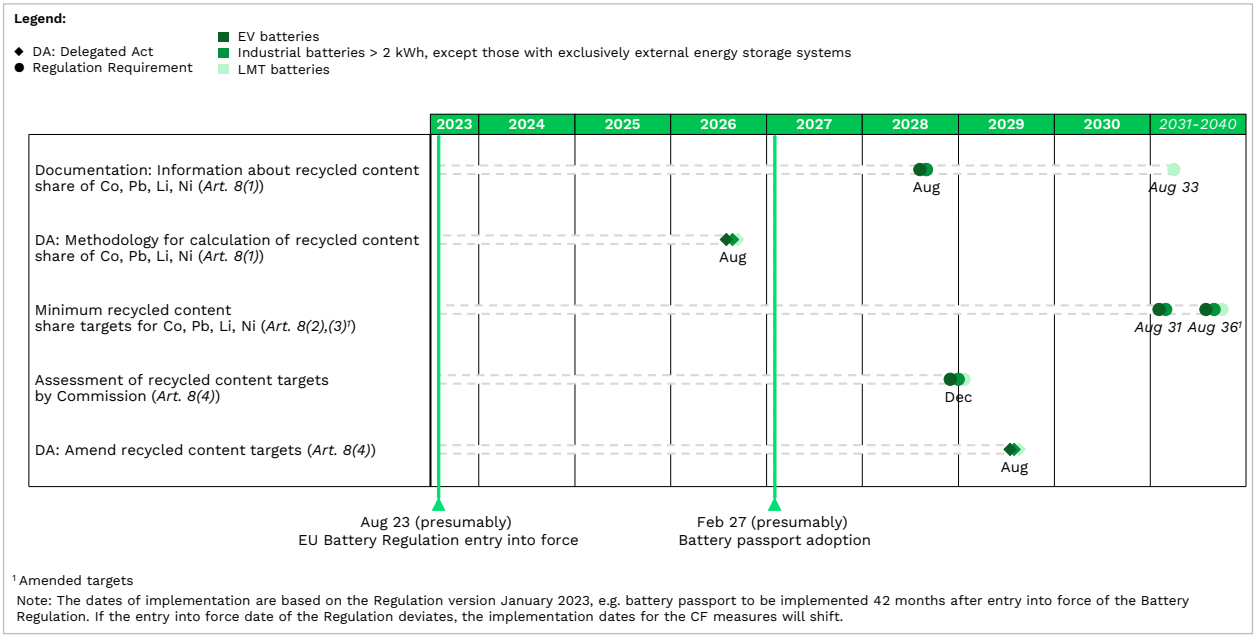
Article 8(1) of the EU Battery Regulation states that industrial batteries with a capacity above 2 kWh (except those with exclusively external storage), electric vehicle batteries, SLI batteries and LMT[61] batteries “that contain **cobalt**, **lead**, **lithium** or **nickel** in active materials, shall be accompanied by documentation containing information about the share of, respectively, cobalt, lithium or nickel recovered from battery manufacturing waste or post-consumer waste present in active materials, and share of lead recovered from waste present in the battery, for each battery model per year and per manufacturing plant.”

The recycled content documentation is required 60 months after entry into force of the EU Battery Regulation or 24 months after entry into force of the delegated act that establishes the recycled content calculation methodology (whichever is later).[62] Hence, the technical documentation verifying the recycled content shares determined and declared in the battery passport will only become mandatory 18 months after battery passport introduction (see timeline in Figure 30 below). The battery categories in scope of the recycled content provisions are not yet clearly defined. While **industrial batteries with exclusively external storage** are

[61] Please note that of the batteries affected by the requirements of *Article 8(1)*, only LMT batteries, industrial batteries with a capacity > 2 kWh and EV batteries receive a battery passport (*Article 65(1)*) - SLI batteries are excluded from the battery passport scope.
[62] For LMT batteries, the provisions only apply from 120 months after entry into force of the EU Battery Regulation.

explicitly exempted from the recycled content obligations, they still require a battery passport if their capacity exceeds 2 kWh. Although these batteries are typically not composed of chemistries including Li, Ni, Co or Pb, it remains open if these batteries fall under the battery passport recycled content obligations. In case of chemistry changes in the future, this could become relevant. The Commission is advised to address these open questions in advance to the battery passport introduction.

Figure 30: Timeline for recycled content requirements and coming into force of delegated acts



[1] Amended targets

Note: The dates of implementation are based on the Regulation version January 2023, e.g. battery passport to be implemented 42 months after entry into force of the Battery Regulation. If the entry into force date of the Regulation deviates, the implementation dates for the CF measures will shift.

During the battery production ramp-up, battery manufacturing waste is likely to be the main source of secondary raw material for battery manufacturing. In contrast, post-consumer battery waste is not expected to account for a significant proportion of recycled material until the 2030s. Therefore, the Battery Regulation includes battery manufacturing waste in the recycled content targets "with the objective to accelerate the development of the necessary recycling infrastructure" (*Recital 20*). According to *Article 2 (39a)*, battery manufacturing waste is defined as "the materials or objects rejected during the battery manufacturing process, which cannot be re-used as an integral part in the same process and need to be recycled." The EU Battery Regulation thus explicitly excludes manufacturing scrap[63] (also called "run-around scrap" (31)) when calculating the recycled content share and meeting the respective targets. This is in line with the definition provided by the standard ISO 14021 (63), stating that recycled content is "the proportion, by mass, of recycled material in a product or packaging; only pre-consumer and post-consumer materials are considered as recycled content."[64]

[63] Manufacturing scrap is further defined in *Recital 22* of the EU Battery Regulation: "[...] the reutilisation of materials such as rework, regrind or scrap generated in the battery manufacturing process, which can be reclaimed within the same process that generated it [...]."

[64] The terminology used in EU law and standardisation with respect to the definition of "waste" differs. Standards define that "waste" cannot exercise any further functions and cannot be recovered. In all other cases the term "material" is preferably used in standards. Accordingly, the standard ISO 14021 (63), defines pre-consumer material as "material diverted from the waste stream during a manufacturing process. Excluded is reutilisation of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it" (63), thus corresponding to the term "manufacturing waste" used in the EU Battery Regulation. Post-consumer material is understood in ISO

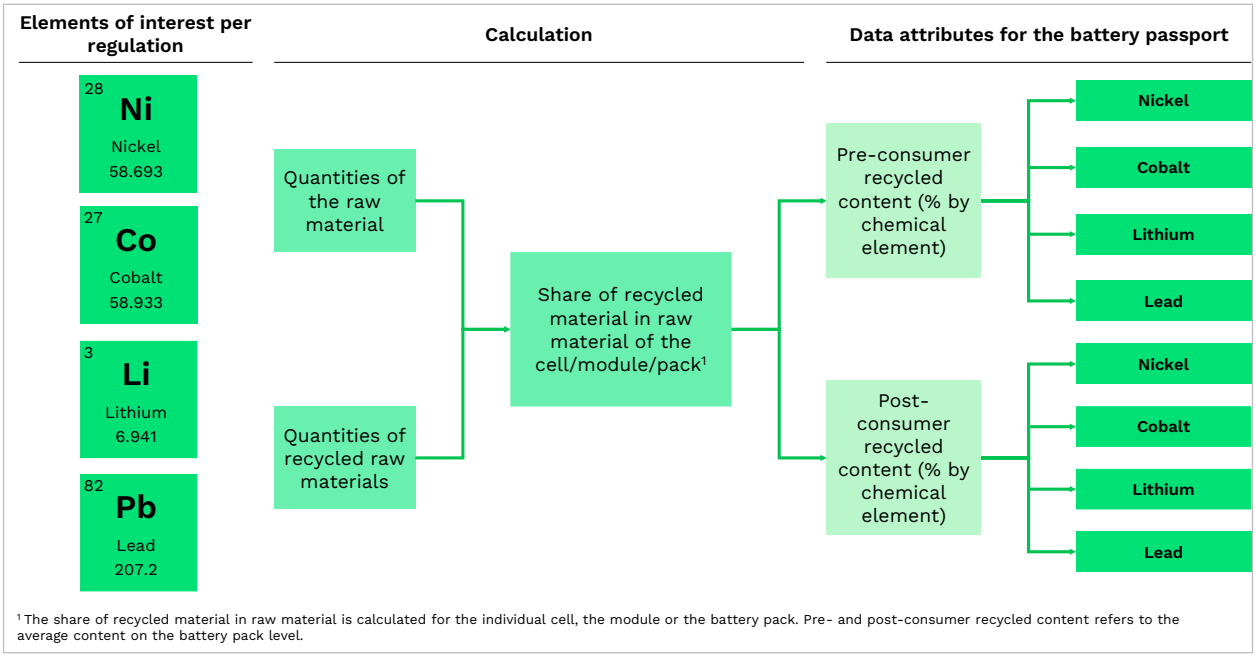
Calculation of recycled content

Following the definition of the recycled content contained in products, the recycled content per chemical element can be calculated. **The recycled content of the respective chemical element equals the mass of the recycled chemical element divided by the total mass of the chemical element:**

$$\text{Recycled content} = \frac{\text{Mass of recycled material (chemical element)}}{\text{Total mass of material (chemical element)}}$$

Currently, the EU Battery Regulation limits the mandatory information on recycled content for the battery passport to the **shares of nickel, lithium, lead, and cobalt**.

Figure 31: Recycled content calculation per chemical element



To calculate the shares of recycled content for each element, the quantities of primary raw material and the quantities of recycled material must be known. As illustrated in Figure 31, the share of nickel, cobalt, and lithium recovered from waste of the active material and the share of lead recovered from waste present in the battery is regarded – on cell, module, or battery pack level. Since the recycled or secondary raw material considered in the calculation either originates from **pre-consumer recycled content** (manufacturing battery waste, excluding run-around scrap) or from **post-consumer recycled content** (end-of-life battery waste), **the Battery Pass consortium suggests calculating and reporting the recycled content share for these two categories separately**, as demonstrated in Figure 31.

To enhance resource efficiency and reduce the EU's dependence on third countries for raw materials, the Battery Regulation aims to promote the use of recyclates (*Recital 20*). To this end, the Battery Regulation (*Article 8*) sets recycled content targets for the elements cobalt, lead, lithium, and nickel, as introduced in the info box below.

14021 as the “material generated by households or by commercial, industrial, and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.”

Minimum recycled content targets

In *Article 8(2)*, the **EU Battery Regulation sets mandatory minimum recycled content targets for cobalt, lead, lithium, and nickel contained in industrial batteries with a capacity above 2 kWh (except those with exclusively external storage), EV, SLI and LMT batteries** (see Table 13). The targets refer to the share of cobalt, lithium, and nickel recovered from battery manufacturing waste or post-consumer waste present in active materials, and to the share of lead recovered from waste present in the battery, for each battery model per year and per manufacturing plant. The requirements shall be met 96 months after entry into force of the regulation. For cobalt, lithium, and nickel increased targets are established 156 months after entry into force of the regulation (*Recital 20*; *Article 8(2)*).

Table 13: Mandatory recycled content targets for battery materials in the EU Battery Regulation

Chemical element	Mandatory recycled content targets [per year/manufacturing plant]	
	96 months after entry into force of the regulation	156 months after entry into force of the regulation
Cobalt	16%	26%
Lead	85%	85%
Lithium	6%	12%
Nickel	6%	15%

The Battery Regulation (*Article 8(3a)*) restricts the scope of the minimum recycled content requirements and targets. These "shall not apply to a battery that has been subject to preparing for re-use, preparing for repurpose or repurposing, or remanufacturing, if the battery had already been placed on the market or put into service before undergoing such operations."

Depending on the future availability or possible lack of cobalt, lead, lithium, and nickel recovered from waste and developments with respect to the battery chemistry and/or material recovery, the Commission shall assess, first, whether it is appropriate to revise the minimum recycled content targets set out in the Regulation (*Article 8(4)*) and, second, whether other materials should be included in the scope (*Article 8(4a)*). To amend the minimum recycled content targets, the Commission is empowered to adopt delegated acts.

6.6.2.2 Renewable content information

According to the EU Battery Regulation (*Annex XIII 1(ha)*), the battery passport shall include information on the share of renewable content, which is related to the battery model and will be accessible to the public (see Table 12). The larger scope of the data attribute is unspecified, although the Battery Regulation states the example of "renewable material such as graphite produced from lignin" (*Recital 93*). We recommend clarifying if this data attribute presents an overall value for the battery or must be discerned in certain components. In addition, it should be specified whether all materials or only active materials are to be reported on.

6.6.3 End-of life battery information and waste management

Battery passport guidance in brief on waste prevention and collection information

Mandatory data: Information on the role of end-users in contributing to waste prevention; information on the role of end-users in contributing to the separate collection of waste batteries in accordance with their obligations under *Article 51* so as to allow their treatment; information on the separate collection, take-back and collection points, preparing for re-use, preparing for repurposing, and recycling operations available for waste batteries (*Article 60 (1a-c)*).

Our suggestions and outlook:

- Include the respective information in the battery passport as URL linking to PDF.
- As introduced in *Article 51*, waste batteries shall be discarded in designated separate collection points (*Article 60(1b)*).
- Producers/producer responsibility organisations shall install take-back and collection points as well as provide end-users with corresponding information, as outlined in *Articles 48*, *48a* and *49*, linked to *Article 51*.
- Additionally, good practices and recommendations concerning the use of batteries aiming at extending their use-phase should be developed and be provided to end-users.

Table 14: Role of end-user in waste prevention and collection – data attributes

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting	Format/ Unit
Role of end-users in contributing to waste prevention	*Article 60(1a)*	Public	General information on the role of the end-user in waste prevention • Responsibility to discard waste batteries separately from other waste streams • Responsibility to bring batteries to separate collection points Good practices and recommendations concerning the use of batteries aiming at extending their use-phase	Provide general information on the role of the end-user in waste prevention and information on good practices and recommendations concerning the use of batteries aiming at extending their use-phase	URL to PDF
Role of end-users in contributing to the separate collection of waste batteries	*Article 60(1b)*	Public	Information on the separate collection of waste from other waste streams according to *Article 51*: • Discard waste separately from other waste streams or municipal waste Use designated separate collection points	Provide information on the practical role of the end-user in contributing to the separate collection of waste batteries	URL to PDF

Data attribute	Battery Regulation reference	Data access	Definition/ Understanding	Suggested reporting	Format/ Unit
Information on the separate collection, the take-back and collection points and preparing for re-use, preparing for repurposing and recycling operations	*Article 60(1c)*	Public	Information on • Location of collection points • Description of the take-back process • Preparing for re-use, preparing for repurposing and recycling operations available Further details outlining the waste process	Provide the exact location of collection points, a description of the take-back process, preparing for re-use, preparing for repurposing and recycling operations available, further details which might be helpful in understanding the waste process	URL to PDF

To increase the recycling rates of batteries and the recovery of raw materials, the Battery Regulation aims at better informing the end-user. Corresponding instructions for the separate disposal of waste batteries and information on take-back and collection points are part of the battery passport. The producer or, where appointed in accordance with *Article 47a(1)*, producer responsibility organisations, are required to provide information on the prevention and management of waste batteries to end-users and distributors as described in *Article 60(1a-c)*, of the EU Battery Regulation.

The abovementioned information shall be made available in regular time intervals for each battery model, from the moment the model concerned is made available on the market for the first time in a Member State. As a minimum the information shall be made accessible at the point of sale in a visible manner and through online marketplaces and in (a) language(s), which can be easily understood by end-users, as determined by the Member State in which the battery is to be made available on the market (*Article 60(1)*).

Data in the battery passport

The abovementioned information is mandatory to be included in the battery passport under public access according to *Annex XIII*.

The information may be included as PDF-file. From there, end-users could receive relevant information on the discard and collection process of their batteries as well as the designated collection points along with all other information necessary to fulfil the requirements laid down in *Article 60(1)*. In this context, *Annex XIII (s)* and *(u)* mention the labelling requirements (*Article 13(3)*) and the informatio regarding the prevention and management of waste batteries (*points (a)* to *(f)* of *Article 60(1)*).

Excursus: The value of recycling traceability information for a circular economy

Currently, end-of-life information for a battery is not required to be reported in the battery passport. At the same time, the Battery Regulation emphasises that a "high level of collection and recycling of waste batteries should be the rule" (*Recital 78*) – stressing that this applies to **all** batteries. However, this information can be just as valuable for sustainability as the upstream supply chain, in particular, the issue of "leakage" of batteries, meaning the loss of battery material through illegal or dubious export accompanied by opaque processes, inferior or non-recycling. The future percentage of leakage will have significant impact on the availability of secondary material. In addition, illegal and inferior recycling often disregards workplace safety, environmental standards, and/or involves child labour while at the same time achieving lower recycling rates for key battery materials.

From the Battery Pass consortium's point of view, the above issues clearly motivate the inclusion of tracing information on recycling in the battery passport connected to the original battery ID. If this is implemented and traceability data is mapped to the quantities of batteries handled in recycling, the information can help reduce the need for primary materials and level the playing field through improved oversight. As a goal, mandatory reporting to Member States (see box in chapter 5.1.3) could be linked to aggregated data from traceability information.

This goal, however, requires thoughtful consideration of how material flows can be traced all the way, particularly when a battery has already been dismantled into its components. This also touches on the scope and system boundaries of the battery passport as currently defined in the Battery Regulation.

6.6.3.1 Role of end-user to waste prevention

"Information on the role of the end-user in contributing to waste prevention, including information on good practices and recommendations concerning the use of batteries aiming at extending their use-phase and the possibilities of re-use, preparing for re-use, preparing for repurpose, repurposing and remanufacturing" is mandatory to be accessible by the public via the battery passport (*Article 60(1a)*).

A definition of the information of *Article 60(1a)* is provided in *Article 51*. The latter outlines the obligations of end-users in contributing to waste prevention. *Article 51(1-2)* describes the obligation of the end-user to discard waste batteries separately from other waste streams, including from mixed municipal waste and in designated separate collection points. Additionally, producers or producer responsibility organisations are asked to set up awareness campaigns or offer incentives to encourage end-users to discard waste batteries in a manner compliant with the information to end-users on prevention and management of waste batteries in *Article 60(1)*. Information on good practices and recommendations for extending the use phase of the battery are not further specified in the regulation.

6.6.3.2 Role of end-user to separate collection

Information "on the role of end-users in contributing to the separate collection of waste batteries in accordance with their obligations under *Article 51* so as to allow their treatment" is mandatory to be accessible by the public via the battery passport (*Article 60(1b)*).

The above reference to *Article 51(1)* refers to collecting waste batteries separately in order to help waste management operators and recyclers to better treat and recycle batteries on the market. According to *Article 48(1)* and *Article 48a(1)*, the responsibility will lie with the producer (or appointed producer responsibility organisation) to ensure the separate collection of all battery categories free of charge, regardless of their nature, chemical composition, condition,

brand or origin, in the territory of a Member State, where batteries have been made available on the market for the first time.

Further details and provisions for the collection of waste portable batteries, waste LMT batteries, waste SLI batteries, industrial batteries, and electric vehicle batteries are provided in *Article 48*, *48a* and *49*. The articles mention similar provisions for the producer or producer responsibility organisation concerning the take-back and collection process, slightly differing between each of the waste battery categories.

6.6.3.3 Separate collection (points) and take-back

Information on "the separate collection, take-back and collection points, preparing for re-use, preparing for repurposing, and recycling operations available for waste batteries" is mandatory content of the battery passport (*Article 60(1c)*) to be accessible by the public.

This data attribute is further defined in *Article 60(1c)*. Here, the obligations of the end-user to discard waste batteries separately from other waste streams and in designated separate collection points, set up by or in accordance with the specific arrangements concluded with the producer or a producer responsibility organisation, in accordance with *Articles 48*, *48a* and *49*, are outlined. Additionally, producers are required to set up awareness campaigns or offer incentives to encourage end-users to discard waste batteries correctly (*Article 60(1a)*).

According to *Article 48(1a-d)*, *Article 48a(1a-e)*, and *Article 49(1)*, it will be the responsibility of the producer to establish a waste battery take-back and collection system – including designated collection points – and offer the collection of waste portable batteries free of charge to the end-users. Additionally, the producer or producer responsibility organisation shall give information on the available operations concerning preparing for re-use, preparing for repurposing and recycling. Producers are furthermore obliged to provide for the necessary practical arrangements for collection and transport including transport containers meeting the requirements of the Directive 2008/68/EC[65] (64) to the connected collection points, install end-of-life vehicle treatment facilities in accordance with *Article 52*, and ensure the establishment of voluntary collection points in accordance with *Article 54*. An obligation to buy a new battery upon returning waste batteries is explicitly not permitted (*Article 48(3)*).

The responsibility covers the whole territory of the Member States, taking into account population size, the expected volume of waste batteries, accessibility and vicinity to end-users and not being limited to where the collection and subsequent management of waste batteries would be most profitable (*Article 48a(2)*). Furthermore, producers need to provide the collection points with suitable collection infrastructure for the separate collection of waste batteries, meeting the applicable safety requirements and covering the necessary costs incurred by those collection points (*Article 49(3a)*). It is important to note that the chemical composition of the battery may not infringe on the end-user's possibility to return waste batteries appropriately. Batteries which are considered "easily removable" should be discarded by the end-users themselves.

Not part of the battery passport, but of importance in the context of circularity are the collection targets for waste portable batteries and waste LMT batteries, as well as recycling efficiency and material recovery targets (see info boxes below). Today, the management of waste batteries varies significantly, depending on the category and composition of the battery.

[65] Directive 2008/68/EC on the inland transport of dangerous goods.

While collection and recycling of, e.g., lead-acid batteries, are established efficiently and cost effectively, this proves difficult for lithium-ion batteries. Therefore, in compliance with its Circular Economy Action Plan of 2020 (52), the EU incorporates measures to improve the collection and recycling rates of **all** batteries in the Battery Regulation. However, specific collection targets are only set for waste portable batteries and waste LMT batteries. Although the regulation states that a "high level of collection and recycling of waste batteries should be the rule" (*Recital 78*), no concrete statements are made about the quality recycling process itself. As a result, the meaning of "quality secondary raw material" (*Recital 78*) and the generation thereof, remains unclear.

Information on the collection of waste batteries as well as on the quality of the recycling processes and reyclates could potentially be made available through the battery passport. At the earliest, the battery passport could cease to exist upon dismantling of the battery, whereas further tracking information on the whereabouts of the battery material could contribute to responsible recycling back to battery grade materials. However, it remains a point of discussion, where a "cut-off" of information on battery recycling in the battery passport is sensible.

Battery Regulation collection targets for waste batteries

The Battery Regulation's collection targets for waste batteries (*Article 48* and *48a*) apply to producers or producer responsibility organisations making the battery available on the market for the first time.

Waste portable batteries

According to *Article 48* of the EU Battery Regulation producers or producer responsibility organisations shall establish waste portable battery take-back and collection systems, including collection points. End-users, when discarding waste portable batteries at these collection points, shall not be charged, or be obliged to buy a new battery. Specific targets are set for the collection of waste portable batteries (*Article 48(4)*):

a. 45% by 31 December 2023;
b. 63% by 31 December 2027;
c. 73% by 31 December 2030.

Waste LMT batteries

Provisions are also made for the collection of waste LMT batteries (*Article 48a*) to ensure that these are taken back by the producer or producer responsibility organisation. Collection targets of waste LMT batteries of at least

a. 51% by 31 December 2028
b. 61% by 31 December 2031

are specified for the producer or producer responsibility organisation (see timeline in Figure 32). Member States will be responsible for adopting necessary measures so that the producers or producer responsibility organisations can fullfill their obligations with respect to the collection rates (*Article 55*).

The collection of waste **SLI batteries, industrial batteries and electric vehicle batteries** is covered in *Article 49*. Although the Battery Regulation calls for the effective collection and high quality recycling of **all** batteries, no concrete specifications with respect to collection targets are made for waste SLI batteries, industrial batteries and electric vehicle batteries.

Obligations of distributors, end-users and of treatment and recycling facilities are defined in *Article 50*, *51* and *52* of the EU Battery Regulation, respectively. *Articles 53* and *54* address the participation of public waste management authorities and voluntary collection points. Moreover, *Article 56* holds that collected waste batteries shall not be landfilled or incinerated.

Minimum recycling efficiencies and levels of recovered materials

The Battery Regulation's minimum recycling efficiencies and levels of recovered materials (*Article 57*) apply to recyclers.

Article 57 stipulates the requirements for recycling efficiencies and material recovery targets, stating that recyclers shall ensure the targets in compliance with *Annex XII, Parts B* and *C* (see chapter on recycled content). Since recyclability, design-for-disassembly and design-for-recycling are not included and regulated under the responsibility of the economic operator placing the battery on the market, the recycler bears the responsibility for such targets. *Annex XII, Part B* and *C* lay down minimum targets by battery type and chemical element as summarized in Table 15 and Table 16. The timeline for the entry into force of the requirements is shown in Figure 32.

Recital 92 additionally states that Member States should report to the commission the recycling efficiencies and the levels of recovered materials achieved taking into account all the individual steps of the recycling process and the output fractions.

Table 15: Minimum recycling efficiencies by battery type

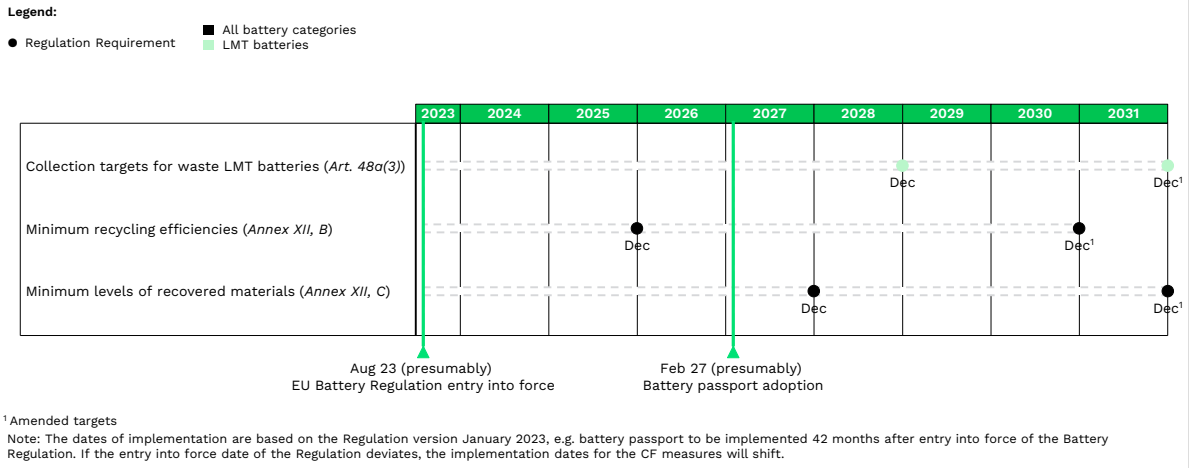
Battery type	Minimum recycling efficiency [in % by average weight of batteries]	
	31 December 2025	31 December 2030
Lead-acid	75%	80%
Lithium-based	65%	70%
Nickel-cadmium	80%	-[1]
Other waste batteries	50%	-[1]

[1] no changes to targets

Table 16: Minimum levels of recovered materials by chemical element

Chemical element	Minimum levels of recovered materials	
	31 December 2027	31 December 2031
Cobalt	90%	95%
Copper	90%	95%
Lead	90%	95%
Lithium	50%	80%
Nickel	90%	95%

Figure 32: Timeline for waste battery collection targets, minimum recycling efficiencies and minimum levels of recovered materials



[1] Amended targets

Note: The dates of implementation are based on the Regulation version January 2023, e.g. battery passport to be implemented 42 months after entry into force of the Battery Regulation. If the entry into force date of the Regulation deviates, the implementation dates for the CF measures will shift.

6.7 Performance and durability

Battery passport guidance in brief on performance and durability

Mandatory data:

- The EU Battery Regulation mandates to report multiple data attributes on battery performance and durability originating from different articles and annexes (*Articles 10*, *14* and *Annexes IV*, *VII* and *XIII*).
- Battery performance reporting occurs through an array of static and dynamic data attributes, including battery capacity, energy, resistance, energy round trip efficiency, and self-discharging.
- Durability data attributes further entail static data, such as expected lifetime in cycles and calendar years. In addition, dynamic data, such as energy and capacity throughput or negative events on temperature conditions and accidents, are intended to provide information on usage patterns that may affect durability.
- Several of the required data attributes are specified for individual battery categories.

Our suggestions and outlook:

- In addition to being reported in the battery passport, many performance and durability data attributes must already be reported 12 months after entry into force of the regulation, both in a document accompanying a battery and in the BMS for batteries that use a BMS.
- Minimum requirements for performance and durability will be introduced in delegated acts by the Commission for industrial batteries with a capacity above 2 kWh and LMT batteries by 30 or 42 months, respectively, after entry into force of the regulation. Minimum requirements for EV batteries will be laid down in the upcoming Euro 7 legislation on vehicle-type approval.
- Most data attributes lack detailed description in the EU Battery Regulation. Guidance on the data attributes is urgently needed for feasible implementation, potentially through delegated acts mentioned in *Articles 10(3a)* and *14(2b)*. In particular, standardised conditions for the evaluation of the data attributes are instrumental for the comparability of values provided.
- Access rules to data should be harmonised across different reporting tools based on use cases of data attributes. In addition, up-to-dateness of dynamic data needs to be specified by required update intervals or variance thresholds. These should consider available connectivity and analogously reflect the respective relevant use case(s) to optimise the value of data in the battery passport. Specifications on access rules and update intervals should be provided within a delegated act, describing details of performance and durability requirements.

The Battery Regulation mandates information about performance and durability, which is a major selling point of a battery. In addition, knowledge of remaining performance and durability, i.e., in-use information for an individual battery, is crucial to any second-life economic operator or user of a battery to identify the residual value. As such the compilation of performance and durability data attributes is important end-user information and a major factor for sustainable and circular battery usage.

This chapter focuses on the general understanding of reporting requirements on performance and durability, such as access or update intervals for dynamic data, based on the information in the respective articles and annexes of the EU Battery Regulation. Additional reporting requirements on performance and durability, which must be implemented before the battery passport, are briefly assessed as well (see info box in chapter 6.7.1). The required data attributes in the battery passport are then individually described.

Standardised measurement conditions are not provided in the regulation but will be instrumental for the comparability of values provided. They are mentioned in this analysis, where applicable, but it is beyond the scope of the Battery Pass project to define any such conditions in detail or exhaustively. It is important that the conditions must differentiate by different design or operation of batteries, such as redox-flow or high temperature batteries. Standardisation efforts are currently underway to address these needs, in particular activities in accordance with the standardisation mandate M/579 by the European Commission regarding performance, safety and sustainability requirements for batteries (65).

The EU Battery Regulation mandates most performance and durability parameters on the battery pack level. Providing most information also on cell, cell-group or module level would include a further dimension of complexity in the battery passport that is currently not addressed in the EU Battery Regulation. The Battery Pass consortium suggests that providing details on module or cell level should be reviewed for future iterations of the EU Battery Regulation (see also info box in chapter 6.1.1).

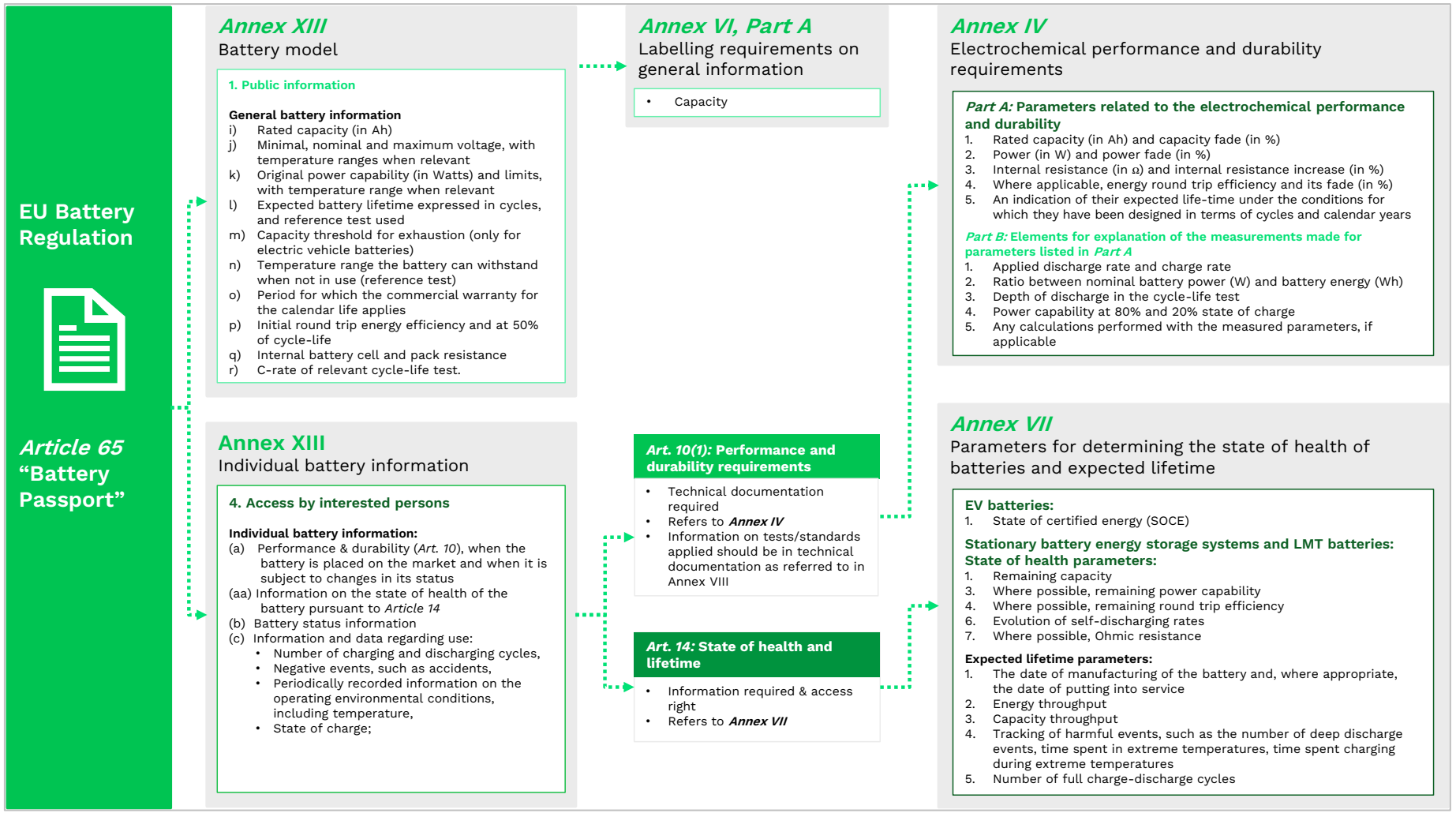
6.7.1 Provisions in the EU Battery Regulation

The EU Battery Regulation refers to several different articles and Annexes for the data attributes on battery performance and durability. The following articles and Annexes contribute to the full picture of battery performance and durability data attributes laid down for reporting in the battery passport and are summarised in Figure 33.

Article 65 **and the corresponding** *Annex XIII* describe the workings and overview on all mandatory data, respectively, of the Battery Passport. *Annex XIII* is separated in different sections. It includes both publicly available static data of performance data attributes on the battery model level, such as rated capacity and nominal voltage, as well as access restricted dynamic data (see overview in Figure 33). The latter emerge from the individual use of a battery and will be accessible only by so-called interested persons (see definition in chapter 4.2). The dynamic data in *Annex XIII* includes specific data attributes like the battery status and number of charging and discharging cycles. Furthermore, it refers to data attributes specified in *Article 10***, "Performance and durability requirements…" and information pursuant to** *Article 14* **"…State of Health and battery lifetime…"**, which are thus added to the scope of mandatory battery passport data.

Article 10 **describes performance and durability requirements and refers to** *Annex IV* for details on the required data attributes. *Annex IV, Part A* points out the required data attributes and their definitions while *Part B* includes data attributes to be used in the explanation of the "technical specifications, standards and conditions used to measure, calculate or estimate the values in *Part A*. Data attributes in *Part B* are thus not mandatory for reporting in the battery passport. The performance and durability requirements may be amended in a future delegated act by the European Commission. Such a delegated act should consider market development and technical and scientific progress, including in particular that related to technical specifications of the UNECE Working Group on Electric Vehicles and the Environment, which has developed the UNECE GTR No. 22 on "In-vehicle Battery Durability for Electrified Vehicles" (66).

Figure 33: Relevant articles and annexes for battery performance and durability and their data attributes[66]



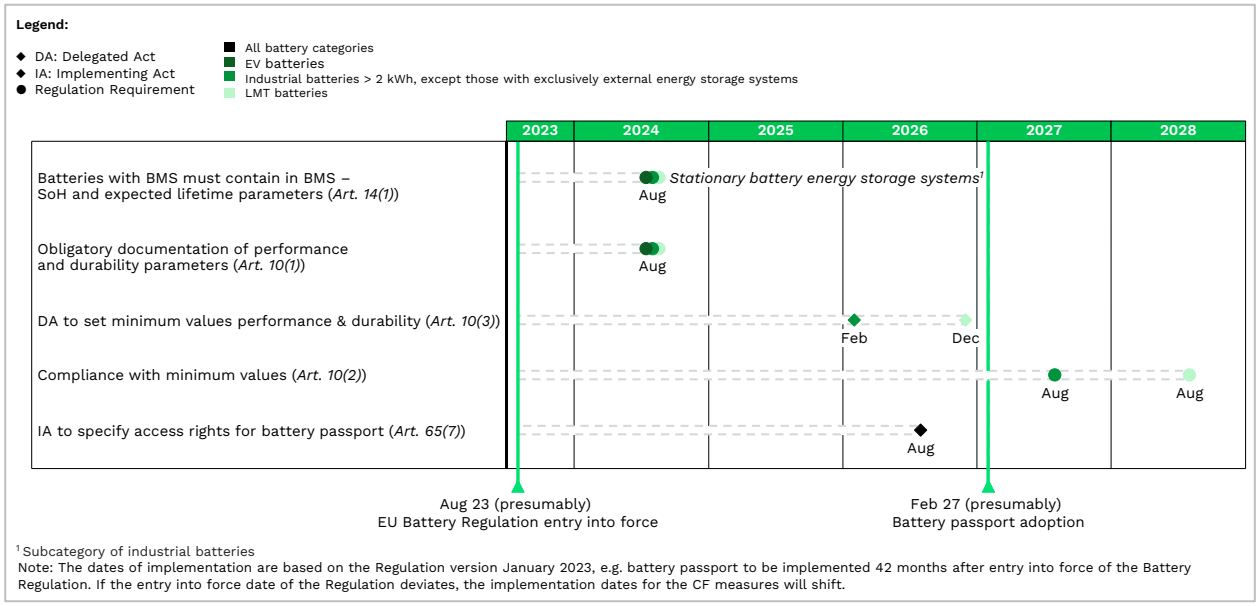
[66] Enumerations, including missing numbers, reflect the current enumeration in the Battery Regulation or omission of other content than performance and durability.

The data attributes specified in *Article 10* are qualified to be made available in the battery passport "when the battery is placed on the market and when it is subject to changes in its status" *Annex XIII 4(a)*. The application of this provision for the required update interval in the battery passport in practice will be discussed below in section "accessibility of data".

Article 10 further describes a path towards **mandatory minimum requirements for rechargeable industrial batteries with a capacity above 2 kWh and LMT batteries**[67] via respective delegated acts and different timelines. The mandatory minimum requirements for rechargeable industrial batteries with a capacity above 2 kWh and LMT batteries should be established by, respectively, 30 or 42 months after entry into force of the Battery Regulation. These must be complied with by 48 or 60 months, respectively, after entry into force of the Battery Regulation or 18 months after entry into force of the respective delegated act, whichever is later. Figure 34 includes this timeline. Minimum requirements for EV batteries will be laid down in the upcoming Euro 7 legislation on vehicle-type approval.

Article 14 **"...State of Health and battery lifetime..."** refers to data attributes listed in *Annex VII* for determining the state of health in *Part A* and the battery lifetime in *Part B*. The wording "...pursuant to *Article 14*" in *Annex XIII* implies that the provisions in *Article 14* and its corresponding *Annex VII*, on the battery category scope for example, will need to be applied to the respective data in the battery passport.

Figure 34: Timeline of reporting tools for performance and durability data attributes[68]



Battery categories

A differentiated scope on battery categories and accessibility originates from *Annex XIII*, *Art 10/Annex IV* and *Art 14/Annex VII*: The battery passport scope in *Article 65* includes industrial batteries with a capacity > 2 kWh, EV and LMT batteries. *Annex XIII* adds the "parameters referred to in *Article 10"/Annex IV* to the battery passport. Thus, these data attributes apply to the abovementioned scope of the battery passport in terms of battery category.

In contrast, the addition of data attributes "pursuant to *Article 14*" and its corresponding *Annex*

[67] EV batteries are not included.
[68] *Article 14* does not apply to all industrial batteries, but only to stationary battery energy storage systems.

VII implies, together with wording in *Article 65*,[69] that the battery category scope in *Article 14* must be considered for data attributes listed in *Annex VII*.

Therefore, the battery passport data attributes originating from *Article 14/Annex VII* apply for stationary battery energy storage systems,[70] EVs and LMT batteries that use a BMS, in contrast with *Article 65* that includes all industrial batteries and makes no restriction based on BMS use. The left part of Figure 35 illustrates the applicability of data attributes in the battery passport for different battery categories based on above description.[71]

This differentiation originates from the challenge of applying data attributes over the different battery categories and applications within the scope of the battery passport. In particular, industrial, EV and LMT batteries experience different system integration such as the availability of a BMS or connectivity. As a result, use cases and the ability to evaluate dynamic data attributes during operation differ among battery categories. Emerging hindrances for implementation of data attributes for different battery categories will be discussed on an overarching level below and for individual data attributes, where necessary.

Figure 35: Reporting of data attributes in the battery passport (left) per battery (sub)categories, originating from three separate articles and their annexes[72]

	Data for battery passport specified in			Documentation	Data in BMS
Battery (sub)categories	*Article 65 / Annex XIII*	*Article 10 / Annex IV*	*Article 14 / Annex VII*[1]	*Article 10*	*Article 14*[1]
EV battery	x	x	x	x	x
LMT battery	x	x	x	x	x
Industrial battery: per subcategory:					
• **Stationary battery energy storage system (> 2 kWh)**	x	x	x	x	x
• **Rechargeable, other industrial batteries (> 2 kWh)**	x	x		x	
• **Non-rechargeable, other industrial batteries (> 2 kWh)**	x	x			

[1] If BMS is used

[69] *Article 65(2ii)*: "Such information shall be included to the extent applicable to the category or subcategory of battery concerned."
[70] A subcategory of industrial batteries. See chapter 4.1 for battery category definitions.
[71] The size exclusion for industrial batteries to a capacity > 2 kWh (*Article 65*) is assumed to apply, even as *Article 14* does not mention size exclusion. It is important to note that batteries with exclusively external storage, particularly redox-flow batteries, are not part of the EU Battery Regulation's definition of stationary battery energy storage systems (see chapter 4.1.1).
[72] "Non-rechargeable, other industrial batteries with a capacity > 2 kWh" is an unlikely case in reality. The middle and right columns describe the battery category scope of additionally required reporting tools besides the battery passport (see box).

Other reporting tools for performance and durability information

In addition to the battery passport two separate reporting tools for performance and durability data attributes are implemented by the Battery Regulation in *Article 10* and *14* (see overview on battery category scope in Figure 35, middle and right column).

According to *Article 10*, all "LMT batteries, rechargeable industrial batteries with a capacity above 2 kWh, and electric vehicle batteries shall be accompanied by a document containing values for the electrochemical performance and durability parameters", already beginning 12 months after entry into force of the Battery Regulation. The information therein will thus be available for any holder of the battery. Separately, a technical documentation is mentioned in *Article 10*, that is referred to in *Annex VIII*. The documentation should 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 that is relevant for conformity assessment. That explanation shall include, at least, the elements laid down in *Part B of Annex IV*."

In another separate provision, the EU Battery Regulation (*Article 14*) adds that "stationary battery energy storage systems, LMT batteries and electric vehicle batteries that use a battery management system shall contain in their battery management system up-to-date data on the parameters for determining the state of health and expected lifetime of batteries as laid down in *Annex VII*". This is required by 12 months after the date of entry into force of the Battery Regulation (see Figure 34). The term 'up-to-date' is specified in *Recital 30* of the Battery Regulation as "at least updated daily and more frequently where this is required by a specific purpose". The details of applying this provision are discussed below in the chapter "Access to and update intervals of data".

The implementation period of 12 months after entry into force of the regulation is particularly critical as many of the required data attributes are not elaborated at the present. It is therefore urgent that the European Commission lays down details on the understanding and required measurement conditions.

Furthermore, the separate duplicate data reporting in the document accompanying the battery, the BMS and the battery passport should be reviewed by the Commission for future Battery Regulation iterations.

Access rules and update intervals

Performance and durability data attributes listed among battery model data in *Annex XIII* will be accessible by the public. In contrast, data listed for individual batteries, including all data from *Article 10* and *14*, shall be available only for so-called interested persons (see chapter 5.1.6). The access rules for data in the battery passport including performance and durability data attributes will be clarified in a delegated act. In addition to the reporting in the battery passport, the data listed in *Article 10* and *14* as well as their respective annexes shall be made available through a document accompanying the battery and/or the BMS (see info box for more details). The Battery Pass consortium recommends that the access rules to data should be harmonised across these different reporting tools based on use cases as non-exhaustively described in *Article 65(2)* and *Article 14(2)*. These include the evaluation of residual value or remaining lifetime, market participation in energy storage, as well as repair, re-use, repurpose, remanufacturing, collection, dismantling and recycling.

In addition to access rules, the Battery Regulation includes different information on the update interval of data, which is particularly relevant for dynamic data because it has a significant impact on effort and expense for testing and data management. *Article 65* includes that data shall be kept "up-to-date", which is not specified further therein.

It is important to clarify whether this references the up-to-date measurement of data, or solely the up-to-date display of the data currently available. Here, we assume the former meaning for up-to-date.

The Battery Regulation refers to up-to-date in *Recital 30*, which describes "up-to-date" only in the context of *Article 14* and data to be made available in the BMS as follows: "Thus, such data should be up-to-date for these purposes, at least updated daily and more frequently where this is required by a specific purpose." Separately, data attributes that originate from *Article 10*, disregarding their static or dynamic nature, are qualified to be made available in the battery passport "when the battery is placed on the market and when it is subject to changes in its status". The understanding of the first part of this provision is clear as it refers to the first making available of the battery, even though dynamic data will not exist at the time of placing on the market. The reference to the battery status describes the data availability during the use phase when a battery may be remanufactured or repurposed for example. It is not specified any further and it remains elusive, how battery status changes will work in practice upon re-use, repurpose, remanufacture or when declaring it waste (see chapter 6.1.7).

The Battery Pass consortium generally recommends that update rules should not be distinguished only based on different articles/annexes of origin – especially because similar and sometimes overlapping data are described in *Annexes XIII*, *IV* and *VII*.[73] Instead, and similar to access rules, the update interval requirements should reflect the respective use case(s) of a data attribute to optimise the value of data in the battery passport. An automated daily update, for example, would not add value for several data attributes, e.g., for remaining capacity or energy of a battery as it does not change in short periods of time. Moreover, a daily evaluation regime for such data attributes would raise questions on the feasibility of implementation as battery availability for use would decrease significantly, if all mandatory dynamic data attributes would have to be evaluated daily. An additional concern is an unnecessary increase of energy consumption. Therefore, we recommend to carefully establish and evaluate the use cases mentioned above and the respectively necessary data. While not included in this current version 1.0 of the Battery Pass Content Guidance, we intend to include an assessment of use cases in the final version of this document. Such assessment also needs to consider the connectivity of batteries – in particular, batteries that so far do not possess any or sufficient connectivity. Further, LMT and EV batteries may be at locations where connectivity infrastructure is not available, e.g., underground parking or general lack of infrastructure.

Specifications on update intervals and access rules should be provided within a delegated act, describing details of performance and durability requirements as mentioned in *Articles 10(3a)* and *14(2b)* and/or the implementing act on the general access rules for the battery passport (*Article 65(7)*). In the following the individual data attributes as described in the Battery Regulation are assessed.

6.7.2 Battery performance data attributes

As described above, battery performance data attributes are added to the battery passport from different annexes of the EU Battery Regulation, which partially overlap in their contents. The chapters in the following thus separate the performance data attributes by content. A simplified overview of the performance data attributes and their definition is available in the tables in each of the following subchapters.

[73] E.g., rated capacity (*Annexes XIII, IV*), capacity fade (*Annex IV*) and remaining capacity (*Annex VII*).

The following chapters describe the Battery Pass consortium's current understanding of each data attribute. In addition, those data attributes which may need more detailed specification for a complete understanding are further defined. Where applicable, the consortium describes concerns regarding its implementation as a comparable data attribute and its added value.

6.7.2.1 Capacity, energy, state of health and voltage

In this chapter all data attributes mentioned in the Battery Regulation (3) concerning state of health (SoH), capacity, energy and voltage are addressed, see also the list of data attributes in Table 17.

Battery capacity and **battery energy** provide a measure of the energy content of a battery and are relevant as general SoH data attributes. They are closely correlated as capacity (in Ah) is equal to the energy (in Wh) divided by the voltage (in V) of the battery. The battery capacity and battery energy are often not entirely available for use, because, if in place, the battery management system (BMS) sets boundaries for maximum charge and discharge of the battery to avoid damage or exceptional degrading of the battery.

State of health (SoH) is a widely used term that the EU Battery Regulation defines in *Article 2(25)* broadly as "a measure of the general condition of a rechargeable battery and its ability to deliver the specified performance compared with its initial condition". This list of data attributes concerning SoH (*Article 14/Annex VII*, cf. Figure 33) is intended to collectively provide such information based on the above definition. The data attributes are elaborated in 6.7.2.1-6.7.2.4 below. In contrast to the general description, SoH today often refers, particularly in EVs, to one specific data attribute that provides a percentage value, informing end-users and other economic operators about remaining capacity or energy. Across battery applications the definition varies in terms of different reference units, e.g., capacity or usable battery energy.[74] Those data attributes that reflect this information in the battery passport are state of certified energy (SOCE) and capacity fade. While all battery categories in the battery passport must report capacity fade, EV batteries are required to also report SOCE, which originates from UNECE global technical regulations (GTR). The information of the two data attributes SOCE and capacity fade is similar due to the close relationship of capacity and energy. While SOCE is vehicle-type specific, capacity fade may be used to provide a value that is applicable among different battery categories. The respective data attributes are elaborated in the sections below.

[74] In addition to capacity or energy, SoH may also refer to resistance or other data attributes and is generally also safety-relevant. Safety measures as part of the battery passport are discussed in chapter 6.6.1.

Table 17: Data attributes with regard to state of health, battery capacity, energy and voltage

Data attribute	Regulation reference	Data access[75] and update interval	Definition/Understanding[76]	Mandatory battery categories[77]	Unit	Data type[78]
Rated capacity	*Annex IV, Part A(1)*, incl. definition. *Annex XIII 1(i)*	Public Upon placement on the market and change of status	"The total number of ampere hours (Ah) that can be withdrawn from a fully charged battery under specific reference conditions." **Comment:** Required for calculation of capacity fade **Comment:** Requires definition of standardised conditions, among them discharge C-Rate, temperature and others	Battery passport scope	Ah	S
Remaining capacity	*Annex VII, Part A(1)*	Interested persons Unspecified	General definition see above. The corresponding in-use data attribute. **Comment:** Required for calculation of capacity fade **Comment:** Requires analysis of implementation during use and definition of standardised condition, among them discharge C-Rate, temperature and others	SBESS and LMT using a BMS **Voluntary** recommendation: battery passport scope	Ah	D
Capacity fade	*Annex IV, Part A(1)*, incl. definition.	Interested persons Upon placement on the market and change of status	"Decrease over time and upon usage in the amount of charge that a battery can deliver at the rated voltage, with respect to the original rated capacity declared by the manufacturer." **Comment:** Calculated based on rated and remaining capacity	Battery passport scope	%	D
Certified usable battery energy	Added by consortium, based on UNECE GTR No 22	Interested persons	The pre-use usable battery energy according to the procedure in the UNECE GTR as determined during the certification of the vehicle.	Not mandatory	kWh	S

[75] Access is derived from the respective wording of the Battery Regulation or categorised analogously to similar parameters, if added by the consortium.
[76] In this column, Terms in quotation marks originate from the battery regulation. See column "Regulation reference" for origin within the Regulation.
[77] Battery passport scope: Industrial (> 2 kWh), LMT and EV batteries; SBESS: Stationary battery energy storage systems.
[78] Abbreviations: S=Static, D=Dynamic.

Data attribute	Regulation reference	Data access[75] and update interval	Definition/Understanding[76]	Mandatory battery categories[77]	Unit	Data type[78]
			Comment: Not mandated by Battery Regulation as separate data attribute, but useful in context of SOCE and needed for its calculation. **Comment:** Applicable only to EV batteries due to vehicle-based testing requirements.	**Voluntary** recommendation for EV batteries		
Remaining usable battery energy	Added by consortium, based on UNECE GTR No 22	Interested persons, Unspecified	The in-use usable battery energy at the present point in the lifetime of a battery as determined according to the procedure in the UNECE GTR. **Comment:** Not mandated by Battery Regulation as separate data attribute but useful in context of SOCE and needed for its calculation. **Comment:** Applicable only to EV batteries due to vehicle-based testing requirements.	**Voluntary** recommendation for EV batteries	kWh	D
State of certified energy (SOCE)	UNECE GTR No 22; *Annex VII, Part A(1)*	Interested persons, Unspecified	The measured or on-board usable battery energy performance at a specific point in its lifetime, expressed as a percentage of the certified usable battery energy. **Comment:** Part of EU Commission's proposal for Euro 7 legislation	Only EV using a BMS	%	D
State of charge (SoC)	*Annex XIII 4(c)* Definition in *Article 2 – paragraph 1 (24)*	Interested persons, Unspecified	"The available energy in a battery expressed as a percentage of rated capacity." **Comment:** The consortium recommends change of the definition to "…expressed as a percentage of remaining capacity." **Comment:** The use case-oriented definition of the required update interval is particularly relevant for the highly frequently changing SoC. (See use case discussion in text)	Battery passport scope	%	D
Minimum voltage	*Annex XIII 1(j)*	Public	"Minimal, nominal and maximum voltage, with temperature ranges when relevant;" **Comment:** Minimal voltage the battery is rated for. **Comment:** The addition of "with temperature ranges when relevant" requires further elaboration.	Battery passport scope	V	S

Data attribute	Regulation reference	Data access[75] and update interval	Definition/Understanding[76]	Mandatory battery categories[77]	Unit	Data type[78]
Maximum voltage	*Annex XIII 1(j)*	Public	"Minimal, nominal and maximum voltage, with temperature ranges when relevant;" **Comment:** Maximum voltage the battery is rated for. **Comment:** The addition of "with temperature ranges when relevant" requires further elaboration.	Battery passport scope	V	S
Nominal voltage	*Annex XIII 1(j)*	Public	"Minimal, nominal and maximum voltage, with temperature ranges when relevant;" **Comment:** Nominal voltage the battery is rated for. **Comment:** The addition of "with temperature ranges when relevant" requires further elaboration.	Battery passport scope	V	S

Capacity, energy and voltage data attributes

State of certified energy (SOCE)

The UNECE Global Technical Regulations (GTR) No. 22 on in-vehicle battery durability (66) have been adopted by the EU and many other countries in April 2022. As a result, the UNECE GTR definition and minimum requirements for SoH decrease are included in *Article 6* of the European Commission's EURO 7 legislation proposal,[79] concerning vehicle-type approval information and thus only EV batteries.

The UNECE GTR No. 22 include a measurement standardisation referred to as "State of certified energy (SOCE)" (in %) which is based on the fade of usable battery energy (UBE). Further term definitions with regard to the UBE are provided below, which the consortium proposes to voluntarily add to the list of data attributes of the battery passport for EV batteries. All values will be accessible by interested persons (see also Table 17):

- "**Usable battery energy (UBE)** means the energy supplied by the battery from the beginning of the test procedure used for certification until the applicable break-off criterion of the test procedure used for certification is reached."
- "**State of certified energy (SOCE)** means the measured or on-board UBE performance at a specific point in its lifetime, expressed as a percentage of the certified usable battery energy."
- "**Certified usable battery energy** refers to the UBE that was determined during the certification of the vehicle, according to *Annex 3* of this GTR."
- "**Measured usable battery energy** means the UBE determined at the present point in the lifetime of the vehicle by the test procedure used for certification, according to *Annex 3* of this GTR."

It is important to note that the test procedure cannot be used for other battery categories than EV batteries because the references test in UNECE GTR No. 15 on worldwide harmonised light vehicles test procedures (WLTP) (67) uses a vehicle speed profile.

Rated capacity (*Annex XIII (1i)*, *Annex IV, Part A(1)*) is a highly relevant static data attribute that must be made publicly accessible. It is defined in *Annex IV* of the EU Battery Regulation as "the total number of ampere hours (Ah) that can be withdrawn from a fully charged battery under specific reference conditions". The **capacity fade** in % (*Annex IV, Part A(1)*) is mandatory content for all battery categories in the battery passport, which will be accessible to interested persons. It is calculated using rated and remaining capacity:

$$\text{Capacity Fade} = (\text{Remaining Capacity} / \text{Rated Capacity}) \times 100\%$$

Remaining capacity (*Annex VII, Part A(1)*) is the dynamic counterpart to rated capacity and is needed to determine capacity fade, although it is only mandatory to be reported in the battery passport for stationary battery energy storage systems and LMT batteries that use a BMS. The Battery Pass consortium recommends that all battery categories should report remaining capacity as it is available and relevant in any case. The measurement of both rated and remaining capacity requires the definition of standardised conditions, such as the battery

[79] Proposal for a regulation of the European Parliament and of the Council on type-approval of motor vehicles and engines and of systems.

charge and discharge rate (C-rate[80]), the time in between charge and discharge as well as the operating temperature.

The nominal voltage of a battery is included as a mandatory, battery model-specific data attribute available to the public in the battery passport (*Annex XIII 1(j)*). In addition to nominal voltage, the voltage limits as upper and lower boundary are required by the Battery Regulation. This minimum and maximum voltage should reflect the safety limits for the operation of the battery and its cells as defined by the manufacturer.

State of Charge (SoC)

The State of Charge (SoC) (*Annex XIII 4(c)*) is defined as the "available energy in a battery expressed as a percentage of rated capacity as declared by the manufacturer" (*Article 2(24)*). In practice, however, the state of charge is usually referenced to the remaining capacity, not to the rated. This disparity is not ideal, as the SoC reading – if defined as percentage of rated capacity – would never approach 100% for batteries with reduced remaining capacity, irritating end-users during charging and with significant consequences for data read-out for energy storage applications. The Battery Pass consortium **recommends to the European Commission changing the definition accordingly for application in the battery passport** as elaboration on many data attributes for the battery passport is still needed.

The update interval of the SoC in the battery passport is an additional point of discussion, which is not addressed in the EU Battery Regulation. The SoC is a highly fluctuating value due to the frequent charge or discharge of the battery during use. This poses a potential issue to record truly up-to-date SoC values for batteries. Use cases should be the origin for determining an update interval. In any case, the time stamp is particularly important in this case in order to identify whether data is up-to-date. With SoC being one of the most significant examples of how the use cases depends on the update interval, use cases are explored in more detail:

Use case 1: Dismantling of a battery usually requires the discharge of the battery. Therefore, knowledge of the SoC through the battery passport could be useful, particularly when no display is available. If dismantlers were to rely on the battery passport data, however, the SoC would need to be up-to-date, which may be difficult in practice as SoC will change during transport or storage. In addition, this raises the question of potential liability claims, if data is not up-to-date or wrong, causing an accident. This is currently not clarified in the Battery Regulation (see also chapter 5.2). Without liability on data correctness in the battery passport, the use case is unlikely to apply as dismantlers would need to safeguard their employees and perform checks for the SoC themselves.

Use case 2: Informing the end-user on the SoC through the battery passport would require constant up-to-date values. This, however, would usually be a duplicate to product interfaces, e.g., displays.

Use case 3: *Article 65 (2)* and *Article 14*, albeit for storage in the BMS, mention that information should be available "for the purpose of making the individual battery available to independent energy aggregators or energy market participants". This would be a use case, where the SoC would need to be made available frequently upon any change. A major question in this use case is, whether battery and grid should preferably be connected directly via a BMS system when a battery is charging instead of the detour via the battery passport. A potential lack of

[80] C-rate is a regularly used term defined as ratio of (dis-)charge current (in A) to the battery capacity (Ah). A C-rate of 1 h-1 (or "1C") is the (dis-)charge of a battery in one hour. Larger and smaller values refer to faster or slower (dis-)charge, respectively.

connectivity of non-stationary batteries must also be taken into account which may occur in case of an EV being parked underground, a significant defect or general lack of infrastructure.

Vital details for the use cases described above for including the SoC in the battery passport must be clarified for specifying its update interval. Considering all of the above, the Battery Pass consortium recommends to define the update of the SoC based on a detailed assessment on its feasibility and added value in practice. The use case for a highly frequent SoC update on the battery passport appears doubtful based on the above use case considerations. It could be reported only when a change in battery status is due as specified for data originating from *Article 10*.

6.7.2.2 Power capability

Battery power capability is referred to in different parts of the EU Battery Regulation as a relevant performance data attribute: Battery **original power capability and its limits** (interpreted **as maximum permitted battery power**) (*Annex XIII (1k)*, *"power" in Annex IV, Part A(2)*) and **power fade** (*Annex IV, Part A(2)*) need to be reported for the battery passport. **Remaining power capability** (*Annex VII, Part A(3)*) applies per regulation to **stationary battery energy storage systems and LMT batteries using a BMS and is qualified as "where possible"**, the meaning of which is not elaborated. It may be understood to mark the data attribute as optional. This restriction on battery categories does not make a difference in reporting effort, as power fade is based on remaining power capability. Consequently, consistency on including this information would mean either both values need to be optional/reduced in scope or none of them. Currently, the latter must be assessed in any case for the battery passport to provide the power fade data attribute. A list of data attributes regarding power capability is available in Table 18.

A standardised measurement procedure will need to be specified for the measurement of power capability. Only few measurement conditions are currently specified in the EU Battery Regulation: The power capability shall be determined **at two different SoC values: 80% and 20%** (*Annex IV, Part B(4)*), which would also be the basis for the power fade calculation. This specification of SoC, however, may be ill-defined for dynamic data because a SoC of 80% will differ for individual batteries depending on their ageing and reduced capacity, as it is usually defined in practice as a percentage of remaining energy or capacity[81] (see also chapter 6.7.2.1). Therefore, this definition should be reviewed. The measurement procedure will also require more detailed specification on charge/discharge, as well as the temperature range during measurement, which is mentioned in *Annex XIII* of the Battery Regulation. Furthermore, the point of measurement needs to be considered in the procedure, as large stationary battery energy storage systems in particular will include transformers and have potential points of measurements with different voltage.

[81] If the SoC definition remains based on rated capacity, a similar issue will arise. Battery ageing may lead to a lower remaining capacity so that the SoC cannot reach 80% of the rated capacity anymore in a later stage of battery lifetime, impeding the intended measurement.

Table 18: Data attributes regarding power capability

Data attribute	Regulation reference	Data access[82] and update interval	Definition/Understanding[83]	Mandatory battery categories[84]	Unit	Data type[85]
Original power capability	*Annex XIII (1k)*, *Annex IV, Part B(4)*	Public	"Original power capability (in Watts) and limits, with temperature range when relevant." "The amount of energy that a battery is capable to provide over a given period of time under reference conditions." **Comment:** *Annex IV, Part B(4)* →measurement at 80% and 20% SoC required. This requirement may not be implementable and should be reviewed together with SoC definition.	Battery passport scope	W	S
Power fade	*Annex IV, Part A(2)* (power fade)	Interested persons, Upon placement on the market and change of status	"Power fade (in %) means the decrease over time and upon usage in the amount of power that a battery can deliver at the rated voltage." **Comment:** *Annex IV, Part B(4)* → measurement at 80% and 20% SoC required. This requirement may not be implementable for remaining power capability and power fade. It, thus, should be reviewed together with SoC definition.	Battery passport scope	%	D
Remaining power capability	*Annex VII, Part A(3)*; *Annex IV, Part B(4)*	Interested persons, Upon placement on the market and change of status	Remaining power capability (in Watts) measured at 80% and 20% SoC, with temperature range when relevant. **Comment:** *Annex IV, B4* → measurement at 80% and 20% SoC required. This requirement may not be implementable and should be reviewed together with SoC definition. **Comment:** needed to calculate power fade.	SBESS and LMT using a BMS **Voluntary:** battery passport scope	W	D
Maximum permitted battery power	*Annex XIII (1k)*	Public	Maximum permitted power the battery is rated for, reflects the data relevant for "power limits".	Battery passport scope	W	S

[82] Access is derived from the respective wording of the Battery Regulation or categorised analogously to similar parameters, if added by the consortium.
[83] In this column, Terms in quotation marks originate from the Battery Regulation. See column "Regulation reference" for origin within the Regulation.
[84] Battery passport scope: Industrial (> 2 kWh), LMT and EV batteries; SBESS: Stationary battery energy storage systems
[85] Abbreviations: S=Static, D=Dynamic.

Data attribute	Regulation reference	Data access[82] and update interval	Definition/Understanding[83]	Mandatory battery categories[84]	Unit	Data type[85]
			"Original power capability (in Watts) and limits, with temperature range when relevant."			
Ratio between nominal battery power and battery energy	*Annex IV, Part B(2)*	Interested Persons Upon placement on the market and change of status	"Ratio between nominal battery power (W) and battery energy (Wh)" **Comment:** provides information on nominal/recommended charge rate (C-rate).	**Voluntary:** battery passport scope	1/h	S

There are concerns regarding the measurement of the **remaining power capability/power fade** at given SoC values during everyday battery use. Comparability of the data attribute requires that the respective data attributes are determine within the given specification of SoC, the problems of which have been discussed above already for original power capability. In addition – as with remaining round trip energy efficiency (see chapter 6.7.2.3) – an everyday assessment of the data attribute, to keep it up-to-date, would unduly consume energy. A physical measurement of the data attribute in the case of an operating EV or LMT battery would also require the use of a chassis dynamometer. Even when assumed that vehicles would require only one chassis dynamometer test a year to keep the value "up-to-date", it would require very high effort and many hours for testing this value alone on millions of EVs and industrial batteries. The consortium therefore recommends that the update frequency of remaining power capability and power fade would be infrequent. This recommendation does not concern initial power capability as battery model-specific value.

The consortium recommends that the measurement for the remaining power capability during the use phase should not be included as an up-to-date value in the BMS, but instead measured and made available in the battery passport when the battery status is subject to change by economic operators, or a third-party acting on their behalf. This for example means that a battery should be evaluated before a sale or transition to a second life to reflect the remaining power capability. This would reduce the major effort necessary for measuring the data attribute but still provide information for the most relevant use cases.

The **ratio of nominal battery power and battery energy** is not a mandatory data attribute but named as an element to be used for the explanation of measurements (*Annex IV, Part B*) for the data attributes in *Annex IV, Part A*. It can also be understood as C-rate in standard use. Generally, this value is used to assess, whether a cell or battery is rather designed to provide much power over short periods of time (high value) or low power over a longer period of time (low value). Its correlation with the performance data attributes mandated in *Annex IV, Part A* is not described in the Battery Regulation. It may provide information on nominal/recommended charge rate (C-rate), which could be included in the battery passport voluntarily.

6.7.2.3 Round trip energy efficiency and self-discharge

Round trip energy efficiency

Round trip energy efficiency is mentioned in different parts of the Battery Regulation and conveys the energy efficiency during a cycle of discharge and recharge of the battery in specific conditions. Please see Table 19 for an overview on round trip energy efficiency data attributes. The data attribute is defined as the "ratio of the net energy delivered by a battery during a discharge test to the total energy required to restore the initial State of Charge by a standard charge" (*Annex IV*).

Initial round trip energy efficiency and at 50% of cycle-life (*Annex XIII (1p)*) are static data on the battery model level, while **remaining round trip energy efficiency** and **round trip energy efficiency fade** are mentioned as in-use data attributes (*Annexes IV, Part A(4)* and *VII, Part A(4)*). The latter two are qualified with "where applicable/where possible", the meaning of which is not elaborated. It may be interpreted to mark the data attribute as "optional".

Table 19: Data attributes regarding round trip energy efficiency

Data attribute	Regulation reference	Data access[86] and Update interval	Definition/Understanding[87]	Mandatory battery categories[88]	Unit	Data type[89]
Initial round trip energy efficiency	*Annex XIII (1p)* *Annex IV, Part A(4)* (definition)	Public	"Initial round trip energy efficiency" "Ratio of the net energy delivered by a battery during a discharge test to the total energy required to restore the initial State of Charge by a standard charge." **Comment:** Pre-use data attribute, measurement conditions yet to be specified. **Comment:** "Where applicable" (*Annex IV*) not applying as also listed in *Annex XIII*.	Battery passport scope	%	S
Round trip energy efficiency at 50% of cycle-life	*Annex XIII (1p)* *Annex IV, Part A(4)* (only definition)	Public	"[...] round trip energy efficiency [...] at 50% of cycle-life." **Comment:** Measured at 50% of cycle-life as determined in a pre-use standardised measurement, that must yet be specified. **Comment:** "Where applicable" (*Annex IV*) not applying as also listed in *Annex XIII*. **Comment:** Standardised conditions should consider non-cycle applications and batteries with very long cycle life.	Battery passport scope	%	S
Remaining round trip energy efficiency	*Annex VII, Part A(4)*	Interested persons Upon placement on the market and change of status	"Where possible, remaining round trip efficiency"; General definition see above; The in-use remaining round trip energy efficiency. **Comment:** Wording "where possible" regarding scope must be elaborated. **Comment:** also needed to calculate energy round trip efficiency fade.	"where possible" SBESS and LMT using a BMS	%	D

[86] Access is derived from the respective wording of the Battery Regulation or categorised analogously to similar parameters, if added by the consortium.
[87] In this column, Terms in quotation marks originate from the battery regulation. See column "Regulation reference" for origin within the Regulation.
[88] Battery passport scope: Industrial (> 2 kWh), LMT and EV batteries; SBESS: Stationary battery energy storage systems.
[89] Abbreviations: S=Static, D=Dynamic.

Data attribute	Regulation reference	Data access[86] and Update interval	Definition/Understanding[87]	Mandatory battery categories[88]	Unit	Data type[89]
Energy round trip efficiency fade	*Annex IV, Part A(4)*	Interested persons, Upon placement on the market and change of status	"Where applicable, energy round trip efficiency and its fade (in %)". Decrease of round trip energy efficiency as percentage. **Comment:** Wording "where applicable" regarding scope must be elaborated.	"where applicable" battery passport scope	%	D
Initial self-discharging rate	*Annex VII, Part A(6)*	Interested persons, Unspecified	"Evolution of self-discharging rates"; No additional definition given in Regulation. **Comment:** Initial and current self-discharging rate needed to calculate evolution of self discharge. Self-discharge in % of capacity per unit of time in defined conditions (temperature range etc.) as pre-use data attribute.	SBESS and LMT using a BMS	%/h	S
Current self-discharging rate	*Annex VII, Part A(6)*	Interested persons, Unspecified	"Evolution of self-discharging rates"; No additional definition given in Regulation **Comment:** Initial and current self-discharging rate needed to calculate evolution of self-discharge. Self-discharge in % of capacity per unit of time in defined conditions (temperature range etc.) during the use phase.	SBESS and LMT using a BMS	%/h	D
Evolution of self-dischar-ging rates	*Annex VII, Part A(6)*	Interested persons, unspecified	"Evolution of self-discharging rates", no further definition given in Regulation. **Comment:** The increase of self-discharging rates as percentage with reference to the initial and current self-discharging rate. **Comment:** Calculated from initial and current self-discharging rate	SBESS and LMT using a BMS	%	D

Generally, standardised conditions are required for the respective test method of the round-trip energy efficiency, among those the **applied charge and discharge rate** (*Annex IV, Part B*), start and end values of the SoC as well as temperature. The specification of standardised conditions for the round-trip energy efficiency at 50% of cycle-life should also consider non-cycle applications and batteries with very long cycle-life. In addition, the point of measurement is relevant to round trip energy efficiency, as large stationary battery energy storage systems in particular will include transformers and have different potential points of measurements that would yield diverging results.

The measurement of **remaining round trip energy efficiency** would also include efficiency loss through the charging infrastructure used for the measurement. This complicates the standardisation of the measurement conditions. End-user charging infrastructure may very well not be able to deliver standard conditions required. Moreover, keeping this data attribute up-to-date or in real time in the BMS causes an overall high number of measurement procedures of discharge and recharge, which would contribute to ageing of the battery and energy consumption.

The consortium recommends that the update interval for measurement of the remaining round trip energy efficiency during the use phase should be infrequent, potentially to be made available in the battery passport when the battery status is subject to change by economic operators, or a third-party acting on their behalf. This means that a battery could be tested before a sale or transition to a second life for example to reflect the remaining round trip energy efficiency. In addition, the measurement shall be based on standardised test procedures which must be developed.

Evolution of self-discharging rates

Self-discharging rates are interpreted as a measure of energy efficiency of a battery as it describes the loss of charge over a period of time. Self-discharging of batteries is usually slow, e.g., in in current lithium-Ion batteries within a range of a several percentage points per month. The frequent use of a battery impedes a meaningful in-use measurement because the corresponding test procedure would require a long run time, during which the device would not be available. The consortium therefore recommends specifying an infrequent update interval for evolution of self-discharging rates.

If the Battery Regulation intends the data attribute to generally ensure battery quality in terms of self-discharge, the self-discharging rate could be added as a pre-use, battery model-specific data attribute (*Annex XIII, Part A*), which is measured in standardised, specific conditions, but not during the battery use life. Such conditions would need to take the battery design into account, where high temperature batteries for example, may need to be considered separately.

6.7.2.4 Internal resistance

Internal resistance is mentioned in different parts of the Battery Regulation and is an indicator for irreversible ageing of the battery cell, module, or pack. Correspondingly, the resistance within a battery pack reflects the overall picture on these ageing processes within the battery components. In addition, higher resistance in the electrical circuit causes lower energy efficiency. For an overview on data attributes regarding internal resistance and electrochemical impedance see Table 20.

Table 20: Data attributes regarding internal resistance and electrochemical impedance

Data attribute	Regulation reference	Data access[90] and update interval	Definition/Understanding[91]	Mandatory battery categories[92]	Unit	Data type[93]
Initial internal battery cell/ module/ pack resistance[94]	*Annex XIII (1q)* *Annex IV, Part A(3)* (definition of internal resistance) *Annex VII, Part A(7)* ("where possible, ohmic resistance")	Public	"The opposition to the flow of current within a cell or a battery under reference conditions that is, the sum of electronic resistance and ionic resistance to the contribution to total effective resistance including inductive/capacitive properties." **Comment:** Measurement of internal resistance on battery cell, module and pack level as pre-use data attribute. **Comment:** Needed for calculating resistance increase.	Battery passport scope (cell and pack level) **Voluntary:** model level	Ω	S
Current internal battery cell/ module/ pack resistance	*Annex IV, Part A(3)* *Annex VII, Part A(7)* ("where possible, ohmic resistance")	Interested persons, Upon placement on the market and change of status	Definition of internal resistance see above. **Comment:** Measurement of internal resistance on battery cell, module and pack level during the use phase. **Comment:** Needed for calculating resistance increase.	Battery passport scope (pack level) **Voluntary:** cell and model level	Ω	D
Internal battery cell/ module/ pack resistance increase	*Annex IV, Part A(3)* *Annex VII, Part A(7)* ("where possible, ohmic resistance")	Interested persons, Upon placement on the market and change of status	No definition provided. **Comment:** Increase of internal resistance in % as calculated from current and initial values.	Battery passport scope (pack level) **Voluntary:** cell and model level	%	D

[90] Access is derived from the respective wording of the Battery Regulation or categorised analogously to similar parameters, if added by the consortium.
[91] In this column, Terms in quotation marks originate from the Battery Regulation. See column "Regulation reference" for origin within the regulation.
[92] Battery passport scope: Industrial (> 2 kWh), LMT and EV batteries; SBESS: Stationary battery energy storage systems.
[93] Abbreviations: S=Static, D=Dynamic.
[94] For this and the following data attributes Cell/Module/Pack values will be separate. Not discerned here to avoid repetition.

Internal resistance is specified as a pre-use model-specific data attribute on both the battery pack level and – as the only data attribute in the battery passport - on the battery cell level (*Annex XIII, (1q)*). The consortium recommends to voluntarily provide the internal resistance on module level, if applicable, to provide a full picture of resistance in a battery. In addition, the **internal resistance increase in %** is mentioned as a data attribute for individual batteries (*Annex IV, Part A(3)*) and thus requires the measurement of current internal resistance during the use phase, which must be made available upon change of battery status, i.e. an infrequent update interval for the measurement of internal resistance increase.

Measurement details:

The measurement of both internal resistance and electrochemical impedance (both in the unit Ohm (Ω)) requires a standardised test procedure to obtain comparable values. The internal resistance is measured in a direct current (DC) circuit.

The internal resistance can be assessed by applying a current pulse for a defined time and evaluating the resulting voltage drop of the cell or battery pack after the current pulse.[95] The DC resistance is usually evaluated at short timescales, which usually are in the range of a few milliseconds to 30 seconds. The data attributes to be defined for a standardised measurement include the current, the duration of the current pulse, temperature and SoC in the measurement.

6.7.3 Battery durability data attributes

Battery durability is a key characteristic for any purchase decision on a battery. Durability information may be provided as static pre-use information or as a measure of effects of the use-phase on a given battery. Durability is defined as “the ability of a product to function as required, under specified conditions of use, maintenance and repair, until a limiting event prevents its functioning” according to the ESPR proposal (6), *Article 2 (21)*.

The data attributes relevant for durability encompass the topics of battery lifetime, environmental conditions such as temperature and negative events which are discussed in the respective chapters.

6.7.3.1 Battery lifetime

Battery lifetime is a key measure of durability that provides crucial information to the economic operator or the battery end-user. The data attributes described below are mandatory per EU Battery Regulation to report on pre-use expected lifetime or on in-use information. An overview on these data attributes is provided in Table 21.

[95] For a detailed analysis, internal resistance may be measured as a function of the duration of the current pulse, which allows to evaluate the influence of internal processes. Such a detailed measurement, however, is beyond the scope of data in the battery passport.

Table 21: Data attributes regarding battery lifetime

Data attribute	Regulation reference	Data access[96] and update interval	Definition/Understanding[97]	Mandatory battery categories[98]	Unit	Data type[99]
Expected lifetime: Number of charge-discharge cycles	*Annex XIII (1l)* *Annex IV, Part A(5)*	Public	"Expected battery lifetime expressed in cycles, and reference test used" (*Annex XIII*). "Their expected life-time under the reference conditions for which they have been designed in terms of cycles, except for non-cycle applications, and calendar years." (*Annex IV*) **Comment:** The exception for non-cycle applications appears sensible, but is not included in the Annex XIII provision. **Comment:** The data attribute is defined by measurement conditions of the cycle-life test such as the C-Rate (see below) and the depth of discharge in the cycle-life test	Battery passport scope	-	S
Number of full charging and discharging cycles	*Annex XIII, (4c)* *Annex VII, Part B(5)*	Interested persons,	In-use number of (full) charging and discharging cycles. **Comment:** Can only be based on addition of partial cycles, which occur in the use phase.	Battery passport scope	-	D
Cycle-life Reference test	*Annex XIII (1l)* *Annex IV, Part A(5)*	Public	Name of reference test for "Expected lifetime: Number of charge-discharge cycles" (see above).	Battery passport scope	-	S
C-rate of relevant cycle-life test	*Annex XIII (1r)*	Public	Measurement parameter for "Expected lifetime: Number of charge-discharge cycles": Applied charge and discharge rate (C-rate) of relevant cycle-life reference test (see above).	Battery passport scope	-	S

[96] Access is derived from the respective wording of the Battery Regulation or categorised analogously to similar parameters, if added by the consortium.
[97] In this column, Terms in quotation marks originate from the battery regulation. See column "Regulation reference" for origin within the Regulation.
[98] Battery passport scope: Industrial (> 2 kWh), LMT and EV batteries; SBESS: Stationary battery energy storage systems.
[99] Abbreviations: S=Static, D=Dynamic.

Data attribute	Regulation reference	Data access[96] and update interval	Definition/Understanding[97]	Mandatory battery categories[98]	Unit	Data type[99]
Energy throughput	*Annex VII, Part B(2)*	Interested persons, Upon placement on the market and change of status	Overall sum of the energy throughput over the battery lifetime. **Comment:** The data attribute should be reported as measured for further potential processing. In addition, the normalisation by usable battery energy could add a further useful value that ensures comparability among battery sizes.	SBESS and LMT using a BMS	kWh	D
Capacity throughput	*Annex VII, Part B(3)*	Interested persons, Upon placement on the market and change of status	**Comment:** Overall sum of the capacity throughput over the battery lifetime **Comment:** The data attribute should be reported as measured for further potential processing. In addition, the normalisation by capacity could add a further useful value that ensures comparability among battery sizes.	SBESS and LMT using a BMS	Ah	D
Capacity threshold for exhaustion	*Annex XIII (1m)*	Public	"Capacity threshold for exhaustion" **Comment:** This data attribute is understood as minimum percentage of rated capacity, above which the battery is still considered operational as EV battery in its current life, provided by economic operator. **Comment:** This data attribute may serve as indicator for a necessary end of current life as EV and may be understood in the context of warranty. A clarified definition is required. **Comment:** Recommended to the Commission to be replaced by "SOCE threshold for exhaustion" (see below) as it appears sensible to adapt the reference unit to SOCE, which is the main data attribute for EV state of health reporting (see below).	EV	%	S

Data attribute	Regulation reference	Data access[96] and update interval	Definition/Understanding[97]	Mandatory battery categories[98]	Unit	Data type[99]
SOCE threshold for exhaustion	Added by consortium	Public	**Comment:** Derived as analogous to "Capacity threshold for exhaustion" and recommended to the EU Commission as its replacement. **Comment:** Minimum percentage of SOCE (see chapter 6.7.2.1), above which the battery is still considered operational as EV battery in its current life, provided by economic operator.	**Voluntary:** EV (see comment)	%	S
Warranty period of the battery	*Annex XIII (1o)*	Public	**Comment:** Period for which the commercial warranty for the calendar life applies.	Battery passport scope	years	S
Date of manufacturing of the battery	*Annex VII, Part B(1)*	See comment	**Comment:** See chapter 6.1.4 for more details as the Battery Regulation mentions manufacturing date multiple times for the battery passport.	See comment	-	S
Date of putting the battery into service	*Annex VII, Part B(1)*	Interested persons; Upon placement on the market and change of status	The date on which a battery is being put into service. **Comment:** Wording "(where appropriate)" is not elaborated, but may apply after the battery being put into service (for meaning of putting into service, see chapters 4.3 and 5.2).	SBESS and LMT using a BMS (where appropriate)	-	S

Battery lifetime in terms of cycles

Annex XIII (1l) and *Annex IV, Part A(5)*[100] list the **pre-use "expected lifetime expressed in cycles"** as a data attribute, which will be accessible publicly and is specific to the battery model. Based on the differing wording of the annexes there may be an exception for non-cycle applications, such as batteries in an uninterruptible power supply system, which remains to be specified. The data attribute is based on a certain standardised user profile that the cycle-life **"reference test used"** (*Annex XIII (1l)*) describes. The test requires the **definition of measurement conditions**, which should include, among others, the C-rate (added in *Annex XIII (1r)*), depth of discharge (mentioned in *Annex IV, Part B(3)*), voltage limits, and temperature during measurement. The measurement of charge-discharge cycles will thus provide a pre-use battery lifetime value that is comparable among different batteries for a standardised user profile.

The **in-use**[101] **number of (full) charge-discharge cycles** is mentioned in *Annex XIII 4(c)* and listed in *Annex VII, Part B(5)* for determining the battery lifetime without any further definition provided. It thus applies **to full battery passport scope**. This data attribute could be intended to provide an estimate of remaining lifetime by comparing it to the expected lifetime. In the use-phase, however, few, if any, charge-discharge cycles will be complete (full) as the use pattern for individual batteries will vary significantly. In particular, the number of charge-discharge cycles cannot reflect whether the battery was used moderately or intensely, i.e. how many of the cycles were fast-charging processes and fast-discharging during use, which has major impact on battery lifetime. As a result, the in-use number of full charging and discharging cycles does not convey valid information on the lifetime of an individual battery. Moreover, it will not be comparable to the pre-use data attribute described above.

Overall and based on the information available, the in-use number of full charging and discharging cycles is limited in providing the information it may have been intended for. The Battery Pass consortium therefore recommends reviewing its added value in the battery passport in future iterations of the EU Battery Regulation.

Battery lifetime in terms of calendar years

A data attribute on the battery lifetime in terms of calendar years may be understood more easily by end-users than a pre-use number of charge-discharge cycles. A guaranteed pre-use expected lifetime is provided by the **commercial warranty period**, that is mandatory information for the battery passport (*Annex XIII (1o)*). The commercial warranty period of the battery typically assures a minimum remaining capacity or SOCE over a certain period of time or usage, which both need to be included for the battery passport for a full understanding. Furthermore, the requirement to provide **the battery lifetime in terms of calendar years (***Annex IV, Part A(5)***) is included**. This value may differ from or be identical to the commercial warranty period given above. It is important to note that the factual battery lifetime will usually exceed the warranty period.

[100] *Annex XIII*: "Expected battery lifetime expressed in cycles, and reference test used" *Annex IV*: "Their expected life-time under the reference conditions for which they have been designed in terms of cycles, except for non-cycle applications, and calendar years."
[101] The "in-use" characterisation is based on the mention in *Annex XIII, 4c* regarding data relating to individual batteries and the intention of *Article 14/Annex VII* to report up-to-date data.

While the EU Battery Regulation includes a general definition of "lifetime",[102] the data attributes above will only describe the lifetime for the intended application, as the economic operator placing the battery on the market cannot account for a potential second-life, where the battery may be used in an application with differing performance demands (see also chapters 4.3 and 5.3).

In the context of expected lifetime in calendar years, the EU Battery Regulation further includes the **date of manufacturing (see also chapter 6.1.4) and, where appropriate, the date of putting into service** in the lifetime-relevant data attributes (*Annex VII, Part B(1)*).

Capacity and energy threshold for exhaustion

The Battery Regulation mandates **capacity threshold for exhaustion (***Annex XIII (1m)***) for EV batteries only** and lacks further definition. The Battery Pass consortium interprets the intended data attribute as the value of remaining capacity in %, below which the economic operator of the EV battery deems the battery capacity as insufficient for further use as EV battery in its current life. This could be related to current practice of describing the commercial warranty with respect to a certain minimum SoH level. Further context, however, is required for a correct understanding of this data attribute.

Based on the above interpretation, this data attribute should be aligned with the choice of SOCE as the specific SoH data attribute (see chapter 6.7.2.1) in order to emphasise that the SOCE is the major data attribute to consider. Therefore, the consortium recommends replacing the capacity threshold for EV batteries by a **SOCE threshold for exhaustion in %**.

Energy and capacity throughput

The list of data attributes for determining the battery lifetime (*Annex VII*) furthermore comprises **"energy throughput" and "capacity throughput", which apply only to LMT batteries and stationary battery energy storage systems that use a BMS**. The data attributes are interpreted as the aggregated energy in kWh or capacity in Ah aggregated over the battery lifetime during use. They are similar to the **in-use number of full charging and discharging cycles (see above)**, as they also do not describe details of the battery use phase and aggregate (partial) discharge. Their measurement is simpler and more applicable than the in-use number of full charging and discharging cycles. On a voluntary basis, the values could additionally be provided as normalised to the equivalent full cycle. That means that the obtained values must be divided by the usable energy or capacity, respectively, of a full cycle, which is also made available via the battery passport (see chapter 6.7.2.1). This calculation provides a value that is comparable among different battery sizes. If only the non-normalised value is provided batteries with large capacity or energy will always show higher values for energy and capacity throughput than smaller batteries.

6.7.3.2 Temperature conditions

Batteries will be used in varying environmental conditions, which will impact battery durability. Temperature, in particular, has significant effects on ageing processes within the battery. Table 22 provides an overview on the data attributes for temperature conditions.

[102] "Lifetime" of a battery means the period of time that starts when the battery is manufactured, and ends when the battery becomes waste.

Table 22: Data attributes regarding temperature conditions

Data attribute	Regulation reference	Data access[103] and Update interval	Definition/Understanding[104]	Mandatory battery categories[105]	Unit	Data type[106]
Temperature range idle state (lower boundary)	*Annex XIII (1n)*	Public	Lower boundary of the surrounding temperature range. **Comment:** This attribute reflects the lower temperature limit the battery can safely withstand.	Battery passport scope	°C	S
Temperature range idle state (upper boundary)	*Annex XIII (1n)*	Public	Upper boundary of the surrounding temperature range. **Comment:** This attribute reflects the upper temperature limit the battery can safely withstand.	Battery passport scope	°C	S
Time spent in extreme temperatures above boundary	*Annex VII, Part B(4)* *(Annex XIII (4c))*	Interested persons, Unspecified	Aggregated time spent above the given upper boundary of temperature. (see temperature range above). **Comment:** Annex XIII ("periodically recorded information on the operating environmental conditions, including temperature") demands temperature information for the battery passport scope, but does not specify further. We interpreted that data named in Annex VII would likely be the relevant concrete information.	Battery passport scope (interpreted, see comment)	minutes	D
Time spent in extreme temperatures below boundary	*Annex VII, Part B(4)* *(Annex XIII (4c))*	Interested persons, Unspecified	Aggregated time spent below the given lower boundary of temperature (see temperature range above). **Comment:** Interpretated as mandatory battery passport scope, see above in "time spent in extreme temperatures above boundary".	Battery passport scope (interpreted, see comment)	minutes	D

[103] Access is derived from the respective wording of the Battery Regulation or categorised analogously to similar parameters, if added by the consortium.
[104] In this column, terms in quotation marks originate from the battery regulation. See column "Regulation reference" for origin within the Regulation.
[105] Battery passport scope: Industrial (> 2 kWh), LMT and EV batteries; SBESS: Stationary battery energy storage systems
[106] Abbreviations: S=Static, D=Dynamic.

Data attribute	Regulation reference	Data access[103] and Update interval	Definition/Understanding[104]	Mandatory battery categories[105]	Unit	Data type[106]
Time spent charging during extreme temperatures above boundary	*Annex VII, Part B(4)* *(Annex XIII (4c))*	Interested persons, Unspecified	Aggregated time spent charging above the given upper boundary of temperature (see temperature range above). **Comment:** Interpretated as mandatory battery passport scope, see above in “time spent in extreme temperatures above boundary”.	Battery passport scope (interpreted, see comment)	minutes	D
Time spent charging during extreme temperatures below boundary	*Annex VII, Part B(4)* *(Annex XIII (4c))*	Interested persons, Unspecified	Aggregated time spent charging below the given lower boundary of temperature (see temperature range above). **Comment:** Interpretated as mandatory battery passport scope, see above in “time spent in extreme temperatures above boundary”.	Battery passport scope (interpreted, see comment)	minutes	D

In order to inform end-users and economic operators on operating boundaries, the Battery Regulation mandates (*Annex XIII (1n)*) the economic operator to provide **static data on the temperature range, i.e., a lower and an upper boundary** in degree Celsius, that a battery can "withstand when not in use". Since temperature safety limits usually apply to the battery at all times, a distinction between operation and idle state is not required from the Battery Pass consortium's point of view.

In addition, *Annex XIII (4c)* states that "periodically recorded information on the **operating environmental conditions, including temperature**", i.e. in-use temperature data should be part of the battery passport. This is interpreted as a monitoring of battery temperature that applies to the **full battery passport scope in terms of battery categories**. Therefore, further data attributes (*Annex VII, Part B(4)*), which describe this temperature monitoring in more detail, but are restricted to LMT batteries and stationary battery energy storage systems using a BMS, are interpreted to apply to the full scope as well. The data attributes named in *Annex VII* are **"time spent in extreme temperatures"** and the time the battery spends **"charging during extreme temperatures"**.

Any temperature measurement on an in-use battery will need to be defined in much more detail. Specifically, the location of temperature sensors will decide upon the merit of values provided in temperature data attributes and their applicability to the entire battery, which may encounter temperature gradients. In addition, "extreme" temperatures lack definition in the EU Battery Regulation. The range of operating temperature described above could be considered to set the boundaries, which, however, reflects safety limits that the BMS will usually not allow to exceed, by limiting the battery performance for example.

With regard to "time the battery spends in extreme temperatures" it should be considered additionally that the BMS and, in case of an EV battery the 12 V electrical circuit, would need to operate constantly to power the instrumentation monitoring the battery temperature – with corresponding energy consumption. In case of an EV battery, the high voltage storage may have to be started periodically as well to power the 12 V system (depending on the design of the 12 V system). In order to reduce this **unwanted energy consumption**, one option is to record the battery temperature periodically. This approach, however, would potentially miss high temperature events, rendering the value provided incomplete and potentially misleading.

In view of these limitations, the overall added value of the data attributes regarding time spent in extreme temperatures is unclear, pending more context on their intended definition. Due to the abovementioned challenges to the measurement and relevance of the data attributes on in-use temperature, the consortium recommends providing more detailed elaboration on how valuable data should be provided. In addition, the data attributes should be distinguished by upper and lower boundary temperature.

6.7.3.3 Negative events

An overview on the following data attributes for negative events is provided in Table 23.

Table 23: Data attributes regarding negative events

Data attribute	Regulation reference	Data access[107] and update interval	Definition/ Understanding[108]	Mandatory battery categories[109]	Unit	Data type[110]
Number of deep discharge events	*Annex VII, Part B(4)*	Interested persons; Unspecified	No further definition provided. **Comment:** Threshold level must be determined for deep discharge.	LMT batteries and SBESS using a BMS	-	D
Number of overcharge events	Added by consortium	Interested persons; Unspecified	**Comment:** Added by consortium as voluntary data attribute due to potential relevance for battery ageing. **Comment:** Threshold level must be determined for deep discharge.	**Voluntary:** battery passport scope	-	D
Information on accidents	*Annex XIII (4c)*	Interested persons; Unspecified	"Negative events, such as accidents". **Comment:** No further definition provided, but crucial for implement-tation and added value.	Battery passport scope	-	D

Number of deep discharge events

The **number of deep discharge events** is mentioned in the EU Battery Regulation as a part of the tracking of harmful events that applies to **LMT batteries and stationary battery energy storage systems using a BMS** (*Annex VII, Part B(4)*). It could be of interest to mandate the reporting also for other battery categories like EV or all industrial batteries with a BMS. The data attribute is relevant for determining the expected lifetime of a battery. A deep discharge of the battery may lead to irreversible damage to a battery because of deterioration of active material. Any effects of material deterioration within the battery will, however, also be reflected quantitatively in the measurements of performance data attributes. As a result, the data

[107] Access is derived from the respective wording of the Battery Regulation or categorised analogously to similar parameters, if added by the consortium.
[108] In this column, terms in quotation marks originate from the battery regulation. See column "Regulation reference" for origin within the Regulation.
[109] Battery passport scope: Industrial (> 2kWh), LMT and EV batteries; SBESS: Stationary battery energy storage systems
[110] Abbreviations: S=Static, D=Dynamic.

attribute adds value to identify origins for battery performance deterioration and potential safety implications.

Deep discharge events are usually detected by a drop in voltage below the operational limits. In current battery systems with a BMS, the BMS monitors the voltage value and usually prevents the battery from a deep discharge and material deterioration during operation. Therefore, the number of deep discharge events may often remain at zero. If circumstances still lead to a deep discharge event, as it is observed in the field, the battery will be out of operation and subject to a detailed examination, which could provide additional information on other data attributes.

The number of overcharge events could be added voluntarily to the battery passport under appropriate definition. The abovementioned discussion applies analogously.

Recording of accidents

In addition to environmental conditions, negative events such as accidents have been added to the list of mandatory battery passport data attributes (*Annex XIII (4c)*) without further specification. An added value of the availability of an accident history is increased work safety during dismantling of the battery pack and module.

The monitoring of accidents generally raises the question on the quality of information that is provided, because information about an accident does not allow a specific conclusion on potential damage to the battery, which depends on accident type and intensity. A recording of a minor accident, which does not affect the battery, could wrongly imply that the battery is damaged, and unnecessarily diminish its second-life potential.

Thus, the implementation of monitoring accidents is crucial for the added value of the data attribute, but complicated: For EV batteries the recording of an accident in the battery passport could be required after activation of an airbag, which would rule out the recording of very minor accidents. For other battery categories, it is also not clear, as there is usually no adequate sensor available. In any case, the sheer reporting of an accident would not cover the impact of an accident on the battery. In addition, relevant accidents are followed up by a professional check of the battery assessing potential damage. To include valuable information on accidents and battery assessment would thus mean manual recording. That in turn requires standardisation of reporting on the accident and effects on the battery to make it machine-readable, which would need to be developed first and cover all potential effects from accidents.

The abovementioned limitations on the process of recording accidents, however, make it appear doubtful, whether the history on accidents, and most importantly their effects on the battery, can be complete and contribute to improve safety of battery handling.

Based on the lack of context, the Battery Pass **consortium is sceptical whether the data attribute can provide useful information** due to likely incomplete data and its difficult interpretation. As the data attribute is included in the battery passport, it is important to provide information on the intended scope, recording process and interpretation of the data attribute.

7 Outlook

This document represents the first publicly available comprehensive guidance to responsible economic operators and other battery value chain participants on how to interpret the battery passport content requirements of the new EU Battery Regulation as well as how to achieve increased sustainability and circularity. Based on extensive discussions with the consortium partners, dozens of expert interviews with external organisations from the broader battery passport ecosystem and intense exchanges with regulators, the Battery Pass assessed and translated the legislative requirements into recommendations for the industry.

As a multi-stakeholder initiative, we appreciate different perspectives to ensure the best possible impact through commonly aligned and accepted results – therefore, we welcome your feedback on the document and encourage you to reach out to us.

While the work of the Battery Pass consortium on the Content Guidance concludes for the time being – since shifting the attention to other elements of the overall project scope (technical standards, demonstrator development and value assessment) – certain aspects around the content requirements might not have been (sufficiently) answered yet and offer room for further clarification and engagement. Table 24 below provides an initial overview on these aspects sorted by the (sub-) chapters of this guidance:

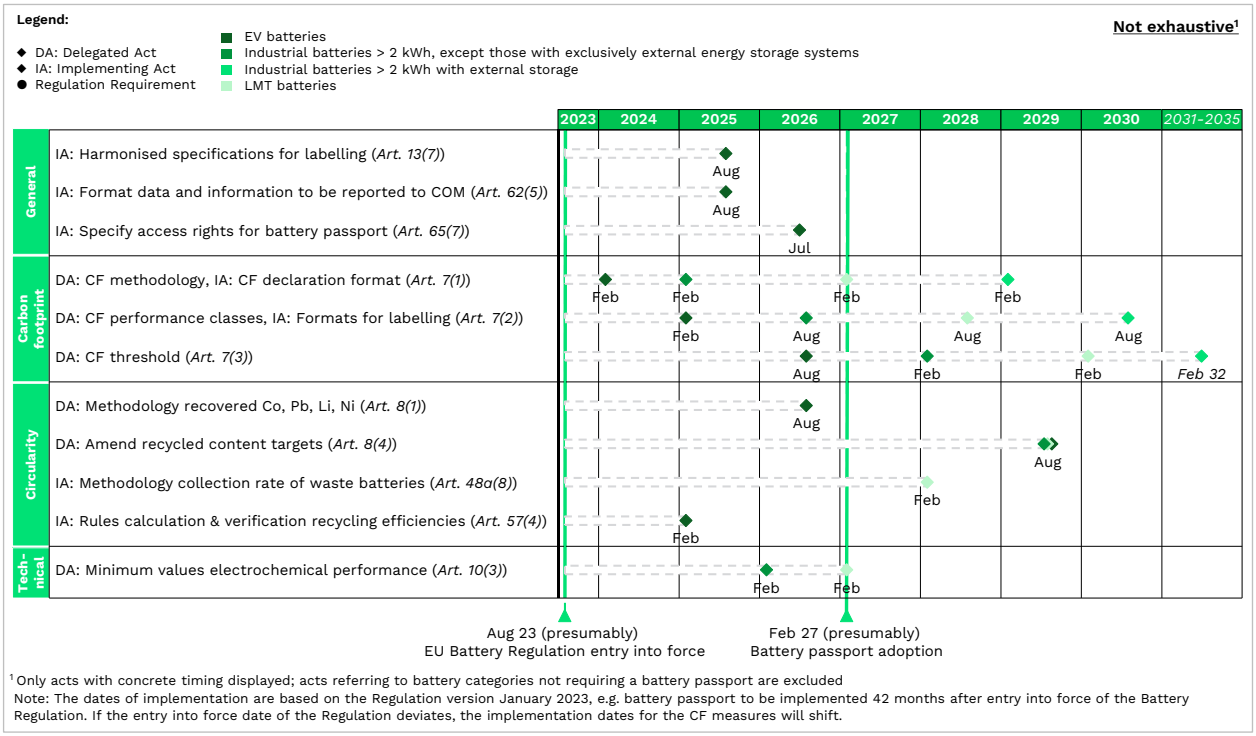
Table 24: Remaining aspects for future clarification and engagement

Chapter	Chapter title	Topic
5.2.	Responsibility and liability	• Scope of “putting into service” activity (inclusion of test batteries and possibility to be carried out by importers) • Responsibility for data transferred from original battery passport(s) • Europe-wide public-legal and possibility of civil-legal consequences in case of non-compliance
5.3.	Battery handling operations	• Elaborate on implications of repair for the battery passport in the context of the definitions of re-use/repurpose • Distinction between waste and non-waste batteries in practice, in view of the definitions of battery handling operations and the implications for transport • Define “ceasing to exist” of a battery passport with regard to continued storage of battery passport data • Clarification of the term and scope of “recycled”, including the different recycling steps, and which end-of-life information should be included in the battery passport
6.3.	Battery carbon footprint	• Update of Battery Pass Rules based on developments after April 2023, particularly the development and specification of the CFF • Specification of carbon footprint rules for industrial and LMT batteries and other chemistries, including methodology to account for second life applications
6.4.	Supply chain due diligence	• Further elaboration and alignment of industry on the implementation of additional voluntary supply chain due diligence information via the battery passport • Deep dive on due diligence requirements beyond the Battery Regulation (e.g., EU CSDDD and national supply chain acts) including strategies to meet these

Chapter	Chapter title	Topic
6.5	Battery materials and composition	• Agreement on nomenclature (e.g., chemistry, related identifiers, materials, substances), specific requirements for unique identifiers, and weighing approach, based on Battery Pass recommendations • Reporting specifications (e.g., detailed approach for materials, hazardous substances, and manufacturing place), based on Battery Pass recommendations • Clarify integration of existing reporting and data systems and requirements (e.g., REACH, SCIP, IMDS, GADSL list, BOMs, SDSs, ESPR requirements on substances of concern)
6.6.	Circularity and resource efficiency	• Aggregation of data from battery passports for public reporting and capacity planning: potential to improve forecasts and to assess the impact of regulatory measures based on battery passport data • Circularity Score: defining indicators that make the removability, replaceability, and recyclability measurable and comparable • Technical documentation of recycled content shares: discussing and advising on contents • Quality of secondary raw materials: evaluating the possibilities of the battery passport to make statements about the quality of the recycling processes and the output material (recyclate)
6.7.	Performance and durability	• Detailed definition of data attributes and of standardized evaluation conditions. Note: The timeline of ongoing standardization processes may not be in line with reporting requirements in a document or the BMS (*Article 10/14*) • Essential aspects for implementation to be specified: such as the definition of mandated update interval for dynamic data (“up to date”), which needs to consider varying designs (e.g., high temperature batteries, redox flow) and available connectivity of batteries • Interpretation of wording “where appropriate”/“where possible” as of *Annexes IV* and *VII*

As the Battery Regulation enters into force, further methodological development takes place – especially through delegated and implementing acts, as well as other regulatory processes such as the ESPR, which will call for an update or extension of the guidance document. The valuable expertise of the consortium could particularly be leveraged in the development of the up to 50 delegated and implementing acts following the Battery Regulation. Some of these need to be published by the Commission up to a certain date, others can be adopted under certain circumstances at the discretion of the Commission. Figure 36 displays a timeline with a focus on the battery categories in scope of the battery passport. It remains to be discussed if and how the consortium partners could be actively involved in the development process to contribute insights and provide helpful advice.

Figure 36: Timeline of some battery passport related delegated and implementing acts following the Battery Regulation



[1] Only acts with concrete timing displayed; acts referring to battery categories not requiring a battery passport are excluded
Note: The dates of implementation are based on the Regulation version January 2023, e.g. battery passport to be implemented 42 months after entry into force of the Battery Regulation. If the entry into force date of the Regulation deviates, the implementation dates for the CF measures will shift.

This document also aims at a variety of questions relevant to standardisation processes. As European norming organisations start responding to standardisation requests for the Battery Regulation overall and battery passports specifically, the Battery Pass Content Guidance will serve as an ideal basis for their response.

Internally, the Battery Pass will build on the developed content by integrating results into the development of a technical guidance providing a recommendation of a suitable set of technical standards, which enables stakeholders in the battery ecosystem to fulfil their responsibilities in a seamless interoperable manner. Additionally, work on a pilot demonstrator has just been kicked-off which will integrate both content and technical guidance in a world's first EU compliant battery passport solution. Furthermore, the qualitative and quantitative value assessment for individual battery value chain participants as well as society and environment alike is ongoing.

Since requirements of the EU Battery Regulation and other applicable regulations are comprehensive and complex in nature, an increased number of ambiguities arise as more detailed analysis are undertaken. The Battery Pass will continue to take up this challenge and collaborate with other initiatives, particularly the Global Battery Alliance, Catena-X and CIRPASS to align on next steps to jointly contribute in the best possible way to advance the implementation of the battery passport in Europe and beyond towards achieving a truly sustainable and circular battery life through digital value chains.

References

1. **European Commission.** Proposal for a Regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020. [Online] 2023. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST_5469_2023_INIT&from=EN.

2. **Circular Economy Initative Deutschland (CEID).** Resource-Efficient Battery Life Cycles. *Driving Electric Mobility with the Circular Economy.* [Online] 2020. [Cited: 20 03 2023.] https://en.acatech.de/publication/resource-efficient-battery-life-cycles/.

3. **European Commission.** Proposal for a regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020. [Online] 2020. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020PC0798.

4. **European Parliament.** Amendments adopted by the European Parliament on 10 March 2022 on the proposal for a regulation of the European Parliament and of the Council concerning batteries and waste batteries. [Online] [Cited: 20 03 2023.] https://www.europarl.europa.eu/doceo/document/TA-9-2022-0077_EN.html.

5. **Council of the European Union.** Draft European battery regulation – general approach of the Council. [Online] 2022. [Cited: 20 03 2023.] https://data.consilium.europa.eu/doc/document/ST-7103-2022-REV-1/en/pdf.

6. **European Commission.** Proposal for a Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC. [Online] [Cited: 20 03 2023.] https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en.

7. **European Commission.** Directive on Corporate Sustainability Due Diligence. [Online] 2022. [Cited: 20 03 2023.] https://eur-lex.europa.eu/resource.html?uri=cellar:bc4dcea4-9584-11ec-b4e4-01aa75ed71a1.0001.02/DOC_1&format=PDF.

8. **European Commission.** Proposal for a regulation of the European Parliament ant the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020. [Online] 2023. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=COM:2023:160:FIN.

9. **European Commission.** European Critical Raw Materials Act. *Critical Raw Materials: ensuring secure and sustainable supply chains for EU's green and digital future.* [Online] 16 03 2023. [Cited: 20 03 2023.] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661.

10. **European Commission.** FAQ: What is the EU Taxonomy Article 8 delegated act and how. [Online] 2021. [Cited: 20 03 2023.] https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/sustainable-finance-taxonomy-article-8-faq_en.pdf.

11. **S&P Global.** A Short Guide to the EU's Taxonomy Regulation. [Online] 2021. [Cited: 20 03 2023.] https://www.spglobal.com/esg/insights/a-short-guide-to-the-eu-s-taxonomy-regulation.

12. **European Commission.** Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. [Online] 2008. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=EN.

13. **Friedrich Ebert Stiftung.** The Supply Chain Due Diligence Act: Germany sets new standards to protect human rights. [Online] 2021. [Cited: 20 03 2023.] https://library.fes.de/pdf-files/iez/18755.pdf.

14. **European Commission.** Proposal for Corporate Sustainability Reporting Directive. [Online] 2021. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0189&from=FR.

15. **European Commission.** Environment. *REACH.* [Online] [Cited: 20 03 2023.] https://ec.europa.eu/environment/chemicals/reach/reach_en.htm.

16. **Umweltbundesamt.** CLP Regulation. [Online] 2012. [Cited: 20 03 2023.] https://www.umweltbundesamt.de/en/topics/chemicals/classification-labelling-of-chemicals/clp-regulation.

17. **European Commission.** Internal Market, Industry, Entrepreneurship and SMEs. *Classification and labelling (CLP/GHS).* [Online] [Cited: 20 03 2023.] https://single-market-economy.ec.europa.eu/sectors/chemicals/classification-and-labelling-clpghs_en#:~:text=The%20CLP%20Regulation%20replaces%20previous,users%20about%20them%20through%20labelling..

18. **Guidance Document Product Circularity Data Sheet.** Guidance for "light" Product Circularity Data Sheet (v3.2). [Online] 2020. [Cited: 20 03 2023.] https://pcds.lu/wp-content/uploads/2020/11/20200213_GuidanceDocument_PCDS_light_v3.2_FINAL.pdf.

19. **Galatola, M.** Digital Product Passport (DPP). *Circular Economy Europe.* [Online] [Cited: 20 03 2023.] https://circulareconomy.europa.eu/platform/sites/default/files/michele-galatola-european-commission.pdf.

20. **CIRPASS.** The Digital Product Passport as defined in the Proposal for Eco-design for Sustainable Product Regulations (ESPR). [Online] 2023. [Cited: 20 03 2023.]

21. **European Commission.** COMMISSION DELEGATED REGULATION (EU) 2022/670 of 2 February 2022 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide real-time traffic information services. [Online] 02 02 2022. [Cited: 21 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022R0670.

22. **European Commission.** The 'Blue Guide' on the implementation of EU products rules. [Online] 2016. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016XC0726(02)&from=BG.

23. **European Commission.** Commission Notice on the Market Surveillance of Products Sold Online. [Online] 2017. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017XC0801(01)&from=EN.

24. **European Commission.** Regulation (EU) 2019/1020 of the European Parliament and the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011. [Online] 2019. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1020&from=DE.

25. **Bundestag.** Act on Corporate Due Diligence Obligations in Supply Chains. [Online] 2021. [Cited: 20 03 2023.] https://www.bmas.de/SharedDocs/Downloads/DE/Internationales/act-corporate-due-diligence-obligations-supply-chains.pdf?__blob=publicationFile&v=4.

26. **Your Europe.** Technical documentation and EU declaration of conformity. [Online] 2022. [Cited: 20 03 2023.] https://europa.eu/youreurope/business/product-requirements/compliance/technical-documentation-conformity/index_en.htm.

27. **European Commission.** Recommendation on the use of Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations. [Online] 2021. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021H2279&from=EN.

28. **European Commission.** Product Environmental Footprint Category Rules Guidance – version 6.3. [Online] 2018. [Cited: 20 03 2023.] https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf.

29. **Recharge.** PEFCR - Product Environmental Footrpint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Applications. [Online] 2018. [Cited: 20 03 2023.] https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_Batteries_Feb%202020-2.pdf.

30. **Joint Research Centre.** Harmonised rules for the calculation of the Carbon Footprint of Electric Vehicle Batteries (CFB-EV) [DRAFT]. [Online] 2023. [Cited: 20 03 2023.] https://eplca.jrc.ec.europa.eu/GRB-CBF_CarbonFootprintRules-EV.pdf.

31. **Global Battery Alliance (GBA).** Greenhouse Gas Rulebook: Generic Rules - Version 1.4. [Online] 2023. [Cited: 20 03 2023.] https://www.globalbattery.org/media/gba-rulebook-master.pdf.

32. **Together for Sustainability (TFS).** The Product Carbon Footprint Guideline for the Chemical Industry. [Online] 2022. [Cited: 20 03 2023.] https://www.tfs-initiative.com/app/uploads/2022/09/TfS_PCF_Guideline_2022_pages.pdf.

33. **World Business Council for Sustainable Development (WBCSD).** Pathfinder Framework: Guidance for the Accounting and Exchange of Product Life Cycle Emissions version 2.0. [Online] 2023. [Cited: 20 03 2023.] https://www.carbon-transparency.com/media/srhhloun/pathfinder-framework.pdf.

34. **European Commission.** European platform on Life Cycle Assessment. *Annex C.* [Online] 2020. [Cited: 20 03 2023.] https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

35. **European Commission.** European Platform on Life Cycle Assessment - Developer Environmental Footprint (EF). [Online] 2023. [Cited: 20 03 2023.] https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

36. **Persson, L. et al.** Outside the Safe Operating Space of the Planetary Boundary for Novel Entities. s.l. : Environ. Sci. Technol., 2022. Vol. 56, 3.

37. **European Commission.** EU Conflicts Minerals Regulation. [Online] 2017. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2017:130:FULL&from=EN.

38. **Erdmann, M. and Franken, G.** *Sustainability Standard Systems for Mineral Resources. A Comparative Overview - 2022.* Hannover : BGR (Bundesanstalt für Geowissenschaften und Rohstoffe), 2022. 978-3-948532-63-5.

39. **Dietrich, V. and Melcher, F.** Mineral Raw Material Supply Chain Transparency and Traceability: Does Provenance Matter in the Supply Chain? s.l. : BHM Berg- und Hüttenmännische Monatshefte volume, 2022. Vol. 167. https://doi.org/10.1007/s00501-022-01274-8.

40. **Transport & Environment.** Due diligence rules for batteries: making them work for the environment and communities. [Online] 2021. [Cited: 20 03 2023.] https://www.transportenvironment.org/wp-content/uploads/2021/10/DD-Paper.docx.pdf.

41. **Keynes, A.** New battery law could help Europe lead the green battery race. *Transport & Environment.* [Online] 12 11 2020. [Cited: 12 09 2022.] https://www.transportenvironment.org/discover/new-battery-law-could-help-europe-lead-green-battery-race/.

42. **RCS Global.** Blockchain for tracibility in minerals and metals supply chains. *Opportunities and Challenges.* [Online] 2017. [Cited: 20 03 2023.] https://www.rcsglobal.com/wp-content/uploads/2018/09/ICMM-Blockchain-for-Traceability-in-Minerals-and-Metal-Supply-Chains.pdf.

43. **London Metal Exchange.** LMEpassport. Frequently asked quetstions - June 2022. [Online] 2022. [Cited: 20 03 2023.]

44. **Noerr.** EU Commission presents proposal for European supply chain directive - plans to expand due diligence duties in supply chains. [Online] 24 02 2022. [Cited: 01 09 2022.] https://www.noerr.com/en/newsroom/news/eu-commission-presents-proposal-for-european-supply-chain-directive.

45. **European Commission.** Communication from the Commission th the European Parliament, the Council, the European Economic and Social Committee and the Commitee of the Regions. *Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability.* [Online] 2020. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0474. COM(2020)474 final.

46. **European Commission.** EU Science Hub. *Raw Materials Information System (RMIS).* [Online] [Cited: 08 03 2023.] https://rmis.jrc.ec.europa.eu/?page=crm-list-2020-e294f6.

47. **Material Data System.** Critical Raw Materials. [Online] [Cited: 22 11 2022.] https://public.mdsystem.com/en/web/imds-public-pages/gadsl-crm.

48. **Global Automotive Declarable Substance List (GADSL).** Global automotive declarable substance list. [Online] [Cited: 22 11 2022.] https://www.gadsl.org/.

49. **European Chemicals Agency (ECHA).** Substance identification. *ECHA.* [Online] [Cited: 17 10 2022.] https://echa.europa.eu/support/substance-identification/what-is-a-substance.

50. **Organization for Economic Co-operation and Development (OECD).** OECD Statistics Portal. *GLossary of statsitical terms. Hazardous substance.* [Online] [Cited: 24 11 2022.] https://stats.oecd.org/glossary/detail.asp?ID=1205.

51. **European Chemicals Agency (ECHA).** Requirements for SCIP notifications. [Online] 2020. [Cited: 20 03 2023.] https://echa.europa.eu/documents/10162/6205986/information_requirements_for_scip_notifications_en.pdf/db2cf898-5ee7-48fb-e5c8-4e6ce49ee9d2.

52. **European Commission.** A new Circular Economy Action Plan. [Online] 2020. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN.

53. **Robertson-Fall, T.** A circular economy for batteries to underpin renewable energy growth. *Ellen MacArthur Foundation.* [Online] 19 07 2021. [Cited: 20 03 2023.] https://ellenmacarthurfoundation.org/articles/a-circular-economy-for-batteries-to-underpin-renewable-energy-growth.

54. **Gaines, L.** The future of automotive lithium-ion battery recycling: Charting a sustainable course. 2014, Vol. Sustainable Materials and Technologies, 1–2 (2014) 2–7.

55. **Battery Design.** Cell to Pack. [Online] 15 April 2022. [Cited: 20 03 2023.] https://www.batterydesign.net/cell-to-pack/.

56. **VDMA; PEM of RWTH Aachen.** Battery module and pack assembly process. [Online] 2018. [Cited: 20 03 2023.] https://www.pem.rwth-aachen.de/global/show_document.asp?id=aaaaaaaaabdqbtl.

57. **Thompson, D. L. et al.** The importance of design in lithium ion battery recycling - a critical review. s.l. : Green Chemistry, 2020. 22.

58. **Shuaib, N. A. et al.** Advances in Machining of Composite Materials. Engineering Materials. *Recycling of Composite Materials.* s.l. : Springer, 2021.

59. **Spiliotopoulos, C. et al.** Product Reparability Scoring System: Specific application to Smartphones and Slate Tablets. s.l. : Publications Office of the European Union, 2022.

60. **Tecchio, P. et al.** Analysis of material efficiency aspects of personal computer product groups. Luxembourg : Publications Office of the European Union, 2018.

61. **European Commission.** First Circular Economy Action Plan. [Online] 2015. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614.

62. **Association of European Automotive and Industrial Batteries Manufactures (EUROBAT).** Position paper on Recycled Content in the new Batteries Regulation. [Online] 2021. [Cited: 20 03 2023.] https://www.eurobat.org/wp-content/uploads/2021/09/EUROBAT_Position_paper_recycled_content_0103.pdf.

63. **The International Organisation for Standardization (ISO).** Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling). [Online] 2016. [Cited: 20 03 2023.] https://www.iso.org/obp/ui/#iso:std:iso:14021:ed-2:v1:en.

64. **European Commission.** Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods. [Online] 2008. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02008L0068-20130515&from=EN.

65. **European Commission.** Commission implementing decision on a standardisation request to the European standardisation organisations as regards. [Online] 2021. [Cited: 20 03 2023.]

66. **United Nations Economic and Social Council (UNECE).** Proposal for a new UN GTR on In-vehicle Battery Durability. [Online] 2022. [Cited: 20 03 2023.] https://unece.org/sites/default/files/2022-01/ECE_TRANS_WP.29_2022_45E.pdf.

67. **United Nations.** United Nations Global Technical Regulation on Worldwide harmonized Light vehicles Test Procedures (WLTP). 2020. Amendment 6.

68. **World Design Organisation (WDO).** Glossary. *WDO.* [Online] [Cited: 17 10 2022.] https://wdo.org/glossary/material/.

69. **Wagner-Wenz, R. et al.** Recycling routes of lithium-ion batteries: A critical review of the development status, the process performance, and life-cycle environmental impacts. s.l. : MRS Energy & Sustainability, 2022.

70. **Verband der Automobilindustrie e.V. (VDA).** VDA 231-106 (10/2021). [Online] 2021. [Cited: 20 03 2023.] https://webshop.vda.de/VDA/en/vda-231-106-102021.

71. **Benchmark Minerals Intelligence.** Battery Production Scrap to be Main Source of Recyclable Material This Decade. [Online] 2022. [Cited: 20 03 2023.] https://www.benchmarkminerals.com/membership/battery-production-scrap-to-be-main-source-of-recyclable-material-this-decade/.

72. **Glöser-Chahoud, S. et al.** Industrial disassembling as a key enabler of circular economy solutions for obsolete electric vehicle battery systems. s.l. : Resources, Conservation and Recycling, 2021, Vol. 174.

73. **Schnicke, F. and Kuhn, T.** Digitaler Zwilling: Aufbau der Industrie 4.0-IT-Infrastruktur. *IESE Fraunhofer.* [Online] 15 10 2020. [Cited: 02 09 2022.] https://www.iese.fraunhofer.de/blog/digitale-zwillinge-it-infrastruktur.

74. **Responsible Business Alliance (RBA).** What is the difference between traceability and chain of custody? [Online] [Cited: 12 09 2022.] https://www.responsiblemineralsinitiative.org/about/faq/rmap/what-is-the-difference-between-traceability-and-chain-of-custody/.

75. **Responsible Minerals Initiative (RMI).** What is the difference between traceability and chain of custody? [Online] 2023. [Cited: 10 02 2023.] https://www.responsiblemineralsinitiative.org/about/faq/rmap/what-is-the-difference-between-traceability-and-chain-of-custody/.

76. **Recharge.** Battery Regulation: The essential role of manufacturing scrap for the European batteries value chain. *Recharge recommendations for the trilogue discussions.* [Online] 2022. [Cited: 20 03 2023.]

77. **REACH Baden-Württemberg.** Glossar. [Online] [Cited: 17 10 2022.] https://www.reach.baden-wuerttemberg.de/-/glossar-material?inheritRedirect=true.

78. **PPIO.** What is Decentralised Storage? *Everything You'll Need To Know To Understand The Future Of Data Storage.* [Online] 06 05 2019. [Cited: 02 09 2022.] https://medium.com/@ppio/what-is-decentralized-storage-9c4b761942e2.

79. **Eurobat.** White Paper: Battery Innovation Roadmap 2030 – version 2.0. [Online] 2022. [Cited: 20 03 2023.] https://www.eurobat.org/wp-content/uploads/2022/07/white_paper_2022_exe_no_annex_web_file.pdf.

80. **Pease, A., Formisano, C. and Hannegan, T.** The New EU Forced Labor Product Ban: Recommendations for Business. *BSR.* [Online] 29 09 2022. [Cited: 07 10 2022.] https://www.bsr.org/en/our-insights/blog-view/the-new-eu-forced-labor-product-ban-recommendations-for-business.

81. **Organization for Economic Co-operation and Development (OECD).** OECD Due Diligence Guidance for Responsible Business Conduct. [Online] 2018. [Cited: 20 03 2023.] https://mneguidelines.oecd.org/OECD-Due-Diligence-Guidance-for-Responsible-Business-Conduct.pdf.

82. **Organization for Economic Co-operation and Development (OECD).** OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. [Online] 2016. [Cited: 20 03 2023.]

83. **Nenadic, N. G., Trabold, T. A. and Thurston, M. G.** Cell Replacement Strategies for Lithium Ion Battery Packs. *Batteries.* 2020, 6 (3).

84. **MD System.** Welcome to the International Material Data System. [Online] [Cited: 23 11 2022.] https://www.mdsystem.com/imdsnt/startpage/index.jsp.

85. **TÜV Süd.** Lithium Battery Testing under UN/DOT 38.3. [Online] 2019. [Cited: 20 03 2023.] https://www.tuvsud.com/en-us/-/media/global/pdf-files/whitepaper-report-e-books/tuvsud-lithium-battery-testing-under-un-dot-38-3.pdf.

86. **Joseph, D. and Friedmann, H.** Transparency and Traceability: Digitizing Global Supply Chains to Unlock the Circular Advantage. *Learnings from Investing in Supply Chain Transparency.* [Online] Closed Loop Partner, 2021. [Cited: 20 03 2023.] https://www.closedlooppartners.com/wp-content/uploads/2021/11/Transparency-and-Traceability_CLP.pdf.

87. **ISEAL Alliance.** Sustainability Claims. *Good Practice Guide.* [Online] 2015. [Cited: 20 03 2023.] https://www.isealalliance.org/sites/default/files/resource/2017-11/ISEAL_Claims_Good_Practice_Guide.pdf.

88. **Iseal Alliance.** Chain of custody models and definitions. [Online] 2016. [Cited: 20 03 2023.] https://www.isealalliance.org/sites/default/files/resource/2017-11/ISEAL_Chain_of_Custody_Models_Guidance_September_2016.pdf.

89. **Initiative for Responsibke Mining Assurance (IRMA).** Chain of Custody. *Standard for Responsibly Mined Materials. Draft V.1.0.* [Online] 2020. [Cited: 20 03 2023.] https://responsiblemining.net/wp-content/uploads/2020/11/IRMA-Chain-of-Custody-Standard-DRAFTv1.0-October2020.pdf.

90. **International Data Spaces Association.** Innovating the future of data exchange in Europe and beyond. *International Data Spaces Association.* [Online] [Cited: 02 09 2022.] https://internationaldataspaces.org/we/.

91. **Haram, M. H. S. M. et al.** Feasibility of utilising second life EV batteries: Applications, lifespan, economics, environmental impact, assessment, and challenges. [Online] 2021. [Cited: 20 03 2023.] https://doi.org/10.1016/j.aej.2021.03.021.

92. **European Commission.** Internal Market, Industry, Entrepreneurship and SMEs. *Vehicle categories.* [Online] 2023. [Cited: 20 03 2023.] https://single-market-economy.ec.europa.eu/sectors/automotive-industry/vehicle-categories_en.

93. **Hallet, G.** Please consume metals sustainability data responsibly. *Financial Times.* [Online] 09 2022. [Cited: 05 09 2022.] https://www.ft.com/content/68781d78-df61-4f03-a8f9-f33a217281ba?accessToken=zwAAAYMM4Irbkc9oeB1432FPA9Oo-fM6IXKBug.MEUCIEHuDAerLCRTdPsvV5YOqz6AP-V5RKQTMFwFdoxL9JYrAiEAxVR7xMQqemRipLQ4foHu0VhzOdZ6TFvoLC2OKJABMZU&sharetype=gift&token=391108b4-0f71-4f12-a897.

94. **GS1.** GS1 Architectural Principles. Release 4.0. *GS1.* [Online] 06 2020. [Cited: 12 09 2022.] https://www.gs1.org/standards/gs1-architecture-principles/current-standard#Preamble.

95. **greenBatt - Kompetenzcluster Recycling & Grüne Batterie.** DemoSens – Digitalisation of automated disassembly and sensor-based mechanical treatment of lithium-ion batteries for high-quality recycling. [Online] 2021. [Cited: 20 03 2023.] https://www.greenbatt-cluster.de/en/projects/demosens/.

96. **Green Token.** Material traceability for increased circularity in the Chemical Industry. *A blockchain-based mass balance approach using GreenToken by SAP.* [Online] 2022. [Cited: 20 03 2023.] https://www.sap.com/documents/2022/03/c81bc8cb-1d7e-0010-bca6-c68f7e60039b.html.

97. **Götz, T. et al.** Digital Product Passport: The ticket to achieving a climate neutral and circular European economy? s.l. : Wuppertal Institut; University of Cambridge, 2022.

98. **Gaia-x.** What is Gaia-X. [Online] [Cited: 02 09 2022.] https://gaia-x.eu/.

99. **Ardente, F. et al.** Accounting for the environmental benefits of remanufactured products: Method and application. s.l. : Journal of Cleaner Production, 2018.

100. **Ernst & Young (EY).** Sustainability reporting. *What to know about the new EU rules?* [Online] 2022. [Cited: 20 03 2023.] https://www.ey.com/en_no/assurance/how-the-eu-s-new-sustainability-directive-will-be-a-game-changer.

101. **European Commission.** Internal Market, Industry, Entrepreneurship and SMEs. *Harmonised Standards.* [Online] [Cited: 22 02 2023.] https://single-market-economy.ec.europa.eu/single-market/european-standards/harmonised-standards_en.

102. **European Commission.** Taxation and Customs Union. *The EU Single Window Environment for Customs.* [Online] [Cited: 16 02 2023.] https://taxation-customs.ec.europa.eu/eu-single-window-environment-customs_en#:~:text=The%20EU%20Single%20Window%20Environment%20for%20Customs%20will%20enable%20interoperability,for%20the%20goods%20clearance%20process..

103. **European Commission.** Ecodesign for sustainable products. *The new regulation will improve EU products' circularity, energy performance and other environmental sustainability aspects.* [Online] 2022. [Cited: 20 03 2023.] https://ec.europa.eu/info/energy-climate-change-

environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products_en.

104. **European Commission.** EU taxonomy for sustainable activities. [Online] 2022. [Cited: 20 03 2023.] https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en.

105. **European Commission.** Corporate sustainability reporting. [Online] 2022. [Cited: 20 03 2023.] https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en.

106. **European Union.** Framework Contract for the Recognition of Equivalence of Supply Chain Due Diligence Schemes under the Regulation (EU) 2017/821 (Conflict Minerals). *Ted, tenders electronic daily.* [Online] 19 09 2022. [Cited: 20 03 2020.] https://ted.europa.eu/udl?uri=TED:NOTICE:522556-2022:TEXT:EN:HTML.

107. **European Cheimicals Agency (ECHA).** Four hazardous chemicals added to the Candidate List. [Online] 01 2022. [Cited: 14 10 2022.] https://echa.europa.eu/de/-/four-hazardous-chemicals-added-to-the-candidate-list.

108. **European Commission.** eDelivery Documentation. *How does eDelivery work.* [Online] [Cited: 12 09 2022.] https://ec.europa.eu/digital-building-blocks/wikis/display/DIGITAL/How+does+eDelivery+work.

109. **European Commission.** A European Strategy for data. *European Commission.* [Online] [Cited: 02 09 2022.] https://digital-strategy.ec.europa.eu/en/policies/strategy-data.

110. **European Commission.** eDelivery. *Exchange documents and data.* [Online] [Cited: 02 09 2022.] https://ec.europa.eu/digital-building-blocks/wikis/display/DIGITAL/eDelivery.

111. **European Commission.** Joinup European Commission. *NIFO - National Interoperability Framework.* [Online] 2022. [Cited: 02 09 2022.] https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/1-introduction.

112. **European Chemicals Agency (ECHA).** Guidance on requirements for substances in articles. [Online] 2017. [Cited: 20 03 2023.]

113. **European Union.** Indicative, non exhaustive list of conflict-affected and high-risk areas under Regulation (EU) 2017/821. [Online] [Cited: 20 03 2023.] https://www.cahraslist.net/.

114. **Eurostat.** NACE: Statistical classification of economic activites in the European community. [Online] 2008. [Cited: 20 03 2023.] https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF.

115. **European Parliament; European Council.** Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commissi. [Online] 2006. [Cited: 20 03 2023.] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32006R1907.

116. **European Parliament; European Council.** Directive 2001/96/EC on general product safety. [Online] 2001. [Cited: 20 03 2023.]

117. **European Commission.** Proposal for Ecodesign for Sustainable Products Regulation (ESPR). *Annexes - Proposal for a Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC.* [Online] 2022. [Cited: 20 03 2023.] https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en.

118. **Ecos, et al.** Enhancing the sustainability of Batteries. *A joint NGOS' position paper on the EU Battery Regulation Proposal.* [Online] 2021. [Cited: 20 03 2023.] https://ecostandard.org/wp-content/uploads/2021/03/Enhancing-the-sustainability-of-batteries-Joint-Policy-Paper.pdf.

119. **Doose, S. et al.** Challenges in Ecofriendly Battery Recycling and Closed Material Cycles: A Perspective on Future Lithium Battery Generations. s.l. : Metals, 2021, Vols. 11, 291.

120. **Desaulty, A.-M., Monfort Climent, D. and Lefebvre, G.** Tracing the origin of lithium in Li-ion batteries using lithium isotopes. s.l. : Nature Communications, 2022, Vol. 13:4172.

121. **Degreif, S., Betz, J. and Farooki, M.** Meeting the Milestones in the Responsible Sourcing Roadmap. [Online] 2022. [Cited: 20 03 2023.] https://re-sourcing.eu/content/uploads/2022/11/d5.2_res_guidance-document_final.pdf.

122. **Dataspaces.** Common European Data Spaces. [Online] 2022. [Cited: 02 09 2022.] http://dataspaces.info/common-european-data-spaces/#page-content.

123. **Database Town.** Centralised Database. *Database Town.* [Online] [Cited: 02 09 2022.] https://databasetown.com/centralized-database-functions-advantages/.

124. **CERA 4in1.** Certification. *CERA 4in1.* [Online] [Cited: 12 09 2022.] https://www.cera4in1.org/certification/system-and-standards.

125. **CERA 4in1.** Manual. *Version 2.0.* [Online] 2020. [Cited: 20 03 2023.] https://www.cera4in1.org/fileadmin/user_upload/Redakteure/05_MediaInfos/PR_Supplies/Manual/CERA4in1_Manual_read.pdf.

126. **Catena-X.** Vision & Goals. *Catena-X.* [Online] [Cited: 02 09 2022.] https://catena-x.net/en/.

127. **Bundesministerium der Justiz.** Act on Corporate Due Diligence Obligations in Supply Chains of July 16 2021. [Online] [Cited: 20 03 2023.] https://www.bmas.de/SharedDocs/Downloads/DE/Internationales/act-corporate-due-diligence-obligations-supply-chains.pdf?__blob=publicationFile&v=4.

128. **Bipartisan Policy Center.** Inflation Reduction Act Summary. Energy and Climate Provisions. s.l. : BPC, 2022.

129. **Reidy, S.** Chain of Custody: The source of control in global supply chains? – IoT Beyond the Buzz. *arviem.* [Online] 25 04 2017. [Cited: 12 09 2022.] https://arviem.com/chain-custody-source-control-global-supply-chains-iot/.

130. **Amnesty International.** THE EU BATTERY REGULATION: ENSURING THAT HUMAN RIGHTS AND THE ENVIRONMENT. [Online] 2021. [Cited: 20 03 2023.] https://www.amnesty.org/en/wp-content/uploads/2021/10/POL4048162021ENGLISH.pdf.

131. **Kamper, A et al.** Battery pack remanufacturing process up to cell level with sorting and repurposing of battery cells. [Online] 2020. https://doi.org/10.1007/s13243-020-00088-6.

132. **AFNUM et al.** Joint position paper. *Removability and replaceability of portable batteries (Art. 11 of Batteries Regulation).* [Online] 2022. [Cited: 20 03 2023.] https://www.digitaleurope.org/resources/joint-position-paper-removability-and-replaceability-of-portable-batteries/.

133. **Advanced Propulsion Centre UK and Innovate UK.** Automotive batteries. *A £4.8bn a year supply chain opportunity by 2030 for UK chemical and material companies.* [Online] 2019. [Cited: 20 03 2023.] https://apcuk.co.uk/app/uploads/2021/09/Automotive-Batteries-Report-Summary-April-2019.pdf.

134. **TÜV Süd.** Lithium Battery Testing under UN/DOT 38.3. [Online] 2019. [Cited: 30 03 2023.] https://www.tuvsud.com/en-us/-/media/global/pdf-files/whitepaper-report-e-books/tuvsud-lithium-battery-testing-under-un-dot-38-3.pdf.

Battery Pass

Have a look at our Website EXPLORE

Follow us on LinkedIn FOLLOW

Subscribe to our Newsletter REGISTER

Drop a line for more information CONTACT US

CONSORTIUM LEAD

SYSTEMIQ

CONSORTIUM PARTNERS

acatech · Audi · BASF We create chemistry · BMW GROUP · Circulor · FIWARE FOUNDATION · Fraunhofer IPK · TWAICE · umicore · VDE RENEWABLES

* under subcontract

This project receives funding from the German Federal Ministry for Economic Affairs and Climate Action by resolution of the German Bundestag under grant agreement No 16BZF335.

Copyright © 2023 Systemiq (for and on behalf of the Battery Pass Consortium). This work is licensed under a Creative Commons License Attribution-NonCommercial 4.0 International (CC BY-NC 4.0). Readers may reproduce material for their own publications, as long as it is not sold commercially and is given appropriate attribution.

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag